EAST BAY
MUNICIPAL UTILITY DISTRICT

REQUEST FOR PROPOSAL (RFP)

for Interceptor Master Plan Project, Engineering Consultant Services

ADDENDA

Prospective bidders are responsible for reviewing any published addenda regarding this bid at
ebmud.com/business-center

CONTACT

Simon Kobayashi, Associate Engineer
(510) 287-1648
simon.kobayashi@ebmud.com

RESPONSE DUE

September 08, 2023
4:00 p.m. PDT

*SUBMIT ELECTRONICALLY TO**

Simon Kobayashi, EBMUD
Simon.Kobayashi@ebmud.com
**Hardcopy proposals will not be accepted*

EAST BAY MUNICIPAL UTILITY DISTRICT

RFP
for
Interceptor Master Plan
Engineering Consultant Services

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ATTACHMENTS

I. STATEMENT OF WORK

A. SCOPE

It is the intent of this request for proposal (RFP) to describe the professional engineering consultant services, terms, and conditions needed for an agreement to prepare an Interceptor Master Plan which includes condition assessment investigations, risk assessment-based prioritization of rehabilitation projects, corrosion prevention study, and development of a maintenance plan for the District's Interceptor System. See Exhibit E for the full scope of work.

The East Bay Municipal Utility District (District) intends to award a contract to the Proposer(s) who best meets the District's requirements. The objectives of this professional services contract are to perform inspections, prepare risk assessments, evaluate corrosion and potential prevention strategies, recommend scheduled inspection and cleaning maintenance activities, identify necessary capital projects, prioritize those projects, and provide guidance on capital projects relating to the Interceptor System.

Facilities to be investigated under this project make up the Interceptor System and include:

- Gravity Sewer Interceptors
  - North Interceptor
  - South Interceptor
  - South Foothill Interceptor
  - Adeline Interceptor
  - Alameda Interceptor
- Pump Stations (PSs) and their associated Force Mains (FMs)
  - A
  - B
  - C
  - D
  - E
  - F
  - G
  - H
  - J
  - K
  - L
  - M
  - N
  - Q
  - R
- Siphons
- Manholes and Junction Structures
- Overflow Structures
- Ettie St Pump Station Force Main

B. PROPOSER QUALIFICATIONS

1. See Exhibit A – RFP Response Packet and the submittal instructions for specific materials to be included in the proposal. Proposer's qualifications should be addressed in the Statement of Qualifications (SOQ).

2. Proposer Minimum Qualifications

   a. Proposer, Proposer's principal, or Proposer's staff shall have been regularly engaged in the business of providing planning services for wastewater collection systems for at least five (5) years within the last ten (10) years.

   b. Lead Firm

      (1) The lead consulting firm must provide information that demonstrates its experience on projects of similar type, size, and complexity as the current project under consideration. Experience must include at least two comprehensive planning studies for a wastewater collection system within the last ten years, with assets similar to the District's. The relevance of cited projects, and the experience of specific individuals proposed for the current project, should be emphasized. The lead firm shall oversee and coordinate all aspects of the proposed project team's scope of work.

   c. Project Manager/Key Personnel

      (1) Provide both technical and managerial qualifications for the proposed Project Manager and Key Personnel. Proposed personnel must meet the following minimum requirements:

         (a) Project Manager must have had successful experience completing at least two (2) planning studies for a wastewater collection system within the last ten years with a minimum fee of $150,000.

         (b) Project Manager must be an employee of the lead firm with at least five years of experience managing civil/water/wastewater process, planning, or design projects for water/wastewater interceptor systems.

         (c) Key Personnel must have at least three years of experience in their respective disciplines and must demonstrate relevant experience from at least two projects.

      (2) The Project Manager will be the primary client contact and is responsible for the day-to-day management of the project and ensuring that the scope, budget, and schedule are met. The

following information should be provided for the Project Manager and Key Personnel:

(a) Years of experience

(b) Percent (%) time available for this project

(c) Resumes (should demonstrate experience beyond minimum qualification requirements)

d. The Qualifications of the proposer's firm, any subconsultant(s), and project team must collectively demonstrate experience on projects of similar type, size, and complexity as the proposed project. A project may be used for more than one category. Experience must include at least the following:

(1) Two (2) comprehensive planning studies for wastewater collection systems completed within the last ten (10) years. At least one project should have had a consultant contract value over $300,000.

(2) Three (3) condition evaluation and risk assessment projects for wastewater collection systems completed within the last ten (10) years. At least one project shall have had a consultant contract value over $300,000.

(3) One (1) sewer wastewater corrosion study involving H2S sampling/measurements in both wastewater and headspace air and chemical dosing evaluations.

e. Proposer's staff or subcontractors shall stamp all deliverables, reports, drawings, and specifications. Stamps shall be of their relevant disciplines including but not limited to:

(1) California Professional Civil Engineer(s) in good standing licensed with the Board for Professional Engineers, Land Surveyors, and Geologists.

f. Proposer shall possess all permits, licenses, and professional credentials necessary to perform services as specified under this RFP.

C. <u>SPECIFIC REQUIREMENTS</u>

Refer to Exhibit E – Scope of Work for more information.

D. DELIVERABLES / REPORTS

1. Refer to Exhibit E – Scope of Work for more information.

ANTICIPATED MAJOR PROJECT MILESTONES

EVENT	DATE
Project Kickoff	January 2024
Cleaning and Inspection Recommendations	September 2024
Condition Assessment Report	September 2024
Comprehensive Risk Assessment	September 2024
Interceptor System Corrosion Prevention Study Report	November 2024
Corrosion Prevention Alternatives Analysis	November 2024
Final Full Project Summary Report Submittal	December 2024

II. CALENDAR OF EVENTS

EVENT	DATE/LOCATION	
RFP Issued	July 31, 2023	
Pre-Proposal Conference (Optional)	August 18, 2023 @ 11:00 AM on Microsoft Teams	Please e-mail simon.kobayashi@ebmud.com for a video conference invitation link.
Addendum (if necessary)	August 22, 2023	
Response Due	September 8, 2023 by 4:00 p.m.	
Potential Interviews	September 25, 2023	
Anticipated Contract Start Date	January 10, 2024	

Note: All dates are subject to change **by District**.

Proposers are responsible for reviewing **https://www.ebmud.com/business-center/requests-proposal-rfps/** for any published addenda. Hard copies of addenda will not be mailed out.

A. PROPOSAL CONFERENCE (OPTIONAL)

Proposal conference (Optional) will be held to:

1. Allow the District to discuss the scope of the project.

2. Provide an opportunity for Proposers to ask specific questions about the project and request RFP clarifications.

3. Provide the District with an opportunity to receive feedback regarding the project and RFP.

All questions deemed to be pertinent by the District will be addressed in Addenda following the site walk/Proposal conference.

III. DISTRICT PROCEDURES, TERMS, AND CONDITIONS

A. RFP ACCEPTANCE AND AWARD

1. RFP responses will be evaluated by the Selection Committee and will be scored and ranked in accordance with the RFP section entitled "Evaluation Criteria/Selection Committee."

2. The Selection Committee will recommend award to the Proposer who, in its opinion, has submitted the RFP response that best serves the overall interests of the District.

3. The District reserves the right to award to a single or to multiple General or Professional Service Providers, dependent upon what is in the best interest of the District.

4. The District has the right to decline to award this contract or any part of it for any reason.

5. Any specifications, terms, or conditions issued by the District, or those included in the Proposer's submission, in relation to this RFP, may be incorporated into any purchase order or contract that may be awarded as a result of this RFP.

6. Award of contract. The District reserves the right to reject any or all proposals, to accept one part of a proposal and reject the other, unless the proposer stipulates to the contrary, and to waive minor technical defects and administrative errors, as the interest of the District may require. Award will be made, or proposals rejected by the District as soon as possible after proposals have been opened.

B. EVALUATION CRITERIA/SELECTION COMMITTEE

All proposals will be evaluated by a Selection Committee. The Selection Committee may be composed of District staff and other parties that have expertise or experience in this type of procurement. The Selection Committee will select a Proposer in accordance with the evaluation criteria set forth in this RFP. The evaluation of the RFP responses shall be within the sole judgment and discretion of the Selection Committee.

The Selection Committee will evaluate each RFP response meeting the qualification requirements set forth in this RFP. Proposer should bear in mind that any RFP response that is unrealistic in terms of the technical or schedule commitments will be deemed reflective of an inherent lack of technical competence or indicative of a failure to comprehend the complexity and risk of the District's requirements as set forth in this

RFP. The Selection Committee also may request to view examples of reports prepared by the Proposer as part of the evaluation process.

RFP responses will be evaluated and scored according to the Evaluation Criteria below and scored according to a zero to five-point scale. The scores for all Evaluation Criteria will then be added to arrive at a weighted score for each RFP response. An RFP response with a high weighted total will be ranked higher than one with a lesser-weighted total.

The Evaluation Criteria are as follows:

	Evaluation Criteria
A.	**Understanding of the Project:** RFP responses will be evaluated against the RFP specifications and the questions below: 1. Has the Proposer demonstrated a thorough understanding of the purpose and scope of the project? 2. How well has the Proposer identified pertinent issues and potential problems related to the project? 3. Has the Proposer demonstrated that it understands the deliverables the District expects it to provide? 4. Has the Proposer demonstrated that it understands the District's time schedule and can meet it?
B.	**Project Implementation and Management:** The Proposer will be evaluated to determine the following: 1. Effective method(s) of carrying out the scope of the work 2. Potential for the Proposer to come up with new approaches and solutions 3. Key staff's (including the Project Manager's) level of availability and commitment
C.	**Implementation Plan and Schedule:** An evaluation will be made of the likelihood that the Proposer's implementation plan and schedule will meet the District's schedule. Additional credit will be given for the identification and planning for mitigation of schedule risks which the Proposer believes may adversely affect any portion of the District's schedule.
D.	**Relevant Experience:** RFP responses will be evaluated against the RFP specifications and the questions below: 1. Does the PM demonstrate effective leadership skills? 2. Do the individuals assigned to the project have experience on similar projects? 3. Did those individuals successfully complete those similar projects on schedule and under budget?

	4. Are résumés complete and do they demonstrate backgrounds that would be desirable for individuals engaged in the work the project requires? 5. How extensive is the applicable education and experience of the personnel designated to work on the project?
E.	**References (See Exhibit A – RFP Response Packet):** References are only performed on the shortlisted Proposers and the score for reference checks is not included in the preliminary short list score. It is the proposer's responsibility to verify their references are reachable at the provided contact information. If the contact information provided is not correct and the listed references cannot be reached, the District reserves the right to declare the proposal non-responsive and incomplete.
F.	**Oral Presentation and Interview:** The proposer will be evaluated based on how well they present their proposal and conduct the interview. The oral interview may consist of standard questions asked of each of the Proposers and specific questions regarding the specific RFP response and the presentation given. Invitations for the interview and presentation are only given to shortlisted Proposers.
G.	**Contract Equity Program:** Proposer shall be eligible for SBE or DVBE preference points if they are a certified small business entity, as described in the guidelines contained in Exhibit A-Contract Equity Program, and they check the appropriate box, requesting preference, in Exhibit A-Proposer Information and Acceptance. Qualified DVBEs and/or SBEs will receive an additional 5 points to their total score.

C. NOTICE OF INTENT TO AWARD AND PROTESTS

At the conclusion of the RFP response evaluation process, all entities who submitted a proposal package will be notified in writing by e-mail or USPS mail with the name of the Proposer being recommended for contract award. The document providing this notification is the Notice of Intent to Award.

Negotiations for a Consulting Services Agreement with a "not to exceed" contract price (for time and expenses) will be scheduled shortly after the Notice of Intent to Award. If an Agreement cannot be achieved, the District will proceed to negotiate with the next highest ranked Proposer.

Protests must be in writing and must be received no later than seven (7) workdays after the District issues the Notice of Intent to Award. The District will reject the protest as untimely if it is received after this specified time frame. Protests will be accepted from proposers or potential proposers only.

If the protest is mailed and not received by the District, the protesting party bears the burden of proof to submit evidence (e.g., certified mail receipt) that the protest was sent in a timely manner so that it would be received by the District within the RFP protest period.

Proposal protests must contain a detailed and complete written statement describing the reason(s) for protest. The protest must include the name and/or number of the proposal, the name of the firm protesting, and include a name, telephone number, email address and physical address of the protester. If a firm is representing the protester, they shall include their contact information in addition to that of the protesting firm.

Protests must be mailed, hand delivered, or emailed to the Manager of Purchasing, Mailstop 102, East Bay Municipal Utility District, 375 Eleventh Street, Oakland, CA 94607 or P.O. Box 24055, Oakland, California 94623. Facsimile and electronic mail protests must be followed by a mailed or hand delivered identical copy of the protest and must arrive within the seven workday time limit. Any proposal protest filed with any other District office shall be forwarded immediately to the Manager of Purchasing.

In the event that the protest is denied, the protester can appeal the determination to the requesting organization's Department Director. The appeal must be submitted to the Department Director no later than five workdays from the date which the protest determination was transmitted by the District, to the protesting party. The appeal shall focus on the points raised in the original protest, and no new points shall be raised in the appeal.

Such an appeal must be made in writing and must include all grounds for the appeal and copies of the original protest and the District's response. The proposal protester must also send the Purchasing Division a copy of all materials sent to the Department Director.

The Department Director will make a determination of the appeal and respond to the protester by certified mail in a timely manner. If the appeal is denied, the letter will include the date, time, and location of the Board of Directors meeting at which staff will make a recommendation for award and inform the protester it may request to address the Board of Directors at that meeting.

The District may transmit copies of the protest and any attached documentation to all other parties who may be affected by the outcome of the protest. The decision of the District as to the validity of any protest is final. This District's final decision will be transmitted to all affected parties in a timely manner.

D. INVOICING

1. Following the Districts acceptance of product(s) meeting all specified requirements, and/or the complete and satisfactory performance of services, the District will render payment within thirty (30) days of receipt of a correct invoice.

2. The District will notify the Professional Service Provider of any invoice adjustments required.

3. Invoices shall contain, at a minimum, District purchase order number, invoice number, remit to address, and itemized services description.

4. The District will pay Professional Service Provider in an amount not to exceed the negotiated amount(s) which will be referenced in the agreement signed by both parties.

IV. RFP RESPONSE SUBMITTAL INSTRUCTIONS AND INFORMATION

A. DISTRICT CONTACTS

All contact during the competitive process is to be through the contact listed on the first page of this RFP. The following persons are to be contacted only for the purposes specified below:

FOR INFORMATION REGARDING RFP:
Attn: Simon Kobayashi, Associate Engineer
EBMUD Wastewater Engineering Division
E-Mail: Simon.Kobayashi@ebmud.com
PHONE: (510) 287-1648

FOR INFORMATION ON THE CONTRACT EQUITY PROGRAM:
Attn: Contract Equity Office
PHONE: (510) 287-0114

AFTER AWARD:
Attn: Simon Kobayashi, Associate Engineer
EBMUD Wastewater Engineering Division
E-Mail: Simon.Kobayashi@ebmud.com
PHONE: (510) 287-1648

B. SUBMITTAL OF RFP RESPONSE

1. At this time, no hardcopy proposals will be accepted. RFP responses, in their entirety, in pdf format and prior to the bid due date/time RFP submittals, shall be submitted electronically by electronic mail (e-mail) to Simon.Kobayashi@ebmud.com. The District's email has limitations on attachment size. Attachments must be less than 25 megabytes. If the file exceeds the limit, multiple emails may be sent to submit the full RFP response. Proposers are solely responsible for ensuring timely delivery of the proposals. The District shall not be responsible for any issues related to transfer of files through email. Proposers may call (510) 287-1648 to check receipt of the proposal.

2. All costs required for the preparation and submission of an RFP response shall be borne by the Proposer.

3. California Government Code Section 4552: In submitting an RFP response to a public purchasing body, the Proposer offers and agrees that if the RFP response is accepted, it will assign to the purchasing body all rights, title, and interest in and to all causes of action it may have under Section 4 of the Clayton Act (15 U.S.C. Sec. 15) or under the Cartwright Act (Chapter 2, commencing with Section 16700, of Part 2 of Division 7 of the Business and Professions Code), arising from purchases of goods, materials, or services by the Proposer for sale to the purchasing body pursuant to the RFP response. Such assignment shall be made and become effective at the time the purchasing body tenders final payment to the Proposer.

4. Proposer expressly acknowledges that it is aware that if a false claim is knowingly submitted (as the terms "claim" and "knowingly" are defined in the California False Claims Act, Cal. Gov. Code, §12650 et seq.), the District will be entitled to civil remedies set forth in the California False Claim Act.

5. The RFP response shall remain open to acceptance and is irrevocable for a period of one hundred eighty (180) days, unless otherwise specified in the RFP documents.

6. It is understood that the District reserves the right to reject any or all RFP responses.

C. RESPONSE FORMAT

1. **Proposers shall not modify the existing text for any part of Exhibits A, B, C, D, E, or F or qualify their RFP responses. Proposers shall not submit to the District a re-typed or otherwise re-created version of these documents or any other District-provided document.**

2. RFP responses, in whole or in part, are NOT to be marked confidential or proprietary. The District may refuse to consider any RFP response or part thereof so marked. RFP responses submitted in response to this RFP may be subject to public disclosure. The District shall not be liable in any way for disclosure of any such records.

EXHIBIT A
RFP RESPONSE PACKET

RFP For – Interceptor Master Plan, Engineering Consultant Services

To: The EAST BAY MUNICIPAL UTILITY District ("District")

From: ____

(Official Name of Proposer)

RFP RESPONSE PACKET GUIDELINES

- **SUBMITTAL SHALL CONTAIN THE FOLLOWING:**
  - **EXHIBIT A – RFP RESPONSE PACKET**
    - **INCLUDING ALL REQUIRED DOCUMENTATION AS DESCRIBED IN "EXHIBIT A-REQUIRED DOCUMENTATION AND SUBMITTALS"**
  - **EXHIBIT B – INSURANCE REQUIREMENTS**
  - **EXHIBIT D – IRAN CONTRACTING ACT CERTIFICATION**

- **PROPOSERS THAT DO NOT COMPLY WITH THE REQUIREMENTS, AND/OR SUBMIT AN INCOMPLETE RFP RESPONSE MAY BE SUBJECT TO DISQUALIFICATION AND THEIR RFP RESPONSE REJECTED IN WHOLE.**

- **IF PROPOSERS ARE MAKING <u>ANY</u> CLARIFICATIONS AND/OR AMENDMENTS, OR TAKING EXCEPTION TO ANY PART OF THIS RFP, THESE <u>MUST</u> BE SUBMITTED IN THE EXCEPTIONS, CLARIFICATIONS, AND AMENDMENTS SECTION OF THIS EXHIBIT A – RFP RESPONSE PACKET. THE DISTRICT, AT ITS SOLE DISCRETION, MAY ACCEPT AMENDMENTS/EXCEPTIONS, OR MAY DEEM THEM TO BE UNACCEPTABLE, THEREBY RENDERING THE RFP RESPONSE DISQUALIFIED.**

- **PROPOSORS SHALL NOT MODIFY DISTRICT LANGUAGE IN ANY PART OF THIS RFP OR ITS EXHIBITS, NOR SHALL THEY QUALIFY THEIR RFP RESPONSE BY INSERTING THEIR OWN LANGUAGE OR FALSE CLAIMS IN THEIR RESPONSE. ANY EXCEPTIONS AND CLARIFICATIONS MUST BE PLACED IN THE "EXCEPTIONS/ CLARIFICATIONS" PAGE, NOT BURIED IN THE PROPOSAL ITSELF.**

EBMUD

PROPOSER INFORMATION AND ACCEPTANCE

1. The undersigned declares that all RFP documents, including, without limitation, the RFP, Addenda, and Exhibits, have been read and that the terms, conditions, certifications, and requirements are agreed to.

2. The undersigned is authorized to offer, and agrees to furnish, the articles and services specified in accordance with the RFP documents.

3. The undersigned acknowledges acceptance of all addenda related to this RFP. List Addenda for this RFP on the line below:

Addendum #	**Date**

4. The undersigned hereby certifies to the District that all representations, certifications, and statements made by the Proposer, as set forth in this RFP Response Packet and attachments, are true and correct and are made under penalty of perjury pursuant to the laws of California.

5. The undersigned acknowledges that the Proposer is, and will be, in good standing in the State of California, with all the necessary licenses, permits, certifications, approvals, and authorizations necessary to perform all obligations in connection with this RFP and associated RFP documents.

6. It is the responsibility of each Proposer to be familiar with all of the specifications, terms, and conditions and, if applicable, the site condition. By the submission of an RFP response, the Proposer certifies that if awarded a contract it will make no claim against the District based upon ignorance of conditions or misunderstanding of the specifications.

7. Patent indemnity: General or Professional Service Providers who do business with the District shall hold the District, its Directors, officers, agents, and employees harmless from liability of any nature or kind, including cost and expenses, for infringement or use of any patent, copyright or other proprietary right, secret process, patented or unpatented invention, article, or appliance furnished or used in connection with the contract or purchase order.

8. Insurance certificates are not required at the time of submission. However, by signing Exhibit A – RFP Response Packet, the Proposer agrees to meet the minimum insurance requirements stated in the RFP. This documentation must be provided to the District prior to execution of an agreement by the District

and shall include an insurance certificate which meets the minimum insurance requirements, as stated in the RFP.

9. The undersigned acknowledges that RFP responses, in whole or in part, are NOT to be marked confidential or proprietary. The District may refuse to consider any RFP response or part thereof so marked. RFP responses submitted in response to this RFP may be subject to public disclosure. The District shall not be liable in any way for disclosure of any such records.

10. The undersigned Proposer hereby submits this RFP response and binds itself to the District. The RFP, subsequent Addenda, Proposers Response Packet, and any attachments, shall be used to form the basis of a Contract, which once executed shall take precedence.

11. The undersigned acknowledges ***ONE*** of the following (please check only one box)*:

    ☐ Proposer is not an SBE nor a DVBE and is ineligible for any Proposal preference; **OR**

    ☐ Proposer is an SBE or DVBE as described in the Contract Equity Program (CEP) and Equal Employment Opportunity (EEO) Guidelines, and has completed the CEP and EEO forms at the hyperlink contained in the CEP and EEO section of this Exhibit A.

    *If no box is checked it will be assumed that the Proposer is ineligible for Proposal preference, and none will be given. For additional information on SBE/DVBE Proposal preference please refer to the Contract Equity Program and Equal Employment Opportunity Guidelines at the above referenced hyperlink.

Official Name of Proposer (exactly as it appears on Proposer's corporate seal and invoice): ____________________

Street Address Line 1: ____________________

Street Address Line 2: ____________________

City: ____________________ State: __________ Zip Code: __________

Webpage: ____________________

Type of Entity / Organizational Structure (check one):

☐ Corporation ☐ Joint Venture

☐ Limited Liability Partnership ☐ Partnership

☐ Limited Liability Corporation ☐ Non-Profit / Church

☐ Other: ____________________

Jurisdiction of Organization Structure: ____________________

Date of Organization Structure: ____________________

Federal Tax Identification Number: ____________________

Department of Industrial Relations (DIR) Registration Number: ____________________

Primary Contact Information:

Name / Title: ____________________

Telephone Number: ____________________ Fax Number: ____________________

E-mail Address: ____________________

Street Address Line 1: ____________________

City: ____________________ State: __________ Zip Code: ____________________

Does proposer or any employee/representative/service provider have any relatives currently employed with EBMUD? (This does not impact award of a qualified proposal; required reporting purposes only.)

☐ YES ☐ NO

If so, please list :

CONTRACTOR OR CONTRACTOR EMPLOYEE FIRST AND LAST NAME	DISTRICT EMPLOYEE FIRST AND LAST NAME	RELATIONSHIP

SIGNATURE: ____________________

Name and Title of Signer (printed): ____________________

Dated this ____________ day of ____________________ 20__________

EBMUD

REQUIRED DOCUMENTATION AND SUBMITTALS

All of the specific documentation listed below is required to be submitted with the Exhibit A – RFP Response Packet. Proposers shall submit all documentation, in the order listed below, and clearly label each section of the RFP response with the appropriate title (i.e., Table of Contents, Letter of Transmittal, Key Personnel, etc.).

1. **Letter of Transmittal**: RFP response shall include a description of the Proposer's capabilities and approach in providing its services to the District, and provide a brief synopsis of the highlights of the RFP response and overall benefits to the District. The letter of transmittal should clearly identify the Consultant, the office location(s) where the work would be performed, the project manager, key technical personnel, and subconsultants that will perform the work. The letter should be signed by an individual having authority to execute an agreement with EBMUD.

2. **Statement of Qualifications**: To be considered for this project, your firm must complete the Statement of Qualifications (SOQ) Form in Exhibit A. The purpose of the SOQ is to clearly identify relevant team experience that qualifies your firm for preparation of the work. The SOQ shall include a complete list of all key personnel and proposed subconsultants associated with the RFP who will provide engineering and engineering support services. The Proposer may use an alternate format to the SOQ Form provided as long as all the requested information is included and presented clearly.

   (a) Fill all fields to demonstrate the Proposer's (Lead Firm) qualifications in regards to RFP Section I.B PROPOSER QUALIFICATIONS.
   (b) References should have similar scope, complexity, and requirements to those outlined in these specifications, terms, and conditions.
      - Proposers must verify the contact information for all references provided is current and valid.
      - Proposers are strongly encouraged to notify all references that the District may be contacting them to obtain a reference.
   (c) The District may contact some or all of the references provided in order to determine Proposer's performance record on work similar to that described in this RFP. The District reserves the right to contact references other than those provided in the Proposal and to use the information gained from them in the evaluation process.
   (d) Provide resumes for all key project personnel.

3. **Description of the Proposed Services**: RFP response shall include a description of the terms and conditions of services to be provided during the contract term including response times. The description shall contain a basis of estimate for services including its scheduled start and completion dates, the number of Proposer's and District personnel involved, and the number

of hours scheduled for each person. The description must: (1) specify how the services in the RFP response will meet or exceed the requirements of the District; (2) explain any special resources or approaches that make the services of the Proposer particularly advantageous to the District; and (3) identify any limitations or restrictions of the Proposer in providing the services that the District should be aware of in evaluating its RFP response to this RFP.

4. **Project Approach:** The proposal should include a clear and complete discussion of how each task in Exhibit E, as applicable, will be completed and in sufficient detail to present the proposed approach. In general, the project approach should demonstrate:

   - Adequate resources and expertise to complete the work.
   - Extensive knowledge of condition assessment, risk assessment, and capital planning of municipal wastewater pipelines and pump stations comparable to scope of work.
   - Extensive knowledge of corrosion mechanisms in wastewater systems and corrosion prevention strategies.
   - Sufficient practical knowledge of traffic control and encroachment permitting.
   - Extensive experience coordinating with municipal and utility agencies and agency staff to facilitate inspections occurring in the public right of way and/or easements, and maintaining positive working relationships with those entities.
   - How Consultant will utilize existing information and data.

   As applicable, the Proposer is encouraged to break tasks into subtasks and describe how these subtasks will contribute to the completion of the task and deliverable. Clearly identify planned meetings, activities where District involvement is required (inspection, submittal review, etc.), and activities where outside party involvement is required for each task. Portions of separate tasks may be performed concurrently. Task and subtask dependency should be reflected in the Proposer's schedule.

   Discuss any reasons for significant changes to the scope of work. As part of the proposal, respondents are encouraged to recommend changes or additions to the scope of work that may improve performance or outcomes, reduce costs, and/or shorten the project schedule. The proposed scope should include any optional services that the Consultant feels may improve successful completion of the project. Resources under this task are for work that is not within the anticipated scope of services described in this RFP package.

5. **Project Management**: The proposal should describe how Consultant's project manager proposes to:

   - Coordinate all deliverables. Draft reports are required prior to all final reports.
   - Attend and support project management and/or working meetings with EBMUD.
   - Manage schedule and budget and report progress.
   - Address any performance issues that may arise during the period of the contract.
   - Ensure quality assurance/quality control for work.
   - Coordinate and work effectively with District Engineering staff.

- Coordinate and work effectively with outside agencies, contractors, and subconsultants.
- See Exhibit E – Scope of Work, Project Management.

Identify the Project Manager and Key Personnel that will lead the project efforts. Indicate any tasks that the Consultant assumes will be completed by EBMUD.

6. **Labor Hours by Task:** Provide a detailed breakdown of labor hours by Task and positions, including subconsultants. The estimate of labor hours presented in the proposal will provide a basis for contract negotiations with the selected Proposers. The Proposer may use the table provided below as a template.

	Estimated Labor Hours by Task			**Total Hours per Task**
	Project Manager	Project Engineer	… (roles listed in the table above, add column for each role)	
Task 1				(Sum hours for this task)
Task 2				
… (add a new row for each Task in Exhibit)				
Total Hours per Role	(Sum hours in rows above within this column)	(Sum hours in rows above within this column)	(Sum hours in rows above within this column)	(Total Project Hours)

7. **Schedule**:

The Proposal shall include a detailed schedule. The schedule should indicate how the Proposer will ensure adherence to the timetables for completing the tasks and deliverables outlined in this RFP. Clearly identify the critical path and tasks that can be worked on concurrently. The major milestone deliverable dates must be included (at a minimum) for each Deliverable and Design Submittal in Exhibit E, Scope of Work.

8. **Exceptions, Clarifications, Amendments:**

(a) The RFP response shall include a separate section calling out all clarifications, exceptions, and amendments, if any, to the RFP and associated RFP documents, which shall be submitted with the proposer's RFP response using the template in the "Exceptions, Clarifications, Amendments" section of this Exhibit A – RFP Response Packet.

(b) Proposer is encouraged to contact the District with questions regarding the RFP, if necessary, during the proposal phase.

(c) **THE DISTRICT IS UNDER NO OBLIGATION TO ACCEPT ANY EXCEPTIONS, AND SUCH EXCEPTIONS MAY BE A BASIS FOR RFP RESPONSE DISQUALIFICATION.**

9. **Contract Equity Program:**

(a) Every proposer must fill out, sign, and submit the appropriate sections of the Contract Equity Program and Equal Employment Opportunity documents located at the hyperlink contained in the last page of this Exhibit A. Special attention should be given to completing Form P-25, "Employment Data and Certification". Any proposer needing assistance in completing these forms should contact the District's Contract Equity Office at (510) 287-0114 prior to submitting an RFP response.

10. **Submittal Length**:

Item	Page Limit
Transmittal Letter	1
SOQ	12
Project Approach and Services	10
Project Management and Staff	4
Labor Hours by Task	2
Schedule	1
Exceptions, Clarifications, Amendments	As needed
Contract Equity Program Forms	As needed
Resumes	Max 2 per person
Exhibit A RFP Response Packet Sheets	4
Exhibit D Iran Contracting Act Sheet	1

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Statement of Qualifications (SOQ) Form
RFP For Interceptor Master Plan
Engineering Consultant Services

Proposer Name:______________________________

Interceptor Master Plan Project, Engineering Consultant Services Statement of Qualifications				
Under Project Team Definition: (1) indicate the estimated portion of the total consulting fee for which each firm is responsible. Total should equal 100%; (2) provide resumes for all key project personnel, and (3) refer to RFP Section I.B for information on minimum qualifications. For qualifying experience, space is provided — add additional rows as needed. This form is available in MS Word by contacting Simon Kobayashi (simon.kobayashi@ebmud.com).				
Project Team Definition				
	Firm/Primary Location	**Expertise** (e.g. Condition Assessment, Design, Peer Review)	**Est %** ($/$)	**M/WBE (Y/N)**
Lead				
Sub				
Sub				
… (insert more rows as needed)				

Lead Firm Key Personnel Qualifications

Name (Title)	**Years of Employment at Lead Firm**	**Total Years of Experience on Relevant Projects**	**General Role (Discipline)**	**PE License No.** (if applicable)
Project Manager				
Project Engineer				
… (insert more rows as needed)				

Subconsultant Key Personnel Qualifications

Name (Title)	**Years of Employment at Lead Firm**	**Total Years of Experience on Relevant Projects**	**General Role (Discipline)**	**PE License No.** (if applicable)
… (insert more rows as needed)				

QUALIFYING EXPERIENCE (fill out additional forms as applicable)

Project 1 Project Name: Subconsultant(s) and Role, if any: Client Name: Project Description: Personnel Involved and Role: Year Prepared (2013-2023): Contract Fee: Lead Firm Contact Name, Title: Lead Firm Contact Phone, Email: Client Contact Name, Title: Contact Phone, Email:
Project 2 Project Name: Subconsultant(s) and Role, if any: Client Name: Project Description: Personnel Involved and Role: Year Prepared (2013-2023): Contract Fee: Lead Firm Contact Name, Title: Lead Firm Contact Phone, Email: Client Contact Name, Title: Contact Phone, Email:
Project 3 Project Name: Subconsultant(s) and Role, if any: Client Name: Project Description: Personnel Involved and Role: Year Prepared (2013-2023): Contract Fee: Lead Firm Contact Name, Title: Lead Firm Contact Phone, Email: Client Contact Name, Title: Contact Phone, Email:

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EXCEPTIONS, CLARIFICATIONS, AMENDMENTS

RFP For - Interceptor Master Plan Project

Proposer Name:______________________________

List below requests for clarifications, exceptions, and amendments, if any, to the RFP and associated RFP documents, and submit with your RFP response.

The District is under no obligation to accept any exceptions and such exceptions may be a basis for RFP response disqualification.

Reference to:			**Description**
Page No.	Section	Item No.	
p. 23	**D**	**1.c.**	***Proposer takes exception to…***

*Print additional pages as necessary

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CONTRACT EQUITY PROGRAM & EQUAL EMPLOYMENT OPPORTUNITY

The District's Board of Directors adopted the Contract Equity Program (CEP) to enhance equal opportunities for business owners of all races, ethnicities, and genders who are interested in doing business with the District. The program has contracting objectives, serving as the minimum level of expected contract participation for the three availability groups: white-men owned businesses, white-women owned businesses, and ethnic minority owned businesses. The contracting objectives apply to all contracts that are determined to have subcontracting opportunities, and to all General or Professional Service Providers regardless of their race, gender, or ethnicity.

All Contractors and their subcontractors performing work for the District must be Equal Employment Opportunity (EEO) employers and shall be bound by all laws prohibiting discrimination in employment. There shall be no discrimination against any person, or group of persons, on account of race, color, religion, creed, national origin, ancestry, gender including gender identity or expression, age, marital or domestic partnership status, mental disability, physical disability (including HIV and AIDS), medical condition (including genetic characteristics or cancer), genetic information, or sexual orientation.

Contractor and its subcontractors shall abide by the requirements of 41 CFR §§ 60-1.4(a), 60-300.5(a) and 60-741.5(a). These regulations prohibit discrimination against qualified individuals based on their status as protected veterans or individuals with disabilities and prohibit discrimination against all individuals based on their race, color, religion, sex, sexual orientation, gender identity, or national origin in the performance of this contract. Moreover, these regulations require that covered prime contractors and subcontractors take affirmative action to employ and advance in employment individuals without regard to race, color, religion, sex, national origin, protected veteran status or disability.

All Contractors shall include the nondiscrimination provisions above in all subcontracts.
Please include the required completed forms with your proposal. Non-compliance with the Guidelines may deem a proposal non-responsive, and therefore, ineligible for contract award. Your firm is responsible for:

1) Reading and understanding the CEP guidelines.

2) Filling out and submitting with your proposal the appropriate forms.

   The CEP guidelines and forms can be downloaded from the District website at the following link:
   https://www.ebmud.com/business-center/contract-equity-program

If you have questions regarding the Contract Equity Program, please call (510) 287-0114.

EXHIBIT B
INSURANCE REQUIREMENTS

PROPOSER shall take out and maintain during the life of the Agreement all insurance required and PROPOSER shall not commence work until such insurance has been approved by DISTRICT. The proof of insurance shall be on forms provided by DISTRICT directly following these Insurance Requirements.

PROPOSERS are not required to submit completed insurance verification documents with their bid but will be required to submit them upon notification of award. By signing Exhibit A – RFP Response Packet, the Proposer agrees to meet the minimum insurance requirements stated in the RFP.

<u>The following provisions applicable to all required insurance:</u>

A. Prior to the beginning of and throughout the duration of Services, and for any additional period of time as specified below, CONTRACTOR shall, at its sole cost and expense, maintain insurance in conformance with the requirements set forth below.

B. CONTRACTOR shall provide Verification of Insurance as required by this Agreement by providing the completed Verification of Insurance as requested below signing and submitting this Exhibit B to the DISTRICT. The Exhibit B may be signed by an officer of the CONTRACTOR (Agent) or by the Insurance Broker for the CONTRACTOR. CONTRACTOR shall update Exhibit B throughout the specified term of the insurance required by this Agreement by resubmitting the completed Exhibit B prior to the expiration date of any of the required insurance. The updated Exhibit B shall become a part of the Agreement but shall not require a change order to the Agreement. The Notice to Proceed shall not be issued, and CONTRACTOR shall not commence Services until such insurance has been accepted by the DISTRICT.

C. CONTRACTOR shall carry and maintain the minimum insurance requirements as defined in this Agreement. CONTRACTOR shall require any subcontractor to carry and maintain the minimum insurance required in this Agreement to the extent they apply to the scope of the services to be performed by subcontractor.

D. Acceptance of verification of Insurance by the DISTRICT shall not relieve CONTRACTOR of any of the insurance requirements, nor decrease liability of CONTRACTOR.

E. The insurance required hereunder may be obtained by a combination of primary, excess and/or umbrella insurance, and all coverage shall be at least as broad as the requirements listed in this Agreement.

F. Any deductibles, self-insurance, or self-insured retentions (SIRs) applicable to the required insurance coverage must be declared to and accepted by the DISTRICT.

G. At the option and request of the DISTRICT, CONTRACTOR shall provide documentation of its financial ability to pay the deductible, self-insurance, or SIR.

H. Any policies with a SIR shall provide that any SIR may be satisfied, in whole or in part, by the DISTRICT or the additional insured at its sole and absolute discretion.

I. Unless otherwise accepted by the DISTRICT, all required insurance must be placed with insurers with a current A.M. Best's rating of no less than A- V.

J. CONTRACTOR shall defend the DISTRICT and pay any damages as a result of failure to provide the waiver of subrogation from the insurance carrier.

K. For any coverage that is provided on a claims-made coverage form (which type of form is permitted only where specified) the retroactive date must be shown and must be before the date of this Agreement, and before the beginning of any Services related to this Agreement.

L. Insurance must be maintained, and updated Verification of Insurance be provided to the DISTRICT before the expiration of insurance by having CONTRACTOR's insurance broker or agent update, sign and return Exhibit B to the DISTRICT's contract manager. For all claims-made policies the updated Verification of Insurance must be provided to the DISTRICT for at least three (3) years after expiration of this Agreement.

M. If claims-made coverage is canceled or non-renewed, and not replaced with another claims-made policy form with a retroactive date prior to the effective date of this Agreement or the start of any Services related to this Agreement, CONTRACTOR must purchase an extended reporting period for a minimum of three (3) years after expiration of the Agreement.

N. If requested by the DISTRICT, a copy of the policies' claims reporting requirement must be submitted to the DISTRICT for review.

O. Where additional insured coverage is required, the additional insured coverage shall be "primary and non-contributory," and will not seek contribution from the DISTRICT's insurance or self-insurance.

P. CONTRACTOR agrees to provide immediate Notice to the DISTRICT of any loss or claim against CONTRACTOR arising out of, pertaining to, or in any way relating to this Agreement, or Services performed under this Agreement. The DISTRICT assumes no obligation or liability by such Notice but has the right (but not the duty) to monitor the handling of any such claim or claims if they are likely to involve the DISTRICT.

Q. CONTRACTOR agrees, upon request by the DISTRICT, to provide complete, certified copies of any policies and endorsements within 10 days of such request (copies of policies may be redacted to eliminate premium details.)

R. It is CONTRACTOR's responsibility to ensure its compliance with the insurance requirements. Any actual or alleged failure on the part of the DISTRICT to obtain proof of insurance required under this Agreement shall not in any way be construed to be a waiver of any right or remedy of the DISTRICT, in this or any regard.

S. **Notice of Cancellation/Non-Renewal/Material Reduction** The insurance requirements hereunder are mandatory, and the DISTRICT may, at its sole and absolute discretion, terminate the services provided by CONTRACTOR, should CONTRACTOR breach its obligations to maintain the required coverage and limits set forth in this Agreement. No coverage required hereunder shall be cancelled, non-renewed or materially reduced in coverage or limits without the DISTRICT being provided at least thirty (30) days prior written notice, other than cancellation for the non-payment of premiums, in which event the DISTRICT shall be provided ten (10) days prior written notice. Replacement of coverage with another policy or insurer, without any lapse in coverage or any reduction of the stated requirements does not require notice beyond submission to the DISTRICT of an updated Verification of Insurance which shall be met by having the CONTRACTOR's insurance broker or agent update, sign and return this EXHIBIT B.

I. Workers' Compensation and Employer's Liability Insurance Coverage

A. Workers' Compensation insurance including Employer's Liability insurance with minimum limits as follows:

Coverage A.	Statutory Benefits Limits	
Coverage B.	Employer's Liability of not less than:	
	Bodily Injury by accident:	\$1,000,000 each accident
	Bodily Injury by disease:	\$1,000,000 each employee
	Bodily Injury by disease:	\$1,000,000 policy limit

B. CONTRACTOR's insurance shall be primary, and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

C. If there is an onsite exposure of injury to CONTRACTOR, subcontractor, and/or subcontractor's employees under the U.S. Longshore and Harbor Workers' Compensation Act, the Jones Act, or under laws, regulations or statutes applicable to maritime employees, coverage is required for such injuries or claims.

D. If CONTRACTOR is self-employed, a sole proprietorship or a partnership, with no employees, and is exempt from carrying Workers' Compensation Insurance, CONTRACTOR must return the completed Verification of Insurance confirming that CONTRACTOR has no employees and is exempt from the State of California Workers' Compensation requirements.

E. If CONTRACTOR is self-insured with respect to Workers' Compensation coverage, CONTRACTOR shall provide to the DISTRICT a Certificate of Consent to Self-Insure from the California Department of Industrial Relations. Such self-insurance shall meet the minimum limit requirements and shall waive subrogation rights in favor of the DISTRICT as stated below in section "F."

F. Waiver of Subrogation. Workers' Compensation policies, including any applicable excess and umbrella insurance, must contain a waiver of subrogation endorsement providing that CONTRACTOR and each insurer waive any and all rights of recovery by subrogation, or otherwise, against the DISTRICT, its directors, board, and committee members, officers, officials, employees, agents, and volunteers. CONTRACTOR shall defend and pay any and all damages, fees, and costs, of any kind arising out of, pertaining to, or in any way relating to CONTRACTOR's failure to provide waiver of subrogation from the insurance carrier.

INSURANCE VERIFICATION DOCUMENTS

Verification of Workers' Compensation and Employer's Liability Insurance Coverage

☐ **By checking the box and signing below, I hereby verify that the CONTRACTOR is exempt from the State of California's requirement to carry workers' compensation insurance.**

As the CONTRACTOR's insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONTRACTOR carries workers' compensation insurance as required by this Agreement, including the relevant provisions applicable to all required insurance.

Self-Insured Retention Amount: $____

Policy Limit: $____

Policy Number: ____

Policy Period: from:___________________________________to: _____________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:____

Insurance Broker or Agent's Signature: ____

II. Commercial General Liability Insurance ("CGL") Coverage

A. CONTRACTOR's insurance shall be primary, and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

B. The insurance requirements under this Agreement shall be the greater of (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policies or proceeds available to the Named Insured. It is agreed that these insurance requirements shall not in any way act to reduce coverage that is broader or that includes higher limits than the minimums required herein. No representation is made that the minimum insurance requirements of this Agreement are sufficient to cover the obligations of the CONTRACTOR.

C. Minimum Requirements. CGL insurance with minimum per occurrence and aggregate limits as follows:

Bodily Injury and Property Damage	$2,000,000 per occurrence & aggregate
Personal Injury/Advertising Injury	$2,000,000 per occurrence & aggregate
Products/Completed Operations	$2,000,000 per occurrence & aggregate

D. Coverage must be on an occurrence basis.

E. Coverage for Products, and Completed Operations, and Ongoing Operations must be included in the insurance policies and shall not contain any "prior work" coverage limitation or exclusion applicable to any Services performed by CONTRACTOR and/or subcontractor under this Agreement.

F. Insurance policies and Additional Insured Endorsement(s) Coverage shall be included for all premises and operations in any way related to this Agreement.

G. There will be no exclusion for explosions, collapse, or underground liability (XCU).

H. Insurance policies and Additional Insured Endorsement(s) shall not exclude liability and damages to work arising out of, pertaining to, or in any way relating to services performed by Subcontractor on CONTRACTOR's behalf.

I. Contractual liability coverage shall be included and shall not limit, by any modification or endorsement, coverage for liabilities assumed by CONTRACTOR under this Agreement as an "insured contract."

J. Waiver of Subrogation. The policy shall be endorsed to include a Waiver of Subrogation ensuring that the CONTRACTOR and its insurer(s) waive any rights of recovery by subrogation, or otherwise, against the DISTRICT, its directors, board, and committee members, officers, officials, agents, volunteers, and employees. CONTRACTOR shall defend and pay any and all damages, fees, and costs, of any kind, arising out of, pertaining to, or in any way resulting from CONTRACTOR's failure to provide the waiver of subrogation from its insurance carrier(s).

K. “Independent CONTRACTOR’s Liability” shall not limit coverage for liability and/or damages arising out of, pertaining to, or in any way resulting from Services provided under this Agreement.

To the fullest extent permitted by law, the DISTRICT, its directors, board, and committee members, officers, officials, employees, agents, and volunteers must be covered as Additional Insureds on a primary and noncontributory basis on all underlying, excess and umbrella policies that shall be evidenced in each case by an endorsement. The Additional Insureds must be covered for liability arising in whole, or in part, from any premises, Products, Ongoing Operations, and Completed Operations by or on behalf of CONTRACTOR, in any way related to Services performed under this Agreement.

L. A severability of interest provision must apply for all the Additional Insureds, ensuring that CONTRACTOR’s insurance shall apply separately to each insured against whom a claim is made, or suit is brought, except with respect to the policies’ limit(s).

Verification of Commercial General Liability (CGL) Insurance Coverage

As the CONTRACTOR’S insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONTRACTOR carries Commercial General Liability insurance, as required by this Agreement, including the relevant provisions applicable to all required insurance:

Self-Insured: Amount: $____

Policy Limit: Per Occurrence: $___________________ **Aggregate: $**______________________

Policy Number: ____

Policy Period: from:________________________________**to:**__________________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:____

Insurance Broker or Agent’s Signature: ____

III. Business Auto Liability Insurance Coverage

CONTRACTOR's insurance shall be primary, and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

A. The insurance requirements under this Agreement shall be the greater of (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policies or proceeds available to the Named Insured. It is agreed that these insurance requirements shall not in any way act to reduce coverage that is broader or that includes higher limits than the minimums required herein. No representation is made that the minimum insurance requirements of this Agreement are sufficient to cover the obligations of the CONTRACTOR.

B. Minimum Requirements. Auto insurance with minimum coverage and limits as follows:

Each Occurrence Limit (per accident) and in the Aggregate:	$2,000,000
Bodily Injury and Property Damage:	$2,000,000

C. Coverage must include either "owned, non-owned, and hired" autos or "any" automobile

This provision ensures the policy covers losses arising out of use of company-owned vehicles ("owned autos"), employee's personal autos ("non-owned autos" meaning not owned by company/insured) or autos that are rented or leased ("hired autos").

D. If CONTRACTOR is transporting hazardous materials or contaminants, evidence of the Motor Carrier Act Endorsement-hazardous materials clean-up (MCS-90, or its equivalent) must be provided.

E. If CONTRACTOR's Scope of Services under this Agreement exposes a potential pollution liability risk related to transport of potential pollutants, seepage, release, escape or discharge of any nature (threatened or actual) of pollutants into the environment arising out of, pertaining to, or in any way related to CONTRACTOR's and/or Subcontractor's performance under this Agreement, then Auto Liability Insurance policies must be endorsed to include Transportation Pollution Liability insurance. Coverage shall also include leakage of fuel or other "pollutants" needed for the normal functioning of covered autos.

F. To the fullest extent permitted by law, the DISTRICT, its directors, board, and committee members, officers, officials, employees, agents, and volunteers must be covered as Additional Insureds on a primary and noncontributory basis on all underlying and excess and umbrella policies. The Additional Insureds must be covered for liability arising in whole, or in part, from any premises, Products, Ongoing Operations, and Completed Operations by or on behalf of CONTRACTOR, in any way related to Services performed under this Agreement.

G. A severability of interest provision must apply for all the Additional Insureds, ensuring that CONTRACTOR's insurance shall apply separately to each insured against whom a claim is made, or suit is brought, except with respect to the insurer's limits of liability.

Verification of Business Auto Liability Insurance Coverage

As the CONTRACTOR'S insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONTRACTOR carries Business Automobile Liability insurance, as required by this Agreement, including the relevant provisions applicable to all required insurance:

Self-Insured: Amount: $____

Policy Limit: Per Accident/Occurrence $________________Aggregate: $ ________________

Policy Number: ____

Policy Period: from:______________________________to: ________________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:_______________________________________

Insurance Broker or Agent's Signature: ______________________________________

IV. Professional Liability (also known as Errors and Omissions) Insurance Coverage

A. CONTRACTOR's insurance shall be primary, and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

B. The insurance requirements under this Agreement shall be the greater of (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policies or proceeds available to the Named Insured. It is agreed that these insurance requirements shall not in any way act to reduce coverage that is broader or that includes higher limits than the minimums required herein. No representation is made that the minimum insurance requirements of this Agreement are sufficient to cover the obligations of the CONTRACTOR.

C. Minimum Requirements: Professional Liability Insurance with minimum limits as follows:

Each Claim or Occurrence Limit:	$2,000,000
Aggregate Limit:	$2,000,000

D. If Coverage is written on a claims-made form, the following shall apply:

1. The retroactive date must be shown and must be before the date of the Agreement or the beginning of the Services.

2. Insurance must be maintained, and evidence of insurance must be provided for a minimum of three (3) years after completion of the Services.

3. If claims-made coverage is canceled or non-renewed, and not replaced with another claims-made policies form with a retroactive date prior to the effective date of the Agreement, CONTRACTOR must purchase an extended period of coverage for a minimum of three (3) years after completion of the Services.

E. Insurance shall include prior acts coverage sufficient to cover the services under this Agreement.

F. Coverage shall be included for all premises and operations in any way related to this Agreement.

<u>Verification of Professional Liability (Errors and Omissions) Insurance Coverage</u>

As the CONTRACTOR'S insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONTRACTOR carries Professional Liability insurance as required by this Agreement, including the relevant provisions applicable to all required insurance.

Self-Insured: Amount: $____

Policy Limit: Per Claim $____________________Aggregate: $ _______________________

Policy Number: ____

Policy Period: from:_______________________to: _______________________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:____

Insurance Broker or Agent's Signature: ____

VI. Excess and/or Umbrella Liability Insurance Coverage

A. CONTRACTOR's insurance shall be primary, and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

B. The insurance requirements under this Agreement shall be the greater of (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policies or proceeds available to the Named Insured. It is agreed that these insurance requirements shall not in any way act to reduce coverage that is broader or that includes higher limits than the minimums required herein. No representation is made that the minimum insurance requirements of this Agreement are sufficient to cover the obligations of the CONTRACTOR.

C. Minimum Requirements: It is expressly understood by the parties that CONTRACTOR's Excess and/or Umbrella Liability policies shall, at minimum, comply with all insurance requirements set forth within this Agreement.

1. Coverage for Products, Completed Operations, and Ongoing Operations must be included in the insurance policies and shall not contain any "prior work" coverage limitation or exclusion applicable to any Services performed under this Agreement and, if it is a claims-made policy, it must be maintained for a minimum of three (3) years following final completion of the Services.

2. Coverage shall be included for all premises and operations in any way related to this Agreement.

3. There will be no exclusion for explosions, collapse, or underground damage (XCU).

4. Insurance policies and Additional Insured Endorsements shall not exclude coverage for liability and damages from services performed by Subcontractor on CONTRACTOR's behalf.

5. Contractual liability coverage shall be included and shall not limit, by any modification or endorsement, coverage for liabilities assumed by CONTRACTOR under this Agreement as an "insured contract."

6. "Independent CONTRACTOR's Liability" shall not limit coverage for liability and/or damage arising out of, pertaining to, or in any way related to Services provided under this Agreement.

7. To the fullest extent permitted by law, the DISTRICT, its directors, officers, officials, agents, volunteers, and employees must be covered as Additional Insureds on a primary and noncontributory basis on all excess and umbrella policies. The Additional Insureds must be covered for liability arising in whole or in part from any premises, Products, Ongoing Operations, and Completed Operations by or on behalf of CONTRACTOR, in any way related to Services performed under this Agreement.

8. A severability of interest provision must apply for all the Additional Insureds, ensuring that the CONTRACTOR's insurance shall apply separately to each insured against whom a claim is made, or suit is brought, except with respect to the policy's limits.

9. CONTRACTOR and its excess and/or umbrella Liability insurance coverage must waive any rights of subrogation against the DISTRICT, its directors, officers, officials, employees, agents, and volunteers, and CONTRACTOR shall defend and pay any damages as a result of failure to provide the waiver of subrogation from the insurance carrier(s).

D. CONTRACTOR shall defend and pay any damages as a result of failure to provide the waiver of subrogation from the insurance carrier(s).

Verification of Excess and/or Umbrella Liability Insurance Coverage

As the CONTRACTOR'S insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONTRACTOR carries Excess and/or Umbrella Liability insurance, as required by this Agreement, including the relevant provisions applicable to all required insurance.

Self-Insured: Amount: $____

Policy Number: ____

Policy Period: from:______________________________**to:** ___________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:_______________________________________

Insurance Broker or Agent's Signature: ____

EXHIBIT C
CONSULTING AND PROFESSIONAL SERVICE AGREEMENT – SAMPLE TEMPLATE

(Standard Consulting Agreement for Contracts Greater than $80,000 - Revised 6/2/2021) (Note: Reference District Procedure No. 451)

CONSULTING AND PROFESSIONAL SERVICES AGREEMENT FOR EAST BAY MUNICIPAL UTILITY DISTRICT
(Project Title)

THIS Agreement is made and entered into this **_______** day of ***(month)***, 202_, by and between **EAST BAY MUNICIPAL UTILITY DISTRICT**, a public entity, hereinafter called "DISTRICT," and ***(CONSULTANT'S FULL LEGAL NAME, BOLD, ALL CAPS followed by type of entity [corporation, etc.])***, hereinafter called "CONSULTANT."

WITNESSETH

WHEREAS, DISTRICT requires consulting services for ***(need for project)***; and

WHEREAS, DISTRICT has completed ***(completed projects that pertain to this project - optional)***; and

WHEREAS, CONSULTANT has submitted a proposal to provide consulting services for ***(state type -"preparation of planning documents", "preparation of design documents", or "construction management support services")*** for the ***(project title)*** and CONSULTANT represents that it has the experience, licenses, qualifications, staff expertise and where necessary the required Department of Industrial Relations (DIR) registration to perform said services in a professional and competent manner; and

IF OVER $80,000:

WHEREAS, DISTRICT Board of Directors has authorized the contract by Motion Number **__________________**;

-OR- IF BETWEEN $30,000 AND $80,000:

WHEREAS, DISTRICT has authorized the contract by approval of the General Manager.

NOW, THEREFORE, it is mutually agreed by DISTRICT and CONSULTANT that for the considerations hereinafter set forth, CONSULTANT shall provide said services to DISTRICT, as set forth in greater detail herein.

ARTICLE 1 - SCOPE OF WORK

1.1 CONSULTANT agrees to furnish services set forth in Exhibit A, Scope of Services, attached hereto and incorporated herein. The services authorized under this Agreement shall also include all reports, manuals, plans, and specifications as set forth in Exhibit A.

1.2 CONSULTANT's work products shall be completed and submitted in accordance with DISTRICT's standards specified, and according to the schedule listed, in Exhibit A. The completion dates specified herein may be modified by mutual agreement between DISTRICT and CONSULTANT provided that DISTRICT's Project Manager notifies CONSULTANT of modified completion dates by letter. CONSULTANT agrees to diligently perform the services to be provided under this Agreement. In the performance of this Agreement, time is of the essence.

1.3 It is understood and agreed that CONSULTANT has the professional skills necessary to perform the work agreed to be performed under this Agreement, that DISTRICT relies upon the professional skills of CONSULTANT to do and perform CONSULTANT's work in a skillful and professional manner, and CONSULTANT thus agrees to so perform the work. CONSULTANT represents that it has all the necessary licenses to perform the work and shall maintain them during the term of this Agreement. CONSULTANT agrees that the work performed under this Agreement shall follow practices usual and customary to the ***(state type - for example "engineering")*** profession and that CONSULTANT is the engineer in responsible charge of the work for all activities performed under this Agreement. Acceptance by DISTRICT of the work performed under this Agreement does not operate as a release of CONSULTANT from such professional responsibility for the work performed.

1.4 CONSULTANT agrees to maintain in confidence and not disclose to any person or entity, without DISTRICT's prior written consent, any trade secret or confidential information, knowledge or data relating to the products, process, or operation of DISTRICT. CONSULTANT further agrees to maintain in confidence and not to disclose to any person or entity, any data, information, technology, or material developed or obtained by CONSULTANT during the term of this Agreement. The covenants contained in this paragraph shall survive the termination of this Agreement for whatever cause.

1.5 The originals of all computations, drawings, designs, graphics, studies, reports, manuals, photographs, videotapes, data, computer files, and other documents prepared or caused to be prepared by CONSULTANT or its subconsultants in connection with these services shall be delivered to and shall become the exclusive property of DISTRICT. DISTRICT is licensed to utilize these documents for DISTRICT applications on other projects or extensions of this project, at its own risk. CONSULTANT and its subconsultants may retain and use copies of such documents, with written approval of DISTRICT.

1.6 CONSULTANT is an independent contractor and not an employee of DISTRICT. CONSULTANT expressly warrants that it will not represent that it is an employee or servant of DISTRICT.

1.7 CONSULTANT is retained to render professional services only and all payments made are compensation solely for such services as it may render and recommendations it may make in carrying out the work.

1.8 It is further understood and agreed by the parties hereto that CONSULTANT in the performance of its obligations hereunder is subject to the control or direction of DISTRICT as to the designation of tasks to be performed, the results to be accomplished by the services hereunder agreed to be rendered and performed, and not the means, methods, or sequence used by the CONSULTANT for accomplishing the results.

1.9 If, in the performance of this agreement, any third persons are employed by CONSULTANT, such person shall be entirely and exclusively under the direction, supervision, and control of CONSULTANT. All terms of employment, including hours, wages, working conditions, discipline, hiring, and discharging, or any other terms of employment or requirements of law, shall be determined by CONSULTANT, and DISTRICT shall have no right or authority over such persons or the terms of such employment.

1.10 It is further understood and agreed that as an independent contractor and not an employee of DISTRICT, neither the CONSULTANT nor CONSULTANT's assigned personnel shall have any entitlement as a DISTRICT employee, right to act on behalf of DISTRICT in any capacity whatsoever as agent, nor to bind DISTRICT to any obligation whatsoever. CONSULTANT shall not be covered by DISTRICT's worker's compensation insurance; nor shall CONSULTANT be entitled to compensated sick leave, vacation leave, retirement entitlement, participation in group health, dental, life or other insurance programs, or entitled to other fringe benefits payable by DISTRICT to employees of DISTRICT.

ARTICLE 2 - COMPENSATION

2.1 For the Scope of Services described in Exhibit A, DISTRICT agrees to pay CONSULTANT actual costs incurred, subject to a Maximum Cost Ceiling of $***(dollars)***. Compensation for services shall be in accordance with the method and amounts described in Exhibit B, attached hereto and incorporated herein. CONSULTANT acknowledges that construction work on public works projects requires DIR registration and is subject to prevailing wage rates and includes work performed during the design and preconstruction phases of construction including, but not limited to, inspection and land surveying work. CONSULTANT certifies that the proposed cost and pricing data used herein reflect the payment of prevailing wage rates where applicable and are complete, current, and accurate.

2.2 In case of changes affecting project scope resulting from new findings, unanticipated conditions, or other conflicts or discrepancies, CONSULTANT shall promptly notify DISTRICT of the identified changes and advise DISTRICT of the recommended solution. Work shall not be performed on such changes without prior written authorization of DISTRICT.

ARTICLE 3 - NOTICE TO PROCEED

3.1 This Agreement shall become effective upon execution of the second signature. CONSULTANT shall commence work upon receipt of DISTRICT's Notice to Proceed, which shall be in the form of a letter signed by DISTRICT's Project Manager. DISTRICT's Notice to Proceed will authorize the Contracted Services described in Exhibit A with ceiling prices described in ARTICLE 2 – COMPENSATION. No work shall commence until the Notice to Proceed is issued.

(Include the following paragraph only if your scope of services includes Optional Services.)

3.2 DISTRICT may at its option issue a Notice to Proceed for some or all of the Optional Services tasks described in Exhibit A. Compensation for Optional Services shall be in accordance with the method and amounts described in Exhibit B.

ARTICLE 4 - TERMINATION

4.1 This Agreement may be terminated by DISTRICT immediately for cause or upon 10 days written notice, without cause, during the performance of the work.

4.2 If this Agreement is terminated CONSULTANT shall be entitled to compensation for services satisfactorily performed to the effective date of termination; provided however, that DISTRICT may condition payment of such compensation upon CONSULTANT's delivery to DISTRICT of any and all documents, photographs, computer software, videotapes, and other materials provided to CONSULTANT or prepared by CONSULTANT for DISTRICT in connection with this Agreement. Payment by DISTRICT for the services satisfactorily performed to the effective date of termination, shall be the sole and exclusive remedy to which CONSULTANT is entitled in the event of termination of the Agreement and CONSULTANT shall be entitled to no other compensation or damages and expressly waives same. Termination under this Article 4 shall not relieve CONSULTANT of any warranty obligations or the obligations under Articles 1.4 and 7.1.

(Optional)

4.3 This Agreement may be terminated by CONSULTANT upon 10 days written notice to DISTRICT only in the event of substantial failure by DISTRICT to fulfill its obligations under this Agreement through no fault of the CONSULTANT.

ARTICLE 5 - PROJECT MANAGERS

5.1 DISTRICT designates ***(District Project Manager's name)*** as its Project Manager, who shall be responsible for administering and interpreting the terms and conditions of this Agreement, for matters relating to CONSULTANT's performance under this Agreement, and for liaison and coordination between DISTRICT and CONSULTANT. CONSULTANT may be requested to assist in such coordinating activities as necessary as part of the services. In the event DISTRICT wishes to make a change in the DISTRICT's representative, DISTRICT will notify CONSULTANT of the change in writing.

5.2 CONSULTANT designates ***(Consultant Project Manager's name)*** as its Project Manager, who shall have immediate responsibility for the performance of the work and for all matters relating to performance under this Agreement. Any change in CONSULTANT designated personnel or subconsultant shall be subject to approval by the DISTRICT Project Manager. ***(The following sentence is optional.)*** CONSULTANT hereby commits an average of ***(1 to 100)*** percent of ***(Consultant Project Manager's name)*** time on this project for the duration of the project.

ARTICLE 6 - CONTRACT EQUITY PROGRAM COMPLIANCE

6.1 CONSULTANT expressly agrees that this Agreement is subject to DISTRICT's Contract Equity Program ("CEP"). CONSULTANT is familiar with the DISTRICT's CEP and Equal Opportunity Guidelines, and has read and understood all of the program requirements. CONSULTANT understands and agrees to comply with the CEP and all requirements therein, including each of the Good Faith Efforts. CONSULTANT further understands and agrees that non-compliance with the CEP requirements may result in termination of this Agreement.

(Paragraph 6.2 to be used when there is subcontracting/subconsulting opportunities. See CEP office for details.)

6.2 Designated CEP compliance for the duration of this Agreement is listed in Exhibit C, which is attached hereto and incorporated herein. CONSULTANT shall maintain records of the total amount actually paid to each subconsultant. Any change of CONSULTANT'S listed subconsultants shall be subject to approval by the DISTRICT'S Project Manager.

ARTICLE 7 - INDEMNIFICATION AND INSURANCE

(IF DEPT. WANTS TO MODIFY INDEMNITY LANGUAGE, PLEASE SUBMIT JUSTIFICATION IN WRITING TO LEGAL, CC: RISK MANAGER.)

(FOR DESIGN PROFESSIONAL CONTRACTS (ENGINEERS, ARCHITECTS, LANDSCAPE ARCHITECTS, LAND SURVEYORS OR THEIR FIRMS), USE 7.1 BEL0W:

7.1 Indemnification

CONSULTANT expressly agrees to defend, indemnify and hold harmless DISTRICT and its Directors, officers, agents and employees from and against any and all loss, liability, expenses, claims, suits, and damages, including attorneys' fees, arising out of or pertaining to, or relating to CONSULTANT's, its associates', employees', subconsultants', or other agents' negligence, recklessness or willful misconduct in the operation and/or performance under this Agreement.

Where applicable by law, the duty to indemnify, including the cost to defend is limited in accordance with California Civil Code § 2782.8.

(OR if contract is <u>NOT</u>* with a design professional (engineers, architects, landscape architects, land surveyors or their firms) *USE THIS PARAGRAPH 7.1 INSTEAD:

7.1 <u>Indemnification</u>

CONSULTANT expressly agrees to defend, indemnify, and hold harmless DISTRICT and its Directors, officers, agents and employees from and against any and all loss, liability, expense, claims, suits, and damages, including attorneys' fees, arising out of or resulting from CONSULTANT's, its associates', employees', subconsultants', or other agents' negligent acts, errors or omissions, or willful misconduct, in the operation and/or performance under this Agreement.

7.2 **(*For construction management support Agreements only)***
CONSULTANT shall perform part of the work at sites where the DISTRICT's facilities are to be constructed, and which may contain unknown working conditions and contaminated materials. CONSULTANT shall be solely responsible for the health and safety of CONSULTANT's employees. CONSULTANT shall designate in writing to DISTRICT the field employee who is responsible for the health and safety of its employees. The responsible employee shall have experience and knowledge of all Federal, State and local health and safety regulation requirements. All CONSULTANT personnel on construction sites shall have received all OSHA required health and safety training.

7.3 **(*For construction management support Agreements only)***
In the event that any hazardous materials are encountered during the services provided by CONSULTANT or the work undertaken by construction contractors, DISTRICT shall sign any and all manifests relating to the generation, treatment, disposal or storage of all wastes associated with the work. Additionally, nothing contained in this Agreement shall be construed or interpreted as requiring CONSULTANT to assume the status of a generator, storer, treater, transporter, or disposal facility as those terms appear within the Resource Conservation and Recovery Act, 42 USCA, Section 6901, et seq. (RCRA), or within any state statute of similar effect governing the generation, storage, treatment, transportation, or disposal of wastes.

7.4 (***For construction management support Agreements only - include only if design consultant and CM consultant are not the same)***
It is agreed and understood by CONSULTANT and DISTRICT that the design services have been completed by ***(design consultant's name)*** and therefore, CONSULTANT did not undertake any design activity or have design responsibility of the facilities to be constructed prior to execution of this Agreement.

7.5 Insurance Requirements

Insurance Requirements are as stated in Exhibit D, Insurance Requirements.

ARTICLE 8 - NOTICES

Any notice which DISTRICT may desire or is required at any time to give or serve CONSULTANT may be delivered personally, or be sent by United States mail, postage prepaid, addressed to:

(consulting firm's name)
(address)
Attention: ***(contact, usually the consultant's project manager)***,

or at such other address as shall have been last furnished in writing by CONSULTANT to DISTRICT.

Any notice which CONSULTANT may desire or is required at any time to give or serve upon DISTRICT may be delivered personally at EBMUD, 375 - 11th Street, Oakland, CA 94607-4240, or be sent by United States mail, postage prepaid, addressed to:

Director of ***(Wastewater Department or Engineering and Construction Department)***
P.O. Box 24055
Oakland, CA 94623-1055

or at such other address as shall have been last furnished in writing by DISTRICT to CONSULTANT.

Such personal delivery or mailing in such manner shall constitute a good, sufficient and lawful notice and service thereof in all such cases.

ARTICLE 9 - MISCELLANEOUS

9.1 This Agreement represents the entire understanding of DISTRICT and CONSULTANT as to those matters contained herein. No prior oral or written understanding shall be of any force or effect with respect to those matters covered hereunder. This Agreement may only be modified by amendment in writing signed by each party.

9.2 This Agreement is to be binding on the successors and assigns of the parties hereto. The services called for herein are deemed unique and CONSULTANT shall not assign, transfer or otherwise substitute its interest in this Agreement or any of its obligations hereunder without the prior written consent of DISTRICT.

9.3 Should any part of this Agreement be declared by a final decision by a court or tribunal of competent jurisdiction to be unconstitutional, invalid or beyond the authority of either party to enter into or carry out, such decision shall not affect the validity of the remainder of this Agreement, which shall continue in full force and effect, provided that the remainder of this Agreement can be interpreted to give effect to the intentions of the parties.

9.4 Multiple copies of this Agreement may be executed by the parties and the parties agree that the Agreement on file at the DISTRICT is the version of the Agreement that shall take precedence should any differences exist among counterparts of the Agreement.

9.5 This Agreement and all matters relating to it shall be governed by the laws of the State of California.

9.6 The District’s waiver of the performance of any covenant, condition, obligation, representation, warranty or promise in this agreement shall not invalidate this Agreement or be deemed a waiver of any other covenant, condition, obligation, representation, warranty or promise. The District’s waiver of the time for performing any act or condition hereunder does not constitute a waiver of the act or condition itself.

9.7 There shall be no discrimination in the performance of this contract, against any person, or group of persons, on account of race, color, religion, creed, national origin, ancestry, gender including gender identity or expression, age, marital or domestic partnership status, mental disability, physical disability (including HIV and AIDS), medical condition (including genetic characteristics or cancer), veteran or military status, family or medical leave status, genetic information, or sexual orientation. CONSULTANT shall not establish or permit any such practice(s) of discrimination with reference to the contract or any part. CONSULTANTS determined to be in violation of this section shall be deemed to be in material breach of this Agreement.

Consultant shall abide by the requirements of 41 CFR §§ 60-1.4(a), 60-300.5(a) and 60-741.5(a). These regulations prohibit discrimination against qualified individuals based on their status as protected veterans or individuals with disabilities, and prohibit discrimination against all individuals based on their race, color, religion, sex, sexual orientation, gender identity, or national origin in the performance of this contract. Moreover, these regulations require that covered prime contractors and subcontractors take affirmative action to employ and advance in employment individuals without regard to race, color, religion, sex, national origin, protected veteran status or disability.

CONSULTANT shall include the nondiscrimination provisions above in all subcontracts.

9.8 CONSULTANT affirms that it does not have any financial interest or conflict of interest that would prevent CONSULTANT from providing unbiased, impartial service to the DISTRICT under this Agreement.

(If this Agreement is to be executed using digital signatures via DocuSign instead of wet signatures, use the following paragraph. Otherwise, delete it.)

9.9 Digital Signatures. The Parties agree that this Agreement may be executed using digital signatures.

(If this Agreement is to be executed by having each party wet sign a separate signature page and submitting all signed pages in original format or via scanning for compilation with the final Agreement, use the following paragraph. Otherwise, delete it.)

9.10 Execution in Counterparts. This Agreement may be executed in counterparts, each of which shall be deemed to be an original but all of which taken together shall constitute one and the same Agreement.

ARTICLE 10 - TERM

Unless terminated pursuant to Article 4 herein, this Agreement shall expire when all tasks have been completed and final payment has been made by DISTRICT.

(NOTE: do not have a page break leaving signatures by themselves—must have at least the "in witness whereof" paragraph on signature page)

IN WITNESS WHEREOF, the parties hereto each herewith subscribe the same in duplicate.

EAST BAY MUNICIPAL UTILITY DISTRICT

By: ____ Date ______________

(Name),

(Insert title - Director of Engineering and Construction or Manager of Support Services)

Approved As To Form

By:__________________________________

for the Office of the General Counsel

(CONSULTING FIRM'S NAME, ALL CAPS & BOLD)

By:____ Date ______________

(Name),

(Title)

Rev. 6/2/2021

EXHIBIT A

East Bay Municipal Utility District
(Project Title)

SCOPE OF SERVICES

I. CONSULTANT SERVICES

CONSULTANT shall provide the following:

<u>Contracted Services</u>

(State each task with associated task number; specifically call out any survey work)

<u>Optional Services</u>

(State each task with associated task number)

II. PROJECT SCHEDULE

(List schedule milestones and completion dates)

EXHIBIT B

East Bay Municipal Utility District
(Project Title)

COMPENSATION

Compensation for services provided in Exhibit A, SCOPE OF SERVICES, shall be in accordance with the methods and specific amounts described in this Exhibit.

1. DISTRICT shall pay CONSULTANT only the actual costs incurred, subject to the Maximum Cost Ceiling. CONSULTANT certifies that the cost and pricing information used herein are complete, current and accurate. CONSULTANT acknowledges that it will expend public funds and hereby agrees to use every appropriate method to contain its fees and minimize costs under this Agreement.

2. Compensation for CONSULTANT services authorized shall be on a cost reimbursement basis and include Direct Labor, Indirect Costs, Subconsultant Services and Other Direct Costs. Costs to be paid comprise the following:

   2.1 <u>Direct Labor</u>

   Direct labor costs shall be the total number of hours worked on the job by each employee times the hourly rate for the employee's labor. Hours worked shall be rounded-up to the nearest quarter-hour (0.25) increment. Labor rates shall be based on a normal 8-hour day, 40-hour week.

   2.2 <u>Indirect Costs</u>

   DISTRICT shall pay CONSULTANT an overhead expense equal to ***(insert overhead rate)*** percent of labor costs incurred by CONSULTANT. CONSULTANT acknowledges and agrees that this overhead compensation is <u>in lieu</u> of itemized payments for indirect and overhead expenses which includes, but is not limited to:

   - Clerical, word processing and/or accounting work.
   - Vehicle usage and mileage between CONSULTANT’s office and DISTRICT offices or work locations within DISTRICT service area. For work outside of the DISTRICT’s services area, DISTRICT approval to charge for vehicle usage and mileage and other travel expenses must be obtained prior to the expenses being incurred.
   - Parking (DISTRICT does <u>NOT</u> provide parking to CONSULTANT in the DISTRICT Administration Building, located at 375 11th Street, Oakland, California. CONSULTANT shall be responsible for parking elsewhere).

- Postage, or for certified or registered mail. Extraordinary postage, overnight delivery, or messenger delivery charges must be approved in advance.
- Routine copying costs for in-house copying.
- Local telephone charges, including cellular phone, modem and telecopier/FAX charges.
- Office space lease.
- Office supplies.
- Computer equipment.
- Computer usage charges.
- Books, publications and periodicals.
- Insurance.
- Miscellaneous hand tools or equipment rental.
- Safety training, seminars or continuing education.
- Utilities.
- Local meals, transportation or other travel charges.
- Inadequately described or miscellaneous expenses.

The above items are illustrative, rather than exhaustive.

2.3 Subconsultant Services

Subconsultant services shall be billed at cost (plus a ***(insert rate)*** percent markup).

2.4. Other Direct Costs

Other Direct Costs shall be approved by DISTRICT in advance in writing, and shall be billed at cost, without markup. These costs include, but are not limited to the following:

2.4.1. Automobile expenses at ***(insert rate)*** cents per mile when CONSULTANT is required to travel outside of the DISTRICT's service area. Mileage will NOT be reimbursed for rental car expenses, where the rental agreement specifies unlimited mileage.

2.4.2. DISTRICT will pay for necessary and reasonable travel expenses provided the travel is approved in advance by DISTRICT Project Manager, and providing that:

- Each expense is separately identified (air fare, hotel, rental car) with an amount and date incurred. Confirming documents may be requested.
- Charged mileage for vehicle mileage shall not exceed the current allowable Internal Revenue Service rate.

- Air travel is coach or economy rate for refundable tickets. Business and first class rates will not be reimbursed.
- Lodging accommodations are moderately priced.
- Meal charges are reasonable. (Reimbursement for meals will only be made in conjunction with out-of-town travel.)
- Taxis or shuttles are used rather than rental cars whenever cost effective.
- Rental cars are intermediate or compact class only.

2.6 Budget Amounts

Contracted Services	Optional Services	Maximum Cost Ceiling*
$***(dollars)***	$***(dollars)***	$***(dollars)***

**** (Maximum Cost Ceiling is the sum of Contracted and Optional Services. If your scope has no Optional Services, delete the Contracted and Optional Services columns.)***

The Maximum Cost Ceiling shown above is based upon the cost estimate and labor hours attached hereto as Exhibit B-1 and Exhibit B-2. Costs described above, comprising Direct Labor, Indirect Costs, Subconsultant Services and Other Direct Costs shall be payable up to the Maximum Cost Ceiling as specified herein.

2.7 Billing and Payment

CONSULTANT shall invoice DISTRICT monthly for the actual costs incurred for work performed during the previous month. Actual costs shall include Direct Labor, Indirect Costs, Subconsultant Services, and Other Direct Costs as specified herein. Actual costs shall be invoiced by task as described in Exhibit A. Invoices shall set forth a description of the actual costs incurred and the services performed, the date the services were performed and the amount of time spent rounded to the nearest quarterly hour increment (.25) on each date services were performed and by whom. Supporting documentation for the invoice shall be organized to clearly identify the task charged and shall be supported by such copies of invoices, payroll records, and other documents as may be required by DISTRICT to authenticate invoiced costs. Copies of all invoices from any subconsultant(s) and outside service(s) shall be attached. ***(Insert the following sentence if paragraph 2.9 below applies and is included in agreement. "Where CONSULTANT is required by law to pay prevailing wage rates, supporting documentation for such work shall be in accordance with guidelines set forth below and shall include certified payroll reports. ")*** DISTRICT shall pay CONSULTANT within thirty (30) days, upon receipt of a proper CONSULTANT invoice, ***(Optional insert - include the following words here only if retention will***

be accumulated: "the amount invoiced less a ten percent (10%) retention amount,"), provided that all invoices are accompanied by sufficient cost documentation, and DISTRICT Form P-47 (Subcontractor Payment Report - CEP Participation), to allow the determination of the reasonableness and accuracy of said invoice. ***(Optional insert - include the following sentence here only if retention will be accumulated: "The retention accumulated to date shall be paid by DISTRICT upon DISTRICT's acceptance of the final version of all documents specified in ARTICLE 1 - SCOPE OF WORK, paragraph 1.6.")***

The Maximum Cost Ceiling is in effect for the entire Scope of Services. If the authorized Maximum Cost Ceiling is reached, CONSULTANT shall complete the agreed-upon work for the authorized Maximum Cost Ceiling. Labor hours may be reallocated within the tasks without renegotiation of the Agreement with written approval from the DISTRICT Project Manager in such a manner so as not to exceed the Maximum Cost Ceiling. In no event shall the Maximum Cost Ceiling be increased unless there is a written amendment of this Agreement.

2.8 Budget Status Reports

For the duration of this Agreement, the CONSULTANT shall provide DISTRICT with ***("bi-weekly" or "monthly" depending on duration of project)*** budget status reports that include, in tabular or graphical format, for each report period: (1) the original cumulative projected cash flows for the duration of the project (prepared at the start of the project), (2) the actual cash flows for the work completed to date, (3) the current projected cash flows to complete the project, and (4) the earned value (the amount of work actually completed to date compared to the budget expended). Current projected cash flows shall be based on all CONSULTANT and subconsultant time sheets up to a date within 3 weeks of the date of the budget status report.

2.9 Prevailing Wages and Other Requirements for Construction Inspection, and Construction Related Work During Design and Preconstruction Phases of Construction. ***(Optional Insert – include this paragraph 2.9 and all its subparagraphs if your Scope of Services includes construction, alteration, demolition, installation, maintenance, repair work, or other construction related work during the design or preconstruction phases of construction including but not limited to inspection and land surveying.)***

2.9.1 All Contractors and Subcontractors of any tier bidding on, or offering to performing work on a public works project shall first be registered with the State Department of Industrial Relations (DIR) pursuant to Section 1725.5 of the Labor Code. No bid will be accepted nor any contract entered into without proof of the Contractor and Subcontractors' current registration with the DIR (LC § 1771.1).

2.9.2 All public works projects awarded after January 1, 2015, are subject to compliance monitoring and enforcement by the DIR (LC § 1771.4) and all Contractors are required post job site notices, “as prescribed by regulation” (LC § 1771.4).

2.9.3 Pursuant to Section 1773 of the Labor Code, the District has obtained from the Director of Industrial Relations of the State of California, the general prevailing rates of per diem wages and the general prevailing rates for holiday and overtime work in the locality in which the Work is to be performed, for each craft, classification, or type of worker needed to execute the contract. A copy of the prevailing wage rates is on file with the District and available for inspection by any interested party at www.dir.ca.gov.

2.9.4 The Contractor shall post a copy of the general prevailing rate of per diem wages at the jobsite pursuant to Section 1773.2 of the Labor Code.

2.9.5 Pursuant to Section 1774 of the Labor Code, the Contractor and any of its Subcontractors shall not pay less than the specified prevailing rate of wages to all workers employed in the execution of the contract.

2.9.6 The Contractor shall, as a penalty to the State or the District, forfeit not more than the maximum set forth in Section 1775 of the Labor Code for each calendar day, or portion thereof, for each worker paid less than the prevailing rates for the work or craft in which the worker is employed under the contract by the Contractor or by any Subcontractor under him. The difference between the prevailing wage rates and the amount paid to each worker for each calendar day or portion thereof for which such worker was paid less than the stipulated prevailing wage rate shall be paid to such worker by the Contractor.

2.9.7 General prevailing wage determinations have expiration dates with either a single asterisk or a double asterisk. Pursuant to California Code of Regulations, Title 8, Section 16204, the single asterisk means that the general prevailing wage determination shall be in effect for the specified contract duration. The double asterisk means that the predetermined wage modification shall be paid after the expiration date. No adjustment in the Contract Sum will be made for the Contractor’s payment of these predetermined wage modifications.

2.9.8 The Contractor and each Subcontractor shall keep an accurate payroll record, showing the name, address, social security number, work classification, straight time and overtime hours worked each day and week, and the actual per diem wages paid to each journeyman, apprentice, worker or other employee employed in connection with the Work. The payroll records shall be certified and shall be available for inspection in accordance with the provisions of Section 1776 of the Labor Code. Certified payroll records shall be on the forms provided by the DIR or contain the same information required on the Department's form

2.9.9 For public works projects awarded on or after April 1, 2015, or that are still ongoing after April 1, 2016, no matter when awarded, each Contractor and Subcontractor shall furnish the certified payroll related records as more specifically described above and in Labor Code section 1776 directly to the Labor Commissioner (see LC § 1771.4). These records shall be provided to the Labor Commissioner at least monthly or more frequently if required by the terms of the Contract. For exception on projects covered by collective bargaining agreements like a PLA, please see Labor Code section 1771.4.

2.9.10 In the event of noncompliance with the requirements of Section 1776 of the Labor Code, the Contractor shall have 10 days in which to comply subsequent to receipt of written notice specifying in what respects such Contractor must comply with said Section. Should noncompliance still be evident after such 10-day period, the Contractor shall, as a penalty to the State or the District, forfeit the amount set forth in Section 1776 of the Labor Code for each calendar day, or portion thereof, for each worker, until strict compliance is effectuated. Upon the request of the Division of Apprenticeship Standards or the Division of Labor Standards Enforcement, such penalties shall be withheld from progress payments then due.

2.9.11 Pursuant to the provisions of Sections 1810, et seq. of the Labor Code the time of service of any worker employed upon the work shall be limited and restricted to eight hours during any one calendar day, and forty hours during any one calendar week, unless work performed by employees of the Contractor in excess of eight hours per day, and forty hours during any one calendar week, shall be permitted upon compensation for all hours worked in excess of eight hours per day at not less than one and one half times the basic rate of pay.

2.9.12 The Contractor shall, as a penalty to the State or the District, forfeit the amount set forth in Section 1813 of the Labor Code for each worker employed by the Contractor or by any Subcontractor for each calendar day during which such worker is required or permitted to work more than eight hours in any calendar day and forty hours in any one calendar week in violation of the provisions of Labor Code, Sections 1810, et seq.

2.9.13 The Contractor and every Subcontractor shall keep an accurate record showing the name of and the actual hours worked each calendar day and each calendar week by each worker employed by him in connection with the Work; the record shall be kept open at all reasonable hours to the inspection of the District and to the Division of Labor Standards Enforcement of the State of California.

2.9.14 In the performance of a public works contract, the Contractor and any Subcontractor shall comply with the provisions concerning the employment of apprentices in Section 1777.5 of the Labor Code and any amendments thereof. In the event the Contractor or any Subcontractor willfully fails to comply with this requirement the Contractor or Subcontractor shall be subject to the penalties for noncompliance in Labor Code section 1777.7.

2.9.15 The Contractor and every Subcontractor shall post at the workplace and comply with all required wage related workplace postings. Copies of the required postings may be downloaded or ordered electronically from the Department of Industrial Relations website at http://www.dir.ca.gov/wpnodb.html.

(Note: this table is prepared by the consultant. The following is provided to show format.)

EXHIBIT B-1

East Bay Municipal Utility District
(Project Title)

COST DISTRIBUTION

	Consultant						**Subconsultants****						
	Direct Labor						**Subconsultant # 1**			**Subconsultant # 2**			
	Project Manager	Project Engineer	Drafting				Project Engineer	Assist. Engineer		Project Engineer	Assist. Engineer		
Hourly Rate ($/hr.)	(***)	(***)	(***)	Total	Indirect Costs	ODCs*	(***)	(***)	Total Cost	(***)	(***)	Total Cost	Total
I. Contracted Services													
Task 1.1:													
Task 1.2:													
Task 2.1:													
Task 2.2:													
Subtotal I.													
II. Optional Services													
Task 3:													
Task 4:													
Subtotal II.													
TOTAL of Subtotals I. & II													

* ODCs = Other Direct Costs.
** Includes any prime consultant markup in subconsultant hourly rates.
****** Insert hourly rate.***

(Note: this table is prepared by the consultant. The following is provided to show format.)

EXHIBIT B-2

East Bay Municipal Utility District
(Project Title)

LABOR DISTRIBUTION*

	Consultant				Subconsultants***						
					Subconsultant # 1			Subconsultant # 2			
	Project Manager	Project Engineer	Drafting	Subtotal	Project Engineer	Assist. Engineer	Subtotal	Project Engineer	Assist. Engineer	Subtotal	Total
I. Contracted Services											
Task 1.1:											
Task 1.2:											
Task 2.1:											
Task 2.2:											
Subtotal I.											
II. Optional Services											
Task 3:											
Task 4:											
Subtotal II.											
TOTAL											

(* Include both consultant and subconsultant hours. Also, include the percent time commitment for key personnel if a critical issue for success of the project.)

EXHIBIT C

East Bay Municipal Utility District
(Project Title)

CEP COMPLIANCE

FIRMS UTILIZED		MINIMUM AMOUNT*	MINIMUM PERCENT**
(Name of Subconsultant's firm)		$***(dollars)***	***(1 to 99)***
(Name of Subconsultant's firm)		$***(dollars)***	***(1 to 99)***
	TOTAL	$***(dollars)***	***(1 to 99)***

* Does not include consultant's markup. ***(Include this footnote only if your contract includes markup on subconsultants.)***

** Based on a Maximum Cost Ceiling amount of $***(dollars)***.

EXHIBIT D
INSURANCE REQUIREMENTS

(Insurance requirements may vary based on the nature of the Agreement. Always make sure these Insurance terms are reviewed by Risk Management for your contract.)

(Change the word "CONSULTANT" if necessary to match the term in the Agreement)

I. Provisions Applicable to All Required Insurance

A. Prior to the beginning of and throughout the duration of Services, and for any additional period of time as specified below, CONSULTANT shall, at its sole cost and expense, maintain insurance in conformance with the requirements set forth below.

B. CONSULTANT shall provide Verification of Insurance as required by this Agreement by providing the completed Verification of Insurance as requested below signing and submitting this Exhibit D to the DISTRICT. The Exhibit D may be signed by an officer of the CONSULTANT (Agent) or by the Insurance Broker for the CONSULTANT. CONSULTANT shall update Exhibit D throughout the specified term of the insurance required by this Agreement by resubmitting the completed Exhibit D prior to the expiration date of any of the required insurance. The updated Exhibit D shall become a part of the Agreement but shall not require a change order to the Agreement. The Notice to Proceed shall not be issued, and CONSULTANT shall not commence Services until such insurance has been accepted by the DISTRICT.

C. CONSULTANT shall carry and maintain the minimum insurance requirements as defined in this Agreement. CONSULTANT shall require any subcontractor to carry and maintain the minimum insurance required in this Agreement to the extent they apply to the scope of the services to be performed by subcontractor.

D. Acceptance of verification of Insurance by the DISTRICT shall not relieve CONSULTANT of any of the insurance requirements, nor decrease liability of CONSULTANT.

E. The insurance required hereunder may be obtained by a combination of primary, excess and/or umbrella insurance, and all coverage shall be at least as broad as the requirements listed in this Agreement.

F. Any deductibles, self-insurance, or self-insured retentions (SIRs) applicable to the required insurance coverage must be declared to and accepted by the DISTRICT.

G. At the option and request of the DISTRICT, CONSULTANT shall provide documentation of its financial ability to pay the deductible, self-insurance, or SIR.

H. Any policies with a SIR shall provide that any SIR may be satisfied, in whole or in part, by the DISTRICT or the additional insured at its sole and absolute discretion.
I. Unless otherwise accepted by the DISTRICT, all required insurance must be placed with insurers with a current A.M. Best's rating of no less than A- V.

J. CONSULTANT shall defend the DISTRICT and pay any damages as a result of failure to provide the waiver of subrogation from the insurance carrier.

K. For any coverage that is provided on a claims-made coverage form (which type of form is permitted only where specified) the retroactive date must be shown and must be before the date of this Agreement, and before the beginning of any Services related to this Agreement.

L. Insurance must be maintained and updated Verification of Insurance be provided to the DISTRICT before the expiration of insurance by having CONSULTANT's insurance broker or agent update, sign and return Exhibit D to the DISTRICT's contract manager. For all claims-made policies the updated Verification of Insurance must be provided to the DISTRICT for at least three (3) years after expiration of this Agreement.

M. If claims-made coverage is canceled or non-renewed, and not replaced with another claims-made policy form with a retroactive date prior to the effective date of this Agreement or the start of any Services related to this Agreement, CONSULTANT must purchase an extended reporting period for a minimum of three (3) years after expiration of the Agreement.

N. If requested by the DISTRICT, a copy of the policies' claims reporting requirement must be submitted to the DISTRICT for review.

O. Where additional insured coverage is required, the additional insured coverage shall be "primary and non-contributory," and will not seek contribution from the DISTRICT's insurance or self-insurance.

P. CONSULTANT agrees to provide immediate Notice to the DISTRICT of any loss or claim against CONSULTANT arising out of, pertaining to, or in any way relating to this Agreement, or Services performed under this Agreement. The DISTRICT assumes no obligation or liability by such Notice, but has the right (but not the duty) to monitor the handling of any such claim or claims if they are likely to involve the DISTRICT.

Q. CONSULTANT agrees, upon request by the DISTRICT, to provide complete, certified copies of any policies and endorsements within 10 days of such request (copies of policies may be redacted to eliminate premium details.)

R. It is CONSULTANT's responsibility to ensure its compliance with the insurance requirements. Any actual or alleged failure on the part of the DISTRICT to obtain proof of insurance required under this Agreement shall not in any way be construed to be a waiver of any right or remedy of the DISTRICT, in this or any regard.

S. **Notice of Cancellation/Non-Renewal/Material Reduction** The insurance requirements hereunder are mandatory and the DISTRICT may, at its sole and absolute discretion, terminate the services provided by CONSULTANT, should CONSULTANT breach its obligations to maintain the required coverage and limits set forth in this Agreement. No coverage required hereunder shall be cancelled, non-renewed or materially reduced in coverage or limits without the DISTRICT being provided at least thirty (30) days prior written notice, other than cancellation for the non-payment of premiums, in which event the DISTRICT shall be provided ten (10) days prior written notice. Replacement of coverage with another policy or insurer, without any lapse in coverage or any reduction of the stated requirements does not require notice beyond submission to the DISTRICT of an updated Verification of Insurance which shall be met by having the CONSULTANT's insurance broker or agent update, sign and return this *Exhibit D*

II. Workers' Compensation and Employer's Liability Insurance Coverage

A. Workers' Compensation insurance including Employer's Liability insurance with minimum limits as follows:

Coverage A. Statutory Benefits Limits

Coverage B. Employer's Liability of not less than:

Bodily Injury by accident:	$1,000,000 each accident
Bodily Injury by disease:	$1,000,000 each employee
Bodily Injury by disease:	$1,000,000 policy limit

B. CONSULTANT's insurance shall be primary and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

C. If there is an onsite exposure of injury to CONSULTANT, subcontractor, and/or subcontractor's employees under the U.S. Longshore and Harbor Workers' Compensation Act, the Jones Act, or under laws, regulations or statutes applicable to maritime employees, coverage is required for such injuries or claims.

D. If CONSULTANT is self-employed, a sole proprietorship or a partnership, with no employees, and is exempt from carrying Workers' Compensation Insurance, CONSULTANT must return the completed Verification of Insurance confirming that CONSULTANT has no employees and is exempt from the State of California Workers' Compensation requirements.

E. If CONSULTANT is self-insured with respect to Workers' Compensation coverage, CONSULTANT shall provide to the DISTRICT a Certificate of Consent to Self-Insure from the California Department of Industrial Relations. Such self-insurance shall meet the minimum limit requirements and shall waive subrogation rights in favor of the DISTRICT as stated below in section "F."

F. Waiver of Subrogation. Workers' Compensation policies, including any applicable excess and umbrella insurance, must contain a waiver of subrogation endorsement providing that CONSULTANT and each insurer waive any and all rights of recovery by subrogation, or otherwise, against the DISTRICT, its directors, board, and committee members, officers, officials, employees, agents, and volunteers. CONSULTANT shall defend and pay any and all damages, fees, and costs, of any kind arising out of, pertaining to, or in any way relating to CONSULTANT's failure to provide waiver of subrogation from the insurance carrier.

<u>Verification of Workers' Compensation and Employer's Liability Insurance Coverage</u>

☐ **By checking the box and signing below, I hereby verify that the CONSULTANT is exempt from the State of California's requirement to carry workers' compensation insurance.**

As the CONSULTANT's insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONSULTANT carries workers' compensation insurance as required by this Agreement, including the relevant provisions applicable to all required insurance.

Self-Insured Retention:Amount: $____

Policy Limit: $____

Policy Number: ____

Policy Period: from:____________________to: __________________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:__________________________________

Insurance Broker or Agent's Signature:__________________________________

<u>III. Commercial General Liability Insurance ("CGL") Coverage</u>

A. CONSULTANT's insurance shall be primary and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

B. The insurance requirements under this Agreement shall be the greater of (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policies or proceeds available to the Named Insured. It is agreed that these insurance requirements shall not in any way act to reduce coverage that is broader or that includes higher limits than the minimums required herein. No representation is made that the minimum insurance requirements of this Agreement are sufficient to cover the obligations of the CONSULTANT.

C. Minimum Requirements. CGL insurance with minimum per occurrence and aggregate limits as follows:

Bodily Injury and Property Damage	$2,000,000 per occurrence & aggregate
Personal Injury/Advertising Injury	$2,000,000 per occurrence & aggregate
Products/Completed Operations	$2,000,000 per occurrence & aggregate

D. Coverage must be on an occurrence basis.

E. Coverage for Products, and Completed Operations, and Ongoing Operations must be included in the insurance policies and shall not contain any “prior work” coverage limitation or exclusion applicable to any Services performed by CONSULTANT and/or subcontractor under this Agreement.

F. Insurance policies and Additional Insured Endorsement(s) Coverage shall be included for all premises and operations in any way related to this Agreement.

G. There will be no exclusion for explosions, collapse, or underground liability (XCU).

H. Insurance policies and Additional Insured Endorsement(s) shall not exclude liability and damages to work arising out of, pertaining to, or in any way relating to services performed by Subcontractor on CONSULTANT’s behalf.

I. Contractual liability coverage shall be included and shall not limit, by any modification or endorsement, coverage for liabilities assumed by CONSULTANT under this Agreement as an “insured contract.”

J. Waiver of Subrogation. The policy shall be endorsed to include a Waiver of Subrogation ensuring that the CONSULTANT and its insurer(s) waive any rights of recovery by subrogation, or otherwise, against the DISTRICT, its directors, board, and committee members, officers, officials, agents, volunteers, and employees. CONSULTANT shall defend and pay any and all damages, fees, and costs, of any kind, arising out of, pertaining to, or in any way resulting from CONSULTANT’s failure to provide the waiver of subrogation from its insurance carrier(s).

K. “Independent CONSULTANT’s Liability” shall not limit coverage for liability and/or damages arising out of, pertaining to, or in any way resulting from Services provided under this Agreement.

To the fullest extent permitted by law, the DISTRICT, its directors, board, and committee members, officers, officials, employees, agents, and volunteers must be covered as Additional Insureds on a primary and noncontributory basis on all underlying, excess and umbrella policies that shall be evidenced in each case by an endorsement. The Additional Insureds must be covered for liability arising in whole, or in part, from any premises, Products, Ongoing Operations, and Completed Operations by or on behalf of CONSULTANT, in any way related to Services performed under this Agreement.

L. A severability of interest provision must apply for all the Additional Insureds, ensuring that CONSULTANT’s insurance shall apply separately to each insured against whom a claim is made or suit is brought, except with respect to the policies’ limit(s).

Verification of Commercial General Liability (CGL) Insurance Coverage

As the CONSULTANT'S insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONSULTANT carries Commercial General Liability insurance, as required by this Agreement, including the relevant provisions applicable to all required insurance:

Self-Insured: Amount: $____

Policy Limit: Per Occurrence: $____________________ Aggregate: $__________________

Policy Number: ____

Policy Period: from:________________________to: ______________________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:______________________________________

Insurance Broker or Agent's Signature:______________________________________

IV. Business Auto Liability Insurance Coverage

CONSULTANT's insurance shall be primary and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

A. The insurance requirements under this Agreement shall be the greater of (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policies or proceeds available to the Named Insured. It is agreed that these insurance requirements shall not in any way act to reduce coverage that is broader or that includes higher limits than the minimums required herein. No representation is made that the minimum insurance requirements of this Agreement are sufficient to cover the obligations of the CONSULTANT.

B. Minimum Requirements. Auto insurance with minimum coverage and limits as follows:
Each Occurrence Limit (per accident) and in the Aggregate: $2,000,000

Bodily Injury and Property Damage: $2,000,000

C. Coverage must include either "owned, non-owned, and hired" autos or "any" automobile

This provision ensures the policy covers losses arising out of use of company-owned vehicles ("owned autos"), employee's personal autos ("non-owned autos" meaning not owned by company/insured) or autos that are rented or leased ("hired autos").

D. If CONSULTANT is transporting hazardous materials or contaminants, evidence of the Motor Carrier Act Endorsement-hazardous materials clean-up (MCS-90, or its equivalent) must be provided.

E. If CONSULTANT's Scope of Services under this Agreement exposes a potential pollution liability risk related to transport of potential pollutants, seepage, release, escape or discharge of any nature (threatened or actual) of pollutants into the environment arising out of, pertaining to, or in any way related to CONSULTANT's and/or Subcontractor's performance under this Agreement, then Auto Liability Insurance policies must be endorsed to include Transportation Pollution Liability insurance. Alternatively, coverage may be provided under the CONSULTANT's Pollution Liability Policies if such policy has no exclusions that would restrict coverage under this Agreement. Coverage shall also include leakage of fuel or other "pollutants" needed for the normal functioning of covered autos.

F. To the fullest extent permitted by law, the DISTRICT, its directors, board, and committee members, officers, officials, employees, agents, and volunteers must be covered as Additional Insureds on a primary and noncontributory basis on all underlying and excess and umbrella policies. The Additional Insureds must be covered for liability arising in whole, or in part, from any premises, Products, Ongoing Operations, and Completed Operations by or on behalf of CONSULTANT, in any way related to Services performed under this Agreement.

G. A severability of interest provision must apply for all the Additional Insureds, ensuring that CONSULTANT's insurance shall apply separately to each insured against whom a claim is made or suit is brought, except with respect to the insurer's limits of liability.

Verification of Business Auto Liability Insurance Coverage

As the CONSULTANT'S insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONSULTANT carries Business Automobile Liability insurance, as required by this Agreement, including the relevant provisions applicable to all required insurance:

Self-Insured: Amount: $______________________________________

Policy Limit: Per Accident/Occurrence $______________Aggregate: $ __________________

Policy Number: ____

Policy Period: from:_________________________to: ________________________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:____

Insurance Broker or Agent's Signature:____

V. Professional Liability (also known as Errors and Omissions) Insurance Coverage

A. CONSULTANT's insurance shall be primary and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

B. The insurance requirements under this Agreement shall be the greater of (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policies or proceeds available to the Named Insured. It is agreed that these insurance requirements shall not in any way act to reduce coverage that is broader or that includes higher limits than the minimums required herein. No representation is made that the minimum insurance requirements of this Agreement are sufficient to cover the obligations of the CONSULTANT.

C. Minimum Requirements: Professional Liability Insurance with minimum limits as follows:

Each Claim or Occurrence Limit:	$2,000,000
Aggregate Limit:	$2,000,000

D. If Coverage is written on a claims-made form, the following shall apply:

1. The retroactive date must be shown, and must be before the date of the Agreement or the beginning of the Services.
2. Insurance must be maintained and evidence of insurance must be provided for a minimum of three (3) years after completion of the Services.
3. If claims-made coverage is canceled or non-renewed, and not replaced with another claims-made policies form with a retroactive date prior to the effective date of the Agreement, CONSULTANT must purchase an extended period of coverage for a minimum of three (3) years after completion of the Services.

E. Insurance shall include prior acts coverage sufficient to cover the services under this Agreement.

F. Coverage shall be included for all premises and operations in any way related to this Agreement.

Verification of Professional Liability (Errors and Omissions) Insurance Coverage

As the CONSULTANT'S insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONSULTANT carries Professional Liability insurance as required by this Agreement, including the relevant provisions applicable to all required insurance.

Self-Insured: Amount: $____

Policy Limit: Per Claim $____________________Aggregate: $ ________________________

Policy Number: ____

Policy Period: from:_________________________to: ________________________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:____

Insurance Broker or Agent's Signature:____

VI. Pollution Liability Insurance Coverage

A. CONSULTANT's insurance shall be primary and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

B. The insurance requirements under this Agreement shall be the greater of (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policies or proceeds available to the Named Insured. It is agreed that these insurance requirements shall not in any way act to reduce coverage that is broader or that includes higher limits than the minimums required herein. No representation is made that the minimum insurance requirements of this Agreement are sufficient to cover the obligations of the CONSULTANT.

C. Minimum Requirements: Pollution Liability Insurance with minimum limits, as follows:
Each Claim or Occurrence Limit: $2,000,000;
Aggregate Limit: $2,000,000.

D. Coverage must be included for bodily injury and property damage, including coverage for loss of use and/or diminution in property value, and for clean-up costs arising out of, pertaining to, or in any way related to the actual, alleged or threatened discharge, dispersal, seepage, migration, release or escape of contaminants or pollutants, arising out of, pertaining to, or in any way resulting from any Services performed by CONSULTANT under this Agreement; including any transportation of hazardous wastes, hazardous materials, or contaminants.

E. If Coverage is written on a claims-made form, the following shall apply:

1. The retroactive date must be shown, and must be before the date of the Agreement or the beginning of the Services.
2. Insurance must be maintained and evidence of insurance must be provided for a minimum of three (3) years after completion of the Services.
3. If coverage is canceled or non-renewed, and not replaced with another claims-made policy form with a retroactive date prior to the effective date of the Agreement, CONSULTANT must purchase an extended period of coverage for a minimum of three (3) years after completion of the Services.

F. Insurance shall include prior acts coverage sufficient to cover the services under this Agreement.

Verification of Pollution Liability Insurance Coverage

As the CONSULTANT'S insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONSULTANT carries Pollution Liability insurance, as required by this Agreement, including the relevant provisions applicable to all required insurance.

Self-Insured: Amount: $ ______________________________

Policy Limit: Per Claim $ ____________ Aggregate: $ ____________________

Policy Number: ______________________________

Policy Period: from: ________________ to: ____________________

Insurance Carrier Name: ______________________________

Insurance Broker or Agent: Print Name: ______________________________

Insurance Broker or Agent's Signature: ______________________________

VII. Excess and/or Umbrella Liability Insurance Coverage

A. CONSULTANT's insurance shall be primary and any insurance or self-insurance procured or maintained by the DISTRICT shall not be required to contribute to it.

B. The insurance requirements under this Agreement shall be the greater of (1) the minimum coverage and limits specified in this Agreement; or (2) the broader coverage and maximum limits of coverage of any insurance policies or proceeds available to the Named Insured. It is agreed that these insurance requirements shall not in any way act to reduce coverage that is broader or that includes higher limits than the minimums required herein. No representation is made that the minimum insurance requirements of this Agreement are sufficient to cover the obligations of the CONSULTANT.

C. Minimum Requirements: It is expressly understood by the parties that CONSULTANT's Excess and/or Umbrella Liability policies shall, at minimum, comply with all insurance requirements set forth within this Agreement.

1. Coverage for Products, Completed Operations, and Ongoing Operations must be included in the insurance policies and shall not contain any "prior work" coverage limitation or exclusion applicable to any Services performed under this Agreement and, if it is a claims-made policy, it must be maintained for a minimum of three (3) years following final completion of the Services.

2. Coverage shall be included for all premises and operations in any way related to this Agreement.

3. There will be no exclusion for explosions, collapse, or underground damage (XCU).

4. Insurance policies and Additional Insured Endorsements shall not exclude coverage for liability and damages from services performed by Subcontractor on CONSULTANT's behalf.

5. Contractual liability coverage shall be included and shall not limit, by any modification or endorsement, coverage for liabilities assumed by CONSULTANT under this Agreement as an "insured contract."

6. "Independent CONSULTANT's Liability" shall not limit coverage for liability and/or damage arising out of, pertaining to, or in any way related to Services provided under this Agreement.

7. To the fullest extent permitted by law, the DISTRICT, its directors, officers, officials, agents, volunteers, and employees must be covered as Additional Insureds on a primary and noncontributory basis on all excess and umbrella policies. The Additional Insureds must be covered for liability arising in whole or in part from any premises, Products, Ongoing Operations, and Completed Operations by or on behalf of CONSULTANT, in any way related to Services performed under this Agreement.

8. A severability of interest provision must apply for all the Additional Insureds, ensuring that the CONSULTANT's insurance shall apply separately to each insured against whom a claim is made or suit is brought, except with respect to the policy's limits.

9. CONSULTANT and its excess and/or umbrella Liability insurance coverage must waive any rights of subrogation against the DISTRICT, its directors, officers, officials, employees, agents, and volunteers, and CONSULTANT shall defend and pay any damages as a result of failure to provide the waiver of subrogation from the insurance carrier(s).

D. CONSULTANT shall defend and pay any damages as a result of failure to provide the waiver of subrogation from the insurance carrier(s).

Verification of Excess and/or Umbrella Liability Insurance Coverage

As the CONSULTANT'S insurance broker/agent, I hereby verify that I have reviewed and confirmed that the CONSULTANT carries Excess and/or Umbrella Liability insurance, as required by this Agreement, including the relevant provisions applicable to all required insurance.

Self-Insured: Amount: $____

Policy Number: ____

Policy Period: from:____________________to: __________________________

Insurance Carrier Name:____

Insurance Broker or Agent: Print Name:________________________________

Insurance Broker or Agent's Signature:_________________________________

EXHIBIT D
IRAN CONTRACTING ACT CERTIFICATION

Pursuant to Public Contract Code (PCC) § 2204, an Iran Contracting Act Certification is required for solicitations of goods or services of $1,000,000 or more.

To submit a bid or proposal to East Bay Municipal Utility District (District), you must complete **ONLY ONE** of the following two paragraphs. To complete paragraph 1, check the corresponding box **and** complete the certification for paragraph 1. To complete paragraph 2, check the corresponding box and attach a copy of the written permission from the District.

☐ 1. We are not on the current list of persons engaged in investment activities in Iran created by the California Department of General Services ("DGS") pursuant to PCC § 2203(b), and we are not a financial institution extending twenty million dollars ($20,000,000) or more in credit to another person, for 45 days or more, if that other person will use the credit to provide goods or services in the energy sector in Iran and is identified on the current list of persons engaged in investment activities in Iran created by DGS.

CERTIFICATION FOR PARAGRAPH 1:

I, the official named below, CERTIFY UNDER PENALTY OF PERJURY, that I am duly authorized to legally bind the proposer/bidder to the clause in paragraph 1. This certification is made under the laws of the State of California.

Firm: ____

By: ______________________________ Date: ____________________
(Signature of Bidder)

Title: ______________________________

Signed at: ____________________ County, State of: ____________________

OR

☐ 2. We have received written permission from the District to submit a bid or proposal pursuant to PCC § 2203(c) or (d). *A copy of the written permission from the District is included with our bid or proposal.*

EXHIBIT E
SCOPE OF WORK

EAST BAY MUNICIPAL UTILITY DISTRICT
INTERCEPTOR MASTER PLAN PROJECT

EXHIBIT E - SCOPE OF WORK

Table of Contents

GENERAL

East Bay Municipal Utility District's (EBMUD's) wastewater collection system (Interceptor System) consists of roughly 29 miles of large-diameter gravity pipeline, 8 miles of pump station discharge lines (combination of force main and gravity pipeline), and 390 manholes or junction structures. Much of the Interceptor System was constructed over 50 years ago using reinforced concrete. There are also 15 pump stations and three wet weather facilities in the Interceptor System. The Interceptor System intercepts sewage that previously flowed from city collection systems directly to the San Francisco Bay without treatment and conveys the flow to the Oakland EBMUD Treatment plant. Those city collection systems, referred to as the satellite collection systems, include the Cities of Alameda, Albany, Berkeley, El Cerrito, Emeryville, Kensington, Oakland, Piedmont, and part of Richmond.

Recently, in conjunction with legal negotiations with the Environmental Protection Agency (EPA) and the resultant Consent Decree, inflow and infiltration (I/I) has been reduced in the satellite collection systems. Additionally, portions of the Interceptor System have been rehabilitated based on condition, totaling 17% of Gravity Interceptors and Siphons completed as of April 2023 and an additional 2.8% in construction with on-going projects.

This project will include a review of the full scope of the interceptor system, including the gravity sewer interceptors, siphons, force mains, manhole structures, overflow structures, and pump stations. Previously, these elements have been studied in separate efforts, and this project marks the first comprehensive study of the system. This project will be informed by the results of flow modeling results provided by the DISTRICT, condition assessments and investigations, corrosion prevention study, risk assessment, and development and evaluation of alternatives.

The objective of the Interceptor Master Plan Project is to evaluate issues and develop a cost-effective long-range plan to extend the life of the interceptor system. The Interceptor Master Plan Project will identify condition and criticality of sewer interceptor segments to provide capital planning priority recommendations beyond the poor condition pipe planned for rehabilitation over the next 5-8 years.

EBMUD has performed a number of inspections, reviews, and evaluations related to corrosion and odor control on the interceptor system components. Related efforts include:

- 2022 Interceptor Pipes and Manholes Condition Assessment Report (closed-circuit television [CCTV])
- 2015 Pump Station Master Plan Update
- 2014 Gravity Sewer System Pipe and Manhole Risk Assessment and Recommendations for Long-Term Management of Gravity Sewer System Assets (CCTV, manhole [MH] inspections)
- 2014 Interceptor Corrosion Prevention Study Report (sampling/monitoring, includes sulfide modeling of the interceptor)
- 2014 Wastewater Pump Station Discharge Pipeline Condition Assessment
- 2013 Evaluation of East Bay Municipal Utility District Pump Station Discharge Lines - Phase 1 Evaluation Report (MH inspections)

- 2011 Interceptor Inspections and Condition Assessment (CCTV, MH inspections)
- 2010 Interceptor Inspections and Condition Assessment (CCTV, MH inspections)
- 2009 Main Wastewater Treatment Plant (MWWTP) Odor Control Master Plan Update (Includes sulfide modeling of the interceptor.)
- 1998 MWWTP Odor Control Master Plan (includes sulfide modeling of the interceptor.)
- 1997 Interceptor Odor Control Study (includes chemical dosing in Alameda.)
- 1996 Evaluation of Influent Pump Station Odor Control Alternatives

The Interceptor Master Plan Project is focused on the following areas:

- Condition and Risk Assessment
- Corrosion Prevention Study Update
- Cleaning and Inspection Plans
- Hydraulic Modeling/Flow Model Update (provided by the DISTRICT)

The documentation and findings will be compiled in a final report which will include or reference all deliverables including a final implementation plan.

The CONSULTANT shall perform the tasks listed herein.

I. CONSULTANT SERVICES

The CONSULTANT shall complete Tasks 1 through 5 as described below. Task 6 covers optional services.

Task 1: Project Management

The CONSULTANT shall coordinate inspections, sampling, monitoring, engineering analysis, and technical memoranda with the DISTRICT; prepare meeting agenda and minutes; attend meetings; manage quality assurance and quality control (QA/QC); prepare deliverables; and provide documents and invoices as necessary to effectively manage this project. The CONSULTANT shall be responsible for project coordination and communication with the project team, subconsultants, and the DISTRICT to facilitate evaluation and development efforts. The CONSULTANT shall prepare an overall project schedule and update it on a monthly basis. The CONSULTANT shall create and maintain an Issues and Decisions Log, prepare monthly project status reports and invoices, and coordinate deliverables. The CONSULTANT shall ensure that all tasks are completed on time and within budget restrictions.

The CONSULTANT shall organize, describe, and tabulate all documents and files prepared, or caused to be prepared, by the CONSULTANT, and will provide the resulting documentation to the DISTRICT, as stipulated in Article 1.5 of the Agreement. Documents and files include, but are not limited to, drawings, specifications, cost estimates, reports, technical memoranda, collected data and materials, models, and calculations. The CONSULTANT shall also prepare a "Data Management Technical Memorandum" including a summary of the data and files provided.

The CONSULTANT shall submit deliverables in draft and final form according to the following submittal requirements.

- Draft Deliverables. The CONSULTANT shall prepare draft documents, each of which shall include the task-required information. The CONSULTANT shall provide electronic copies of each draft document in both source file format (e.g., Microsoft Word document) and PDF formats. The CONSULTANT shall allow a minimum of two weeks for the DISTRICT to review and provide comments on Technical Memoranda and Reports.

- Final Deliverables. The CONSULTANT shall prepare final documents, addressing and incorporating comments received from the DISTRICT on the draft versions. The CONSULTANT shall provide two (2) hard copies of each final document. The CONSULTANT shall also include an electronic version (PDF) of each document and each document in its source file format (e.g., Microsoft Word, ArcMap, etc.). All final deliverables shall be stamped and signed by a licensed Professional Engineer in Civil Engineering registered in the State of California. One full size and one half size pdf files of any drawing sets shall be provided with the final deliverables.

Task 1.1: Meetings and Workshops.

The CONSULTANT shall prepare agenda, prepare and coordinate review by DISTRICT of presentation slides, conduct meeting, and document meeting minutes for all the key meetings and workshops listed below. Meetings and workshops are expected to be conducted virtually through an online meeting platform such as Microsoft Teams, unless explicitly specified as an in-person meeting. These meetings do not encompass all the meetings throughout the project by all levels of the project team staff necessary for development and coordination. Meetings will include representatives from various DISTRICT Divisions. All meetings, except the management briefings, shall be scheduled at least two weeks in advance. Management briefings shall be scheduled at least one month in advance.

The following key meetings are anticipated:

- Kick-Off Meeting: The purpose of the meeting is to confirm understanding of scope, review previous relevant work conducted by the DISTRICT and consultants, identify outstanding issues, identify potential risks and mitigations, discuss the project schedule, and discuss coordination protocol between the CONSULTANT and the DISTRICT.

- Bi-Weekly Team Meetings: Meeting agendas and notes will be maintained. Presentation slides are not required for these meetings. Bi-weekly meetings with the DISTRICT and key members of the CONSULTANT's team to review the project status, including upcoming submittals, progress of individual team members, action items, new issues and general coordination through completion of the project.

- User Group Workshops: The purpose of these meeting is present the criteria, findings, alternatives, general approach and layout of improvements, and to discuss and solicit input on approach and issues. There will be one user group workshop per task.

- Focused Workshops: There will be smaller focused workshops on subtasks involving relevant Operations Staff and Engineering staff. Anticipate eight (8) 1.5-hour meetings.

- Management Briefings: Two management briefings will be planned for the project. One briefing will provide a status update approximately halfway through the project schedule to present work to date. The second briefing will be to present final findings and recommendations.

Deliverable: For all meetings, the CONSULTANT shall prepare an agenda, presentation slides, meeting minutes following the meeting, and a decision, action item, and risks log. All documents shall be provided in their source file format and PDF format.

Task 1.2: Project Reporting

This task includes management and coordination of project with the DISTRICT and members of the project team. The CONSULTANT shall provide brief project status summaries of services completed, outstanding action items, and budget status with each monthly invoice. A Gantt-type project schedule, tracking progress by task, should be included with the monthly reporting.

Deliverables: The CONSULTANT shall submit monthly invoices throughout the project and shall provide timely responses to any questions from DISTRICT regarding content.

Task 2: Data Collection and Review

The CONSULTANT shall identify what existing information is required or will substantially benefit their understanding and analysis of the system and will work with the DISTRICT to try to collect that information. The CONSULTANT shall make an initial site visit to become familiar with the project condition assessment sites. The DISTRICT will be present and coordinate access to the facilities.

Deliverable: The CONSULTANT shall reference collected information or organize it in appendices to the technical memoranda and reports required under relevant project tasks.

Task 3: Interceptor System Comprehensive Assessments

The CONSULTANT shall prepare an assessment of the Interceptor System. The assessment shall consist of the following subtasks.

Task 3.1 Inspection Plan Development

CONSULTANT shall provide recommendations for frequency of inspection of all interceptor system assets – gravity sewers, force mains, pump stations, and appurtenances. The plan shall include, but not be limited to, the following:

- Current industry standards, codes, and guidelines to be used in evaluation
- Approach to field investigations

- Approach to evaluations including criteria, reviews, and screening
- Inventory and tracking system for facilities and elements

Inspection Plan shall provide for long-term inspection schedule recommendations with specific segments indicated at specified years for the first ten years. The recommendations shall be realistic and take into account the effort involved in these inspections, including shutdown and coordination.

<u>Assumptions:</u> All pipes will be inspected a minimum of once every 10 years – with more frequent inspection for poor condition pipe.

<u>Deliverable</u>: The CONSULTANT shall summarize the findings in an Inspection Plan Technical Memorandum. The technical memorandum shall include periodicity of inspections, an inspection schedule for all assets, and cost estimates for the work. Digital GIS files and/or spreadsheet file with scheduling and prioritization data shall be provided to the DISTRICT.

Task 3.2 Asset Inspections

CONSULTANT shall perform the Year 1 inspections of the finalized Inspection Plan. The inspection will require planning and coordination with DISTRICT Operations Staff to minimize flow to the areas to be inspected. Cleaning efforts may also be required as part of inspections to inspect the inner pipe wall surfaces. Approximately 22,000 LF of interceptor sewer segments (gravity and force main) will be inspected in Year 1.

<u>Deliverable:</u> Condition Assessment digital record information including rating information, CCTV files and all other created inspection files.

Task 3.3 Condition Assessment and Likelihood of Failure

CONSULTANT shall use existing and new inspection data to assess the condition of all interceptor assets. Condition rating shall provide clear ranking information for use in risk assessment. Risk assessment shall include a translation of condition score information into a Likelihood of Failure score. Basis for condition rating shall be clearly communicated to District and be found agreeable to District staff. Results of Condition Assessment will be used by CONSULTANT to update Inspection Plan where necessary.

<u>Deliverable:</u> Condition Assessment Report with condition-based prioritization. Updated Inspection Plan.

Task 3.4 Consequence of Failure Analysis

CONSULTANT shall perform a Consequence of Failure (CoF) analysis of all interceptor assets. CoF rating shall provide clear ranking information for use in risk assessment. Basis for CoF rating shall be clearly communicated to District and be found agreeable to District staff. CoF shall incorporate but not be limited to consideration of:

- Public health
- Normal operation businesses and residences

- Transportation corridors and infrastructure
- Emergency corridors and infrastructure
- Utility infrastructure
- Duration of impacts
- Emergency costs – both financial and reputational

Deliverable: Provide Subtask Report and spreadsheet file with CoF data.

Task 3.5 Comprehensive Risk Assessment

CONSULTANT shall perform a Comprehensive Risk Assessment analysis of all interceptor assets. Risk Assessment ratings shall provide clear ranking information for use in risk assessment. Formula for Risk Assessment rating shall be clearly communicated to District and be found agreeable to District staff. CONSULTANT shall develop recommendations for performance objectives and acceptable risk level for use in future evaluations. Final Ranking of projects shall be discussed with staff to ensure appropriate projects are prioritized.

Deliverable: Comprehensive Risk Assessment Subtask Report.

Task 3.6 Update Interceptor System Capital Improvement Project (CIP) Schedule

CONSULTANT shall update the Interceptor CIP implementation schedule to reflect Risk Assessment results and available budget. Basis and scheduling of CIP projects shall be clearly communicated to District and be found agreeable to District staff.

Deliverable: CIP Schedule Recommendation.

Task 3.7 Full Project Summary Report

CONSULTANT shall prepare a Full Project Summary encompassing all tasks to be included with the above listed task 3 items as a summary report of work completed and recommendations. Tasks 4 and higher shall be summarized in the main report and included as appendices.

Deliverable: Task 3 Summary including all finalized subtask reports and appendices as a combined document.

Task 4: Corrosion Prevention Study

The CONSULTANT shall prepare a corrosion prevention study concerning the Interceptor System assets susceptibility to corrosion, primarily focused on hydrogen sulfide. The CONSULTANT shall perform condition inspection and monitoring to determine areas of concern, develop corrosion hotspots, mitigation alternatives, and cost estimates. The DISTRICT will provide past related reports where requested.

The purpose of the corrosion prevention work is to determine suitable corrosion prevention methods and applications for the EBMUD's wastewater interceptor system. Methods that may be evaluated in this study include, but are not limited to, the following:

- Chemical Dosing (various chemicals)
- Oxygenation
- Crown Spraying
- Protective Barriers
- Operation and Maintenance Changes

Consultant is encouraged to present additional options for corrosion prevention outside of the above listed methods.

The scope of work includes evaluation of prevention methods, development of site-specific applications, alternatives analyses (including cost analyses), and development of recommendations.

All corrosion software models developed for this project shall be submitted electronically to the DISTRICT for future use.

Task 4.1 Monitoring and Sampling

The CONSULTANT shall work with the DISTRICT to clearly establish a sampling and monitoring plan of H2S within the Interceptor System to determine hot spots and corrosive potential within the Interceptor System.

Deliverable: CONSULTANT shall summarize findings and shall include a mapping document and dataset that delineates the hotspots.

Task 4.2 Screening of Methods and Applications

CONSULTANT shall perform an initial review corrosion prevention methods and application on EBMUD's interceptor system considering that different methods may be suitable to different areas. The evaluation shall include effectiveness, means of monitoring effectiveness, and cost for each method to establish a basis for justifying further analysis.

Deliverable: Initial Review of Methods and Applications Technical Memorandum covering review, analysis method, information considered, and outcome.

Task 4.3 Analyze and Review Methods and Applications

For each method, determine site-specific requirements, procurement requirements, anticipated effectiveness and criteria for monitoring effectiveness. Develop application requirements and specification sufficient to develop capital and Operation and Maintenance scopes and costs and perform a present worth life-cycle cost alternative analysis, including prevention methods alternatives and capital rehabilitation alternatives, and develop recommendations.

Deliverable: Evaluation of Methods and Applications Technical Memorandum covering review, analysis method, information considered, alternative analysis, and outcome.

Task 4.4 Alternatives Analysis Update

CONSULTANT shall review past recommendations to mitigate corrosion regarding infrastructure additions, rehabilitation, and investigations technologies and methods and update and revise alternatives and lifecycle analyses based on new technologies and economic conditions as well as results of a system flow model capacity analysis provided by the DISTRICT.

Deliverable: The CONSULTANT shall summarize the findings in an Infrastructure and Technology Recommendations Technical Memorandum. The technical memorandum shall include any alternatives for rehabilitation or improvements and inspection technologies and cost estimates for the work.

Task 4.5 Interceptor System Corrosion Prevention Study Report

The Interceptor System Corrosion Prevention Study Report shall include descriptions of all efforts performed under Consultant's scope of work. All Technical Memoranda and collected information shall be provided as appendices.

Deliverable: Interceptor Corrosion Prevention Study Report documenting all collected information, investigations, findings, analysis, and recommendations.

Task 5: Cleaning and Inspection Recommendations/Options

The DISTRICT has limited regular maintenance and inspection activities in managing the Interceptor System. CONSULTANT shall advise on best practices for Interceptor System maintenance, cleaning, and inspection activities. Recommendations shall include methods, frequencies, staffing, and case study references. Recommendations shall include cost estimates.

Deliverable: The CONSULANT shall summarize findings in a Final Cleaning and Inspection Recommendations Technical Memorandum for presentation to the DISTRICT's User Group.

Task 6: Optional Services

Optional services, if warranted, will be negotiated at a future date at the discretion of the DISTRICT. Optional services may include additional engineering services identified during the course of this project. At the discretion of the DISTRICT, the following services may be considered, but are not limited to:

- Specialized field tests and inspections
- Specialized modeling or evaluation

II. PROJECT SCHEDULE COMPLETION MILESTONES

Project Kick-off	January 2023
Task 2: Data Collection and Review	February 2024
Task 3.1: Interceptor Condition and Risk Assessments	September 2024
Task 3.2: Alternatives Analysis Update	September 2024
Task 3.3: Condition Assessment Report	September 2024
Task 3.4: CoF Analysis	August 2024
Task 3.5: Comprehensive Risk Assessment Report	September 2024
Task 3.7: Full Project Summary Report	October 2024
Task 4: Corrosion Prevention Study	---
Task 4.1: Monitoring and Sampling	September 2024
Task 4.2: Initial Review of Methods and Applications	June 2024
Task 4.3: Analyze and Review of Methods and Applications	September 2024
Task 4.4: Corrosion Prevention Alternatives Analysis	October 2024
Task 4.5: Interceptor System Corrosion Prevention Study Report	October 2024
Task 5: Cleaning and Inspection Recommendations	September 2024
Task 6: Optional Services	TBD

- End Exhibit E -

EXHIBIT F
Reference Material

2014

GRAVITY SEWER SYSTEM PIPE AND MANHOLE

RISK ASSESSMENT

and

RECOMMENDATIONS

FOR LONG-TERM MANAGEMENT OF GRAVITY SEWER SYSTEM ASSETS

PREPARED BY

Maura A. Bonnarens
Senior Civil Engineer
EBMUD Wastewater Department
Asset Management Program Manager

November 13, 2014

Table of Contents

Executive Summary

The gravity portion of the District's Interceptor System consists of approximately 29 miles of pipes ranging in diameter from 12-inches to 108-inches, and 325 manholes. In 2010, the District started work on a comprehensive project to gather condition assessment information on all of the gravity sewer pipes and manholes on the Interceptor System; to develop schedules for the types of Interceptor System repairs and replacement as needed based on the results of the inspection work; and to develop Interceptor System maintenance protocols.

The physical characteristics and structural condition of 28.7 miles of gravity interceptor pipe was obtained over a four year period using CCTV, or, where CCTV was not feasible, sonar technology. Depending on the ability to access gravity system manholes, as well as gas levels in the manholes, 323 manholes were inspected via person-drops into the manhole, remote camera, or CCTV. Two of the manholes were buried and inaccessible for inspection work. All of the inspection work was done during dry weather periods in 2010, 2011, 2012, and 2013.

The District used a risk-based methodology to develop recommendations for managing its gravity Interceptor System assets. This methodology takes into consideration the condition of the asset, and the corresponding likelihood it could fail, as well as the consequences if the asset fails.

Following are key findings/recommendations for gravity system assets:

- Major defects were observed in 14 pipe segments (total length approximately 5,000 linear feet) and 19 manholes. Major defects warrant inclusion of affected assets in one of the four interceptor rehabilitation projects in the current FY14-23 Capital Improvement program.
- 26 pipe segments (total length 14,300 linear feet) and 52 manholes should be re-inspected in 2021 based on their condition and/or risk.
- All interceptor system assets should be re-inspected in 20 years and the risk assessment should be updated at that time.

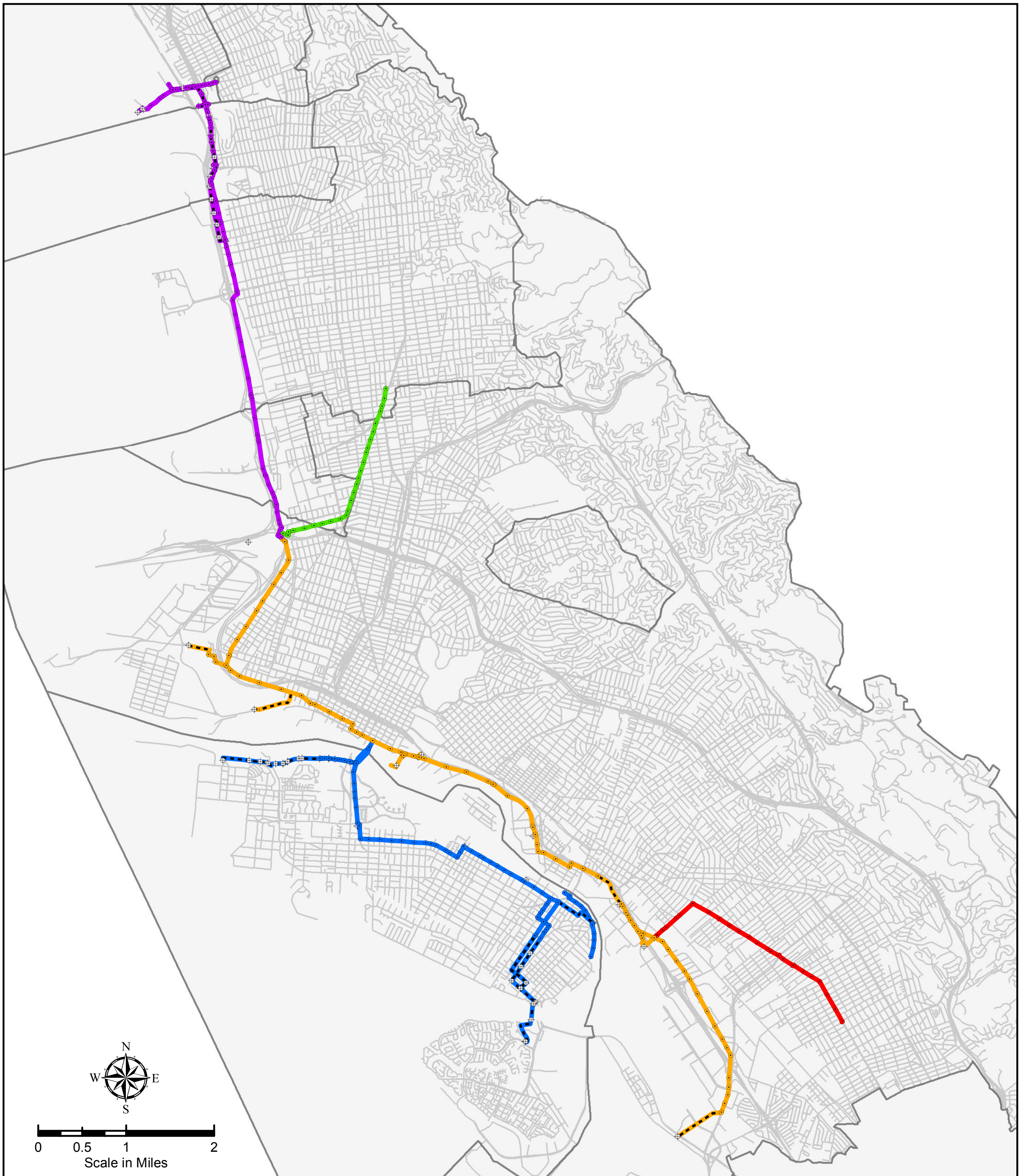
Introduction

The gravity portion of the District's Interceptor System consists of approximately 29 miles of pipes ranging in diameter from 12-inches to 108-inches, and 325 manholes. Figure 1 is a map of the Interceptor System, and shows the North, South, Alameda, Adeline and South Foothill Interceptors. Figure 2 shows segments along each of the five interceptors.

A comprehensive assessment of the District's Interceptor System was performed in 1995, under the Interceptor Damage Assessment Project (IDAP). In 2006, some limited inspection work was completed in order to update the IDAP. In 2009, the District was mandated via a Stipulated Order (SO) issued by the U.S. Environmental Protection Agency (EPA), the California State Water Resources Control Board (SWRCB), and the California Regional Water Quality Control Board (RWQCB) to inspect the entire Interceptor System within five years, to develop Interceptor System maintenance protocols, and to develop schedules for the types of Interceptor System repairs and replacement as needed based on the results of the inspection work. To comply with the SO, the District started work on a comprehensive project in 2010 to gather condition assessment information on all of the gravity sewer pipes and manholes on the Interceptor System. The findings from both the IDAP work and the SO-related work were considered in developing the Risk Assessment used to develop recommendations for schedules for repair and replacement, as needed, as well as in developing recommendations for future inspection work.

This report focuses on the gravity portion of the District's Interceptor System and presents the findings from the inspection work, the approach to developing the Risk Assessment, and the recommendations for future capital and operations/maintenance work. The SO-required work for the District's pump stations, pump station force mains, siphons and overflow structures are addressed in separate reports.

Figure 1: EBMUD Interceptor System

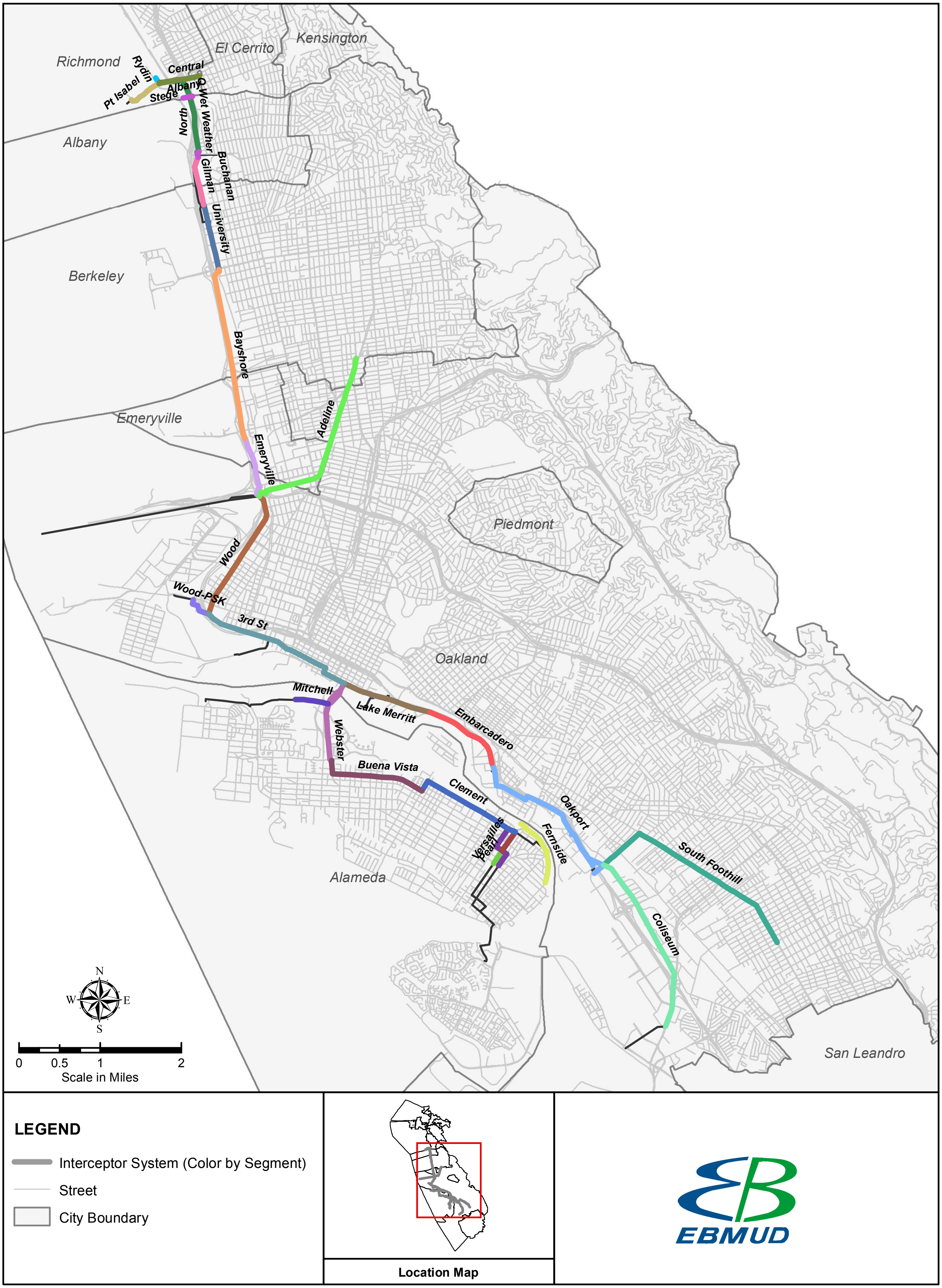


LEGEND

Interceptors	Gravity Manholes
North	North Interceptor
North-Adeline	North-Adeline Interceptor
Alameda	Alameda Interceptor
South	South Interceptor
South-South Foothill	South-South Foothill Interceptor
Forcemains	Pressure Manholes and Other Facilities

EBMUD

Figure 2: EBMUD Interceptor Segments



Condition Inspections Summary

The physical characteristics and structural condition of 29 miles of gravity interceptor pipe were obtained over a four year period using CCTV, or, where CCTV was not feasible, sonar technology. Depending on the ability to access gravity system manholes, as well as gas levels in the manholes, 323 manholes were inspected via person-drops into the manhole, remote camera, or CCTV. All of the inspection work was done during dry weather periods in 2010, 2011, 2012, and 2013.

Visually observed defects in manholes and pipes from the CCTV inspections were recorded in general compliance with the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP) and Manholes Assessment and Certification Program (MACP) defect codes.

The PACP/MACP condition grading system assigns a condition grade of 1 through 5 to each defect code with 1 being a minor defect (e.g., surface spalling) and 5 being the most severe (e.g., collapsed pipe.) For this project, the PACP/MACP grades were augmented by incorporating additional field data of scratch and hammer tests done during manhole entries performed during the Phase 1 work. All of this data was used to group the assets into the categories described in Table 1 for the following defect types: Corrosion, Structural/Infiltration, and Lining Failure.

Table A-1 in Appendix A lists all the Interceptor System gravity system pipe segments, along with the corresponding pipe diameter, pipe material, pipe length, Interceptor name, Interceptor Segment name, and the condition rating for Corrosion, Structural/Infiltration, and Lining Failure.

Table A-2 in Appendix A lists all the Interceptor System gravity system manholes, along with the corresponding Interceptor name, Interceptor Segment name, and the condition rating for Corrosion, Structural/Infiltration, and Lining Failure.

Note that condition ratings have been updated for assets that were rehabilitated or replaced between 2010 and 2012.

Maps have been prepared that show the assets in each category for each defect type. Category A assets are shown in green. Category B assets are shown in blue. Category C assets are shown in yellow. Category D assets are shown in red.

The following figures present the condition assessment findings for the inspection work performed:

- Figure 3: Manhole Corrosion Defects – 2010, 2011, 2012 & 2013 Inspection Results
- Figure 4: Manhole Structural/Infiltration Defects – 2010, 2011, 2012 & 2013 Inspection Results
- Figure 5: Manhole Lining Defects – 2010, 2011, 2012 & 2013 Inspection Results
- Figure 6: Pipe Corrosion Defects – 2010, 2011, 2012 & 2013 Inspection Results
- Figure 7: Pipe Structural/Infiltration Defects – 2010, 2011, 2012 & 2013 Inspection Results
- Figure 8: Pipe Lining Defects – 2010, 2011, 2012 & 2013 Inspection Results

Table 1: Summary of Condition Categories

Category	Definition	Examples of Observations
No Defects	No defects observed	No defects observed.
A	Minor defects observed	Corrosion: Mortar missing (small), surface roughness, surface spalling Structural/Infiltration: Crack (circumferential/longitudinal/ spiral), angular joint, offset joint, joint separated, tap break-in defective, infiltration stain, slow seepage of infiltration through a defect or faulty joint or pipe wall but no visible drips, infiltration dripping through a defect or faulty joint or pipe wall but not a continuous flow Lining: Lining wrinkled, undercut connection
B	Moderate defects observed	Corrosion: Mortar missing (medium), surface aggregate visible/projecting/missing, surface corrosion for metal pipe Structural/Infiltration: Multiple cracks, fracture (circumferential/ longitudinal/spiral), displaced brick, infiltration running as a continuous flow through a faulty joint or pipe wall Lining: Lining blistered, pinhole
C	Significant defects observed	Corrosion: Mortar missing (large), surface reinforcement visible/projecting Structural/Infiltration: Broken, hole, deformed, dropped invert, infiltration enter "under pressure" through a defect or faulty joint Lining: Defective end, connection cut shifted, overcut connection, circumferential failure, longitudinal failure, localized liner defective, patch defective, point defective
D	Major defects observed	Corrosion: Surface reinforcement corroded, surface missing portions of manhole wall Structural/Infiltration: Broken and soil/void visible, hole and soil/void visible, missing brick Lining: Lining buckled/detached/delaminating, multiple failures, spiral failure

Figure 3: Manhole Corrosion Defects - 2010, 2011, 2012 & 2013 Inspection Results

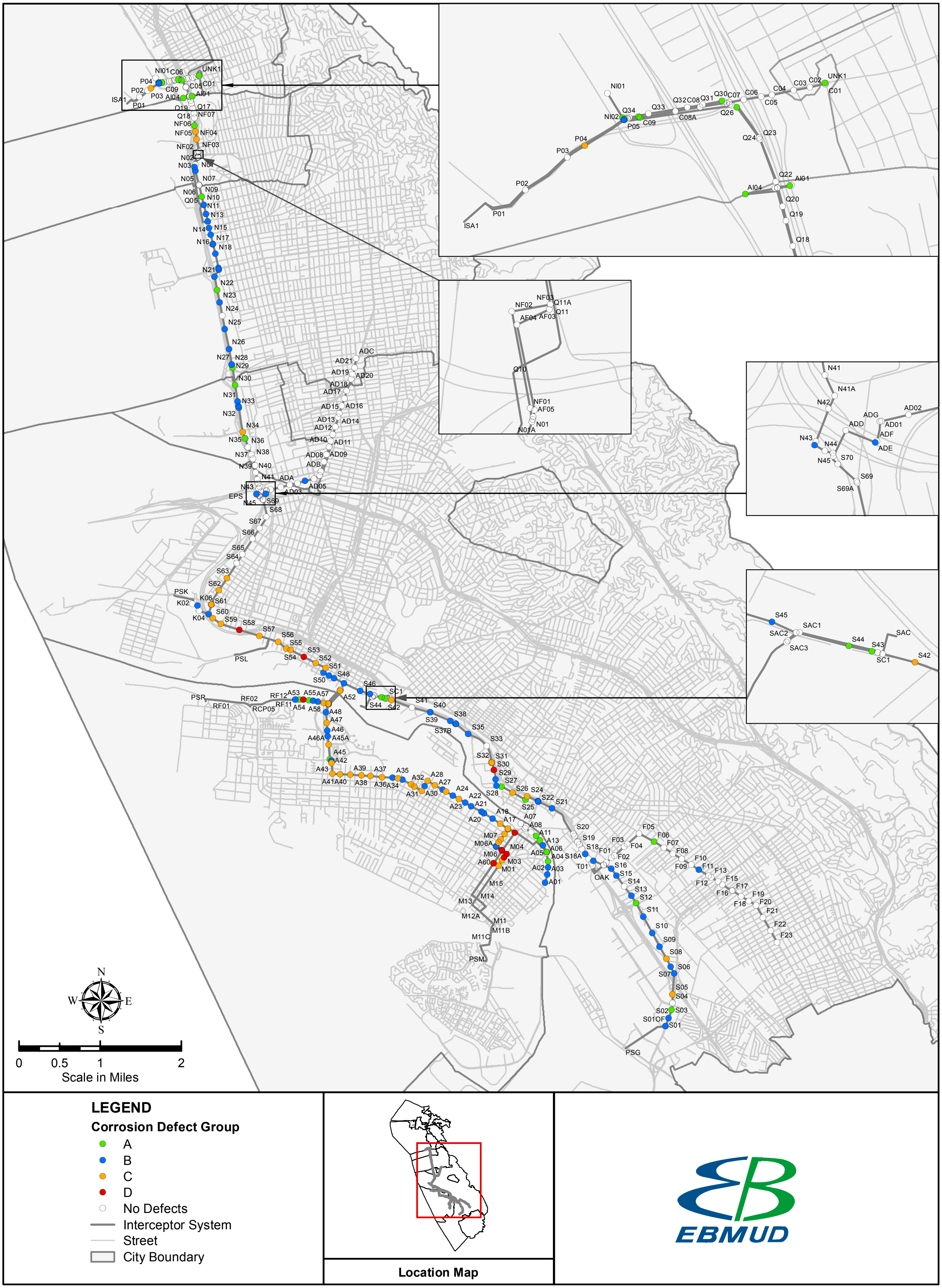


Figure 4: Manhole Structural/Infiltration Defects - 2010, 2011, 2012 & 2013 Inspection Results

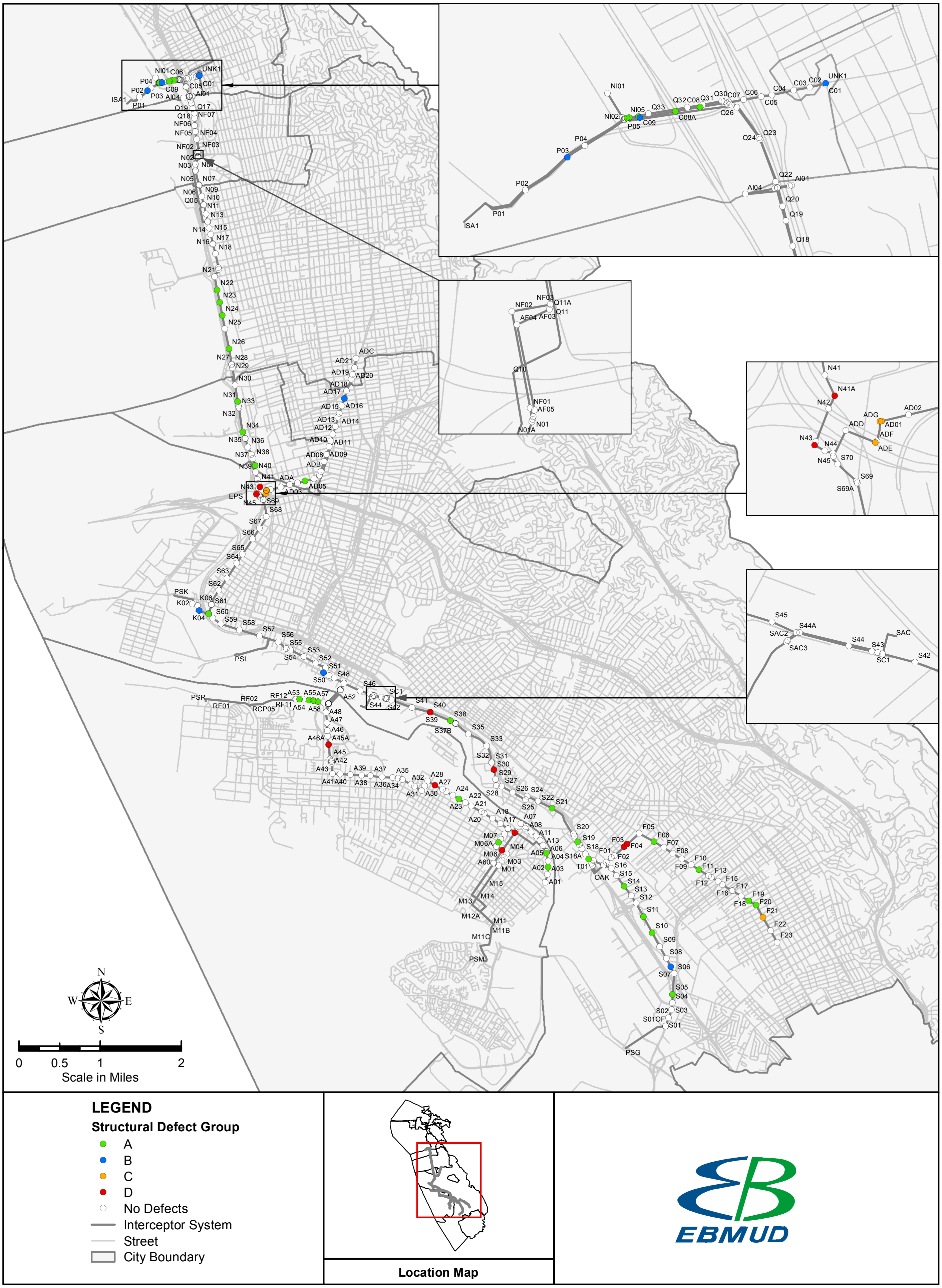


Figure 5: Manhole Lining Defects - 2010, 2011, 2012 & 2013 Inspection Results

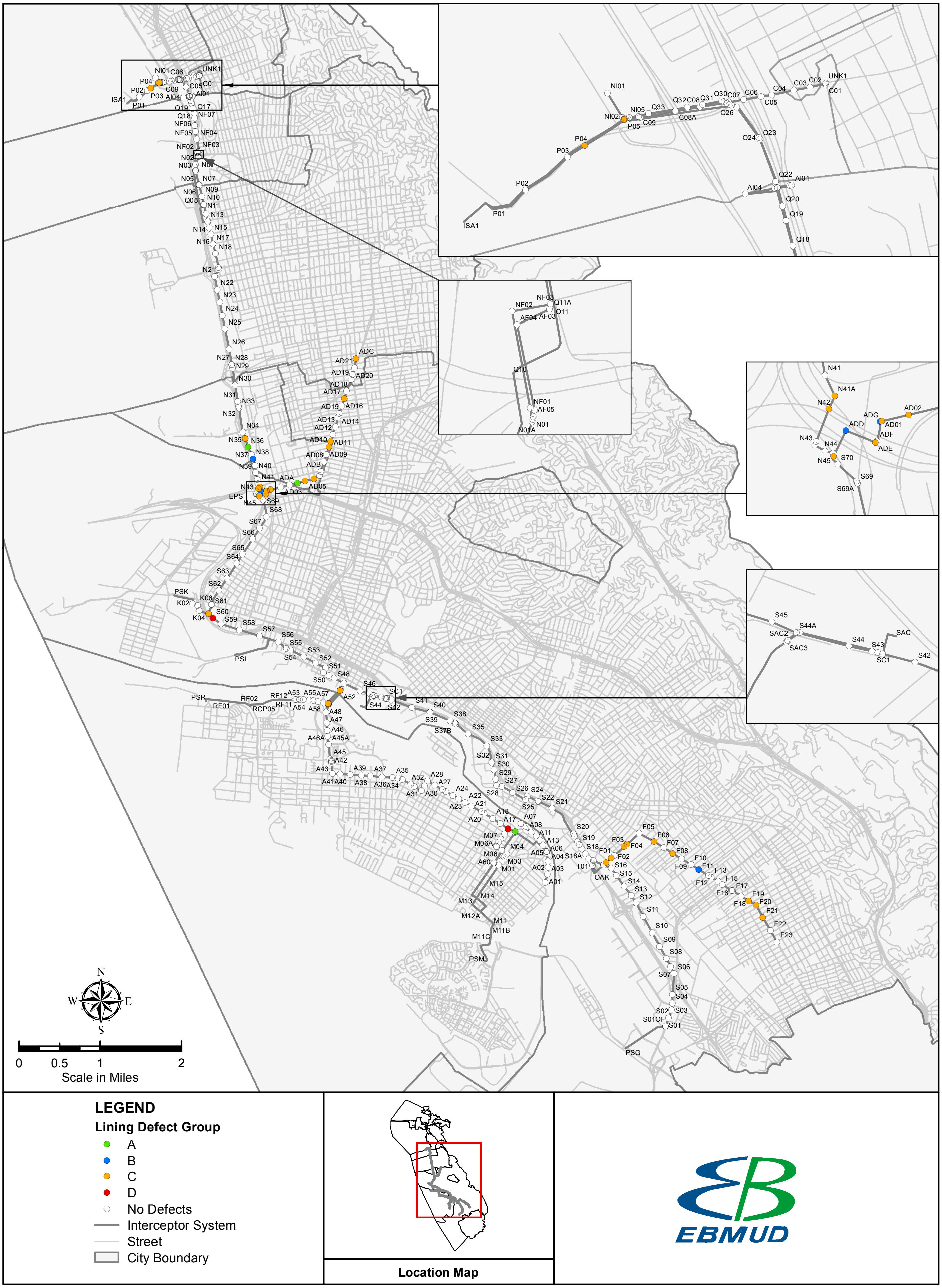


Figure 6: Pipe Corrosion Defects - 2010, 2011, 2012 & 2013 Inspection Results

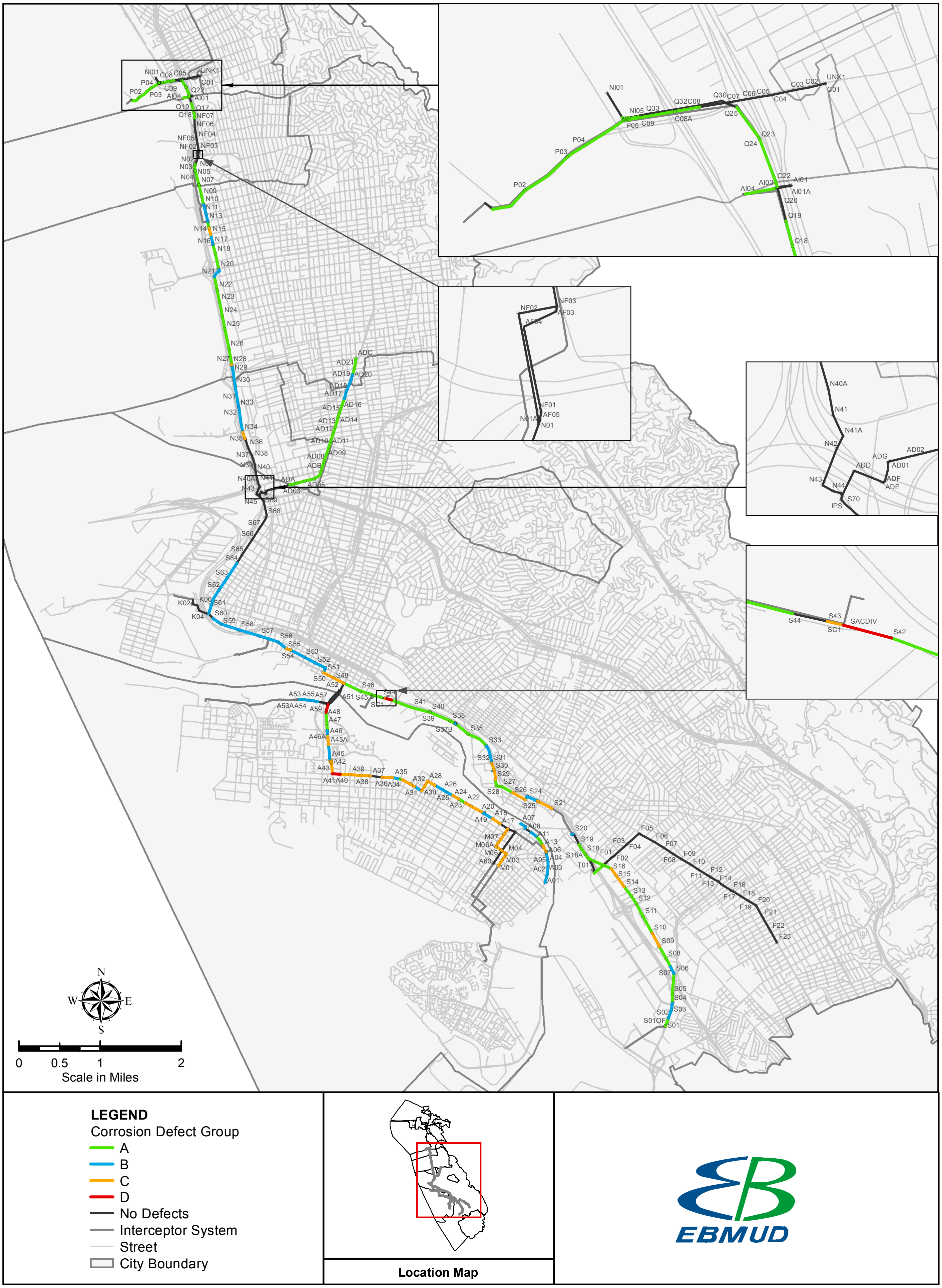


Figure 7: Pipe Structural/Infiltration Defects - 2010, 2011, 2012 & 2013 Inspection Results

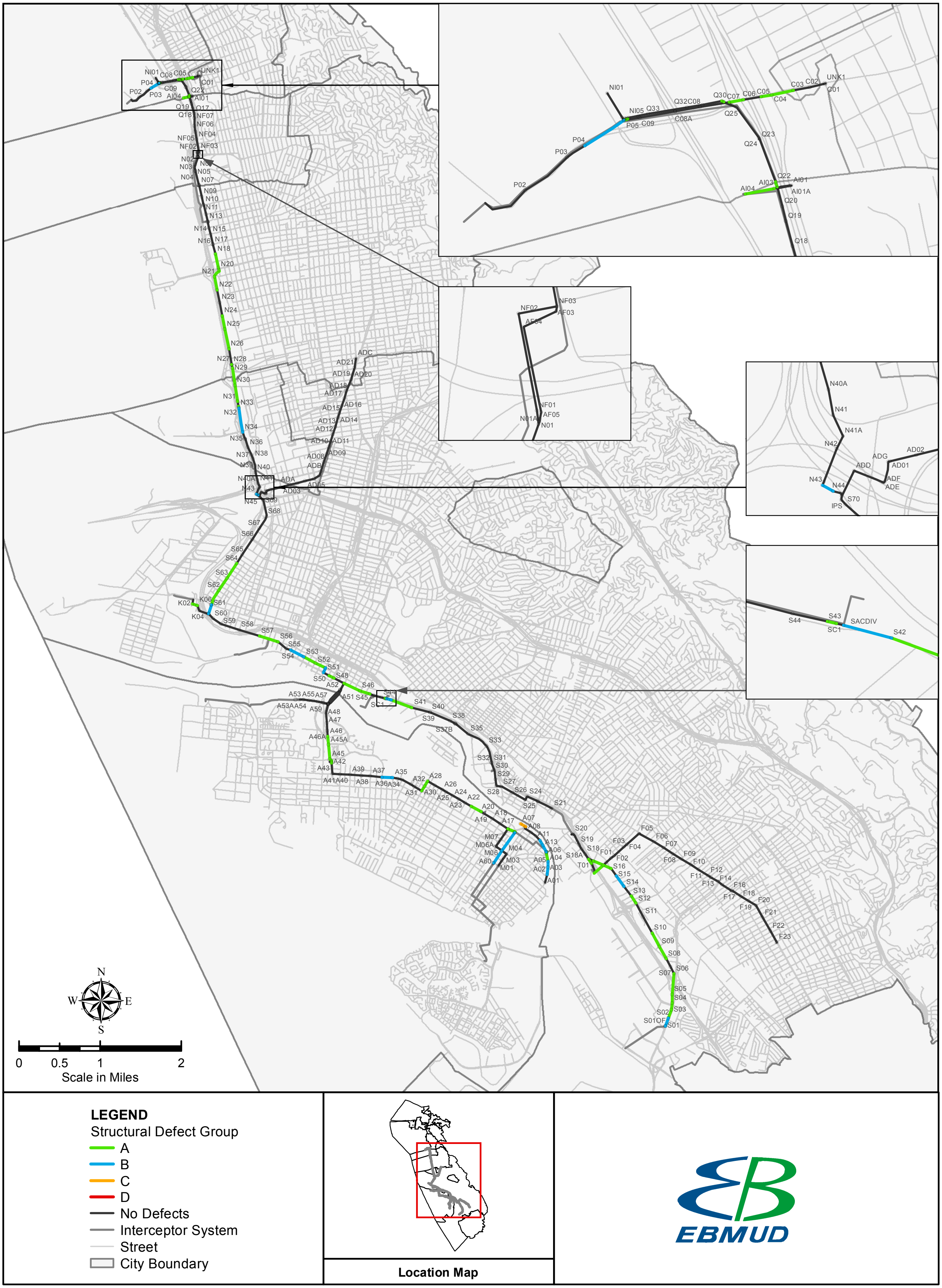
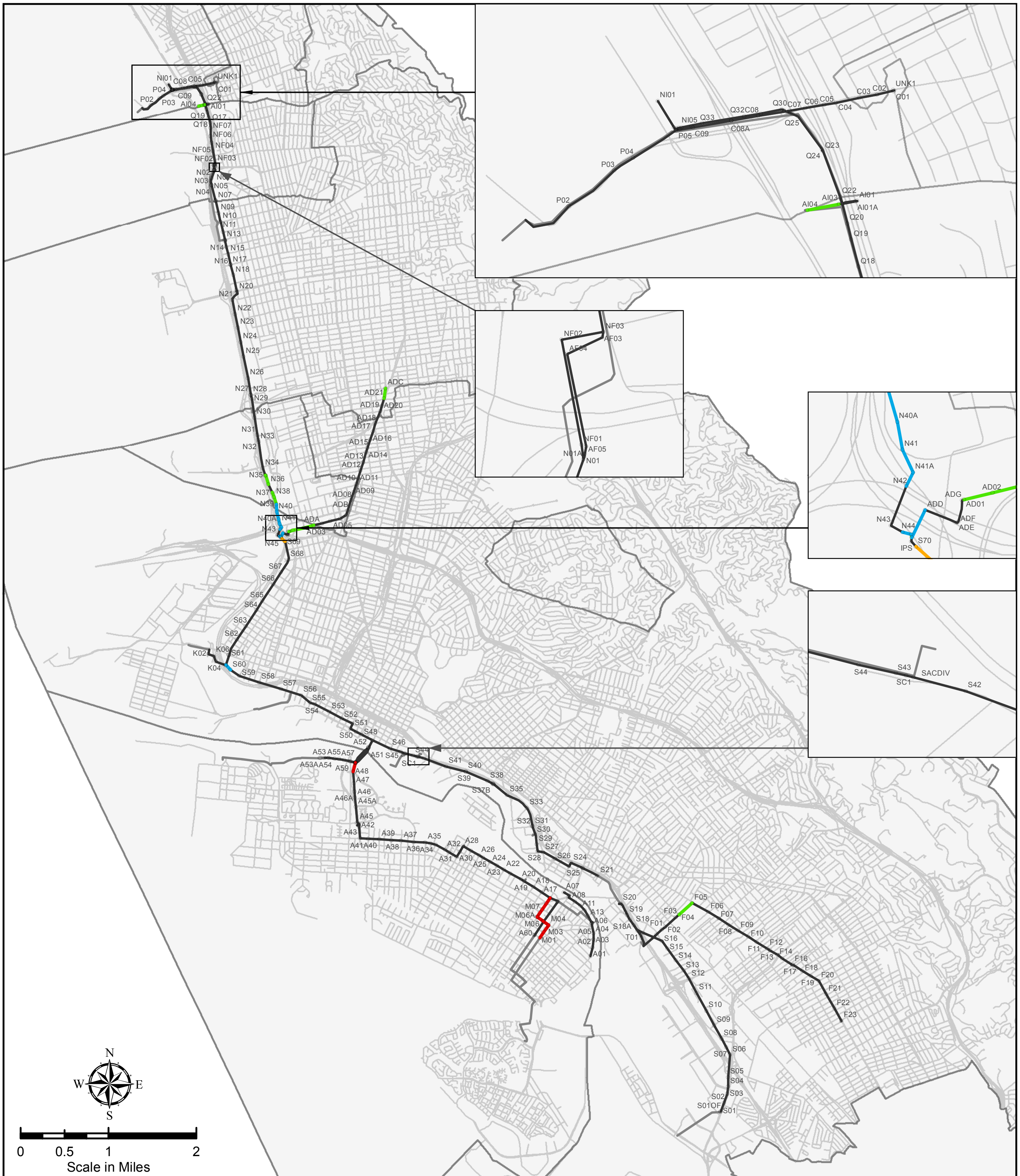
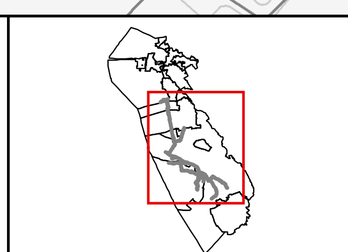


Figure 8: Pipe Lining Defects - 2010, 2011, 2012 & 2013 Inspection Results



LEGEND
Lining Defect Group
- A
- B
- C
- D
- No Defects
- Interceptor System
- Street
- City Boundary



Location Map

Approach

The District used a risk-based methodology to develop recommendations for managing its gravity Interceptor System assets. This methodology takes into consideration the condition of the asset, and the corresponding likelihood it could fail, as well as the consequences if the asset fails. A numerical value is assigned to both the likelihood and the consequence. The higher the likelihood or the more significant the consequence, the higher the number assigned to the asset. The likelihood and consequence scores are then multiplied to produce a numeric value indicating “risk”. The relative risk of each asset can then be compared and efforts for maintenance and capital investment can be focused on the higher risk assets.

Likelihood of Failure

The numeric scale used for likelihood of failure is 1 to 5, with 5 being the “most likely” to fail.

The following method was used to assign the numeric value to each individual asset:

1. The condition assessment data provides condition ratings for three categories: Corrosion, Structural, and Lining. To simplify the process, the overall asset rating was defined as the worst of any one of the individual ratings. For example, if an asset received a rating of “C” for corrosion, “No Defect” for lining, and “B” for structural, the overall asset rating was defined as “C”. It is recognized that the significance of the contribution to likelihood of failure from a corrosion defect versus a structural defect versus a lining defect is not necessarily the same. However this simplified approach for assigning a condition rating will provide a more conservative condition rating for the assets.
2. Each overall asset rating was converted to a numeric rating as follows:

   D=5

   C=4

   B=3

   A=2

   No Defect=1

3. The likelihood based on the 2010-2013 inspections was refined by using the 1995 inspection data. The 1995 condition ratings scored an asset on a scale of 0 to 8 with 8 indicating a pipe that is in poor condition. If the 1995 asset rating was 5 or higher, the likelihood rating for Category B assets was moved to the next higher rating. For example, if the 1995 inspections rated a pipe segment at 5, and the 2013 rated it as a B, the asset was assigned a likelihood of 4 rather than 3.

Table A-3 in Appendix A lists all the Interceptor System gravity pipe segments, the 1995 rating, the overall 2010-2013 condition rating, and the 2014 assigned likelihood rating.

Table A-4 in Appendix A lists all the Interceptor System gravity manholes, the 1995 rating, the overall 2010-2013 condition rating, and the 2014 assigned likelihood rating.

Consequence of Failure

The criteria in Table 2 were used to develop the consequence score for each asset. Consequence ratings were determined for the various criteria based on viewing plan and profile drawings of each asset, as well as referencing Google Maps on line to view current images of the area around the asset. The consequence score is the sum of the consequence ratings.

Table 2: Consequence of Failure Rating

	Consequence			Rating	
Criteria	**Very Serious (5)**	**Serious (4)**	**Moderate (3)**	**Minor (2)**	**Negligible (1)**
Disruption to Commerce	i.e., Oakland Airport, Port of Oakland, or major industrial facility	Major shopping area or significant industrial area	Minor shopping area or industrial area	Mix of residential and shopping area	Primarily residential or in a parking lot
Environmentally Sensitive Area	Pipeline immersed in water	Pipeline within 100 feet of major waterway or environmentally sensitive area (marsh, creek, etc) or crossing under or over a major storm line	Pipeline within 200 feet of major waterway	Some potential that sewage could get to a waterway but not very likely	No waterway nearby
Traffic Impact	Critical roadway (interstate, Hegenberger, International Blvd, etc)	Major Roadway with rerouting very challenging	Major Roadway with rerouting feasible but disruptive	Major roadway but rerouting relatively easy or moderate roadway	Minor roadway
Constructability	Very few options available	If not addressed early, options become fewer and more expensive; pipe diameter 72-inches or bigger	Not used for this criteria	Some cost effective options available.	Multiple options available to cost effectively rehab

Table A-3 in Appendix A lists all the Interceptor System gravity pipe segments and the consequence rating assigned to each for the following criteria: disruption to commerce, environmentally sensitive area, traffic impact, and constructability.

Table A-4 in Appendix A lists all the Interceptor System gravity manholes and the consequence rating assigned to each for the following criteria: disruption to commerce, environmentally sensitive area, and traffic impact. Constructability was not considered for the manholes since that is less of a variable for manholes than it is for pipes.

Assignment of Risk

Risk is the product of likelihood and consequence of failure. For this analysis, a weighting factor was used to better define risk.

For the gravity pipe segments, the constructability factor in the consequence rating was doubled. This reflects the significance of the economic impact to the District to have to implement more costly repair methods by delaying rehabilitation. In addition, increasing this rating correlates with the challenges of rehabilitating larger pipes (which in turn carry larger flows.) The constructability of larger pipes is typically rated higher than smaller pipes since the options for rehabilitation decrease in larger pipes as compared to smaller pipes, often due to the amount of flow in the pipes and the inability to bypass flows.

For the gravity manholes, the environmental factor in the consequence rating was doubled. This represents the significance of the economic impact of potential regulatory fines should the asset fail and discharge wastewater to a public waterway. A sensitivity analysis was performed for considering doubling the disruption to commerce factor in lieu of the environmental factor. Although the final risk score for several of the manholes changes (some increase, some decrease) the results from this analysis produce the same final recommendations for rehabilitation and future inspections.

Table A-5 in Appendix A lists all the Interceptor System gravity system pipe segments, the likelihood rating, the consequence ratings including the weighting for constructability, and the risk. Table A-6 in Appendix A lists all the Interceptor System gravity system manholes, the likelihood rating, the consequence ratings including the weighting for environmental impact, and the risk.

Figure 9 depicts the risk assignment for all Interceptor System gravity system pipeline assets. Figure 10 depicts the risk assignments for all the Interceptor System gravity system manholes.

For both the risk tables and figures the following color scheme is used:

Red: High Risk

Orange: High-Medium Risk

Yellow: Medium Risk

Green: Medium-Low Risk

Blue: Low Risk

No condition data was obtained for buried Manholes A59 and S05A. Hence, no risk can be assigned at this time.

Figure 9: Gravity System Pipe Risk Assignment

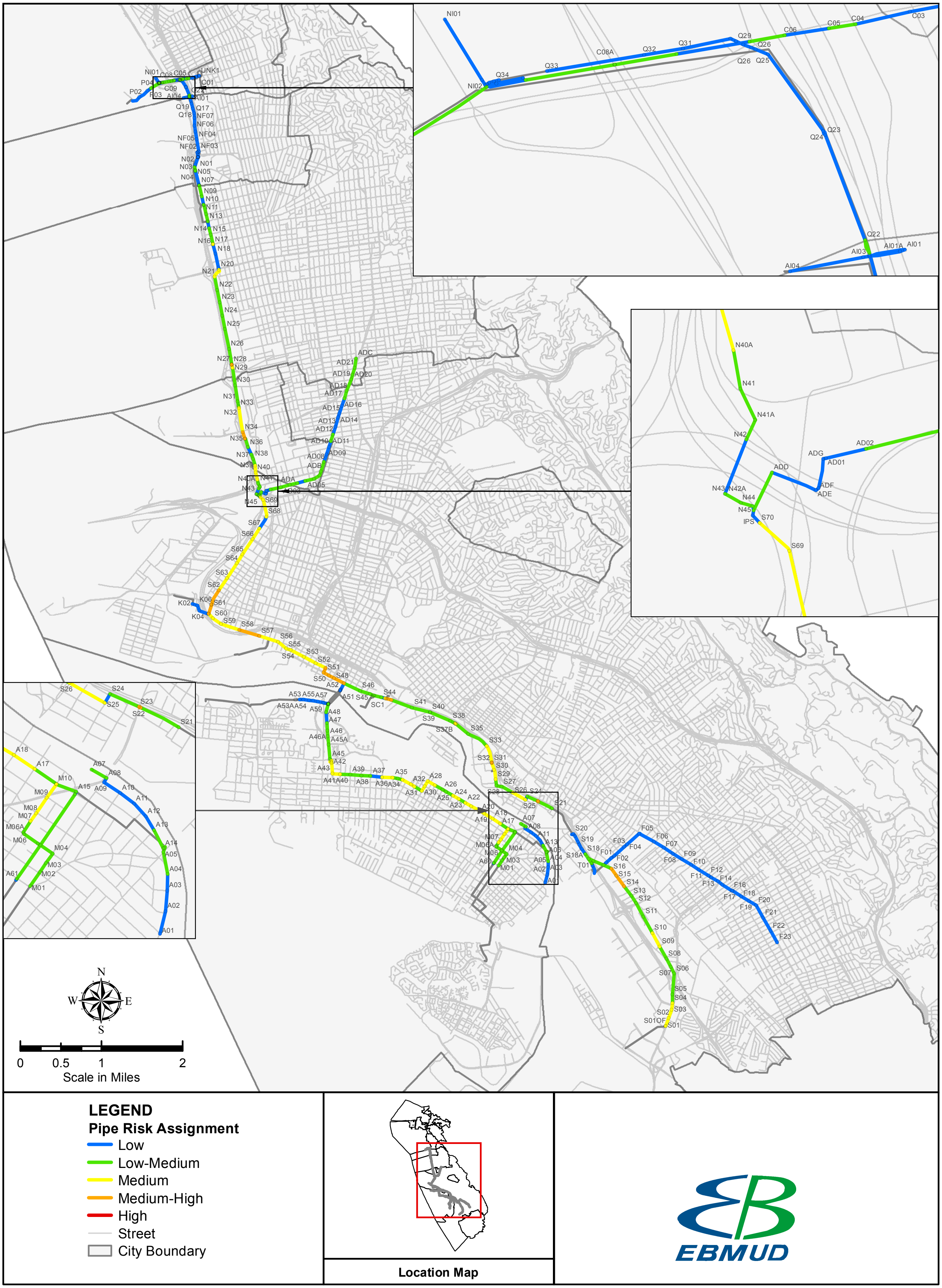
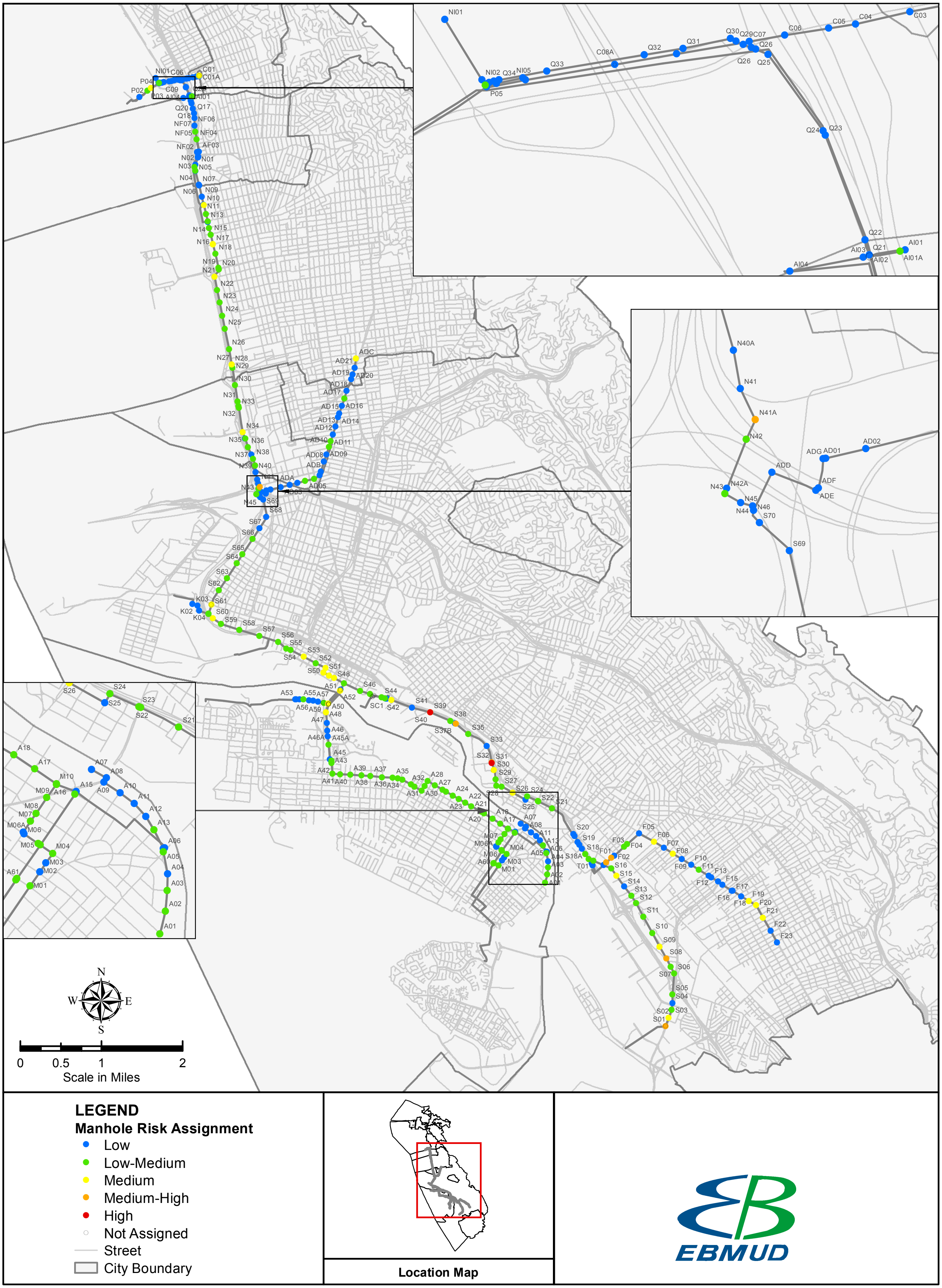


Figure 10: Gravity System Manhole Risk Assignment



Recommendations for Repair and Rehabilitation

Category D Assets

Category D assets should be rehabilitated regardless of risk since the repair of a failed asset is always more expensive than rehabilitating the asset prior to failure. Rehabilitation of all Category D assets from the 2010-2013 inspections is included in projects in the current FY14-FY23 Capital Improvement Program (CIP). The following projects are included in the FY14-FY23 CIP:

- Wood Street Interceptor Rehabilitation
- Versailles Interceptor Rehabilitation
- Alameda Interceptor Rehabilitation
- 3rd Street Interceptor Rehabilitation

Table 3 lists all the Category D assets (gravity system pipe segments and manholes) and identifies which CIP project will include their rehabilitation.

Table 3: Category D Assets

ASSET ID	FY14-23 CIP PROJECT
A40A411	Alameda
A48A491	Wood Street
M01M021	Versailles
M02M031	Versailles
M03M041	Versailles
M04MC11	Versailles
M05M061	Versailles
M06AM071	Versailles
M06M06A1	Versailles
M07M081	Versailles
M08M091	Versailles
M09M101	Versailles
PSF01A43	Alameda
S42SACDIV1	3rd Street
A27	Alameda
A45A	Alameda
A55	Alameda
A60	Versailles
A62	Versailles
F03	3rd Street
F04	3rd Street
M03	Versailles

ASSET ID	FY14-23 CIP PROJECT
M04	Versailles
M05	Versailles
M10	Versailles
MC1	Versailles
N41A	3rd Street
N43	3rd Street
S30	3rd Street
S39	3rd Street
S53	3rd Street
S58	3rd Street
S60	3rd Street

Category A, B and C Assets

Rehabilitation of Category C assets should be driven by risk. Category A and B assets generally should not be rehabilitated. If Category A and B assets present a high risk, the long term inspection plan for these assets should reflect a more frequent inspection cycle to monitor the condition of the asset and to better predict the timing for rehabilitating the asset. It should be noted that, for economic reasons, some lower risk assets that were rated Category A or B from the condition assessment work may be rehabilitated on an earlier schedule than normal if they are in close proximity to higher risk assets that are scheduled for rehabilitation.

Table A-7 in Appendix A is a table of all gravity system pipeline assets categorized as A, B, or C. The table is ranked by order of risk with the highest risk assets at the top. Also included on this table is the FY14-F23 CIP project that plans to address the rehabilitation of the asset. It should be noted that not all Category C assets represent a high risk for the District.

Table A-8 in Appendix A is a table of all gravity system manhole assets categorized as A, B, or C. The table is ranked by order of risk with the highest risk assets at the top. Also included on this table is the FY14-F23 CIP project that plans to address the rehabilitation of an asset. It should be noted that not all Category C assets represent a high risk for the District.

Based on review of Tables A-7 and A-8, there is one Category C high risk asset (Manhole S31) that is included in the 3rd Street Interceptor Rehabilitation Project. All other Category A, B, and C assets are high-medium risk or lower. Rehabilitation of these assets is not required at this time.

Recommendations for Future Inspections

2021 Inspections

All Category C assets that are not scheduled for rehabilitation should be inspected every 10 years. Assets defined as Category A or B should be inspected every 20 years (or more frequently if the risk assignment indicates the need). Assets that had no observable defects should be inspected every 20 years.

The majority of the gravity system was inspected in 2011. Hence the 10 year inspections should occur in 2021. The 20 year inspections should occur in 2031.

In order to better refine the list of those Category A and B assets that should be inspected earlier than 2031, an analysis was done to ascertain the risk if the next inspection resulted in a one point increase in likelihood of failure (i.e., the asset progressed from an "A" to a "B" or a "B" to a "C".) If the increase in likelihood places the asset risk assignment into the high-medium risk range, then the asset should be inspected in 10 years instead of 20 years. The results of these analyses are presented in Tables A-9 and A-10 in Appendix A, sorted by hypothetical risk. All Category C assets and those assets with High-Medium risk or higher should be inspected in 2021.

Table 4 is a list of gravity system pipe segments that should be inspected in 10 years. Table 5 is a list of gravity system manholes that should be inspected in 10 years.

Figure 11 shows all the gravity system pipe segments that should be inspected in 2021. Figure 12 shows all the gravity system manholes that should be inspected in 2021.

2031 Inspections

All gravity system manholes and pipes (including those rehabilitated since 2010) should be inspected in 2031. This work should be phased over two to three dry weather seasons.

Table 4: Gravity System Pipe Segments Scheduled for 2021 Inspection

ASSET ID	SIZE	LENGTH	CURRENT COND	RISK	HYPOTHETICAL 2021 RISK
N34N351	66	432	**C**	85	102
S15S161	63	574	**C**	80	100
N27N281	33	32	**C**	76	95
S14S151	63	857	**C**	76	95
S09S101	63	1014	**C**	68	85
S01S021	42	576	B	63	84
S02S031	42	567	B	60	80
S03S041	42	433	B	60	80
S36BS37A2	48	53	B	60	80
A23A241	48	463	**C**	56	70
A27A281	48	570	**C**	56	70
A28A291	54	355	**C**	56	70
S25S261	63	507	**C**	56	70
A29A301	54	351	**C**	52	65
A31A321	54	268	**C**	52	65
A32A331	57	631	**C**	52	65
A35A361	57	703	**C**	52	65
S29S311	66	1103	**C**	52	65
A39A401	60	640	**C**	48	60
A38A391	60	744	**C**	48	60
A37A381	60	591	**C**	48	60
A45AA461	60	545	**C**	44	55
N14N151	48	403	**C**	40	50
S21S221	57	1001	**C**	40	50
A07A081	12	404	**C**	36	45
A13A141	12	480	**C**	32	40

Table 5: Gravity System Manholes Scheduled for 2021 Inspection

ASSET ID	CURRENT CONDITION	RISK	HYPOTHETICAL 2021 RISK
S01	B	75	100
S08	C	68	85
F01	C	64	80
F1A	C	64	80
S02	B	57	76
S09	B	57	76
S15	B	57	76
S40	B	54	72
N21	B	51	68
N27	B	51	68
A49/50	C	55	66
N34	C	52	65
N11	B	48	64
A51/52	C	50	60
ADC	C	44	55
F06	C	44	55
F08	C	44	55
F19	C	44	55
F20	C	44	55
F21	C	44	55
P04	C	44	55
S26	C	44	55
NF05	C	36	45
S60A	C	36	45
A16	C	32	40
A17	C	32	40
A23	C	32	40
A61	C	32	40
AD05	C	32	40
AD06	C	32	40
AD10	C	32	40
AD11	C	32	40
AD17	C	32	40
N42	C	32	40
N35A	C	30	40
A32	C	28	35

ASSET ID	CURRENT CONDITION	RISK	HYPOTHETICAL 2021 RISK
A59A	**C**	28	35
NF04	**C**	28	35
NI03	**C**	28	35
S05	**C**	28	35
A37	**C**	24	30
A38	**C**	24	30
A39	**C**	24	30
S24	**C**	24	30
AD01	**C**	20	25
AD02	**C**	20	25
ADE	**C**	20	25
ADG	**C**	20	25
N46	**C**	20	25
Q36A	**C**	16	20
A59	None	See note	
S05A	None	See note	

Note: No condition data was obtained for buried Manholes A59 and S05A. Hence, no risk can be assigned at this time.

Figure 11: Gravity System Pipe Segments Scheduled for Inspection in 2021

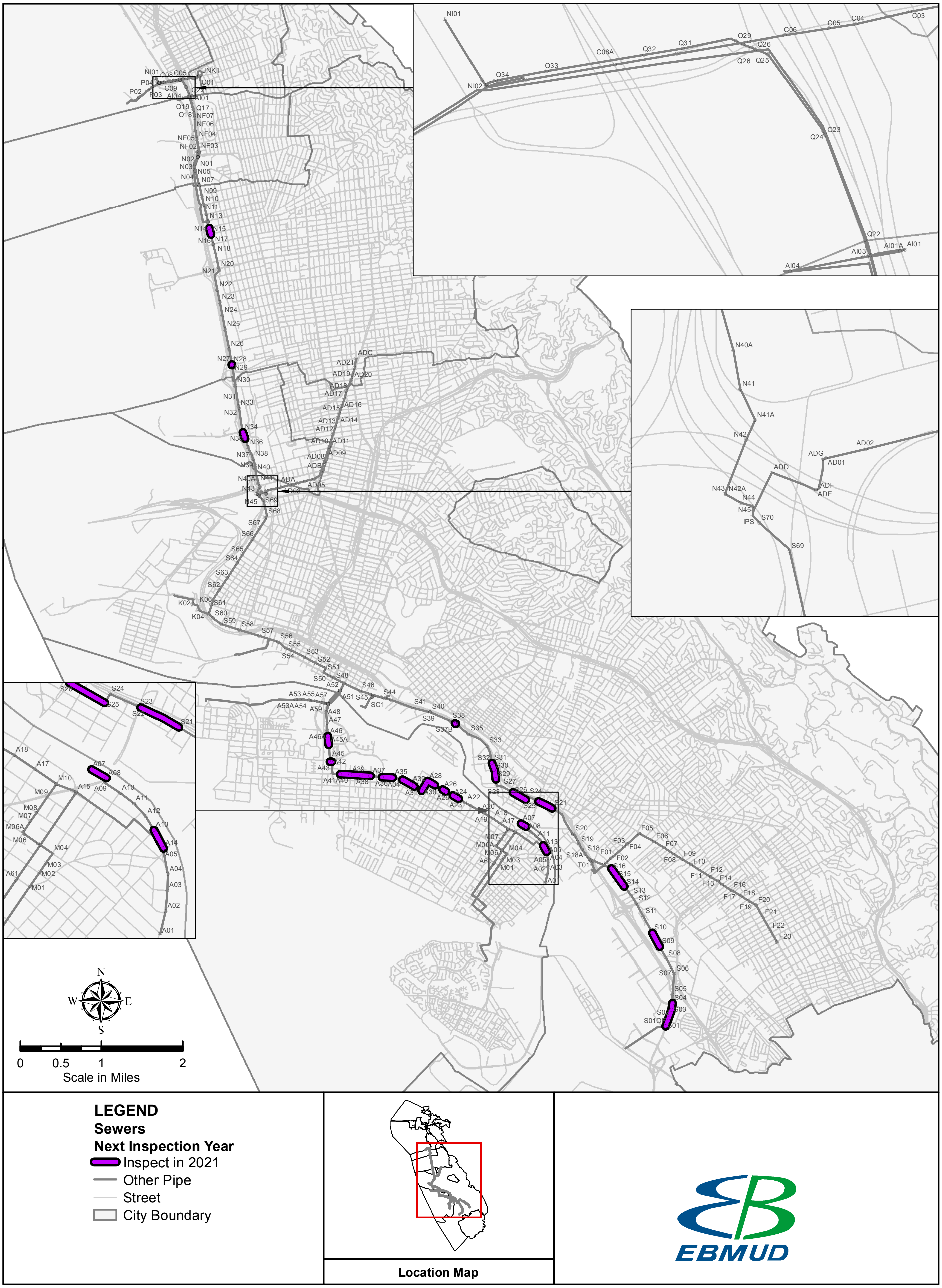
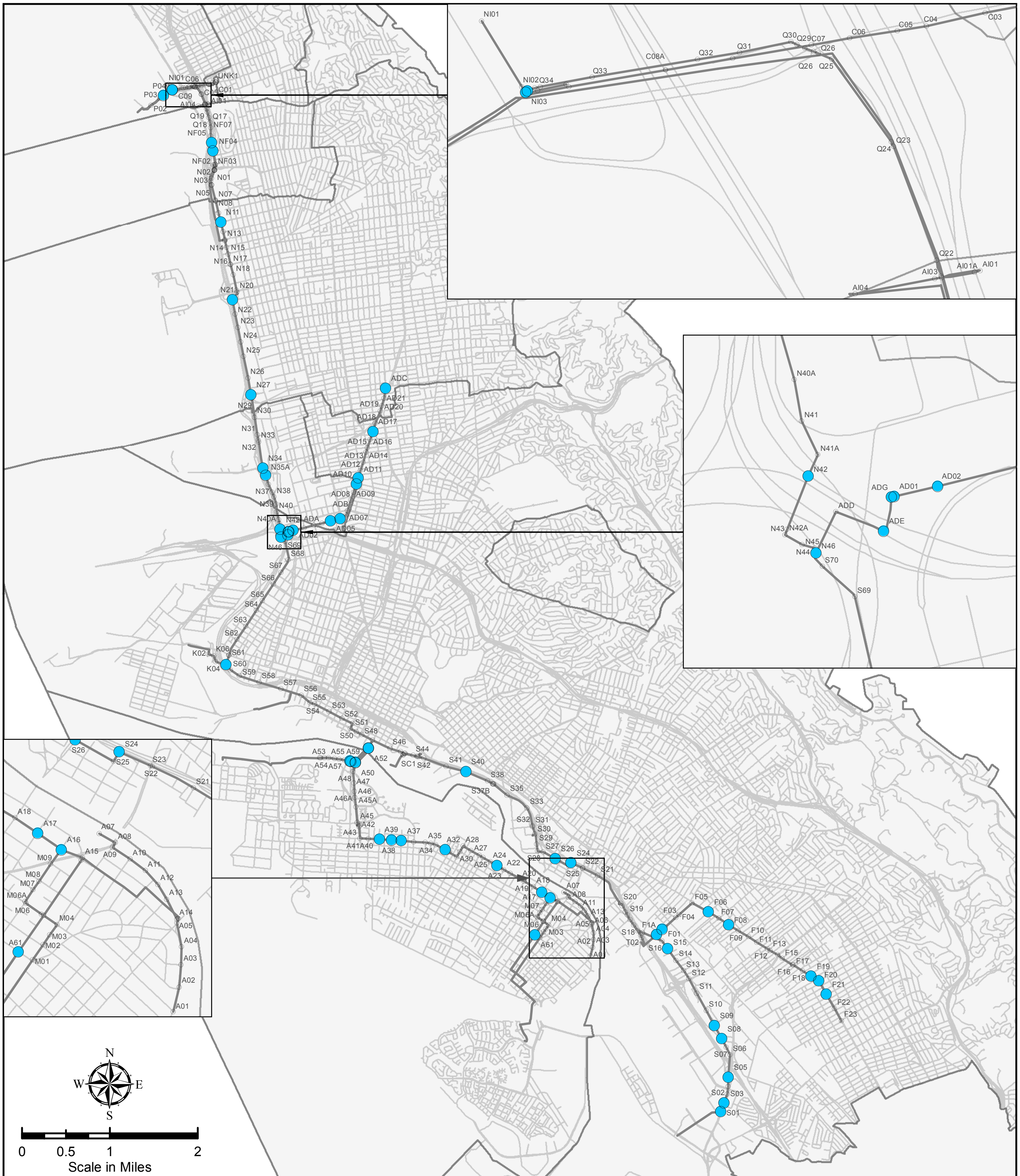
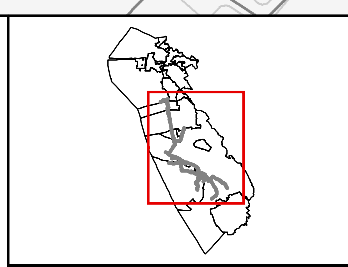


Figure 12: Gravity System Manholes Scheduled for Inspection in 2021





APPENDIX A

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Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
A01A021	15	RCP	550	Alameda	Fernside A	B	No Defects	No Defects
A02A031	15	RCP	479	Alameda	Fernside A	B	No Defects	B
A03A041	15	RCP	390	Alameda	Fernside A	B	No Defects	B
A04A051	15	RCP	545	Alameda	Fernside A	B	No Defects	A
A05A061	21	RCP	94	Alameda	Fernside A	B	No Defects	A
A06PSB1	15	RCP	33	Alameda	Fernside A	B	No Defects	No Defects
A07A081	12	RCP	404	Alameda	Fernside B	B	No Defects	C
A08A091	12	RCP	118	Alameda	Fernside B	B	No Defects	No Defects
A09A101	12	RCP	443	Alameda	Fernside B	No Defects	No Defects	No Defects
A10A111	12	RCP	416	Alameda	Fernside B	B	No Defects	No Defects
A11A121	12	RCP	403	Alameda	Fernside B	A	No Defects	No Defects
A12A131	12	RCP	369	Alameda	Fernside B	A	No Defects	B
A13A141	12	RCP	480	Alameda	Fernside B	C	No Defects	B
A14A061	12	RCP	24	Alameda	Fernside B	A	No Defects	No Defects
A15A161	42	RCP	517	Alameda	Clement	No Defects	No Defects	A
A16M101	42	RCP	10	Alameda	Clement	No Defects	No Defects	No Defects
A17A181	42	RCP	595	Alameda	Clement	C	No Defects	No Defects
A18A191	42	RCP	647	Alameda	Clement	B	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
A19A201	48	RCP	184	Alameda	Clement	B	No Defects	No Defects
A20A211	48	RCP	759	Alameda	Clement	C	No Defects	A
A21A221	48	RCP	455	Alameda	Clement	C	No Defects	No Defects
A22A231	48	RCP	488	Alameda	Clement	A	No Defects	No Defects
A23A241	48	RCP	463	Alameda	Clement	C	No Defects	No Defects
A24A251	48	RCP	500	Alameda	Clement	B	No Defects	No Defects
A25A261	48	RCP	262	Alameda	Clement	B	No Defects	No Defects
A26A271	48	RCP	556	Alameda	Clement	B	No Defects	No Defects
A27A281	48	RCP	570	Alameda	Clement	C	No Defects	No Defects
A28A291	54	RCP	355	Alameda	Clement	C	No Defects	A
A29A301	54	RCP	351	Alameda	Clement	C	No Defects	A
A30A311	54	RCP	559	Alameda	Buena Vista	B	No Defects	No Defects
A31A321	54	RCP	268	Alameda	Buena Vista	C	No Defects	No Defects
A32A331	57	RCP	631	Alameda	Buena Vista	C	No Defects	No Defects
A33A341	57	RCP	320	Alameda	Buena Vista	A	No Defects	No Defects
A34A351	57	RCP	318	Alameda	Buena Vista	B	No Defects	No Defects
A35A361	57	RCP	703	Alameda	Buena Vista	C	No Defects	B
A36A371	60	RCP	746	Alameda	Buena Vista	No Defects	No Defects	No Defects
A37A381	60	RCP	591	Alameda	Buena Vista	C	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
A38A391	60	RCP	744	Alameda	Buena Vista	C	No Defects	No Defects
A39A401	60	RCP	640	Alameda	Buena Vista	C	No Defects	No Defects
A40A411	60	RCP	502	Alameda	Buena Vista	D	No Defects	No Defects
A41A421	60	RCP	713	Alameda	Buena Vista	C	No Defects	No Defects
A42A441	60	RCP	172	Alameda	Buena Vista	C	No Defects	A
A44A451	60	RCP	138	Alameda	Webster	B	No Defects	A
A45A45A1	60	RCP	931	Alameda	Webster	B	No Defects	A
A45AA461	60	RCP	545	Alameda	Webster	C	No Defects	A
A46A46A1	60	RCP	380	Alameda	Webster	B	No Defects	No Defects
A46AA471	60	RCP	500	Alameda	Webster	A	No Defects	No Defects
A47A481	60	RCP	691	Alameda	Webster	A	No Defects	No Defects
A48A491	60	RCP	572	Alameda	Webster	D	D	No Defects
A52A52A1	96	RCP	65	Alameda	Webster	No Defects	No Defects	No Defects
A52AS471	96	RCP	526	Alameda	Webster	No Defects	No Defects	No Defects
A53A53A1	24	RCP	38	Alameda	Mitchell	B	No Defects	No Defects
A53AA541	24	RCP	235	Alameda	Mitchell	B	No Defects	No Defects
A54A551	24	RCP	229	Alameda	Mitchell	B	No Defects	No Defects
A55A561	24	RCP	366	Alameda	Mitchell	B	No Defects	No Defects
A56A571	24	RCP	265	Alameda	Mitchell	B	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
A57A581	24	RCP	345	Alameda	Mitchell	B	No Defects	No Defects
A58A591	24	RCP	338	Alameda	Mitchell	No Defects	No Defects	No Defects
A59A59A1	24	RCP	68	Alameda	Mitchell	No Defects	No Defects	No Defects
A59AA491	24	RCP	284	Alameda	Mitchell	No Defects	No Defects	No Defects
A60A611	24	RCP	33	Alameda	Pearl	No Defects	No Defects	No Defects
A61MC11	21	RCP	945	Alameda	Pearl	No Defects	No Defects	B
A62A151	21	RCP	63	Alameda	Pearl	No Defects	No Defects	No Defects
AD01ADG1	60	RCP	17	North	Adeline	No Defects	No Defects	No Defects
AD02AD011	60	RCP	371	North	Adeline	No Defects	A	No Defects
AD03AD021	60	RCP	742	North	Adeline	No Defects	A	No Defects
AD04ADA1	54	RCP	504	North	Adeline	A	No Defects	No Defects
AD05AD041	54	RCP	527	North	Adeline	A	No Defects	No Defects
AD06AD051	54	RCP	616	North	Adeline	A	No Defects	No Defects
AD07AD061	54	RCP	452	North	Adeline	A	No Defects	No Defects
AD08ADB1	48	RCP	659	North	Adeline	A	No Defects	No Defects
AD09AD081	48	RCP	502	North	Adeline	A	No Defects	No Defects
AD10AD091	48	RCP	520	North	Adeline	A	No Defects	No Defects
AD11AD101	48	RCP	379	North	Adeline	A	No Defects	No Defects
AD12AD111	48	RCP	451	North	Adeline	A	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
AD13AD121	48	RCP	549	North	Adeline	A	No Defects	No Defects
AD14AD131	48	RCP	616	North	Adeline	A	No Defects	No Defects
AD15AD141	48	RCP	261	North	Adeline	A	No Defects	No Defects
AD16AD151	48	RCP	544	North	Adeline	A	No Defects	No Defects
AD17AD161	48	RCP	489	North	Adeline	A	No Defects	No Defects
AD18AD171	48	RCP	533	North	Adeline	B	No Defects	No Defects
AD19AD181	48	RCP	800	North	Adeline	B	No Defects	No Defects
AD20AD191	48	RCP	308	North	Adeline	B	No Defects	No Defects
AD21AD201	48	RCP	465	North	Adeline	A	No Defects	No Defects
ADAAD031	60	RCP	606	North	Adeline	No Defects	A	No Defects
ADBAD071	54	RCP	269	North	Adeline	A	No Defects	No Defects
ADCAD211	48	RCP	645	North	Adeline	A	A	No Defects
ADDN461	60	RCP	275	North	Adeline	No Defects	B	No Defects
ADEADD1	60	RCP	308	North	Adeline	No Defects	No Defects	No Defects
ADFADE1	60	RCP	21	North	Adeline	No Defects	No Defects	No Defects
ADGADF1	60	RCP	192	North	Adeline	No Defects	No Defects	No Defects
AF03AF041	24	DIP	120	North	Albany	No Defects	No Defects	No Defects
AF04AF051	24	DIP	284	North	Albany	No Defects	No Defects	No Defects
AF05AF061	24	DIP	30	North	Albany	No Defects	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
AF06N011	24	DIP	30	North	Albany	No Defects	No Defects	No Defects
AI01AI01A1	30	DIP	27	North	Albany	No Defects	No Defects	No Defects
AI01Q211	30	DIP	188	North	Albany	No Defects	No Defects	No Defects
AI01AQ211	30	DIP	161	North	Albany	No Defects	No Defects	No Defects
AI03AI041	30	DIP	424	North	Albany	A	A	A
C01C021	48	RCP	213	North	Central	No Defects	No Defects	No Defects
C02C031	48	RCP	216	North	Central	No Defects	No Defects	No Defects
C03C041	48	RCP	229	North	Central	No Defects	No Defects	A
C04C051	48	RCP	138	North	Central	No Defects	No Defects	A
C05C061	48	RCP	234	North	Central	No Defects	No Defects	No Defects
C06C071	48	RCP	190	North	Central	No Defects	No Defects	A
C07C081	48	RCP	348	North	Central	No Defects	No Defects	No Defects
C08AC091	48	RCP	471	North	Central	A	No Defects	No Defects
C08C08A1	48	RCP	316	North	Central	A	No Defects	No Defects
C09Q36A1	48	RCP	209	North	Central	A	No Defects	No Defects
F01F1A1	66	RCP	466	South	South Foothill	No Defects	No Defects	No Defects
F02F011	66	RCP	255	South	South Foothill	No Defects	No Defects	No Defects
F03F021	66	RCP	848	South	South Foothill	No Defects	No Defects	No Defects
F04F031	66	RCP	265	South	South Foothill	No Defects	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
F05F041	66	RCP	1039	South	South Foothill	No Defects	A	No Defects
F06F051	60	RCP	1140	South	South Foothill	No Defects	No Defects	No Defects
F07F061	60	RCP	732	South	South Foothill	No Defects	No Defects	No Defects
F08F071	60	RCP	698	South	South Foothill	No Defects	No Defects	No Defects
F09F081	60	RCP	698	South	South Foothill	No Defects	No Defects	No Defects
F10F091	60	RCP	712	South	South Foothill	No Defects	No Defects	No Defects
F11F101	54	RCP	587	South	South Foothill	No Defects	No Defects	No Defects
F12F111	54	RCP	747	South	South Foothill	No Defects	No Defects	No Defects
F13F121	54	RCP	197	South	South Foothill	No Defects	No Defects	No Defects
F14F131	54	RCP	510	South	South Foothill	No Defects	No Defects	No Defects
F15F141	48	RCP	345	South	South Foothill	No Defects	No Defects	No Defects
F16F151	48	RCP	727	South	South Foothill	No Defects	No Defects	No Defects
F17F161	48	RCP	69	South	South Foothill	No Defects	No Defects	No Defects
F18F171	36	RCP	657	South	South Foothill	No Defects	No Defects	No Defects
F19F181	36	RCP	591	South	South Foothill	No Defects	No Defects	No Defects
F1AS16A1	66	RCP	238	South	South Foothill	No Defects	No Defects	No Defects
F20F191	36	RCP	542	South	South Foothill	No Defects	No Defects	No Defects
F21F201	30	RCP	924	South	South Foothill	No Defects	No Defects	No Defects
F22F211	30	RCP	991	South	South Foothill	No Defects	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
F23F221	30	RCP	847	South	South Foothill	No Defects	No Defects	No Defects
K02K031	36	RCP	365	South	Wood-PSK	No Defects	No Defects	A
K03K041	36	RCP	352	South	Wood-PSK	No Defects	No Defects	No Defects
K04K051	36	RCP	640	South	Wood-PSK	No Defects	No Defects	No Defects
K05S60a1	36	RCP	10	South	Wood-PSK	No Defects	No Defects	No Defects
M01M021	24	DIP	400	Alameda	Versailles	C	D	No Defects
M02M031	24	DIP	260	Alameda	Versailles	C	D	No Defects
M03M041	24	DIP	273	Alameda	Versailles	C	D	No Defects
M04MC11	24	DIP	612	Alameda	Versailles	C	D	No Defects
M05M061	24	DIP	500	Alameda	Versailles	C	D	No Defects
M06AM071	24	DIP	312	Alameda	Versailles	C	D	No Defects
M06M06A1	24	DIP	33	Alameda	Versailles	C	D	No Defects
M07M081	24	DIP	233	Alameda	Versailles	C	D	No Defects
M08M091	24	DIP	435	Alameda	Versailles	C	D	No Defects
M09M101	24	DIP	394	Alameda	Versailles	C	D	No Defects
M10A171	42	RCP	621	Alameda	Clement	No Defects	No Defects	No Defects
MC1A621	21	RCP	1400	Alameda	Pearl	No Defects	No Defects	B
MC1M051	24	DIP	71	Alameda	Versailles	C	D	No Defects
N01AN021	42	RCP	498	North	Gilman	No Defects	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
N01N01A1	42	RCP	267	North	Gilman	No Defects	No Defects	No Defects
N02N031	42	RCP	172	North	Gilman	A	No Defects	No Defects
N03N041	42	RCP	239	North	Gilman	A	No Defects	No Defects
N04N051	48	RCP	20	North	Gilman	A	No Defects	No Defects
N05N061	48	RCP	887	North	Gilman	A	No Defects	No Defects
N06N071	48	RCP	51	North	Gilman	A	No Defects	No Defects
N07N081	48	RCP	31	North	Gilman	A	No Defects	No Defects
N08N091	48	RCP	721	North	Gilman	A	No Defects	No Defects
N09N101	48	RCP	549	North	Gilman	A	No Defects	No Defects
N10N111	48	RCP	20	North	University	B	No Defects	No Defects
N11N121	48	RCP	621	North	University	B	No Defects	No Defects
N12N131	48	RCP	477	North	University	B	No Defects	No Defects
N13AN141	48	RCP	382	North	University	A	No Defects	No Defects
N13N13A1	48	RCP	62	North	University	A	No Defects	No Defects
N14N151	48	RCP	403	North	University	C	No Defects	No Defects
N15N161	48	RCP	679	North	University	B	No Defects	No Defects
N16N171	48	RCP	20	North	University	B	No Defects	No Defects
N17N181	54	RCP	627	North	University	A	No Defects	No Defects
N18N191	54	RCP	943	North	University	A	No Defects	A

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
N19N201	30	RCP	91	North	University	No Defects	No Defects	No Defects
N19N202	30	RCP	91	North	University	No Defects	No Defects	No Defects
N20N211	66	RCP	464	North	Bayshore	B	No Defects	A
N21N221	66	RCP	871	North	Bayshore	A	No Defects	A
N22N231	66	RCP	801	North	Bayshore	A	No Defects	No Defects
N23N241	66	RCP	880	North	Bayshore	A	No Defects	No Defects
N24N251	66	RCP	895	North	Bayshore	A	No Defects	A
N25N261	66	RCP	1314	North	Bayshore	A	No Defects	A
N26N271	66	RCP	1020	North	Bayshore	A	No Defects	No Defects
N27N281	33	RCP	32	North	Bayshore	C	No Defects	A
N28N291	66	RCP	188	North	Bayshore	B	No Defects	No Defects
N29N301	66	RCP	1161	North	Bayshore	B	No Defects	A
N30N311	66	RCP	1084	North	Bayshore	B	No Defects	A
N31N321	66	RCP	320	North	Bayshore	B	No Defects	No Defects
N32N331	66	RCP	102	North	Bayshore	B	No Defects	A
N33N341	66	RCP	1581	North	Bayshore	B	No Defects	B
N34N351	66	RCP	432	North	Bayshore	C	No Defects	No Defects
N35AN361	72	RCP	585	North	Emeryville	No Defects	A	No Defects
N35N35A1	72	RCP	33	North	Emeryville	No Defects	A	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
N36N371	72	RCP	512	North	Emeryville	No Defects	No Defects	No Defects
N37N381	84	RCP	300	North	Emeryville	No Defects	A	No Defects
N38N391	84	RCP	449	North	Emeryville	No Defects	A	No Defects
N39N401	84	RCP	467	North	Emeryville	No Defects	B	No Defects
N40AN411	84	RCP	254	North	Emeryville	No Defects	B	No Defects
N40N40A1	84	RCP	490	North	Emeryville	No Defects	B	No Defects
N41AN421	84	RCP	141	North	Emeryville	No Defects	B	No Defects
N41N41A1	84	RCP	225	North	Emeryville	No Defects	B	No Defects
N42N431	84	RCP	318	North	Emeryville	No Defects	No Defects	No Defects
N42N431	84	RCP	33	North	Emeryville	No Defects	No Defects	No Defects
N43N441	84	RCP	119	North	Emeryville	No Defects	No Defects	B
N44N451	84	RCP	80	North	Emeryville	No Defects	B	No Defects
N45N461	84	RCP	30	North	Emeryville	No Defects	A	No Defects
N46IPS1	84	RCP	33	North	Emeryville	No Defects	No Defects	No Defects
NF01N01A1	16	FRP	45	North	North	No Defects	No Defects	No Defects
NF02NF011	30	VCP	322	North	North	No Defects	No Defects	No Defects
NF03AF031	30	RPM	10	North	Albany	No Defects	No Defects	No Defects
NF03NF021	30	SP	124	North	Albany	No Defects	No Defects	No Defects
NF04NF031	30	VCP	809	North	North	No Defects	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
NF05NF041	30	VCP	500	North	North	No Defects	No Defects	No Defects
NF06NF051	30	VCP	395	North	North	No Defects	No Defects	No Defects
NF07NF061	30	VCP	505	North	North	No Defects	No Defects	No Defects
NI01NI021	60	RCP	370	North	Rydin	No Defects	No Defects	No Defects
NI02Q36A1	60	RCP	35	North	Rydin	A	No Defects	No Defects
NI04P051	48	RCP	54	North	Stege	A	No Defects	A
NI05NI04	48	RCP	142	North	Stege	A	No Defects	No Defects
OAKT031	24	ZZZ	544	South	Oakport	No Defects	No Defects	No Defects
P02P011	72	RCP	521	North	Pt Isabel	A	No Defects	No Defects
P03P021	72	RCP	702	North	Pt Isabel	A	No Defects	No Defects
P04P031	72	RCP	276	North	Pt Isabel	A	No Defects	No Defects
P05P041	72	RCP	601	North	Pt Isabel	A	No Defects	B
PSF01A431	20	CAS	106	Alameda	Buena Vista	D	No Defects	No Defects
Q16Q171	36	SP	325	North	Q Wet Weather	A	No Defects	No Defects
Q17Q181	36	SP	321	North	Q Wet Weather	A	No Defects	No Defects
Q18Q191	36	SP	339	North	Q Wet Weather	A	No Defects	No Defects
Q19Q201	36	SP	214	North	Q Wet Weather	No Defects	No Defects	No Defects
Q20Q211	36	SP	236	North	Q Wet Weather	No Defects	No Defects	No Defects
Q21AI031	30	DIP	40	North	Albany	No Defects	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
Q21Q221	36	SP	90	North	Q Wet Weather	A	No Defects	A
Q21Q222	36	SP	90	North	Q Wet Weather	A	No Defects	No Defects
Q22Q231	60	SP	581	North	Q Wet Weather	A	No Defects	No Defects
Q23Q241	36	SP	30	North	Q Wet Weather	No Defects	No Defects	No Defects
Q23Q242	36	SP	30	North	Q Wet Weather	No Defects	No Defects	No Defects
Q24Q251	60	SP	483	North	Q Wet Weather	A	No Defects	No Defects
Q25Q261	60	SP	77	North	Q Wet Weather	No Defects	No Defects	No Defects
Q26Q271	24	SP	16	North	Q Wet Weather	No Defects	No Defects	No Defects
Q27Q281	60	SP	59	North	Q Wet Weather	No Defects	No Defects	No Defects
Q28Q291	24	SP	40	North	Q Wet Weather	No Defects	No Defects	No Defects
Q29Q301	48	SP	13	North	Q Wet Weather	No Defects	No Defects	A
Q30Q311	60	SP	263	North	Q Wet Weather	No Defects	No Defects	No Defects
Q31Q321	60	SP	212	North	Q Wet Weather	No Defects	No Defects	No Defects
Q32Q331	60	SP	475	North	Q Wet Weather	No Defects	No Defects	No Defects
Q33Q341	60	SP	287	North	Q Wet Weather	No Defects	No Defects	No Defects
Q34Q351	48	SP	23	North	Q Wet Weather	A	No Defects	No Defects
Q35Q361	60	SP	130	North	Q Wet Weather	A	No Defects	No Defects
Q36AP051			16	North	Q Wet Weather	A	No Defects	No Defects
Q36Q36A1	60	SP	20	North	Q Wet Weather	A	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
S01S021	42	RCP	576	South	Coliseum	A	No Defects	B
S02S031	42	RCP	567	South	Coliseum	B	No Defects	A
S03S041	42	RCP	433	South	Coliseum	B	No Defects	A
S04S051	42	RCP	763	South	Coliseum	A	No Defects	A
S05AS06	42	RCP	1166	South	Coliseum	A	No Defects	A
S05S05A1	42	RCP	197	South	Coliseum	A	No Defects	A
S06S071	42	RCP	526	South	Coliseum	B	No Defects	No Defects
S07S081	42	RCP	576	South	Coliseum	A	No Defects	No Defects
S08S091	51	RCP	910	South	Coliseum	A	No Defects	A
S09S101	63	RCP	1014	South	Coliseum	C	No Defects	A
S10S111	63	RCP	1200	South	Coliseum	A	No Defects	No Defects
S11S121	63	RCP	996	South	Coliseum	A	No Defects	No Defects
S12S131	63	RCP	562	South	Coliseum	A	No Defects	A
S13S141	63	RCP	785	South	Coliseum	A	No Defects	No Defects
S14S151	63	RCP	857	South	Coliseum	C	No Defects	B
S15S161	63	RCP	574	South	Coliseum	C	No Defects	No Defects
S16AS171	63	RCP	721	South	Oakport	A	No Defects	A
S16S16A1	63	RCP	538	South	Coliseum	A	No Defects	A
S17S181	63	RCP	712	South	Oakport	A	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
S18AS191	66	RCP	322	South	Oakport	A	No Defects	No Defects
S18S18A1	66	RCP	396	South	Oakport	No Defects	No Defects	A
S19AS19B1	66	RCP	438	South	Oakport	No Defects	No Defects	No Defects
S19BS201	66	RCP	166	South	Oakport	No Defects	No Defects	No Defects
S19S19A1	66	RCP	201	South	Oakport	No Defects	No Defects	No Defects
S20PSH1	63	RCP	115	South	Oakport	B	No Defects	No Defects
S21S221	57	RCP	1001	South	Oakport	C	No Defects	No Defects
S22S231	36	RCP	50	South	Oakport	C	No Defects	No Defects
S22S232	36	RCP	50	South	Oakport	C	No Defects	No Defects
S23S241	63	RCP	742	South	Oakport	B	No Defects	No Defects
S24S251	63	RCP	239	South	Oakport	B	No Defects	No Defects
S25S261	63	RCP	507	South	Oakport	C	No Defects	No Defects
S26S271	66	RCP	723	South	Oakport	A	No Defects	No Defects
S27S281	66	RCP	348	South	Oakport	A	No Defects	No Defects
S28S291	66	RCP	409	South	Oakport	A	No Defects	No Defects
S29S311	66	RCP	1103	South	Oakport	C	No Defects	No Defects
S30S311	12	DIP	33	South	Oakport	B	No Defects	No Defects
S31S321		RCP	43	South	Embarcadero	A	No Defects	No Defects
S32S331	78	RCP	1135	South	Embarcadero	B	No Defects	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
S33S351	78	RCP	2483	South	Embarcadero	A	No Defects	No Defects
S35S36A1	78	RCP	1057	South	Embarcadero	A	No Defects	No Defects
S36BS37A1	48	RCP	53	South	Embarcadero	No Defects	No Defects	No Defects
S36BS37A2	48	RCP	53	South	Embarcadero	B	No Defects	No Defects
S37BS381	78	RCP	333	South	Embarcadero	A	No Defects	No Defects
S38S391	75	RCP	1424	South	Embarcadero	A	No Defects	No Defects
S39S401	78	RCP	19	South	Embarcadero	A	No Defects	No Defects
S40S411	84	RCP	1220	South	Lake Merritt	A	No Defects	No Defects
S41S421	84	RCP	1426	South	Lake Merritt	A	No Defects	A
S42SACDIV1	84	RCP	326	South	Lake Merritt	D	No Defects	B
S43S441	42	RCP	228	South	Lake Merritt	No Defects	No Defects	No Defects
S44AS451	84	RCP	258	South	Lake Merritt	A	No Defects	No Defects
S44S44A1	84	RCP	530	South	Lake Merritt	A	No Defects	No Defects
S45S46A1	84	RCP	684	South	Lake Merritt	A	No Defects	A
S46AS471	84	RCP	1171	South	Lake Merritt	A	No Defects	A
S47S481	105	RCP	716	South	3rd St	C	No Defects	No Defects
S48S491	105	RCP	393	South	3rd St	C	No Defects	A
S49S501	105	RCP	392	South	3rd St	C	No Defects	No Defects
S50S511	105	RCP	326	South	3rd St	B	No Defects	B

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
S51S521	105	RCP	1008	South	3rd St	B	No Defects	A
S52S531	105	RCP	836	South	3rd St	B	No Defects	A
S53S541	105	RCP	1000	South	3rd St	B	No Defects	B
S54S551	105	RCP	299	South	3rd St	C	No Defects	No Defects
S55S561	105	RCP	920	South	3rd St	B	No Defects	No Defects
S56S571	105	RCP	1282	South	3rd St	B	No Defects	A
S57S581	105	RCP	1360	South	3rd St	B	No Defects	No Defects
S58S591	105	RCP	1240	South	3rd St	B	No Defects	No Defects
S59S601	105	RCP	675	South	3rd St	B	No Defects	No Defects
S60AS611	105	RCP	738	South	Wood	B	No Defects	B
S60S60A1	108	RCP	399	South	3rd St	No Defects	B	No Defects
S61S621	105	RCP	1277	South	Wood	B	No Defects	A
S62S631	105	RCP	960	South	Wood	B	No Defects	A
S63S641	105	RCP	1165	South	Wood	B	No Defects	A
S64S651	105	RCP	680	South	Wood	B	No Defects	A
S65S661	105	RCP	1188	South	Wood	B	No Defects	C
S66S671	105	RCP	847	South	Wood	B	No Defects	C
S67S681	105	RCP	880	South	Wood	No Defects	A	No Defects
S68S691	105	RCP	1119	South	Wood	No Defects	C	No Defects

Table A-1: Gravity System Pipe Segment Condition Ratings

Asset ID	Diameter	Material	Length	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
S69S701	105	RCP	267	South	Wood	No Defects	B	No Defects
S70IPS1	105	RCP	66	South	Wood	No Defects	No Defects	No Defects
SACDIVSC11	84	RCP	46	South	Lake Merritt	C	No Defects	No Defects
SC1S431	84	RCP	63	South	Lake Merritt	C	No Defects	A
T01S181	24	RCP	405	South	Oakport	A	No Defects	No Defects
T02T011	24	ZZZ	351	South	Oakport	No Defects	No Defects	A
T03T021	24	ZZZ	135	South	Oakport	No Defects	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
A01	Alameda	Fernside A	B	No Defects	No Defects
A02	Alameda	Fernside A	B	No Defects	No Defects
A03	Alameda	Fernside A	B	No Defects	A
A04	Alameda	Fernside A	A	No Defects	No Defects
A05	Alameda	Fernside A	No Defects	No Defects	A
A06	Alameda	Fernside A	A	No Defects	No Defects
A07	Alameda	Fernside B	No Defects	No Defects	No Defects
A08	Alameda	Fernside B	No Defects	No Defects	No Defects
A09	Alameda	Fernside B	No Defects	No Defects	No Defects
A10	Alameda	Fernside B	No Defects	No Defects	No Defects
A11	Alameda	Fernside B	A	No Defects	No Defects
A12	Alameda	Fernside B	A	No Defects	No Defects
A13	Alameda	Fernside B	B	No Defects	No Defects
A14	Alameda	Fernside B	A	No Defects	No Defects
A15	Alameda	Clement	No Defects	A	No Defects
A16	Alameda	Clement	C	No Defects	No Defects
A17	Alameda	Clement	C	No Defects	No Defects
A18	Alameda	Clement	B	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
A19	Alameda	Clement	B	No Defects	No Defects
A20	Alameda	Clement	B	No Defects	No Defects
A21	Alameda	Clement	B	No Defects	No Defects
A22	Alameda	Clement	B	No Defects	No Defects
A23	Alameda	Clement	C	No Defects	A
A24	Alameda	Clement	B	No Defects	No Defects
A25	Alameda	Clement	C	No Defects	No Defects
A26	Alameda	Clement	B	No Defects	No Defects
A27	Alameda	Clement	C	No Defects	D
A28	Alameda	Clement	C	No Defects	No Defects
A29	Alameda	Clement	B	No Defects	No Defects
A30	Alameda	Clement	C	No Defects	No Defects
A31	Alameda	Clement	C	No Defects	No Defects
A32	Alameda	Buena Vista	C	No Defects	No Defects
A33	Alameda	Buena Vista	B	No Defects	No Defects
A34	Alameda	Buena Vista	C	No Defects	No Defects
A35	Alameda	Buena Vista	B	No Defects	No Defects
A36	Alameda	Buena Vista	C	No Defects	No Defects
A37	Alameda	Buena Vista	C	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
A38	Alameda	Buena Vista	C	No Defects	No Defects
A39	Alameda	Buena Vista	C	No Defects	No Defects
A40	Alameda	Buena Vista	C	No Defects	No Defects
A41	Alameda	Buena Vista	C	No Defects	No Defects
A42	Alameda	Buena Vista	C	No Defects	No Defects
A43	Alameda	Buena Vista	B	No Defects	No Defects
A44	Alameda	Webster	B	No Defects	No Defects
A45	Alameda	Webster	A	No Defects	No Defects
A45A	Alameda	Webster	C	No Defects	D
A46	Alameda	Webster	No Defects	No Defects	No Defects
A46A	Alameda	Webster	B	No Defects	No Defects
A47	Alameda	Webster	C	No Defects	No Defects
A48	Alameda	Webster	B	No Defects	No Defects
A49/50	Alameda	Webster	C	C	No Defects
A51/52	Alameda	Webster	C	C	No Defects
A52A	Alameda	Webster	No Defects	No Defects	No Defects
A53	Alameda	Mitchell	B	No Defects	No Defects
A53A	Alameda	Mitchell	No Defects	No Defects	No Defects
A54	Alameda	Mitchell	A	No Defects	A

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
A55	Alameda	Mitchell	D	No Defects	No Defects
A56	Alameda	Mitchell	A	No Defects	A
A57	Alameda	Mitchell	B	No Defects	A
A58	Alameda	Mitchell	B	No Defects	A
A59	Alameda	Mitchell	Buried	Buried	Buried
A59A	Alameda	Mitchell	C	No Defects	No Defects
A60	Alameda	Pearl	D	No Defects	No Defects
A61	Alameda	Pearl	C	No Defects	No Defects
A62	Alameda	Pearl	D	No Defects	D
AD01	North	Adeline	No Defects	C	C
AD02	North	Adeline	No Defects	C	No Defects
AD03	North	Adeline	No Defects	No Defects	No Defects
AD04	North	Adeline	No Defects	A	No Defects
AD05	North	Adeline	B	C	A
AD06	North	Adeline	No Defects	C	No Defects
AD07	North	Adeline	No Defects	No Defects	No Defects
AD08	North	Adeline	No Defects	No Defects	No Defects
AD09	North	Adeline	No Defects	No Defects	No Defects
AD10	North	Adeline	No Defects	C	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
AD11	North	Adeline	No Defects	C	No Defects
AD12	North	Adeline	No Defects	No Defects	No Defects
AD13	North	Adeline	No Defects	No Defects	No Defects
AD14	North	Adeline	No Defects	No Defects	No Defects
AD15	North	Adeline	No Defects	No Defects	No Defects
AD16	North	Adeline	No Defects	No Defects	No Defects
AD17	North	Adeline	No Defects	C	B
AD18	North	Adeline	No Defects	No Defects	No Defects
AD19	North	Adeline	No Defects	No Defects	No Defects
AD20	North	Adeline	No Defects	No Defects	No Defects
AD21	North	Adeline	No Defects	No Defects	No Defects
ADA	North	Adeline	No Defects	No Defects	No Defects
ADB	North	Adeline	No Defects	No Defects	No Defects
ADC	North	Adeline	No Defects	C	No Defects
ADD	North	Adeline	No Defects	B	No Defects
ADE	Adeline	Adeline	B	C	C
ADF	Adeline	Adeline	No Defects	No Defects	No Defects
ADG	Adeline	Adeline	No Defects	B	C
AF03	North	Albany	No Defects	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
AF04	North	Albany	No Defects	No Defects	No Defects
AF05	North	Albany	No Defects	No Defects	No Defects
AF06	North	Albany	No Defects	No Defects	No Defects
AI01	North	Albany	No Defects	No Defects	No Defects
AI01A	North	Albany	A	No Defects	No Defects
AI03	North	Albany	No Defects	No Defects	No Defects
AI04	North	Albany	A	No Defects	No Defects
C01	North	Central	No Defects	No Defects	No Defects
C01A	North	Central	No Defects	No Defects	B
C02	North	Central	No Defects	No Defects	No Defects
C03	North	Central	No Defects	No Defects	No Defects
C04	North	Central	No Defects	No Defects	No Defects
C05	North	Central	No Defects	No Defects	No Defects
C06	North	Central	No Defects	No Defects	No Defects
C07	North	Central	No Defects	No Defects	No Defects
C08	North	Central	No Defects	No Defects	A
C08A	North	Central	No Defects	No Defects	A
C09	North	Central	A	No Defects	B
F01	South	South Foothill	No Defects	C	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
F02	South	South Foothill	No Defects	No Defects	No Defects
F03	South	South Foothill	No Defects	C	D
F04	South	South Foothill	No Defects	C	D
F05	South	South Foothill	No Defects	No Defects	No Defects
F06	South	South Foothill	A	C	A
F07	South	South Foothill	No Defects	No Defects	No Defects
F08	South	South Foothill	No Defects	C	No Defects
F09	South	South Foothill	No Defects	No Defects	No Defects
F10	South	South Foothill	No Defects	No Defects	No Defects
F11	South	South Foothill	B	B	A
F12	South	South Foothill	No Defects	No Defects	No Defects
F13	South	South Foothill	No Defects	No Defects	No Defects
F14	South	South Foothill	No Defects	No Defects	No Defects
F15	South	South Foothill	No Defects	No Defects	No Defects
F16	South	South Foothill	No Defects	No Defects	No Defects
F17	South	South Foothill	No Defects	No Defects	No Defects
F18	South	South Foothill	No Defects	No Defects	No Defects
F19	South	South Foothill	No Defects	C	A
F1A	Foothill	South Foothill	No Defects	C	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
F20	South	South Foothill	No Defects	C	A
F21	South	South Foothill	No Defects	C	C
F22	South	South Foothill	No Defects	No Defects	No Defects
F23	South	South Foothill	No Defects	No Defects	No Defects
K02	South	Wood-PSK	No Defects	No Defects	No Defects
K03	South	Wood-PSK	B	No Defects	No Defects
K04	South	Wood-PSK	No Defects	No Defects	B
K05	South	Wood-PSK	B	No Defects	A
M01	Alameda	Versailles	C	No Defects	No Defects
M02	Alameda	Versailles	C	No Defects	No Defects
M03	Alameda	Versailles	D	No Defects	No Defects
M04	Alameda	Versailles	D	No Defects	No Defects
M05	Alameda	Versailles	D	No Defects	No Defects
M06	Alameda	Versailles	B	No Defects	No Defects
M06A	Alameda	Versailles	B	No Defects	No Defects
M07	Alameda	Versailles	C	No Defects	A
M08	Alameda	Versailles	C	No Defects	No Defects
M09	Alameda	Versailles	C	No Defects	No Defects
M10	Alameda	Clement	B	D	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
MC1	Alameda	Versailles	D	No Defects	D
N01	North	Gilman	No Defects	No Defects	No Defects
N01A	North	Gilman	No Defects	No Defects	No Defects
N02	North	Gilman	No Defects	No Defects	No Defects
N03	North	Gilman	B	No Defects	No Defects
N04	North	Gilman	B	No Defects	No Defects
N05	North	Gilman	No Defects	No Defects	No Defects
N06	North	Gilman	No Defects	No Defects	No Defects
N07	North	Gilman	No Defects	No Defects	No Defects
N08	North	Gilman	No Defects	No Defects	No Defects
N09	North	Gilman	A	No Defects	No Defects
N10	North	University	No Defects	No Defects	No Defects
N11	North	University	B	No Defects	No Defects
N12	North	University	B	No Defects	No Defects
N13	North	University	B	No Defects	No Defects
N13A	North	University	No Defects	No Defects	No Defects
N14	North	University	B	No Defects	No Defects
N15	North	University	B	No Defects	No Defects
N16	North	University	B	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
N17	North	University	B	No Defects	No Defects
N18	North	University	B	No Defects	No Defects
N19	North	University	B	No Defects	No Defects
N20	North	Bayshore	B	No Defects	No Defects
N21	North	Bayshore	B	No Defects	No Defects
N22	North	Bayshore	A	No Defects	A
N23	North	Bayshore	B	No Defects	A
N24	North	Bayshore	No Defects	No Defects	A
N25	North	Bayshore	B	No Defects	No Defects
N26	North	Bayshore	B	No Defects	A
N27	North	Bayshore	B	No Defects	No Defects
N28	North	Bayshore	A	No Defects	No Defects
N29	North	Bayshore	A	No Defects	No Defects
N30	North	Bayshore	A	No Defects	No Defects
N31	North	Bayshore	B	No Defects	A
N32	North	Bayshore	B	No Defects	No Defects
N33	North	Bayshore	B	No Defects	No Defects
N34	North	Bayshore	C	No Defects	A
N35	North	Emeryville	A	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
N35A	North	Emeryville	No Defects	C	No Defects
N36	North	Emeryville	No Defects	A	No Defects
N37	North	Emeryville	No Defects	No Defects	No Defects
N38	North	Emeryville	No Defects	B	No Defects
N39	North	Emeryville	No Defects	No Defects	A
N40	North	Emeryville	No Defects	No Defects	No Defects
N40A	North	Emeryville	No Defects	No Defects	No Defects
N41	North	Emeryville	No Defects	No Defects	No Defects
N41A	North	Emeryville	No Defects	C	D
N42	North	Emeryville	No Defects	C	No Defects
N42A	North	Emeryville	No Defects	No Defects	No Defects
N43	North	Emeryville	B	No Defects	D
N44	North	Emeryville	No Defects	No Defects	No Defects
N45	North	Emeryville	No Defects	No Defects	No Defects
N46	North	Emeryville	No Defects	C	No Defects
NF01	North	Albany	No Defects	No Defects	No Defects
NF02	North	Albany	No Defects	No Defects	No Defects
NF03	North	Albany	No Defects	No Defects	No Defects
NF04	North	Albany	C	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
NF05	North	Albany	C	No Defects	No Defects
NF06	North	Albany	A	No Defects	No Defects
NF07	North	Albany	No Defects	No Defects	No Defects
NI01	North	Rydin	No Defects	No Defects	No Defects
NI02	North	Rydin	A	No Defects	No Defects
NI03	North	Rydin	B	C	No Defects
NI04	North	Stege	No Defects	No Defects	No Defects
NI05	North	Stege	A	No Defects	A
P02	North	Pt Isabel	No Defects	No Defects	No Defects
P03	North	Pt Isabel	No Defects	No Defects	B
P04	North	Pt Isabel	C	C	No Defects
P05	North	Pt Isabel	B	No Defects	No Defects
Q17	North	Q Wet Weather	No Defects	No Defects	No Defects
Q18	North	Q Wet Weather	No Defects	No Defects	No Defects
Q19	North	Q Wet Weather	No Defects	No Defects	No Defects
Q20	North	Q Wet Weather	No Defects	No Defects	No Defects
Q21	North	Q Wet Weather	No Defects	No Defects	No Defects
Q22	North	Q Wet Weather	No Defects	No Defects	No Defects
Q23	North	Q Wet Weather	No Defects	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
Q24	North	Q Wet Weather	No Defects	No Defects	No Defects
Q25	North	Q Wet Weather	A	No Defects	No Defects
Q26	North	Q Wet Weather	No Defects	No Defects	No Defects
Q27	North	Q Wet Weather	No Defects	No Defects	No Defects
Q28	North	Q Wet Weather	No Defects	No Defects	No Defects
Q29	North	Q Wet Weather	No Defects	No Defects	No Defects
Q30	North	Q Wet Weather	A	No Defects	No Defects
Q31	North	Q Wet Weather	No Defects	No Defects	No Defects
Q32	North	Q Wet Weather	No Defects	No Defects	No Defects
Q33	North	Q Wet Weather	No Defects	No Defects	No Defects
Q34	North	Q Wet Weather	No Defects	No Defects	A
Q35	North	Q Wet Weather	No Defects	No Defects	A
Q36	North	Q Wet Weather	No Defects	No Defects	No Defects
Q36A	North	Q Wet Weather	A	C	No Defects
S01	South	Coliseum	B	No Defects	No Defects
S02	South	Coliseum	B	No Defects	No Defects
S03	South	Coliseum	A	No Defects	No Defects
S04	South	Coliseum	No Defects	No Defects	No Defects
S05	South	Coliseum	C	No Defects	A

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
S05A	South	Coliseum	Buried	Buried	Buried
S06	South	Coliseum	B	No Defects	No Defects
S07	South	Coliseum	B	No Defects	B
S08	South	Coliseum	C	No Defects	No Defects
S09	South	Coliseum	B	No Defects	No Defects
S10	South	Coliseum	B	No Defects	A
S11	South	Coliseum	B	No Defects	A
S12	South	Coliseum	A	No Defects	No Defects
S13	South	Coliseum	B	No Defects	No Defects
S14	South	Coliseum	No Defects	No Defects	A
S15	South	Coliseum	B	No Defects	No Defects
S16	South	Coliseum	B	No Defects	No Defects
S16A	South	Oakport	No Defects	No Defects	No Defects
S17	South	Oakport	B	No Defects	No Defects
S18	South	Oakport	B	No Defects	No Defects
S18A	South	Oakport	No Defects	No Defects	No Defects
S19	South	Oakport	No Defects	No Defects	No Defects
S19A	South	Oakport	No Defects	No Defects	A
S19B	South	Oakport	No Defects	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
S20	South	Oakport	No Defects	No Defects	No Defects
S21	South	Oakport	B	No Defects	A
S22	South	Oakport	B	No Defects	No Defects
S23	South	Oakport	B	No Defects	No Defects
S24	South	Oakport	C	No Defects	No Defects
S25	South	Oakport	A	No Defects	No Defects
S26	South	Oakport	C	No Defects	No Defects
S27	South	Oakport	A	No Defects	No Defects
S28	South	Oakport	B	No Defects	No Defects
S29	South	Oakport	B	No Defects	No Defects
S30	South	Oakport	D	No Defects	D
S31	South	Embarcadero	C	No Defects	No Defects
S32	South	Embarcadero	C	No Defects	No Defects
S33	South	Embarcadero	No Defects	No Defects	No Defects
S35	South	Embarcadero	B	No Defects	No Defects
S36A	South	Embarcadero	B	No Defects	No Defects
S36B	South	Embarcadero	B	No Defects	No Defects
S37A	South	Embarcadero	No Defects	No Defects	No Defects
S37B	South	Embarcadero	No Defects	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
S38	South	Embarcadero	B	No Defects	A
S39	South	Embarcadero	B	No Defects	D
S40	South	Embarcadero	A	No Defects	B
S41	South	Lake Merritt	No Defects	No Defects	No Defects
S42	South	Lake Merritt	C	No Defects	No Defects
S43	South	Lake Merritt	A	No Defects	No Defects
S44	South	Lake Merritt	A	A	No Defects
S44A	South	Lake Merritt	No Defects	No Defects	No Defects
S45	South	Lake Merritt	B	No Defects	No Defects
S46	South	Lake Merritt	B	No Defects	No Defects
S47	South	3rd St	B	No Defects	No Defects
S48	South	3rd St	B	No Defects	No Defects
S49	South	3rd St	B	No Defects	No Defects
S50	South	3rd St	B	No Defects	B
S51	South	3rd St	C	No Defects	No Defects
S52	South	3rd St	C	No Defects	No Defects
S53	South	3rd St	D	No Defects	No Defects
S54	South	3rd St	C	No Defects	No Defects
S55	South	3rd St	C	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	Interceptor	Segment	Corrosion Severity	Lining Severity	Structural/ Infiltration Severity
S56	South	3rd St	C	No Defects	No Defects
S57	South	3rd St	C	No Defects	No Defects
S58	South	3rd St	D	No Defects	No Defects
S59	South	3rd St	C	No Defects	No Defects
S60	South	3rd St	C	D	No Defects
S60A	South	Wood	No Defects	C	No Defects
S61	South	Wood	C	No Defects	No Defects
S62	South	Wood	C	No Defects	No Defects
S63	South	Wood	C	No Defects	No Defects
S64	South	Wood	C	No Defects	No Defects
S65	South	Wood	B	No Defects	No Defects
S66	South	Wood	C	No Defects	No Defects
S67	South	Wood	A	No Defects	No Defects
S68	South	Wood	No Defects	No Defects	No Defects
S69	South	Wood	No Defects	No Defects	No Defects
S69A	South	Wood	No Defects	No Defects	No Defects
S70	South	Wood	No Defects	No Defects	No Defects
SACDIV	South	Lake Merritt	No Defects	No Defects	No Defects
SC1	South	Lake Merritt	No Defects	No Defects	No Defects

Table A-2: Gravity System Manhole Condition Ratings

Asset ID	**Interceptor**	**Segment**	**Corrosion Severity**	**Lining Severity**	**Structural/ Infiltration Severity**
T01	South	Oakport	No Defects	No Defects	A
T02	South	Oakport	No Defects	No Defects	No Defects
T03	South	Oakport	No Defects	No Defects	No Defects

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
A01A021	1	B	3	1	1	2	3	7
A02A031	1	B	3	1	1	2	3	7
A03A041	1	B	3	1	1	2	3	7
A04A051	1	B	3	1	2	3	4	10
A05A061	1	B	3	1	2	3	2	8
A06PSB1	1	B	3	1	1	4	2	8
A07A081	1	C	4	1	2	4	1	8
A08A091	1	B	3	1	1	4	1	7
A09A101	1	No Defects	1	1	1	3	1	6
A10A111	1	B	3	1	1	3	1	6
A11A121	1	A	2	1	1	3	1	6
A12A131	1	B	3	1	1	3	1	6
A13A141	1	C	4	1	2	3	1	7
A14A061	1	A	2	1	2	3	2	8
A15A161	0	A	2	3	4	1	3	11

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
A16M101	5	No Defects	1	3	4	1	4	12
A17A181	6	C	4	3	4	1	4	12
A18A191	5	B	4	3	4	1	3	11
A19A201	4	B	4	3	4	1	3	11
A20A211	5	C	4	3	4	1	3	11
A21A221	3	C	4	3	4	1	3	11
A22A231	3	A	2	3	4	1	3	11
A23A241	4	C	4	3	4	1	3	11
A24A251	3	B	3	3	4	1	3	11
A25A261	3	B	3	3	4	1	3	11
A26A271	3	B	3	3	4	1	3	11
A27A281	4	C	4	3	4	1	3	11
A28A291	3	C	4	3	4	1	3	11
A29A301	3	C	4	3	3	1	3	10
A30A311	3	B	3	3	3	1	3	10
A31A321	3	C	4	3	3	1	3	10

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
A32A331	2	C	4	3	3	1	3	10
A33A341	3	A	2	3	3	1	3	10
A34A351	3	B	3	3	3	1	3	10
A35A361	3	C	4	3	3	1	3	10
A36A371	7	No Defects	1	3	3	1	3	10
A37A381	3	C	4	3	2	1	3	9
A38A391	3	C	4	3	2	1	3	9
A39A401	3	C	4	3	2	1	3	9
A40A411	3	D	5	3	3	1	4	11
A41A421	4	C	4	3	4	1	4	12
A42A441	4	C	4	3	4	1	4	12
A44A451	2	B	3	3	3	1	4	11
A45A45A1	3	B	3	3	2	1	3	9
A45AA461	3	C	4	3	2	1	2	8
A46A46A1	2	B	3	3	2	1	1	7
A46AA471	6	A	4	3	2	1	1	7

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			**CONSEQUENCE OF FAILURE** (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
A47A481	3	A	2	3	2	1	1	7
A48A491	5	D	5	3	2	1	1	7
A52A52A1	7	No Defects	1	4	2	4	1	11
A52AS471	7	No Defects	1	4	4	4	2	14
A53A53A1	3	B	3	2	1	1	1	5
A53AA541	3	B	3	2	1	1	1	5
A54A551	1	B	3	2	2	1	1	6
A55A561	1	B	3	2	2	1	1	6
A56A571	1	B	3	2	2	1	1	6
A57A581	1	B	3	2	2	1	1	6
A58A591	1	No Defects	1	2	2	1	3	8
A59A59A1	1	No Defects	1	2	2	1	3	8
A59AA491	1	No Defects	1	2	2	1	4	9
A60A611	3	No Defects	1	2	3	1	3	9
A61MC11	0	B	3	2	3	1	3	9
A62A151	0	No Defects	1	2	3	1	3	9

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	1995 Inspection Rating	2010-2013 Inspection Rating	RATING	Constructability	Disruption to Commerce	Environmentally Sensitive Area	Traffic Impact	RATING
AD01ADG1	0	No Defects	1	3	1	1	1	6
AD02AD011	0	A	2	3	1	1	1	6
AD03AD021	None	A	2	3	4	4	3	14
AD04ADA1	None	A	2	3	4	1	3	11
AD05AD041	None	A	2	3	4	1	1	9
AD06AD051	None	A	2	3	4	1	3	11
AD07AD061	None	A	2	3	4	1	5	13
AD08ADB1	0	A	2	3	4	1	4	12
AD09AD081	1	A	2	3	2	1	2	8
AD10AD091	None	A	2	3	2	1	2	8
AD11AD101	None	A	2	3	2	1	2	8
AD12AD111	None	A	2	3	2	4	2	11
AD13AD121	None	A	2	3	2	1	2	8
AD14AD131	None	A	2	3	2	1	2	8
AD15AD141	None	A	2	3	2	1	2	8
AD16AD151	None	A	2	3	2	1	2	8

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
AD17AD161	None	A	2	3	2	1	2	8
AD18AD171	None	B	3	3	2	1	2	8
AD19AD181	None	B	3	3	4	1	4	12
AD20AD191	None	B	3	3	4	1	4	12
AD21AD201	None	A	2	3	4	1	4	12
ADAAD031	None	A	2	3	4	1	3	11
ADBAD071	0	A	2	3	4	1	4	12
ADCAD211	None	A	2	3	4	1	4	12
ADDN461	None	B	3	3	2	1	1	7
ADEADD1	0	No Defects	2	3	5	1	1	10
ADFADE1	0	No Defects	2	3	2	1	1	7
ADGADF1	0	No Defects	2	3	2	1	1	7
AF03AF041	None	No Defects	1	2	4	1	5	12
AF04AF051	0	No Defects	1	2	1	4	1	8
AF05AF061	7	No Defects	1	2	1	5	1	9
AF06N011	0	No Defects	1	2	1	4	1	8

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
AI01AI01A1	1	No Defects	1	2	4	4	3	13
AI01Q211	1	No Defects	1	2	5	4	5	16
AI01AQ211	2	No Defects	1	2	5	4	5	16
AI03AI041	2	A	2	2	1	4	1	8
C01C021	1	No Defects	1	2	3	5	3	13
C02C031	1	No Defects	1	2	3	2	3	10
C03C041	1	A	2	2	3	1	3	9
C04C051	1	A	2	2	4	1	4	11
C05C061	1	No Defects	1	2	4	1	5	12
C06C071	1	A	2	2	4	1	5	12
C07C081	1	No Defects	1	2	4	1	4	11
C08AC091	1	A	2	2	5	1	5	13
C08C08A1	1	A	2	2	2	1	1	6
C09Q36A1	1	A	2	2	1	1	1	5
F01F1A1	0	No Defects	1	2	3	4	3	12
F02F011	0	No Defects	1	2	5	4	2	13

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
F03F021	0	No Defects	1	2	5	1	4	12
F04F031	None	No Defects	1	2	3	1	2	8
F05F041	None	A	2	2	3	1	2	8
F06F051	None	No Defects	1	2	4	1	4	11
F07F061	None	No Defects	1	2	4	4	4	14
F08F071	None	No Defects	1	2	4	1	4	11
F09F081	None	No Defects	1	2	4	1	4	11
F10F091	None	No Defects	1	2	4	1	4	11
F11F101	0	No Defects	1	2	4	4	4	14
F12F111	0	No Defects	1	2	4	1	4	11
F13F121	0	No Defects	1	2	4	1	4	11
F14F131	0	No Defects	1	2	4	1	4	11
F15F141	None	No Defects	1	2	4	1	4	11
F16F151	None	No Defects	1	2	4	1	4	11
F17F161	None	No Defects	1	2	4	1	4	11
F18F171	None	No Defects	1	2	4	1	4	11

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
F19F181	0	No Defects	1	2	4	1	4	11
F1AS16A1	0	No Defects	1	2	4	4	1	11
F20F191	0	No Defects	1	2	4	1	4	11
F21F201	0	No Defects	1	2	4	1	4	11
F22F211	None	No Defects	1	2	4	4	4	14
F23F221	None	No Defects	1	2	4	4	4	14
K02K031	None	A	2	2	1	1	1	5
K03K041	None	No Defects	1	2	1	1	1	5
K04K051	None	No Defects	1	2	5	1	5	13
K05S60a1	None	No Defects	1	2	5	1	1	9
M01M021	6	D	5	2	2	1	2	7
M02M031	6	D	5	2	2	1	1	6
M03M041	6	D	5	2	2	1	2	7
M04MC11	6	D	5	2	2	1	3	8
M05M061	6	D	5	2	2	1	3	8
M06AM071	6	D	5	2	2	1	3	8

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			**CONSEQUENCE OF FAILURE** (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
M06M06A1	6	D	5	2	2	1	3	8
M07M081	6	D	5	2	3	1	3	9
M08M091	6	D	5	2	3	1	3	9
M09M101	6	D	5	2	4	1	4	11
M10A171	7	No Defects	5	2	2	1	2	7
MC1A621	0	B	3	2	2	1	2	7
MC1M051	6	C	5	2	2	1	3	8
N01AN021	7	No Defects	1	2	3	4	1	10
N01N01A1	3	No Defects	1	2	3	4	1	10
N02N031	3	A	2	2	3	2	1	8
N03N041	2	A	2	2	4	2	3	11
N04N051	2	A	2	4	3	4	1	12
N05N061	2	A	2	2	3	3	1	9
N06N071	2	A	2	2	3	4	1	10
N07N081	2	A	2	2	3	5	1	11
N08N091	3	A	2	2	3	4	2	11

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			**CONSEQUENCE OF FAILURE** (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
N09N101	3	A	2	2	3	2	3	10
N10N111	2	B	3	2	4	1	4	11
N11N121	1	B	3	2	3	1	3	9
N12N131	2	B	3	2	3	1	2	8
N13AN141	2	A	2	2	3	1	2	8
N13N13A1	2	A	2	2	3	1	2	8
N14N151	1	C	4	2	3	1	2	8
N15N161	2	B	3	2	3	1	3	9
N16N171	2	B	3	4	3	4	3	14
N17N181	2	A	2	2	3	1	2	8
N18N191	1	A	2	2	4	1	3	10
N19N201	3	No Defects	1	4	3	3	2	12
N19N202	3	No Defects	1	4	3	3	2	12
N20N211	3	B	3	3	3	4	5	15
N21N221	2	A	2	3	2	5	5	15
N22N231	1	A	2	3	2	5	1	11

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
N23N241	1	A	2	3	2	5	1	11
N24N251	2	A	2	3	2	5	1	11
N25N261	2	A	2	3	2	5	1	11
N26N271	1	A	2	3	2	5	5	15
N27N281	None	C	4	4	2	4	5	15
N28N291	None	B	3	3	2	4	5	14
N29N301	None	B	3	3	2	3	5	13
N30N311	2	B	3	3	2	2	5	12
N31N321	2	B	3	3	2	2	5	12
N32N331	1	B	3	3	2	2	5	12
N33N341	2	B	3	3	4	2	5	14
N34N351	8	C	5	3	4	2	5	14
N35AN361	None	A	2	4	4	2	1	11
N35N35A1	None	A	2	4	4	2	1	11
N36N371	None	No Defects	1	4	4	5	1	14
N37N381	None	A	2	4	4	4	4	16

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
N38N391	None	A	2	4	4	2	4	14
N39N401	0	B	3	4	4	2	4	14
N40AN411	None	B	3	4	4	2	1	11
N40N40A1	None	B	3	4	4	2	4	14
N41AN421	0	B	3	4	3	4	1	12
N41N41A1	None	B	3	4	4	2	1	11
N42AN431	0	No Defects	1	4	1	1	1	7
N42N42A1	0	No Defects	1	4	3	2	1	10
N43N441	None	B	3	4	1	1	1	7
N44N451	None	B	3	4	1	1	1	7
N45N461	None	A	2	4	1	1	1	7
N46IPS1	None	No Defects	1	4	1	1	1	7
NF01N01A1	0	No Defects	1	2	1	5	1	9
NF02NF011	0	No Defects	1	2	1	2	1	6
NF03AF031	0	No Defects	1	2	1	1	3	7
NF03NF021	7	No Defects	1	2	4	1	5	12

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
NF04NF031	0	No Defects	1	2	3	1	2	8
NF05NF041	0	No Defects	1	2	3	1	2	8
NF06NF051	0	No Defects	1	2	3	1	2	8
NF07NF061	0	No Defects	1	2	3	1	2	8
NI01NI021	0	No Defects	1	2	3	3	1	9
NI02Q36A1	1	A	2	2	3	2	1	8
NI04P051	1	A	2	2	3	2	1	8
NI05NI04	1	A	2	2	3	2	1	8
OAKT031	None	No Defects	1	2	1	5	1	9
P02P011	1	A	2	2	3	3	2	10
P03P021	1	A	2	2	3	3	2	10
P04P031	1	A	2	2	3	3	2	10
P05P041	1	B	3	2	3	3	2	10
PSF01A431	None	D	5	4	3	1	3	11
Q16Q171	None	A	2	2	3	1	2	8
Q17Q181	None	A	2	2	3	1	2	8

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
Q18Q191	None	A	2	2	3	1	2	8
Q19Q201	None	No Defects	1	2	3	1	2	8
Q20Q211	1	No Defects	1	2	3	1	2	8
Q21AI031	2	No Defects	1	2	3	4	3	12
Q21Q221	1	A	2	2	3	5	2	12
Q21Q222	1	A	2	2	3	5	2	12
Q22Q231	1	A	2	2	3	2	2	9
Q23Q241	1	No Defects	1	2	3	5	2	12
Q23Q242	1	No Defects	1	2	3	5	2	12
Q24Q251	1	A	2	2	3	2	2	9
Q25Q261	None	No Defects	1	2	4	1	4	11
Q26Q271	None	No Defects	1	2	4	1	4	11
Q27Q281	None	No Defects	1	2	4	1	4	11
Q28Q291	None	No Defects	1	2	2	1	3	8
Q29Q301	None	A	2	2	2	1	2	7
Q30Q311	1	No Defects	1	2	2	1	1	6

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
Q31Q321	1	No Defects	1	2	1	1	1	5
Q32Q331	1	No Defects	1	2	5	1	5	13
Q33Q341	None	No Defects	1	2	1	1	1	5
Q34Q351	None	A	2	2	1	1	1	5
Q35Q361	None	A	2	2	1	1	1	5
Q36AP051	None	A	2	2	1	1	1	5
Q36Q36A1	1	A	2	2	1	1	1	5
S01S021	2	B	3	4	5	3	5	17
S02S031	2	B	3	4	5	2	5	16
S03S041	2	B	3	4	5	2	5	16
S04S051	2	A	2	4	5	2	5	16
S05AS06	2	A	2	4	5	1	5	15
S05S05A1	2	A	2	4	5	1	5	15
S06S071	2	B	3	4	3	1	1	9
S07S081	2	A	2	4	3	5	3	15
S08S091	2	A	2	4	3	5	2	14

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
S09S101	1	C	4	4	4	4	1	13
S10S111	1	A	2	4	5	2	1	12
S11S121	2	A	2	4	4	5	5	18
S12S131	2	A	2	4	4	2	3	13
S13S141	2	A	2	4	4	2	3	13
S14S151	3	C	4	4	4	4	3	15
S15S161	2	C	4	4	4	5	3	16
S16AS171	2	A	2	4	3	5	1	13
S16S16A1	2	A	2	4	3	5	3	15
S17S181	2	A	2	2	4	1	5	12
S18AS191	None	A	2	2	4	1	3	10
S18S18A1	None	A	2	2	4	1	3	10
S19AS19B1	None	No Defects	1	2	4	1	1	8
S19BS201	None	No Defects	1	2	4	1	1	8
S19S19A1	None	No Defects	1	2	4	1	3	10
S20PSH1	2	B	3	2	2	1	1	6

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
S21S221	3	C	4	2	3	1	2	8
S22S231	5	C	4	5	4	4	5	18
S22S232	5	C	4	5	4	4	5	18
S23S241	2	B	3	2	4	1	5	12
S24S251	3	B	3	2	2	1	1	6
S25S261	2	C	4	2	4	1	5	12
S26S271	2	A	2	2	4	4	5	15
S27S281	2	A	2	2	4	4	4	14
S28S291	2	A	2	2	4	1	4	11
S29S311	2	C	4	2	4	1	4	11
S31S321	5	C	4	5	4	4	4	17
S32S331	2	B	3	4	4	1	5	14
S33S351	2	A	2	4	4	4	5	17
S35S36A1	2	A	2	4	3	1	2	10
S36BS37A1	2	No Defects	1	5	3	5	2	15
S36BS37A2	2	B	3	5	3	5	2	15

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
S37BS381	3	A	2	4	3	4	2	13
S38S391	3	A	2	4	3	3	3	13
S39S401	3	A	2	5	3	3	3	14
S40S411	2	A	2	4	3	3	3	13
S41S421	2	A	2	4	3	4	3	14
S42SACDIV1	3	D	5	4	3	3	3	13
S43S441	2	No Defects	1	5	3	5	3	16
S44AS451	2	A	2	4	3	3	3	13
S44S44A1	2	A	2	5	3	5	3	16
S45S46A1	2	A	2	4	3	2	3	12
S46AS471	2	A	2	4	4	2	3	13
S47S481	5	C	4	5	4	2	5	16
S48S491	5	C	4	5	4	2	5	16
S49S501	5	C	4	5	4	2	5	16
S50S511	5	B	4	5	4	2	4	15
S51S521	4	B	3	5	4	1	3	13

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
S52S531	4	B	3	5	4	1	3	13
S53S541	4	B	3	5	4	1	3	13
S54S551	5	C	4	5	4	1	2	12
S55S561	5	B	4	5	4	1	3	13
S56S571	5	B	4	5	4	1	3	13
S57S581	5	B	4	5	5	1	3	14
S58S591	5	B	4	5	2	1	1	9
S59S601	5	B	4	5	5	1	1	12
S60AS611	5	B	4	5	5	1	3	14
S60S60A1	0	B	3	5	5	1	1	12
S61S621	5	B	4	5	5	1	3	14
S62S631	5	B	4	5	2	1	2	10
S63S641	5	B	4	5	2	1	2	10
S64S651	5	B	4	5	3	1	2	11
S65S661	5	C	4	5	3	1	2	11
S66S671	5	C	4	5	3	1	2	11

Table A-3: Gravity System Pipe Segment Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of constructability)				
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Constructability**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
S67S681	5	A	1	5	3	1	2	11
S68S691	5	C	4	5	3	1	2	11
S69S701	5	B	3	5	5	1	1	12
S70IPS1	None	No Defects	1	5	1	1	1	8
SACDIVSC11	3	C	4	4	3	4	3	14
SC1S431	3	C	4	4	3	4	3	14
T01S181	None	A	2	2	3	1	3	9
T02T011	0	A	2	2	3	4	3	12
T03T021	0	No Defects	1	2	3	5	3	13

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			**CONSEQUENCE OF FAILURE** (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
A01	2	B	3	1	2	3	6
A02	2	B	3	1	2	3	6
A03	2	B	3	1	2	3	6
A04	1	A	2	1	2	3	6
A05	2	A	2	2	3	4	9
A06	1	A	2	2	3	2	7
A07	1	No Defects	1	2	4	1	7
A08	1	No Defects	1	1	4	1	6
A09	1	No Defects	1	1	3	1	5
A10	1	No Defects	1	1	3	1	5
A11	2	A	2	1	3	1	5
A12	1	A	2	1	3	1	5
A13	2	B	3	1	3	1	5
A14	1	A	2	2	3	1	6
A15	7	A	1	4	1	3	8
A16	3	C	4	3	1	3	7
A17	3	C	4	3	1	3	7
A18	3	B	3	4	1	4	9
A19	3	B	3	3	1	3	7
A20	2	B	3	4	1	3	8

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
A21	3	B	3	3	1	3	7
A22	3	B	3	3	1	3	7
A23	3	C	4	3	1	3	7
A24	2	B	3	3	1	3	7
A25	5	C	4	3	1	3	7
A26	3	B	3	3	1	3	7
A27	4	D	5	3	1	3	7
A28	6	C	4	3	1	3	7
A29	2	B	3	3	1	3	7
A30	5	C	4	2	1	3	6
A31	5	C	4	2	1	3	6
A32	3	C	4	2	1	3	6
A33	4	B	3	2	1	3	6
A34	5	C	4	2	1	3	6
A35	5	B	4	2	1	3	6
A36	7	C	5	2	1	3	6
A37	3	C	4	1	1	3	5
A38	3	C	4	1	1	3	5
A39	4	C	4	1	1	3	5
A40	7	C	5	1	1	3	5
A41	4	C	4	3	1	4	8

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			**CONSEQUENCE OF FAILURE** (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
A42	5	C	4	3	1	4	8
A43	2	B	3	3	1	4	8
A44	2	B	3	3	1	4	8
A45	4	A	2	2	1	3	6
A45A	5	D	5	2	1	2	5
A46	None	No Defects	1	2	1	1	4
A46A	5	B	4	2	1	1	4
A47	5	C	4	2	1	1	4
A48	5	B	4	2	4	1	7
A49/50	7	C	5	2	4	1	7
A51/52	7	C	5	1	4	1	6
A52A	None	No Defects	1	2	3	2	7
A53	3	B	3	1	1	1	3
A53A	None	No Defects	1	1	1	1	3
A54	2	A	2	1	1	1	3
A55	2	D	5	3	1	1	5
A56	2	A	2	1	1	1	3
A57	2	B	3	2	1	2	5
A58	2	B	3	2	1	1	4
A59	2	None	None	2	1	3	6
A59A	None	C	4	2	1	3	6

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
A60	5	D	5	3	1	3	7
A61	5	C	4	3	1	3	7
A62	3	D	5	3	1	3	7
AD01	0	C	4	1	1	1	3
AD02	None	C	4	1	1	1	3
AD03	None	No Defects	1	4	1	2	7
AD04	None	A	2	4	1	1	6
AD05	None	C	4	4	1	1	6
AD06	None	C	4	4	1	1	6
AD07	None	No Defects	1	3	1	3	7
AD08	0	No Defects	1	2	1	3	6
AD09	None	No Defects	1	2	1	3	6
AD10	None	C	4	2	1	3	6
AD11	None	C	4	2	1	3	6
AD12	None	No Defects	1	2	1	3	6
AD13	None	No Defects	1	2	1	3	6
AD14	None	No Defects	1	2	1	3	6
AD15	None	No Defects	1	2	1	3	6
AD16	None	No Defects	1	2	1	3	6
AD17	None	C	4	2	1	3	6
AD18	None	No Defects	1	2	1	3	6

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			**CONSEQUENCE OF FAILURE** (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
AD19	None	No Defects	1	4	1	4	9
AD20	None	No Defects	1	4	1	4	9
AD21	None	No Defects	1	4	1	4	9
ADA	None	No Defects	1	4	1	1	6
ADB	0	No Defects	1	4	1	4	9
ADC	None	C	4	4	1	4	9
ADD	None	B	3	1	1	1	3
ADE	None	C	4	1	1	1	3
ADF	None	No Defects	1	1	1	1	3
ADG	None	C	4	1	1	1	3
AF03	None	No Defects	1	3	1	2	6
AF04	None	No Defects	1	1	1	1	3
AF05	1	No Defects	1	1	3	1	5
AF06	3	No Defects	1	1	3	1	5
AI01	0	No Defects	1	3	4	3	10
AI01A	None	A	2	3	4	3	10
AI03	2	No Defects	1	3	4	3	10
AI04	2	A	2	1	4	1	6
C01	1	No Defects	1	3	4	3	10
C01A	None	B	3	3	4	3	10
C02	1	No Defects	1	3	3	3	9

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
C03	1	No Defects	1	3	2	3	8
C04	1	No Defects	1	3	1	3	7
C05	1	No Defects	1	4	1	4	9
C06	1	No Defects	1	4	1	4	9
C07	1	No Defects	1	4	1	4	9
C08	None	A	2	1	1	1	3
C08A	None	A	2	1	1	1	3
C09	1	B	3	1	1	1	3
F01	None	C	4	3	4	1	8
F02	0	No Defects	1	3	3	1	7
F03	None	D	5	3	1	1	5
F04	None	D	5	2	1	2	5
F05	None	No Defects	1	3	1	3	7
F06	None	C	4	4	1	4	9
F07	None	No Defects	1	4	1	4	9
F08	None	C	4	4	1	4	9
F09	None	No Defects	1	4	1	4	9
F10	None	No Defects	1	4	1	4	9
F11	0	B	3	4	1	4	9
F12	None	No Defects	1	4	1	4	9
F13	0	No Defects	1	4	1	4	9

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
F14	None	No Defects	1	4	1	4	9
F15	None	No Defects	1	4	1	4	9
F16	None	No Defects	1	4	1	4	9
F17	None	No Defects	1	4	1	4	9
F18	None	No Defects	1	4	1	4	9
F19	0	C	4	4	1	4	9
F1A	None	C	4	3	4	1	8
F20	0	C	4	4	1	4	9
F21	None	C	4	4	1	4	9
F22	None	No Defects	1	4	1	4	9
F23	None	No Defects	1	4	1	4	9
K02	None	No Defects	1	1	1	1	3
K03	None	B	3	1	1	1	3
K04	None	B	3	1	1	1	3
K05	None	B	3	5	1	1	7
M01	3	C	4	2	1	2	5
M02	3	C	4	1	1	1	3
M03	5	D	5	1	1	1	3
M04	4	D	5	2	1	2	5
M05	3	D	5	2	1	2	5
M06	5	B	3	2	1	2	5

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
M06A	4	B	3	2	1	2	5
M07	4	C	4	2	1	2	5
M08	4	C	4	2	1	2	5
M09	3	C	4	3	1	3	7
M10	3	D	5	3	1	2	6
MC1	6	D	5	2	1	1	4
N01	3	No Defects	1	3	4	1	8
N01A	5	No Defects	1	3	4	1	8
N02	2	No Defects	1	3	2	1	6
N03	2	B	3	3	2	1	6
N04	2	B	3	3	4	1	8
N05	None	No Defects	1	3	4	1	8
N06	2	No Defects	1	3	4	1	8
N07	1	No Defects	1	3	5	1	9
N08	2	No Defects	1	3	5	1	9
N09	3	A	2	3	2	3	8
N10	2	No Defects	1	4	4	4	12
N11	1	B	3	4	4	4	12
N12	2	B	3	3	2	2	7
N13	2	B	3	3	2	2	7
N13A	0	No Defects	1	3	2	2	7

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
N14	1	B	3	3	2	2	7
N15	2	B	3	3	2	3	8
N16	2	B	3	3	4	3	10
N17	1	B	3	3	4	3	10
N18	1	B	3	3	2	2	7
N19	3	B	3	3	3	2	8
N20	2	B	3	3	3	2	8
N21	2	B	3	4	4	5	13
N22	1	A	2	1	5	5	11
N23	1	B	3	1	5	1	7
N24	2	A	2	1	5	1	7
N25	2	B	3	1	5	1	7
N26	2	B	3	1	4	1	6
N27	None	B	3	4	4	5	13
N28	None	A	2	4	4	5	13
N29	None	A	2	4	4	5	13
N30	None	A	2	4	2	5	11
N31	2	B	3	3	2	2	7
N32	2	B	3	3	2	5	10
N33	None	B	3	3	2	5	10
N34	5	C	4	4	2	5	11

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
N35	None	A	2	4	2	2	8
N35A	None	C	3	4	2	2	8
N36	None	A	2	4	3	2	9
N37	None	No Defects	1	2	5	2	9
N38	None	B	3	4	3	3	10
N39	None	A	2	4	2	4	10
N40	None	No Defects	1	4	2	4	10
N40A	None	No Defects	1	4	2	2	8
N41	None	No Defects	1	4	2	2	8
N41A	None	D	5	4	4	2	10
N42	0	C	4	2	2	2	6
N42A	None	No Defects	1	2	1	1	4
N43	4	D	5	2	1	1	4
N44	None	No Defects	1	2	1	1	4
N45	None	No Defects	1	2	1	1	4
N46	None	C	4	2	1	1	4
NF01	5	No Defects	1	1	3	1	5
NF02	5	No Defects	1	1	1	1	3
NF03	3	No Defects	1	3	1	2	6
NF04	3	C	4	3	1	2	6
NF05	3	C	4	3	2	2	7

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
NF06	3	A	2	3	2	2	7
NF07	1	No Defects	1	3	1	2	6
NI01	0	No Defects	1	3	4	1	8
NI02	1	A	1	2	3	1	6
NI03	1	C	4	2	2	1	5
NI04	1	No Defects	1	2	2	1	5
NI05	2	A	2	1	1	1	3
P02	1	No Defects	1	3	3	2	8
P03	1	B	3	3	3	2	8
P04	None	C	4	3	3	2	8
P05	1	B	2	2	2	2	6
Q17	None	No Defects	1	3	1	2	6
Q18	None	No Defects	1	3	1	2	6
Q19	None	No Defects	1	3	1	2	6
Q20	None	No Defects	1	3	1	2	6
Q21	0	No Defects	1	3	4	2	9
Q22	1	No Defects	1	3	4	2	9
Q23	1	No Defects	1	3	4	2	9
Q24	1	No Defects	1	3	4	2	9
Q25	None	A	2	3	2	3	8
Q26	None	No Defects	1	4	4	4	12

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
Q27	None	No Defects	1	4	4	4	12
Q28	None	No Defects	1	3	4	3	10
Q29	None	No Defects	1	3	4	2	9
Q30	None	A	2	2	2	1	5
Q31	1	No Defects	1	2	1	1	4
Q32	1	No Defects	1	2	1	1	4
Q33	None	No Defects	1	1	1	1	3
Q34	None	A	2	1	1	1	3
Q35	None	A	2	1	1	1	3
Q36	None	No Defects	1	1	1	1	3
Q36A	0	C	4	1	1	1	3
S01	3	B	3	5	5	5	15
S02	2	B	3	5	3	5	13
S03	2	A	2	5	2	5	12
S04	2	No Defects	1	5	2	5	12
S05	None	C	4	3	1	1	5
S05A	None	None	None	5	1	5	11
S06	2	B	3	3	1	1	5
S07	3	B	3	3	2	1	6
S08	2	C	4	3	4	2	9
S09	3	B	3	3	5	1	9

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
S10	1	B	3	4	2	1	7
S11	1	B	3	4	2	1	7
S12	2	A	2	4	2	3	9
S13	2	B	3	4	1	3	8
S14	2	A	2	4	1	3	8
S15	4	B	3	4	4	3	11
S16	2	B	3	4	2	3	9
S16A	2	No Defects	1	3	4	1	8
S17	2	B	3	3	2	1	6
S18	2	B	3	4	1	3	8
S18A	None	No Defects	1	4	1	3	8
S19	2	No Defects	1	4	1	3	8
S19A	None	A	2	3	1	1	5
S19B	None	No Defects	1	3	1	1	5
S20	2	No Defects	1	3	1	4	8
S21	3	B	3	3	1	2	6
S22	3	B	3	4	1	4	9
S23	3	B	3	4	1	5	10
S24	3	C	4	2	1	1	4
S25	3	A	2	2	1	1	4
S26	3	C	4	3	1	5	9

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			**CONSEQUENCE OF FAILURE** (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
S27	2	A	2	3	4	4	11
S28	2	B	3	4	1	4	9
S29	2	B	3	4	1	4	9
S30	8	D	5	4	1	3	8
S31	6	C	5	4	4	3	11
S32	5	C	4	4	4	3	11
S33	2	No Defects	1	3	4	1	8
S35	2	B	3	3	1	2	6
S36A	5	B	4	3	4	2	9
S36B	5	B	4	3	2	2	7
S37A	1	No Defects	1	3	4	2	9
S37B	1	No Defects	1	3	4	2	9
S38	1	B	3	3	2	2	7
S39	3	D	5	3	4	3	10
S40	3	B	3	3	4	3	10
S41	2	No Defects	1	3	2	2	7
S42	4	C	4	3	2	2	7
S43	2	A	2	3	5	2	10
S44	None	A	2	3	5	2	10
S44A	None	No Defects	1	3	2	2	7
S45	2	B	3	3	2	2	7

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
S46	3	B	3	3	2	3	8
S47	3	B	3	4	2	3	9
S48	2	B	3	4	2	5	11
S49	3	B	3	4	2	5	11
S50	4	B	3	4	2	5	11
S51	3	C	4	4	1	4	9
S52	3	C	4	4	1	3	8
S53	3	D	5	4	1	3	8
S54	3	C	4	4	1	2	7
S55	3	C	4	4	1	2	7
S56	4	C	4	4	1	3	8
S57	3	C	4	4	1	3	8
S58	2	D	5	2	1	1	4
S59	4	C	4	2	1	1	4
S60	0	D	5	5	1	1	7
S60A	0	C	4	5	1	1	7
S61	6	C	4	5	1	3	9
S62	3	C	4	2	1	2	5
S63	6	C	4	2	1	2	5
S64	3	C	4	2	1	2	5
S65	3	B	3	3	1	2	6

Table A-4: Gravity System Manhole Assignment of Likelihood and Consequence of Failure Ratings

	LIKELIHOOD OF FAILURE			CONSEQUENCE OF FAILURE (with no weighting of environmentally sensitive area)			
Asset ID	**1995 Inspection Rating**	**2010-2013 Inspection Rating**	**RATING**	**Disruption to Commerce**	**Environmentally Sensitive Area**	**Traffic Impact**	**RATING**
S66	7	C	4	3	1	2	6
S67	5	A	2	3	1	2	6
S68	5	No Defects	1	3	1	2	6
S69	5	No Defects	1	5	1	2	8
S69A	None	No Defects	1	5	1	2	8
S70	None	No Defects	1	3	1	1	5
SACDIV	None	No Defects	1	3	4	2	9
SC1	None	No Defects	1	3	4	2	9
T01	2	A	2	3	3	3	9
T02	1	No Defects	1	3	3	3	9
T03	1	No Defects	1	1	4	1	6

Table A-5: Gravity System Pipe Segment Risk Assignment

Color Coding for Risk Assignment column

101-125	*High*
76-100	*Medium High*
51-75	*Medium*
26-50	*Low-Medium*
5-25	*Low*

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
A01A021	15	550	B	3	8	24	
A02A031	15	479	B	3	8	24	
A03A041	15	390	B	3	8	24	
A04A051	15	545	B	3	11	33	
A05A061	21	94	B	3	9	27	
A06PSB1	15	33	B	3	9	27	
A07A081	12	404	**C**	4	9	36	
A08A091	12	118	B	3	8	24	
A09A101	12	443	No Defects	1	7	7	
A10A111	12	416	B	3	7	21	
A11A121	12	403	A	2	7	14	
A12A131	12	369	B	3	7	21	
A13A141	12	480	**C**	4	8	32	
A14A061	12	24	A	2	9	18	
A15A161	42	517	A	2	14	28	
A16M101	42	10	No Defects	1	15	15	

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
A17A181	42	595	**C**	4	15	60	Alameda
A18A191	42	647	B	4	14	56	Alameda
A19A201	48	184	B	4	14	56	Alameda
A20A211	48	759	**C**	4	14	56	Alameda
A21A221	48	455	**C**	4	14	56	Alameda
A22A231	48	488	A	2	14	28	
A23A241	48	463	**C**	4	14	56	
A24A251	48	500	B	3	14	42	
A25A261	48	262	B	3	14	42	
A26A271	48	556	B	3	14	42	
A27A281	48	570	**C**	4	14	56	
A28A291	54	355	**C**	4	14	56	
A29A301	54	351	**C**	4	13	52	
A30A311	54	559	B	3	13	39	
A31A321	54	268	**C**	4	13	52	
A32A331	57	631	**C**	4	13	52	
A33A341	57	320	A	2	13	26	
A34A351	57	318	B	3	13	39	
A35A361	57	703	**C**	4	13	52	
A36A371	60	746	No Defects	1	13	13	
A37A381	60	591	**C**	4	12	48	
A38A391	60	744	**C**	4	12	48	
A39A401	60	640	**C**	4	12	48	
A40A411	60	502	**D**	5	14	70	Alameda
A41A421	60	713	**C**	4	15	60	Alameda
A42A441	60	172	**C**	4	15	60	Alameda

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
A44A451	60	138	B	3	14	42	
A45A45A1	60	931	B	3	12	36	
A45AA461	60	545	**C**	4	11	44	
A46A46A1	60	380	B	3	10	30	
A46AA471	60	500	A	4	10	40	Alameda
A47A481	60	691	A	2	10	20	
A48A491	60	572	**D**	5	10	50	Wood Street
A52A52A1	96	65	No Defects	1	15	15	
A52AS471	96	526	No Defects	1	18	0	
A53A53A1	24	38	B	3	7	21	
A53AA541	24	235	B	3	7	21	
A54A551	24	229	B	3	8	24	
A55A561	24	366	B	3	8	24	
A56A571	24	265	B	3	8	24	
A57A581	24	345	B	3	8	24	
A58A591	24	338	No Defects	1	10	10	
A59A59A1	24	68	No Defects	1	10	10	
A59AA491	24	284	No Defects	1	11	11	
A60A611	24	33	No Defects	1	11	11	
A61MC11	21	945	B	3	11	33	
A62A151	21	63	No Defects	1	11	11	
AD01ADG1	60	17	No Defects	1	9	9	
AD02AD011	60	371	A	2	9	18	
AD03AD021	60	742	A	2	17	34	
AD04ADA1	54	504	A	2	14	28	
AD05AD041	54	527	A	2	12	24	

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
AD06AD051	54	616	A	2	14	28	
AD07AD061	54	452	A	2	16	32	
AD08ADB1	48	659	A	2	15	30	
AD09AD081	48	502	A	2	11	22	
AD10AD091	48	520	A	2	11	22	
AD11AD101	48	379	A	2	11	22	
AD12AD111	48	451	A	2	14	28	
AD13AD121	48	549	A	2	11	22	
AD14AD131	48	616	A	2	11	22	
AD15AD141	48	261	A	2	11	22	
AD16AD151	48	544	A	2	11	22	
AD17AD161	48	489	A	2	11	22	
AD18AD171	48	533	B	3	11	33	
AD19AD181	48	800	B	3	15	45	
AD20AD191	48	308	B	3	15	45	
AD21AD201	48	465	A	2	15	30	
ADAAD031	60	606	A	2	14	28	
ADBAD071	54	269	A	2	15	30	
ADCAD211	48	645	A	2	15	30	
ADDN461	60	275	B	3	10	30	
ADEADD1	60	308	No Defects	2	13	26	
ADFADE1	60	21	No Defects	2	10	20	
ADGADF1	60	192	No Defects	2	10	20	
AF03AF041	24	120	No Defects	1	14	14	
AF04AF051	24	284	No Defects	1	10	10	
AF05AF061	24	30	No Defects	1	11	11	

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
AF06N011	24	30	No Defects	1	10	10	
AI01AI01A1	30	27	No Defects	1	15	15	
AI01Q211	30	188	No Defects	1	18	18	
AI01AQ211	30	161	No Defects	1	18	18	
AI03AI041	30	424	A	2	10	20	
C01C021	48	213	No Defects	1	15	15	
C02C031	48	216	No Defects	1	12	12	
C03C041	48	229	A	2	11	22	
C04C051	48	138	A	2	13	26	
C05C061	48	234	No Defects	1	14	14	
C06C071	48	190	A	2	14	28	
C07C081	48	348	No Defects	1	13	13	
C08AC091	48	471	A	2	15	30	
C08C08A1	48	316	A	2	8	16	
C09Q36A1	48	209	A	2	7	14	
F01F1A1	66	466	No Defects	1	14	14	
F02F011	66	255	No Defects	1	15	15	
F03F021	66	848	No Defects	1	14	14	
F04F031	66	265	No Defects	1	10	10	
F05F041	66	1039	A	2	10	20	
F06F051	60	1140	No Defects	1	13	13	
F07F061	60	732	No Defects	1	16	16	
F08F071	60	698	No Defects	1	13	13	
F09F081	60	698	No Defects	1	13	13	
F10F091	60	712	No Defects	1	13	13	
F11F101	54	587	No Defects	1	16	16	

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
F12F111	54	747	No Defects	1	13	13	
F13F121	54	197	No Defects	1	13	13	
F14F131	54	510	No Defects	1	13	13	
F15F141	48	345	No Defects	1	13	13	
F16F151	48	727	No Defects	1	13	13	
F17F161	48	69	No Defects	1	13	13	
F18F171	36	657	No Defects	1	13	13	
F19F181	36	591	No Defects	1	13	13	
F1AS16A1	66	238	No Defects	1	13	13	
F20F191	36	542	No Defects	1	13	13	
F21F201	30	924	No Defects	1	13	13	
F22F211	30	991	No Defects	1	16	16	
F23F221	30	847	No Defects	1	16	16	
K02K031	36	365	A	2	7	14	
K03K041	36	352	No Defects	1	7	7	
K04K051	36	640	No Defects	1	15	15	
K05S60a1	36	10	No Defects	1	11	11	
M01M021	24	400	D	5	9	45	Versailles
M02M031	24	260	D	5	8	40	Versailles
M03M041	24	273	D	5	9	45	Versailles
M04MC11	24	612	D	5	10	50	Versailles
M05M061	24	500	D	5	10	50	Versailles
M06AM071	24	312	D	5	10	50	Versailles
M06M06A1	24	33	D	5	10	50	Versailles
M07M081	24	233	D	5	11	55	Versailles
M08M091	24	435	D	5	11	55	Versailles

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
M09M101	24	394	**D**	5	13	65	Versailles
M10A171	42	621	No Defects	5	9	45	?
MC1A621	21	1400	B	3	9	27	
MC1M051	24	71	**C**	5	10	50	Versailles
N01AN021	42	498	No Defects	1	12	12	
N01N01A1	42	267	No Defects	1	12	12	
N02N031	42	172	A	2	10	20	
N03N041	42	239	A	2	13	26	
N04N051	48	20	A	2	16	32	
N05N061	48	887	A	2	11	22	
N06N071	48	51	A	2	12	24	
N07N081	48	31	A	2	13	26	
N08N091	48	721	A	2	13	26	
N09N101	48	549	A	2	12	24	
N10N111	48	20	B	3	13	39	
N11N121	48	621	B	3	11	33	
N12N131	48	477	B	3	10	30	
N13AN141	48	382	A	2	10	20	
N13N13A1	48	62	A	2	10	20	
N14N151	48	403	**C**	4	10	40	
N15N161	48	679	B	3	11	33	
N16N171	48	20	B	3	18	54	
N17N181	54	627	A	2	10	20	
N18N191	54	943	A	2	12	24	
N19N201	30	91	No Defects	1	16	16	
N19N202	30	91	No Defects	1	16	16	

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
N20N211	66	464	B	3	18	54	
N21N221	66	871	A	2	18	36	
N22N231	66	801	A	2	14	28	
N23N241	66	880	A	2	14	28	
N24N251	66	895	A	2	14	28	
N25N261	66	1314	A	2	14	28	
N26N271	66	1020	A	2	18	36	
N27N281	33	32	**C**	4	19	76	
N28N291	66	188	B	3	17	51	
N29N301	66	1161	B	3	16	48	
N30N311	66	1084	B	3	15	45	
N31N321	66	320	B	3	15	45	
N32N331	66	102	B	3	15	45	
N33N341	66	1581	B	3	17	51	
N34N351	66	432	**C**	5	17	85	
N35AN361	72	585	A	2	15	30	
N35N35A1	72	33	A	2	15	30	
N36N371	72	512	No Defects	1	18	18	
N37N381	84	300	A	2	20	40	
N38N391	84	449	A	2	18	36	
N39N401	84	467	B	3	18	54	
N40AN411	84	254	B	3	15	45	
N40N40A1	84	490	B	3	18	54	
N41AN421	84	141	B	3	16	48	
N41N41A1	84	225	B	3	15	45	
N42AN431	84	33	No Defects	1	11	11	

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
N42N42A1	84	318	No Defects	1	14	14	
N43N441	84	119	B	3	11	33	
N44N451	84	80	B	3	11	33	
N45N461	84	30	A	2	11	22	
N46IPS1	84	33	No Defects	1	11	11	
NF01N01A1	16	45	No Defects	1	11	11	
NF02NF011	30	322	No Defects	1	8	8	
NF03AF031	30	10	No Defects	1	9	9	
NF03NF021	30	124	No Defects	1	14	14	
NF04NF031	30	809	No Defects	1	10	10	
NF05NF041	30	500	No Defects	1	10	10	
NF06NF051	30	395	No Defects	1	10	10	
NF07NF061	30	505	No Defects	1	10	10	
NI01NI021	60	370	No Defects	1	11	11	
NI02Q36A1	60	35	A	2	10	20	
NI04P051	48	54	A	2	10	20	
NI05NI04	48	142	A	2	10	20	
OAKT031	24	544	No Defects	1	11	11	
P02P011	72	521	A	2	12	24	
P03P021	72	702	A	2	12	24	
P04P031	72	276	A	2	12	24	
P05P041	72	601	B	3	12	36	
PSF01A431	20	106	D	5	15	75	
Q16Q171	36	325	A	2	10	20	
Q17Q181	36	321	A	2	10	20	
Q18Q191	36	339	A	2	10	20	

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
Q19Q201	36	214	No Defects	1	10	10	
Q20Q211	36	236	No Defects	1	10	10	
Q21AI031	30	40	No Defects	1	14	14	
Q21Q221	36	90	A	2	14	28	
Q21Q222	36	90	A	2	14	28	
Q22Q231	60	581	A	2	11	22	
Q23Q241	36	30	No Defects	1	14	14	
Q23Q242	36	30	No Defects	1	14	14	
Q24Q251	60	483	A	2	11	22	
Q25Q261	60	77	No Defects	1	13	13	
Q26Q271	24	16	No Defects	1	13	13	
Q27Q281	60	59	No Defects	1	13	13	
Q28Q291	24	40	No Defects	1	10	10	
Q29Q301	48	13	A	2	9	18	
Q30Q311	60	263	No Defects	1	8	8	
Q31Q321	60	212	No Defects	1	7	7	
Q32Q331	60	475	No Defects	1	15	15	
Q33Q341	60	287	No Defects	1	7	7	
Q34Q351	48	23	A	2	7	14	
Q35Q361	60	130	A	2	7	14	
Q36AP051	0	16	A	2	7	14	
Q36Q36A1	60	20	A	2	7	14	
S01S021	42	576	B	3	21	63	
S02S031	42	567	B	3	20	60	
S03S041	42	433	B	3	20	60	
S04S051	42	763	A	2	20	40	

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
S05AS06	42	1166	A	2	19	38	
S05S05A1	42	197	A	2	19	38	
S06S071	42	526	B	3	13	39	
S07S081	42	576	A	2	19	38	
S08S091	51	910	A	2	18	36	
S09S101	63	1014	**C**	4	17	68	
S10S111	63	1200	A	2	16	32	
S11S121	63	996	A	2	22	44	
S12S131	63	562	A	2	17	34	
S13S141	63	785	A	2	17	34	
S14S151	63	857	**C**	4	19	76	
S15S161	63	574	**C**	4	20	80	
S16AS171	63	721	A	2	17	34	
S16S16A1	63	538	A	2	19	38	
S17S181	63	712	A	2	14	28	
S18AS191	66	322	A	2	12	24	
S18S18A1	66	396	A	2	12	24	
S19AS19B1	66	438	No Defects	1	10	10	
S19BS201	66	166	No Defects	1	10	10	
S19S19A1	66	201	No Defects	1	12	12	
S20PSH1	63	115	B	3	8	24	
S21S221	57	1001	**C**	4	10	40	
S22S231	36	50	**C**	4	23	92	3rd Street
S22S232	36	50	**C**	4	23	92	3rd Street
S23S241	63	742	B	3	14	42	
S24S251	63	239	B	3	8	24	

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
S25S261	63	507	**C**	4	14	56	
S26S271	66	723	A	2	17	34	
S27S281	66	348	A	2	16	32	
S28S291	66	409	A	2	13	26	
S29S311	66	1103	**C**	4	13	52	
S31S321	0	43	**C**	4	22	88	3rd Street
S32S331	78	1135	B	3	18	54	
S33S351	78	2483	A	2	21	42	
S35S36A1	78	1057	A	2	14	28	
S36BS37A1	48	53	No Defects	1	20	20	
S36BS37A2	48	53	B	3	20	60	
S37BS381	78	333	A	2	17	34	
S38S391	75	1424	A	2	17	34	
S39S401	78	19	A	2	19	38	
S40S411	84	1220	A	2	17	34	
S41S421	84	1426	A	2	18	36	
S42SACDIV1	84	326	**D**	5	17	85	3rd Street
S43S441	42	228	No Defects	1	21	21	
S44AS451	84	258	A	2	17	34	
S44S44A1	84	530	A	2	21	42	
S45S46A1	84	684	A	2	16	32	
S46AS471	84	1171	A	2	17	34	
S47S481	105	716	**C**	4	21	84	3rd Street
S48S491	105	393	**C**	4	21	84	3rd Street
S49S501	105	392	**C**	4	21	84	3rd Street
S50S511	105	326	B	4	20	80	3rd Street

Table A-5: Gravity System Pipe Segment Risk Assignment

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
S51S521	105	1008	B	3	18	54	3rd Street
S52S531	105	836	B	3	18	54	3rd Street
S53S541	105	1000	B	3	18	54	3rd Street
S54S551	105	299	**C**	4	17	68	3rd Street
S55S561	105	920	B	4	18	72	3rd Street
S56S571	105	1282	B	4	18	72	3rd Street
S57S581	105	1360	B	4	19	76	3rd Street
S58S591	105	1240	B	4	14	56	3rd Street
S59S601	105	675	B	4	17	68	3rd Street
S60AS611	105	738	B	4	19	76	Wood Street
S60S60A1	108	399	B	3	17	51	
S61S621	105	1277	B	4	19	76	Wood Street
S62S631	105	960	B	4	15	60	Wood Street
S63S641	105	1165	B	4	15	60	Wood Street
S64S651	105	680	B	4	16	64	Wood Street
S65S661	105	1188	**C**	4	16	64	Wood Street
S66S671	105	847	**C**	4	16	64	Wood Street
S67S681	105	880	A	1	16	16	
S68S691	105	1119	**C**	4	16	64	Wood Street
S69S701	105	267	B	3	17	51	
S70IPS1	105	66	No Defects	1	13	13	
SACDIVSC11	84	46	**C**	4	18	72	3rd Street
SC1S431	0	0	**C**	4	18	72	3rd Street
T01S181	24	405	A	2	11	22	
T02T011	24	351	A	2	14	28	
T03T021	24	135	No Defects	1	15	15	

Table A-6: Gravity System Manhole Risk Assignment

Color Coding for Risk Assignment column

81-100	*High*
61-80	*Medium High*
41-60	*Medium*
21-40	*Low-Medium*
4-20	*Low*

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
A01	B	3	8	24	
A02	B	3	8	24	
A03	B	3	8	24	
A04	A	2	8	16	
A05	A	2	12	24	
A06	A	2	10	20	
A07	No Defects	1	11	11	
A08	No Defects	1	10	10	
A09	No Defects	1	8	8	
A10	No Defects	1	8	8	
A11	A	2	8	16	
A12	A	2	8	16	
A13	B	3	8	24	
A14	A	2	9	18	
A15	A	1	9	9	
A16	**C**	4	8	32	

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
A17	**C**	4	8	32	
A18	B	3	10	30	
A19	B	3	8	24	
A20	B	3	9	27	
A21	B	3	8	24	
A22	B	3	8	24	
A23	**C**	4	8	32	
A24	B	3	8	24	
A25	**C**	4	8	32	Alameda
A26	B	3	8	24	
A27	**D**	5	8	40	Alameda
A28	**C**	4	8	32	Alameda
A29	B	3	8	24	
A30	**C**	4	7	28	Alameda
A31	**C**	4	7	28	Alameda
A32	**C**	4	7	28	
A33	B	3	7	21	
A34	**C**	4	7	28	Alameda
A35	B	4	7	28	Alameda
A36	**C**	5	7	35	Alameda
A37	**C**	4	6	24	
A38	**C**	4	6	24	
A39	**C**	4	6	24	
A40	**C**	5	6	30	Alameda
A41	**C**	4	9	36	Alameda
A42	**C**	4	9	36	Alameda

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
A43	B	3	9	27	
A44	B	3	9	27	
A45	A	2	7	14	
A45A	**D**	5	6	30	Alameda
A46	No Defects	1	5	5	
A46A	B	4	5	20	Alameda
A47	**C**	4	5	20	Alameda
A48	B	4	11	44	Alameda
A49/50	**C**	5	11	55	
A51/52	**C**	5	10	50	
A52A	No Defects	1	10	10	
A53	B	3	4	12	
A53A	No Defects	1	4	4	
A54	A	2	4	8	
A55	**D**	5	6	30	Alameda
A56	A	2	4	8	
A57	B	3	6	18	
A58	B	3	5	15	
A59	None	None	7	N/A	
A59A	**C**	4	7	28	
A60	**D**	5	8	40	Versailles
A61	**C**	4	8	32	
A62	**D**	5	8	40	Versailles
AD01	**C**	4	5	20	
AD02	**C**	4	5	20	
AD03	No Defects	1	9	9	

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
AD04	A	2	8	16	
AD05	**C**	4	8	32	
AD06	**C**	4	8	32	
AD07	No Defects	1	9	9	
AD08	No Defects	1	8	8	
AD09	No Defects	1	8	8	
AD10	**C**	4	8	32	
AD11	**C**	4	8	32	
AD12	No Defects	1	8	8	
AD13	No Defects	1	8	8	
AD14	No Defects	1	8	8	
AD15	No Defects	1	8	8	
AD16	No Defects	1	8	8	
AD17	**C**	4	8	32	
AD18	No Defects	1	8	8	
AD19	No Defects	1	11	11	
AD20	No Defects	1	11	11	
AD21	No Defects	1	11	11	
ADA	No Defects	1	8	8	
ADB	No Defects	1	11	11	
ADC	**C**	4	11	44	
ADD	B	3	5	15	
ADE	**C**	4	5	20	
ADF	No Defects	1	5	5	
ADG	**C**	4	5	20	
AF03	No Defects	1	7	7	

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
AF04	No Defects	1	4	4	
AF05	No Defects	1	8	8	
AF06	No Defects	1	8	8	
AI01	No Defects	1	14	14	
AI01A	A	2	14	28	
AI03	No Defects	1	14	14	
AI04	A	2	10	20	
C01	No Defects	1	14	14	
C01A	B	3	14	42	
C02	No Defects	1	12	12	
C03	No Defects	1	10	10	
C04	No Defects	1	8	8	
C05	No Defects	1	10	10	
C06	No Defects	1	10	10	
C07	No Defects	1	10	10	
C08	A	2	4	8	
C08A	A	2	4	8	
C09	B	3	4	12	
F01	**C**	4	16	64	
F02	No Defects	1	13	13	
F03	**D**	5	7	35	3rd Street
F04	**D**	5	7	35	3rd Street
F05	No Defects	1	9	9	
F06	**C**	4	11	44	
F07	No Defects	1	11	11	
F08	**C**	4	11	44	

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
F09	No Defects	1	11	11	
F10	No Defects	1	11	11	
F11	B	3	11	33	
F12	No Defects	1	11	11	
F13	No Defects	1	11	11	
F14	No Defects	1	11	11	
F15	No Defects	1	11	11	
F16	No Defects	1	11	11	
F17	No Defects	1	11	11	
F18	No Defects	1	11	11	
F19	**C**	4	11	44	
F1A	**C**	4	16	64	
F20	**C**	4	11	44	
F21	**C**	4	11	44	
F22	No Defects	1	11	11	
F23	No Defects	1	11	11	
K02	No Defects	1	4	4	
K03	B	3	4	12	
K04	B	3	4	12	
K05	B	3	8	24	
M01	**C**	4	6	24	Versailles
M02	**C**	4	4	16	Versailles
M03	**D**	5	4	20	Versailles
M04	**D**	5	6	30	Versailles
M05	**D**	5	6	30	Versailles
M06	B	3	6	18	Versailles

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
M06A	B	3	6	18	Versailles
M07	**C**	4	6	24	Versailles
M08	**C**	4	6	24	Versailles
M09	**C**	4	8	32	Versailles
M10	**D**	5	7	35	Versailles
MC1	**D**	5	5	25	Versailles
N01	No Defects	1	12	12	
N01A	No Defects	1	12	12	
N02	No Defects	1	8	8	
N03	B	3	8	24	
N04	B	3	12	36	
N05	No Defects	1	12	12	
N06	No Defects	1	12	12	
N07	No Defects	1	14	14	
N08	No Defects	1	14	14	
N09	A	2	10	20	
N10	No Defects	1	16	16	
N11	B	3	16	48	
N12	B	3	9	27	
N13	B	3	9	27	
N13A	No Defects	1	9	9	
N14	B	3	9	27	
N15	B	3	10	30	
N16	B	3	14	42	
N17	B	3	14	42	
N18	B	3	9	27	

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
N19	B	3	11	33	
N20	B	3	11	33	
N21	B	3	17	51	
N22	A	2	16	32	
N23	B	3	12	36	
N24	A	2	12	24	
N25	B	3	12	36	
N26	B	3	10	30	
N27	B	3	17	51	
N28	A	2	17	34	
N29	A	2	17	34	
N30	A	2	13	26	
N31	B	3	9	27	
N32	B	3	12	36	
N33	B	3	12	36	
N34	**C**	4	13	52	
N35	A	2	10	20	
N35A	**C**	3	10	30	
N36	A	2	12	24	
N37	No Defects	1	14	14	
N38	B	3	13	39	
N39	A	2	12	24	
N40	No Defects	1	12	12	
N40A	No Defects	1	10	10	
N41	No Defects	1	10	10	
N41A	**D**	5	14	70	3rd Street

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
N42	**C**	4	8	32	
N42A	No Defects	1	5	5	
N43	**D**	5	5	25	3rd Street
N44	No Defects	1	5	5	
N45	No Defects	1	5	5	
N46	**C**	4	5	20	
NF01	No Defects	1	8	8	
NF02	No Defects	1	4	4	
NF03	No Defects	1	7	7	
NF04	**C**	4	7	28	
NF05	**C**	4	9	36	
NF06	A	2	9	18	
NF07	No Defects	1	7	7	
NI01	No Defects	1	12	12	
NI02	A	1	9	9	
NI03	**C**	4	7	28	
NI04	No Defects	1	7	7	
NI05	A	2	4	8	
P02	No Defects	1	11	11	
P03	B	3	11	33	
P04	**C**	4	11	44	
P05	B	2	8	16	
Q17	No Defects	1	7	7	
Q18	No Defects	1	7	7	
Q19	No Defects	1	7	7	
Q20	No Defects	1	7	7	

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
Q21	No Defects	1	13	13	
Q22	No Defects	1	13	13	
Q23	No Defects	1	13	13	
Q24	No Defects	1	13	13	
Q25	A	2	10	20	
Q26	No Defects	1	16	16	
Q27	No Defects	1	16	16	
Q28	No Defects	1	14	14	
Q29	No Defects	1	13	13	
Q30	A	2	7	14	
Q31	No Defects	1	5	5	
Q32	No Defects	1	5	5	
Q33	No Defects	1	4	4	
Q34	A	2	4	8	
Q35	A	2	4	8	
Q36	No Defects	1	4	4	
Q36A	**C**	4	4	16	
S01	B	3	25	75	
S02	B	3	19	57	
S03	A	2	16	32	
S04	No Defects	1	16	16	
S05	**C**	4	7	28	
S05A	None	None	13	N/A	
S06	B	3	7	21	
S07	B	3	10	30	
S08	**C**	4	17	68	

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
S09	B	3	19	57	
S10	B	3	11	33	
S11	B	3	11	33	
S12	A	2	13	26	
S13	B	3	10	30	
S14	A	2	10	20	
S15	B	3	19	57	
S16	B	3	13	39	
S16A	No Defects	1	16	16	
S17	B	3	10	30	
S18	B	3	10	30	
S18A	No Defects	1	10	10	
S19	No Defects	1	10	10	
S19A	A	2	7	14	
S19B	No Defects	1	7	7	
S20	No Defects	1	10	10	
S21	B	3	8	24	
S22	B	3	11	33	3rd Street
S23	B	3	12	36	3rd Street
S24	**C**	4	6	24	
S25	A	2	6	12	
S26	**C**	4	11	44	
S27	A	2	19	38	
S28	B	3	11	33	
S29	B	3	11	33	
S30	**D**	5	10	50	3rd Street

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
S31	**C**	5	19	95	3rd Street
S32	**C**	4	19	76	3rd Street
S33	No Defects	1	16	16	
S35	B	3	8	24	
S36A	B	4	17	68	3rd Street
S36B	B	4	11	44	3rd Street
S37A	No Defects	1	17	17	
S37B	No Defects	1	17	17	
S38	B	3	11	33	
S39	**D**	5	18	90	3rd Street
S40	B	3	18	54	
S41	No Defects	1	11	11	
S42	**C**	4	11	44	3rd Street
S43	A	2	20	40	
S44	A	2	20	40	
S44A	No Defects	1	11	11	
S45	B	3	11	33	
S46	B	3	12	36	
S47	B	3	13	39	3rd Street
S48	B	3	15	45	3rd Street
S49	B	3	15	45	3rd Street
S50	B	3	15	45	3rd Street
S51	**C**	4	11	44	3rd Street
S52	**C**	4	10	40	3rd Street
S53	**D**	5	10	50	3rd Street
S54	**C**	4	9	36	3rd Street

Table A-6: Gravity System Manhole Risk Assignment

ASSET ID	CURRENT CONDITION	LIKELIHOOD	CONSEQUENCE (weighted)	RISK	PART OF FY14-23 CIP
S55	**C**	4	9	36	3rd Street
S56	**C**	4	10	40	3rd Street
S57	**C**	4	10	40	3rd Street
S58	**D**	5	6	30	3rd Street
S59	**C**	4	6	24	3rd Street
S60	**D**	5	9	45	
S60A	**C**	4	9	36	
S61	**C**	4	11	44	Wood Street
S62	**C**	4	7	28	Wood Street
S63	**C**	4	7	28	Wood Street
S64	**C**	4	7	28	Wood Street
S65	B	3	8	24	Wood Street
S66	**C**	4	8	32	Wood Street
S67	A	2	8	16	
S68	No Defects	1	8	8	
D	**No Defects**	1	10	10	
S69A	No Defects	1	10	10	
S70	No Defects	1	7	7	
SACDIV	No Defects	1	17	17	
SC1	No Defects	1	17	17	
T01	A	2	12	24	
T02	No Defects	1	12	12	
T03	No Defects	1	10	10	

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

Color Coding for Risk Assignment column

101-125	*High*
76-100	*Medium High*
51-75	*Medium*
26-50	*Low-Medium*
5-25	*Low*

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
S22S231	36	50	**C**	92	3rd Street
S22S232	36	50	**C**	92	3rd Street
S31S321	0	43	**C**	88	3rd Street
N34N351	66	432	**C**	85	
S47S481	105	716	**C**	84	3rd Street
S48S491	105	393	**C**	84	3rd Street
S49S501	105	392	**C**	84	3rd Street
S15S161	63	574	**C**	80	
S50S511	105	326	B	80	3rd Street
N27N281	33	32	**C**	76	
S14S151	63	857	**C**	76	
S57S581	105	1360	B	76	3rd Street
S60AS611	105	738	B	76	Wood Street
S61S621	105	1277	B	76	Wood Street
S55S561	105	920	B	72	3rd Street

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
S56S571	105	1282	B	72	3rd Street
SACDIVSC11	84	46	**C**	72	3rd Street
SC1S431	0	0	**C**	72	3rd Street
S09S101	63	1014	**C**	68	
S54S551	105	299	**C**	68	3rd Street
S59S601	105	675	B	68	3rd Street
S64S651	105	680	B	64	Wood Street
S65S661	105	1188	**C**	64	Wood Street
S66S671	105	847	**C**	64	Wood Street
S68S691	105	1119	**C**	64	Wood Street
S01S021	42	576	B	63	
A17A181	42	595	**C**	60	Alameda
A41A421	60	713	**C**	60	Alameda
A42A441	60	172	**C**	60	Alameda
S02S031	42	567	B	60	
S03S041	42	433	B	60	
S36BS37A2	48	53	B	60	
S62S631	105	960	B	60	Wood Street
S63S641	105	1165	B	60	Wood Street
A18A191	42	647	B	56	Alameda
A19A201	48	184	B	56	Alameda
A20A211	48	759	**C**	56	Alameda
A21A221	48	455	**C**	56	Alameda
A23A241	48	463	**C**	56	
A27A281	48	570	**C**	56	
A28A291	54	355	**C**	56	

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
S25S261	63	507	**C**	56	
S58S591	105	1240	B	56	3rd Street
N16N171	48	20	B	54	
N20N211	66	464	B	54	
N39N401	84	467	B	54	
N40N40A1	84	490	B	54	
S32S331	78	1135	B	54	
S51S521	105	1008	B	54	3rd Street
S52S531	105	836	B	54	3rd Street
S53S541	105	1000	B	54	3rd Street
A29A301	54	351	**C**	52	
A31A321	54	268	**C**	52	
A32A331	57	631	**C**	52	
A35A361	57	703	**C**	52	
S29S311	66	1103	**C**	52	
N28N291	66	188	B	51	
N33N341	66	1581	B	51	
S60S60A1	108	399	B	51	
S69S701	105	267	B	51	
MC1M051	24	71	**C**	50	Versailles
A37A381	60	591	**C**	48	
A38A391	60	744	**C**	48	
A39A401	60	640	**C**	48	
N29N301	66	1161	B	48	
N41AN421	84	141	B	48	
AD19AD181	48	800	B	45	

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
AD20AD191	48	308	B	45	
N30N311	66	1084	B	45	
N31N321	66	320	B	45	
N32N331	66	102	B	45	
N40AN411	84	254	B	45	
N41N41A1	84	225	B	45	
A45AA461	60	545	**C**	44	
S11S121	63	996	A	44	
A24A251	48	500	B	42	
A25A261	48	262	B	42	
A26A271	48	556	B	42	
A44A451	60	138	B	42	
S23S241	63	742	B	42	
S33S351	78	2483	A	42	
S44S44A1	84	530	A	42	
A46AA471	60	500	A	40	Alameda
N14N151	48	403	**C**	40	
N37N381	84	300	A	40	
S04S051	42	763	A	40	
S21S221	57	1001	**C**	40	
A30A311	54	559	B	39	
A34A351	57	318	B	39	
N10N111	48	20	B	39	
S06S071	42	526	B	39	
S05AS06	42	1166	A	38	
S05S05A1	42	197	A	38	

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
S07S081	42	576	A	38	
S16S16A1	63	538	A	38	
S39S401	78	19	A	38	
A07A081	12	404	**C**	36	
A45A45A1	60	931	B	36	
N21N221	66	871	A	36	
N26N271	66	1020	A	36	
N38N391	84	449	A	36	
P05P041	72	601	B	36	
S08S091	51	910	A	36	
S41S421	84	1426	A	36	
AD03AD021	60	742	A	34	
S12S131	63	562	A	34	
S13S141	63	785	A	34	
S16AS171	63	721	A	34	
S26S271	66	723	A	34	
S37BS381	78	333	A	34	
S38S391	75	1424	A	34	
S40S411	84	1220	A	34	
S44AS451	84	258	A	34	
S46AS471	84	1171	A	34	
A04A051	15	545	B	33	
A61MC11	21	945	B	33	
AD18AD171	48	533	B	33	
N11N121	48	621	B	33	
N15N161	48	679	B	33	

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
N43N441	84	119	B	33	
N44N451	84	80	B	33	
A13A141	12	480	**C**	32	
AD07AD061	54	452	A	32	
N04N051	48	20	A	32	
S10S111	63	1200	A	32	
S27S281	66	348	A	32	
S45S46A1	84	684	A	32	
A46A46A1	60	380	B	30	
AD08ADB1	48	659	A	30	
AD21AD201	48	465	A	30	
ADBAD071	54	269	A	30	
ADCAD211	48	645	A	30	
ADDN461	60	275	B	30	
C08AC091	48	471	A	30	
N12N131	48	477	B	30	
N35AN361	72	585	A	30	
N35N35A1	72	33	A	30	
A15A161	42	517	A	28	
A22A231	48	488	A	28	
AD04ADA1	54	504	A	28	
AD06AD051	54	616	A	28	
AD12AD111	48	451	A	28	
ADAAD031	60	606	A	28	
C06C071	48	190	A	28	
N22N231	66	801	A	28	

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
N23N241	66	880	A	28	
N24N251	66	895	A	28	
N25N261	66	1314	A	28	
Q21Q221	36	90	A	28	
Q21Q222	36	90	A	28	
S17S181	63	712	A	28	
S35S36A1	78	1057	A	28	
T02T011	24	351	A	28	
A05A061	21	94	B	27	
A06PSB1	15	33	B	27	
MC1A621	21	1400	B	27	
A33A341	57	320	A	26	
C04C051	48	138	A	26	
N03N041	42	239	A	26	
N07N081	48	31	A	26	
N08N091	48	721	A	26	
S28S291	66	409	A	26	
A01A021	15	550	B	24	
A02A031	15	479	B	24	
A03A041	15	390	B	24	
A08A091	12	118	B	24	
A54A551	24	229	B	24	
A55A561	24	366	B	24	
A56A571	24	265	B	24	
A57A581	24	345	B	24	
AD05AD041	54	527	A	24	

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
N06N071	48	51	A	24	
N09N101	48	549	A	24	
N18N191	54	943	A	24	
P02P011	72	521	A	24	
P03P021	72	702	A	24	
P04P031	72	276	A	24	
S18AS191	66	322	A	24	
S18S18A1	66	396	A	24	
S20PSH1	63	115	B	24	
S24S251	63	239	B	24	
AD09AD081	48	502	A	22	
AD10AD091	48	520	A	22	
AD11AD101	48	379	A	22	
AD13AD121	48	549	A	22	
AD14AD131	48	616	A	22	
AD15AD141	48	261	A	22	
AD16AD151	48	544	A	22	
AD17AD161	48	489	A	22	
C03C041	48	229	A	22	
N05N061	48	887	A	22	
N45N461	84	30	A	22	
Q22Q231	60	581	A	22	
Q24Q251	60	483	A	22	
T01S181	24	405	A	22	
A10A111	12	416	B	21	
A12A131	12	369	B	21	

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
A53A53A1	24	38	B	21	
A53AA541	24	235	B	21	
A47A481	60	691	A	20	
AI03AI041	30	424	A	20	
F05F041	66	1039	A	20	
N02N031	42	172	A	20	
N13AN141	48	382	A	20	
N13N13A1	48	62	A	20	
N17N181	54	627	A	20	
NI02Q36A1	60	35	A	20	
NI04P051	48	54	A	20	
NI05NI04	48	142	A	20	
Q16Q171	36	325	A	20	
Q17Q181	36	321	A	20	
Q18Q191	36	339	A	20	
A14A061	12	24	A	18	
AD02AD011	60	371	A	18	
Q29Q301	48	13	A	18	
C08C08A1	48	316	A	16	
S67S681	105	880	A	16	
A11A121	12	403	A	14	
C09Q36A1	48	209	A	14	
K02K031	36	365	A	14	
Q34Q351	48	23	A	14	
Q35Q361	60	130	A	14	
Q36AP051	0	16	A	14	

Table A-7: Category A, B, C Gravity System Pipe Segments Ranked by Risk

ASSET ID	SIZE	LENGTH	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
Q36Q36A1	60	20	A	14	

Table A-8: Category A, B, C Gravity System Manholes Ranked by Risk

Color Coding for Risk Assignment column

81-100	*High*
61-80	*Medium High*
41-60	*Medium*
21-40	*Low-Medium*
4-20	*Low*

ASSET ID	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
S31	**C**	95	3rd Street
S32	**C**	76	3rd Street
S01	B	75	
S08	**C**	68	
S36A	B	68	3rd Street
F01	**C**	64	
F1A	**C**	64	
S02	B	57	
S09	B	57	
S15	B	57	
A49/50	**C**	55	
S40	B	54	
N34	**C**	52	
N21	B	51	
N27	B	51	
A51/52	**C**	50	

Table A-8: Category A, B, C Gravity System Manholes Ranked by Risk

ASSET ID	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
N11	B	48	
S48	B	45	3rd Street
S49	B	45	3rd Street
S50	B	45	3rd Street
A48	B	44	Alameda
ADC	**C**	44	
F06	**C**	44	
F08	**C**	44	
F19	**C**	44	
F20	**C**	44	
F21	**C**	44	
P04	**C**	44	
S26	**C**	44	
S36B	B	44	3rd Street
S42	**C**	44	3rd Street
S51	**C**	44	3rd Street
S61	**C**	44	Wood Street
C01A	B	42	
N16	B	42	
N17	B	42	
S43	A	40	
S44	A	40	
S52	**C**	40	3rd Street
S56	**C**	40	3rd Street
S57	**C**	40	3rd Street
N38	B	39	

Table A-8: Category A, B, C Gravity System Manholes Ranked by Risk

ASSET ID	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
S16	B	39	
S47	B	39	3rd Street
S27	A	38	
A41	**C**	36	Alameda
A42	**C**	36	Alameda
N04	B	36	
N23	B	36	
N25	B	36	
N32	B	36	
N33	B	36	
NF05	**C**	36	
S23	B	36	3rd Street
S46	B	36	
S54	**C**	36	3rd Street
S55	**C**	36	3rd Street
S60A	**C**	36	
A36	**C**	35	Alameda
N28	A	34	
N29	A	34	
F11	B	33	
N19	B	33	
N20	B	33	
P03	B	33	
S10	B	33	
S11	B	33	
S22	B	33	3rd Street

Table A-8: Category A, B, C Gravity System Manholes Ranked by Risk

ASSET ID	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
S28	B	33	
S29	B	33	
S38	B	33	
S45	B	33	
A16	**C**	32	
A17	**C**	32	
A23	**C**	32	
A25	**C**	32	Alameda
A28	**C**	32	Alameda
A61	**C**	32	
AD05	**C**	32	
AD06	**C**	32	
AD10	**C**	32	
AD11	**C**	32	
AD17	**C**	32	
M09	**C**	32	Versailles
N22	A	32	
N42	**C**	32	
S03	A	32	
S66	**C**	32	Wood Street
A18	B	30	
A40	**C**	30	Alameda
N15	B	30	
N26	B	30	
N35A	**C**	30	
S07	B	30	

Table A-8: Category A, B, C Gravity System Manholes Ranked by Risk

ASSET ID	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
S13	B	30	
S17	B	30	
S18	B	30	
A30	**C**	28	Alameda
A31	**C**	28	Alameda
A32	**C**	28	
A34	**C**	28	Alameda
A35	B	28	Alameda
A59A	**C**	28	
AI01A	A	28	
NF04	**C**	28	
NI03	**C**	28	
S05	**C**	28	
S62	**C**	28	Wood Street
S63	**C**	28	Wood Street
S64	**C**	28	Wood Street
A20	B	27	
A43	B	27	
A44	B	27	
N12	B	27	
N13	B	27	
N14	B	27	
N18	B	27	
N31	B	27	
N30	A	26	
S12	A	26	

Table A-8: Category A, B, C Gravity System Manholes Ranked by Risk

ASSET ID	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
A01	B	24	
A02	B	24	
A03	B	24	
A05	A	24	
A13	B	24	
A19	B	24	
A21	B	24	
A22	B	24	
A24	B	24	
A26	B	24	
A29	B	24	
A37	**C**	24	
A38	**C**	24	
A39	**C**	24	
K05	B	24	
M01	**C**	24	Versailles
M07	**C**	24	Versailles
M08	**C**	24	Versailles
N03	B	24	
N24	A	24	
N36	A	24	
N39	A	24	
S21	B	24	
S24	**C**	24	
S35	B	24	
S59	**C**	24	3rd Street

Table A-8: Category A, B, C Gravity System Manholes Ranked by Risk

ASSET ID	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
S65	B	24	Wood Street
T01	A	24	
A33	B	21	
S06	B	21	
A06	A	20	
A46A	B	20	Alameda
A47	**C**	20	Alameda
AD01	**C**	20	
AD02	**C**	20	
ADE	**C**	20	
ADG	**C**	20	
AI04	A	20	
N09	A	20	
N35	A	20	
N46	**C**	20	
Q25	A	20	
S14	A	20	
A14	A	18	
A57	B	18	
M06	B	18	Versailles
M06A	B	18	Versailles
NF06	A	18	
A04	A	16	
A11	A	16	
A12	A	16	
AD04	A	16	

Table A-8: Category A, B, C Gravity System Manholes Ranked by Risk

ASSET ID	CURRENT CONDITION	RISK	PART OF FY14-23 CIP
M02	**C**	16	Versailles
P05	B	16	
Q36A	**C**	16	
S67	A	16	
A58	B	15	
ADD	B	15	
A45	A	14	
Q30	A	14	
S19A	A	14	
A53	B	12	
C09	B	12	
K03	B	12	
K04	B	12	
S25	A	12	
A15	A	9	
NI02	A	9	
A54	A	8	
A56	A	8	
C08	A	8	
C08A	A	8	
NI05	A	8	
Q34	A	8	
Q35	A	8	
A59	None	N/A	
S05A	None	N/A	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

Color Coding for Risk Assignment column

101-125	*High*
76-100	*Medium High*
51-75	*Medium*
26-50	*Low-Medium*
5-25	*Low*

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
S22S231	**C**	4	5	23	92	115	3rd Street
S22S232	**C**	4	5	23	92	115	3rd Street
S31S321	**C**	4	5	22	88	110	3rd Street
S47S481	**C**	4	5	21	84	105	3rd Street
S48S491	**C**	4	5	21	84	105	3rd Street
S49S501	**C**	4	5	21	84	105	3rd Street
N34N351	**C**	5	6	17	85	102	
S50S511	B	4	5	20	80	100	3rd Street
S15S161	**C**	4	5	20	80	100	
S57S581	B	4	5	19	76	95	3rd Street
S60AS611	B	4	5	19	76	95	Wood Street
S61S621	B	4	5	19	76	95	Wood Street
N27N281	**C**	4	5	19	76	95	
S14S151	**C**	4	5	19	76	95	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
S55S561	B	4	5	18	72	90	3rd Street
S56S571	B	4	5	18	72	90	3rd Street
SACDIVSC11	**C**	4	5	18	72	90	3rd Street
SC1S431	**C**	4	5	18	72	90	3rd Street
S59S601	B	4	5	17	68	85	3rd Street
S09S101	**C**	4	5	17	68	85	
S54S551	**C**	4	5	17	68	85	3rd Street
S01S021	B	3	4	21	63	84	
S64S651	B	4	5	16	64	80	Wood Street
S02S031	B	3	4	20	60	80	
S03S041	B	3	4	20	60	80	
S36BS37A2	B	3	4	20	60	80	
S65S661	**C**	4	5	16	64	80	Wood Street
S66S671	**C**	4	5	16	64	80	Wood Street
S68S691	**C**	4	5	16	64	80	Wood Street
S62S631	B	4	5	15	60	75	Wood Street
S63S641	B	4	5	15	60	75	Wood Street
A17A181	**C**	4	5	15	60	75	Alameda
A41A421	**C**	4	5	15	60	75	Alameda
A42A441	**C**	4	5	15	60	75	Alameda
N16N171	B	3	4	18	54	72	
N20N211	B	3	4	18	54	72	
N39N401	B	3	4	18	54	72	
N40N40A1	B	3	4	18	54	72	
S32S331	B	3	4	18	54	72	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
S51S521	B	3	4	18	54	72	3rd Street
S52S531	B	3	4	18	54	72	3rd Street
S53S541	B	3	4	18	54	72	3rd Street
A18A191	B	4	5	14	56	70	Alameda
A19A201	B	4	5	14	56	70	Alameda
S58S591	B	4	5	14	56	70	3rd Street
A20A211	**C**	4	5	14	56	70	Alameda
A21A221	**C**	4	5	14	56	70	Alameda
A23A241	**C**	4	5	14	56	70	
A27A281	**C**	4	5	14	56	70	
A28A291	**C**	4	5	14	56	70	
S25S261	**C**	4	5	14	56	70	
N28N291	B	3	4	17	51	68	
N33N341	B	3	4	17	51	68	
S60S60A1	B	3	4	17	51	68	
S69S701	B	3	4	17	51	68	
S11S121	A	2	3	22	44	66	
A29A301	**C**	4	5	13	52	65	
A31A321	**C**	4	5	13	52	65	
A32A331	**C**	4	5	13	52	65	
A35A361	**C**	4	5	13	52	65	
S29S311	**C**	4	5	13	52	65	
N29N301	B	3	4	16	48	64	
N41AN421	B	3	4	16	48	64	
S33S351	A	2	3	21	42	63	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
S44S44A1	A	2	3	21	42	63	
N37N381	A	2	3	20	40	60	
S04S051	A	2	3	20	40	60	
AD19AD181	B	3	4	15	45	60	
AD20AD191	B	3	4	15	45	60	
N30N311	B	3	4	15	45	60	
N31N321	B	3	4	15	45	60	
N32N331	B	3	4	15	45	60	
N40AN411	B	3	4	15	45	60	
N41N41A1	B	3	4	15	45	60	
MC1M051	**C**	5	6	10	50	60	Versailles
A39A401	**C**	4	5	12	48	60	
A38A391	**C**	4	5	12	48	60	
A37A381	**C**	4	5	12	48	60	
S05AS06	A	2	3	19	38	57	
S05S05A1	A	2	3	19	38	57	
S07S081	A	2	3	19	38	57	
S16S16A1	A	2	3	19	38	57	
S39S401	A	2	3	19	38	57	
A25A261	B	3	4	14	42	56	
A26A271	B	3	4	14	42	56	
A44A451	B	3	4	14	42	56	
S23S241	B	3	4	14	42	56	
A24A251	B	3	4	14	42	56	
A45AA461	**C**	4	5	11	44	55	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
N21N221	A	2	3	18	36	54	
N26N271	A	2	3	18	36	54	
N38N391	A	2	3	18	36	54	
S08S091	A	2	3	18	36	54	
S41S421	A	2	3	18	36	54	
A30A311	B	3	4	13	39	52	
A34A351	B	3	4	13	39	52	
N10N111	B	3	4	13	39	52	
S06S071	B	3	4	13	39	52	
AD03AD021	A	2	3	17	34	51	
S12S131	A	2	3	17	34	51	
S13S141	A	2	3	17	34	51	
S16AS171	A	2	3	17	34	51	
S26S271	A	2	3	17	34	51	
S37BS381	A	2	3	17	34	51	
S38S391	A	2	3	17	34	51	
S40S411	A	2	3	17	34	51	
S44AS451	A	2	3	17	34	51	
S46AS471	A	2	3	17	34	51	
A46AA471	A	4	5	10	40	50	Alameda
N14N151	**C**	4	5	10	40	50	
S21S221	**C**	4	5	10	40	50	
AD07AD061	A	2	3	16	32	48	
N04N051	A	2	3	16	32	48	
S10S111	A	2	3	16	32	48	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
S27S281	A	2	3	16	32	48	
S45S46A1	A	2	3	16	32	48	
A45A45A1	B	3	4	12	36	48	
P05P041	B	3	4	12	36	48	
AD08ADB1	A	2	3	15	30	45	
AD21AD201	A	2	3	15	30	45	
ADBAD071	A	2	3	15	30	45	
ADCAD211	A	2	3	15	30	45	
C08AC091	A	2	3	15	30	45	
N35AN361	A	2	3	15	30	45	
N35N35A1	A	2	3	15	30	45	
A07A081	**C**	4	5	9	36	45	
A04A051	B	3	4	11	33	44	
A61MC11	B	3	4	11	33	44	
AD18AD171	B	3	4	11	33	44	
N11N121	B	3	4	11	33	44	
N15N161	B	3	4	11	33	44	
N43N441	B	3	4	11	33	44	
N44N451	B	3	4	11	33	44	
A15A161	A	2	3	14	28	42	
A22A231	A	2	3	14	28	42	
AD04ADA1	A	2	3	14	28	42	
AD06AD051	A	2	3	14	28	42	
AD12AD111	A	2	3	14	28	42	
ADAAD031	A	2	3	14	28	42	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
C06C071	A	2	3	14	28	42	
N22N231	A	2	3	14	28	42	
N23N241	A	2	3	14	28	42	
N24N251	A	2	3	14	28	42	
N25N261	A	2	3	14	28	42	
Q21Q221	A	2	3	14	28	42	
Q21Q222	A	2	3	14	28	42	
S17S181	A	2	3	14	28	42	
S35S36A1	A	2	3	14	28	42	
T02T011	A	2	3	14	28	42	
A46A46A1	B	3	4	10	30	40	
ADDN461	B	3	4	10	30	40	
N12N131	B	3	4	10	30	40	
A13A141	**C**	4	5	8	32	40	
A33A341	A	2	3	13	26	39	
C04C051	A	2	3	13	26	39	
N03N041	A	2	3	13	26	39	
N07N081	A	2	3	13	26	39	
N08N091	A	2	3	13	26	39	
S28S291	A	2	3	13	26	39	
AD05AD041	A	2	3	12	24	36	
N06N071	A	2	3	12	24	36	
N09N101	A	2	3	12	24	36	
N18N191	A	2	3	12	24	36	
P02P011	A	2	3	12	24	36	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
P03P021	A	2	3	12	24	36	
P04P031	A	2	3	12	24	36	
S18AS191	A	2	3	12	24	36	
S18S18A1	A	2	3	12	24	36	
A05A061	B	3	4	9	27	36	
A06PSB1	B	3	4	9	27	36	
MC1A621	B	3	4	9	27	36	
AD09AD081	A	2	3	11	22	33	
AD10AD091	A	2	3	11	22	33	
AD11AD101	A	2	3	11	22	33	
AD13AD121	A	2	3	11	22	33	
AD14AD131	A	2	3	11	22	33	
AD15AD141	A	2	3	11	22	33	
AD16AD151	A	2	3	11	22	33	
AD17AD161	A	2	3	11	22	33	
C03C041	A	2	3	11	22	33	
N05N061	A	2	3	11	22	33	
N45N461	A	2	3	11	22	33	
Q22Q231	A	2	3	11	22	33	
Q24Q251	A	2	3	11	22	33	
T01S181	A	2	3	11	22	33	
S67S681	A	1	2	16	16	32	
A01A021	B	3	4	8	24	32	
A02A031	B	3	4	8	24	32	
A03A041	B	3	4	8	24	32	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
A08A091	B	3	4	8	24	32	
A54A551	B	3	4	8	24	32	
A55A561	B	3	4	8	24	32	
A56A571	B	3	4	8	24	32	
A57A581	B	3	4	8	24	32	
S20PSH1	B	3	4	8	24	32	
S24S251	B	3	4	8	24	32	
A47A481	A	2	3	10	20	30	
AI03AI041	A	2	3	10	20	30	
F05F041	A	2	3	10	20	30	
N02N031	A	2	3	10	20	30	
N13AN141	A	2	3	10	20	30	
N13N13A1	A	2	3	10	20	30	
N17N181	A	2	3	10	20	30	
NI02Q36A1	A	2	3	10	20	30	
NI04P051	A	2	3	10	20	30	
NI05NI04	A	2	3	10	20	30	
Q16Q171	A	2	3	10	20	30	
Q17Q181	A	2	3	10	20	30	
Q18Q191	A	2	3	10	20	30	
A10A111	B	3	4	7	21	28	
A12A131	B	3	4	7	21	28	
A53A53A1	B	3	4	7	21	28	
A53AA541	B	3	4	7	21	28	
A14A061	A	2	3	9	18	27	

Table A-9: Gravity System Pipe Segments Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	PART OF FY14-23 CIP
AD02AD011	A	2	3	9	18	27	
Q29Q301	A	2	3	9	18	27	
C08C08A1	A	2	3	8	16	24	
A11A121	A	2	3	7	14	21	
C09Q36A1	A	2	3	7	14	21	
K02K031	A	2	3	7	14	21	
Q34Q351	A	2	3	7	14	21	
Q35Q361	A	2	3	7	14	21	
Q36AP051	A	2	3	7	14	21	
Q36Q36A1	A	2	3	7	14	21	

Table A-10: Gravity System Manholes Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

Color Coding for Risk Assignment column

81-100	*High*
61-80	*Medium High*
41-60	*Medium*
21-40	*Low-Medium*
4-20	*Low*

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	Notes
S31	**C**	5	6	19	95	114	3rd Street
S01	B	3	4	25	75	100	
S32	**C**	4	5	19	76	95	3rd Street
S08	**C**	4	5	17	68	85	
S36A	B	4	5	17	68	85	3rd Street
F01	**C**	4	5	16	64	80	
F1A	**C**	4	5	16	64	80	
S02	B	3	4	19	57	76	
S09	B	3	4	19	57	76	
S15	B	3	4	19	57	76	
S40	B	3	4	18	54	72	
N21	B	3	4	17	51	68	
N27	B	3	4	17	51	68	
A49/50	**C**	5	6	11	55	66	
N34	**C**	4	5	13	52	65	
N11	B	3	4	16	48	64	

Table A-10: Gravity System Manholes Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	Notes
A51/52	**C**	5	6	10	50	60	
S43	A	2	3	20	40	60	
S44	A	2	3	20	40	60	
S48	B	3	4	15	45	60	3rd Street
S49	B	3	4	15	45	60	3rd Street
S50	B	3	4	15	45	60	3rd Street
S27	A	2	3	19	38	57	
C01A	B	3	4	14	42	56	
N16	B	3	4	14	42	56	
N17	B	3	4	14	42	56	
A48	B	4	5	11	44	55	Alameda
ADC	**C**	4	5	11	44	55	
F06	**C**	4	5	11	44	55	
F08	**C**	4	5	11	44	55	
F19	**C**	4	5	11	44	55	
F20	**C**	4	5	11	44	55	
F21	**C**	4	5	11	44	55	
P04	**C**	4	5	11	44	55	
S26	**C**	4	5	11	44	55	
S36B	B	4	5	11	44	55	3rd Street
S42	**C**	4	5	11	44	55	3rd Street
S51	**C**	4	5	11	44	55	3rd Street
S61	**C**	4	5	11	44	55	Wood Street
N38	B	3	4	13	39	52	
S16	B	3	4	13	39	52	

Table A-10: Gravity System Manholes Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	Notes
S47	B	3	4	13	39	52	3rd Street
N28	A	2	3	17	34	51	
N29	A	2	3	17	34	51	
S52	**C**	4	5	10	40	50	3rd Street
S56	**C**	4	5	10	40	50	3rd Street
S57	**C**	4	5	10	40	50	3rd Street
N04	B	3	4	12	36	48	
N22	A	2	3	16	32	48	
N23	B	3	4	12	36	48	
N25	B	3	4	12	36	48	
N32	B	3	4	12	36	48	
N33	B	3	4	12	36	48	
S03	A	2	3	16	32	48	
S23	B	3	4	12	36	48	3rd Street
S46	B	3	4	12	36	48	
A41	**C**	4	5	9	36	45	Alameda
A42	**C**	4	5	9	36	45	Alameda
NF05	**C**	4	5	9	36	45	
S54	**C**	4	5	9	36	45	3rd Street
S55	**C**	4	5	9	36	45	3rd Street
S60A	**C**	4	5	9	36	45	
F11	B	3	4	11	33	44	
N19	B	3	4	11	33	44	
N20	B	3	4	11	33	44	
P03	B	3	4	11	33	44	

Table A-10: Gravity System Manholes Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	Notes
S10	B	3	4	11	33	44	
S11	B	3	4	11	33	44	
S22	B	3	4	11	33	44	3rd Street
S28	B	3	4	11	33	44	
S29	B	3	4	11	33	44	
S38	B	3	4	11	33	44	
S45	B	3	4	11	33	44	
A36	**C**	5	6	7	35	42	Alameda
AI01A	A	2	3	14	28	42	
A16	**C**	4	5	8	32	40	
A17	**C**	4	5	8	32	40	
A18	B	3	4	10	30	40	
A23	**C**	4	5	8	32	40	
A25	**C**	4	5	8	32	40	Alameda
A28	**C**	4	5	8	32	40	Alameda
A61	**C**	4	5	8	32	40	
AD05	**C**	4	5	8	32	40	
AD06	**C**	4	5	8	32	40	
AD10	**C**	4	5	8	32	40	
AD11	**C**	4	5	8	32	40	
AD17	**C**	4	5	8	32	40	
M09	**C**	4	5	8	32	40	Versailles
N15	B	3	4	10	30	40	
N26	B	3	4	10	30	40	
N35A	**C**	3	4	10	30	40	

Table A-10: Gravity System Manholes Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	Notes
N42	**C**	4	5	8	32	40	
S07	B	3	4	10	30	40	
S13	B	3	4	10	30	40	
S17	B	3	4	10	30	40	
S18	B	3	4	10	30	40	
S66	**C**	4	5	8	32	40	Wood Street
N30	A	2	3	13	26	39	
S12	A	2	3	13	26	39	
A05	A	2	3	12	24	36	
A20	B	3	4	9	27	36	
A40	**C**	5	6	6	30	36	Alameda
A43	B	3	4	9	27	36	
A44	B	3	4	9	27	36	
N12	B	3	4	9	27	36	
N13	B	3	4	9	27	36	
N14	B	3	4	9	27	36	
N18	B	3	4	9	27	36	
N24	A	2	3	12	24	36	
N31	B	3	4	9	27	36	
N36	A	2	3	12	24	36	
N39	A	2	3	12	24	36	
T01	A	2	3	12	24	36	
A30	**C**	4	5	7	28	35	Alameda
A31	**C**	4	5	7	28	35	Alameda
A32	**C**	4	5	7	28	35	

Table A-10: Gravity System Manholes Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	Notes
A34	**C**	4	5	7	28	35	Alameda
A35	B	4	5	7	28	35	Alameda
A59A	**C**	4	5	7	28	35	
NF04	**C**	4	5	7	28	35	
NI03	**C**	4	5	7	28	35	
S05	**C**	4	5	7	28	35	
S62	**C**	4	5	7	28	35	Wood Street
S63	**C**	4	5	7	28	35	Wood Street
S64	**C**	4	5	7	28	35	Wood Street
A01	B	3	4	8	24	32	
A02	B	3	4	8	24	32	
A03	B	3	4	8	24	32	
A13	B	3	4	8	24	32	
A19	B	3	4	8	24	32	
A21	B	3	4	8	24	32	
A22	B	3	4	8	24	32	
A24	B	3	4	8	24	32	
A26	B	3	4	8	24	32	
A29	B	3	4	8	24	32	
K05	B	3	4	8	24	32	
N03	B	3	4	8	24	32	
S21	B	3	4	8	24	32	
S35	B	3	4	8	24	32	
S65	B	3	4	8	24	32	Wood Street
A06	A	2	3	10	20	30	

Table A-10: Gravity System Manholes Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	Notes
A37	**C**	4	5	6	24	30	
A38	**C**	4	5	6	24	30	
A39	**C**	4	5	6	24	30	
AI04	A	2	3	10	20	30	
M01	**C**	4	5	6	24	30	Versailles
M07	**C**	4	5	6	24	30	Versailles
M08	**C**	4	5	6	24	30	Versailles
N09	A	2	3	10	20	30	
N35	A	2	3	10	20	30	
Q25	A	2	3	10	20	30	
S14	A	2	3	10	20	30	
S24	**C**	4	5	6	24	30	
S59	**C**	4	5	6	24	30	3rd Street
A33	B	3	4	7	21	28	
S06	B	3	4	7	21	28	
A14	A	2	3	9	18	27	
NF06	A	2	3	9	18	27	
A46A	B	4	5	5	20	25	Alameda
A47	**C**	4	5	5	20	25	Alameda
AD01	**C**	4	5	5	20	25	
AD02	**C**	4	5	5	20	25	
ADE	**C**	4	5	5	20	25	
ADG	**C**	4	5	5	20	25	
N46	**C**	4	5	5	20	25	
A04	A	2	3	8	16	24	

Table A-10: Gravity System Manholes Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	Notes
A11	A	2	3	8	16	24	
A12	A	2	3	8	16	24	
A57	B	3	4	6	18	24	
AD04	A	2	3	8	16	24	
M06	B	3	4	6	18	24	Versailles
M06A	B	3	4	6	18	24	Versailles
P05	B	2	3	8	16	24	
S67	A	2	3	8	16	24	
A45	A	2	3	7	14	21	
Q30	A	2	3	7	14	21	
S19A	A	2	3	7	14	21	
A58	B	3	4	5	15	20	
ADD	B	3	4	5	15	20	
M02	**C**	4	5	4	16	20	Versailles
Q36A	**C**	4	5	4	16	20	
A15	A	1	2	9	9	18	
NI02	A	1	2	9	9	18	
S25	A	2	3	6	12	18	
A53	B	3	4	4	12	16	
C09	B	3	4	4	12	16	
K03	B	3	4	4	12	16	
K04	B	3	4	4	12	16	
A54	A	2	3	4	8	12	
A56	A	2	3	4	8	12	
C08	A	2	3	4	8	12	

Table A-10: Gravity System Manholes Ranked by Hypothetical 2021 Risk if 2021 Condition One Grade Worse than 2011

ASSET ID	CURRENT CONDITION	LIKELIHOOD	HYPOTHETICAL 2021 LIKELIHOOD	CONSEQUENCE	RISK	HYPOTHETICAL 2021 RISK	Notes
C08A	A	2	3	4	8	12	
NI05	A	2	3	4	8	12	
Q34	A	2	3	4	8	12	
Q35	A	2	3	4	8	12	
A59	None	None	N/A	7	N/A	N/A	
S05A	None	None	N/A	13	N/A	N/A	

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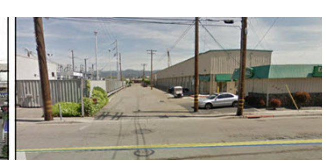
Interceptor Corrosion Prevention Study Report

March 2014

Consequence of Failure (Flow in MGD)				
	10 - 15		HS 7 (13.5 million gallons per day [MGD], 27 years)	
	5 - 10	HS 6 (5.5 MGD, 37 years)		HS 1 (9.8 MGD, 9 years)
	<5			HS 4 (3.8 MGD, 12 years)
		30 - 40+	15 - 30	< 15
		Likelihood of Failure (Years to Rehabilitation)		



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Oakland, CA

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Interceptor Corrosion Prevention Study Report

Prepared for

East Bay Municipal Utility District

Oakland, CA

March 2014

Charles W. Joyce

CA License No. C33165

David W. McEwen

CA License No. 69475

BC Project No. 144408

Brown AND Caldwell

201 North Civic Drive, Suite 115

Walnut Creek, CA 94596

Phone: 925.937.9010

Fax: 925.937.9026

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ASCE	American Society of Civil Engineers
Ave Day	average day
BOD	biochemical oxygen demand
BC	Brown and Caldwell
CIP	Capital Improvement Plan
CIPP	cured in place pipe
District	East Bay Municipal Utility District
DO	dissolved oxygen
FY	fiscal year
H_2S	hydrogen sulfide
HS	hot spot
IDAP	Interceptor Damage Assessment Project
M	million
MGD	million gallons per day
mg/L	milligrams per liter
MOP-69	Manual of Practive Number 69
MWWTP	main waste water treatment plant
O&M	operations and maintenance
OCMP	Odor Control Master Plan
ppmv	part per million by volume
TM	technical memorandum
V&A	Villalobos and Associates
VCP	vitrified clay pipe

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Section 1

Introduction

This section provides a summary of the tasks that make up Task B - Interceptor Corrosion Prevention Study of the scope of work described in the agreement between V&A Consulting Engineers (V&A) and East Bay Municipal Utility District (District) dated March 2013.

1.1 Project Overview

In Task B, Brown and Caldwell (BC) analyzed the District's wastewater interceptor system and industry-standard corrosion control and prevention methods. This work is part of a larger project being completed in conjunction with V&A Consulting Engineers. In Task A, V&A investigated the condition of the District's wastewater pump station discharge pipelines and portions of the gravity interceptor system.

The two primary purposes of Task B are as follows:

- Identify "hot spot" areas – sequences of reaches between manholes – within the interceptor system that currently have high levels of corrosion or a high potential for corrosion, as indicated by the 2010-2012 Condition Assessment and historical and newly collected field sulfide data.
- Analyze and review corrosion control methods for each identified hot spot and provide recommendations for protection through a 50-year life cycle.

This study focused on the North, South, and Alameda interceptors as noted in in Figure 1-1. The North-Adeline and South-Foothill interceptors were not investigated in this study. The North-Adeline Interceptor has no evidence of sever corrosion, and the South-Foothill Interceptor has corrosion barrier protection in place.

1.2 Technical Memoranda Scope of Services

This report addresses Task B.4 (Study Report) and summarizes work completed in Task B.1, B.2 and B.3, as presented in technical memorandum (TM) B.2 "Initial Interceptor Corrosion Control Preliminary Assessment" (October 10, 2013) and TM B.3 "Interceptor Corrosion Prevention Methods and Applications Evaluation" (February 7, 2014). The following outlines the major scope items that were addressed in each task and identifies the section that addresses each task item in the previous TMs:

Task B.1: Data Collection and Review

- Compilation of historical data associated with corrosion-related parameters, including liquid-phase sulfide concentrations, gas-phase hydrogen sulfide (H_2S) concentrations, pH, biochemical oxygen demand (BOD), temperature, and dissolved oxygen (DO). Historical data is analyzed in TM B.2 and is summarized in TM B.2 Attachment C.
- Identification of data gaps which were addressed in the Fall 2013 field sampling program. Data gaps are discussed in TM B.2 Section 2.3.

Task B.2: Initial Review of Methods and Applications

- Identification of corrosion "hot spots," which are defined as interceptor areas of either (1) high historical liquid-phase sulfide or gas-phase H_2S concentrations, as determined following analysis of data provided by the District and in the 2009 Interceptor Model, or (2) areas where pipe reaches were designated as Pipe Severity Group "C" or "D" in the 2010-2012 Condition Assessment. Initial hot spot identification is discussed in TM B.2 Section 2.2.

- Compilation of additional sampling needs to further confirm or evaluate candidate hot spot areas and development of a field data collection plan to be executed in Task B.3. This is discussed in TM B.2 Section 2.3.
- Comparison and preliminary evaluation of industry-standard corrosion control technologies that could be used in the District interceptor system. Technologies evaluated included liquid-phase treatment (chemical or oxygen addition) and operation and maintenance (O&M) near-term activities whose intention is to extend the life of the pipe, and rehabilitation efforts, which would include either installation of a physical barrier or pipe replacement. This evaluation is discussed in TM B.2 Section 3.
- Preliminary analysis of hot spots that do not have a designated rehabilitation effort planned for them and recommendations of near-term and rehabilitation corrosion control options that are further evaluated in TM B.3. This analysis is presented in TM B.2 Section 4.

Task B.3: Analyze and Review Methods and Applications

- Completion of a sampling program to address data gaps (completed in September of 2013), and a discussion of the sampling results and how they differ from the historical data. The sampling program is reviewed and the results are summarized in TM B.3 Section 2.
- Completion of an updated sulfide accumulation model and calibration to the 2013 field sampling results. The model was based on hydraulic data that was included in the previous version of the model (the 2009 Interceptor Model produced as part of the 2009 Odor Control Master Plan Update) and included data from the Info Net database and flows from the 2010 dynamic hydraulic model. The updated model is discussed in TM B.3 Section 3 and plots are provided in Attachment B.
- Updating the list of hot spots based on results of the sampling and from the baseline sulfide accumulation model. This analysis is discussed in TM B.3 Section 4.
- Final analysis of the hot spots that do not have a designated rehabilitation effort planned for them and recommendations of near-term and rehabilitation corrosion control options. This analysis includes calculation of remaining pipe life within the hot spots and life cycle costs of corrosion control options. This analysis is discussed in TM B.3 Section 4 and Attachment C.
- Discussion of recommended means for monitoring the effectiveness of the recommended system for corrosion control. This discussion is provided in TM B.3 Section 5.
- Listing of recommended corrosion control approaches for each of the hot spots analyzed during the project and potential alternate approaches that may be considered by the District. This is provided in a table located in TM B.3 Section 5.

1.3 Report Outline

This Task B.4 report contains the following sections:

- Section 1 provides an introduction to this report and summarizes major scope items for Task B.
- Sections 2 and 3 of this report summarize the initial work done for Tasks B.1 and B.2. Major scope items discussed include the means by which the hot spots were identified (Section 2) and the preliminary recommendations for corrosion control for each hot spot (Section 3)
- Sections 4 and 5 summarize work completed for Task B.3. Section 4 discusses the production of the updated sulfide accumulation model and corrosion calculations; Section 5 provides a summary of the corrosion assessment and conceptual cost calculations, including recommended approaches for each hot spot.

- Sections 6 and 7 summarize work completed for Task B.4, which includes development of a risk assessment matrix and review of recommended approaches and costs for each hot spot.

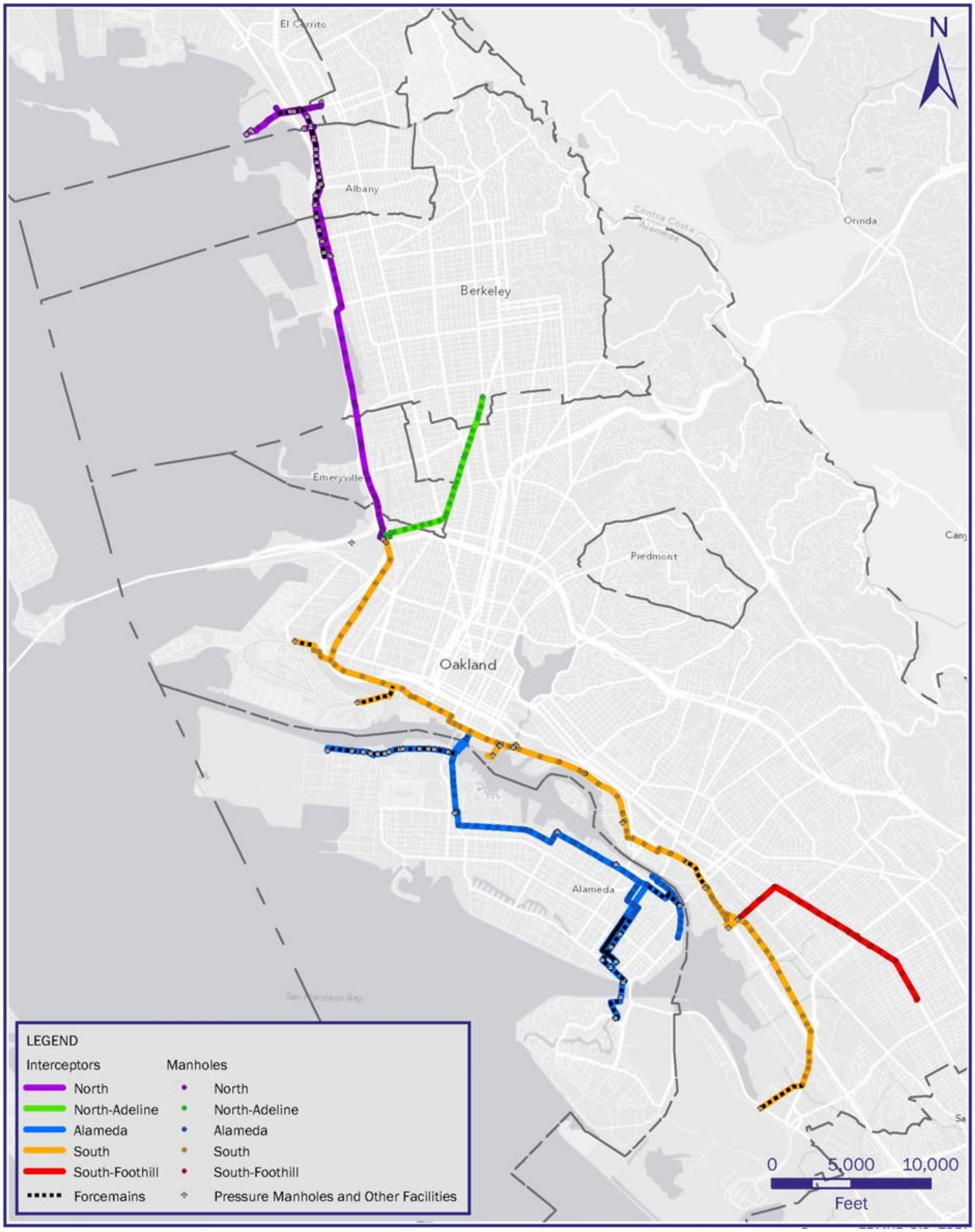

Figure 1-1. Overview of the District Interceptor System

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Section 2

Hot Spot Identification

2.1 Historical Interceptor Liquid Sulfide and H_2S Concentrations

In the initial interceptor corrosion control evaluation, historical data was reviewed from the following reports, each of which contains references to field measurements of either liquid-phase sulfide concentration and/or gas-phase H_2S concentration in the District's interceptor system:

- 1996 Interceptor Odor Control Study: included field sampling conducted in 1995 and an evaluation of various chemical treatment alternatives. The goal of the study was to minimize sulfide loading into the Main Wastewater Treatment Plant (MWWTP) influent pump station.
- 1997 Interceptor Damage Assessment Project (IDAP): included field sampling for liquid sulfides and a condition assessment of all manholes and pipe reaches in the District's interceptor system.
- 1998 MWWTP Odor Control Master Plan (OCMP): included new sulfide accumulation and H_2S emission modeling using the CH2M HILL Interceptor Model. Sampling data from the 1997 IDAP was used to calibrate the model.
- 2009 MWWTP Odor Control Master Plan Update: included limited sampling of wastewater for liquid sulfide concentrations and continuous H_2S monitoring at several manholes using OdaLog data loggers. Using the collected data, the 1998 CH2M HILL Interceptor model was updated.
- 2010-2012 Interceptor Condition Assessment: included a corrosion evaluation of manholes and pipe reaches on a severity of damage scale in which an "A" rating was given to a manhole or pipe reach that was in excellent condition, and a "D" rating was given to one that required immediate attention. The Pipe Severity "D" rated locations are scheduled to be rehabilitated in the current District capital improvement program (CIP). Clear non-corrosion related damage to manholes and pipes were not included in this data review.

Appendix C of TM B.2 provides a table of data compiled from this study, and Section 2 of TM B.2 provides details of the historical data analysis.

2.2 Additional Data Collection

Data gaps were noted based on the review of sources listed above, in particular for liquid-phase sulfide and gas-phase H_2S concentrations in the three analyzed interceptors. Data gaps were noted for areas that met at least one of the following criteria:

- For reaches ascribed Pipe Severity "C" or "D" for corrosion in the 2010-2012 Condition Assessment and did not have any historical or recent liquid-phase sulfide and gas-phase H_2S data.
- For manholes and reaches where historical gas-phase H_2S data did not correlate with corresponding historical liquid-phase sulfide data.
- For reaches where historical liquid-phase sulfide or gas-phase H_2S data did not correlate with findings from the 2010-2012 Condition Assessment.

A field sampling program at key points along the three interceptors was developed to address the data gaps in the historical record that was reviewed for Task B.1 and B.2. Section 2 of TM B.3 discusses the details of the data collection protocol and results.

2.3 Areas of Corrosion Concern

Based on the review of historical data and the 2009 Interceptor Model, corrosion hot spots were identified for the North, Alameda, and South Interceptors. Hot spots represent interceptor pipe locations (multiple reaches of sequential nodes) in the system in which significant corrosion has either already been identified in the 2010-2012 Interceptor Condition Assessment (pipe severity groups “C” or “D”) or in which there is significant potential for future corrosion in the pipe based upon historical measured liquid-phase sulfide and/or gas-phase H_2S concentrations.

Table 2-1 lists the identified hot spots and the corrosion severity level, and Figure 2-1 shows the location of the identified hot spots in the interceptor system TM B.2 Section 2.2 provides more information on the identified hot spots.

Table 2-1. Corrosion Hot Spots

Hot Spot (HS)	Location (Nodes)		Pipe Corrosion Severity Level	
	Upstream	Downstream	Liquid-Phase	Gas-Phase
HS1	N31	N35	Moderate-High	Low
HS2	M01	M10	High	High
HS3	A17	A21	Moderate – High	High
HS4	A21	A46a	High	High
HS5	A46a	S47	High	High
HS6	S09	S16	Moderate	Moderate - High
HS7	S21	S31	Low	High
HS8	S47	S50	Moderate-High	High
HS9	S54	S57	High	High

For the liquid-phase entries in Table 2-1, severity levels are defined as follows:

- Low – Less than 0.5 milligrams per liter (mg/L) dissolved sulfides concentration
- Medium – 0.5-1.0 mg/L dissolved sulfides concentration
- High – Greater than 1.0 mg/L dissolved sulfides concentration

For the gas-phase entries in Table 2-1, severity levels are defined as follows:

- Low – Less than 2 parts per million by volume (ppmv) H_2S
- Medium – 2-5 ppmv H_2S
- High – Greater than 5 ppmv H_2S

The highlighted rows indicate hot spots that have planned rehabilitation and therefore were not analyzed in the corrosion calculations and life-cycle analysis. Note that the list does not include the following three identified high-sulfide, high-corrosion areas for the reasons stated:

1. The section of the North Interceptor from NF07 to NF04; this section of pipe is constructed with vitrified clay pipe (VCP).
2. The Buchanan Street segment of the North Interceptor from Manhole NF04 to Manhole NF01; this section of pipe was rehabilitated in 2012.
3. The section of the South Interceptor from Manhole S60 to the MWWTP; this section is currently undergoing rehabilitation with a plastic barrier.

Figure 2-1. Identified Interceptor Hot Spots

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Section 3

Initial Review of Methods

3.1 Corrosion Control Methods

TM B.2, Section 3 presents an overview of corrosion control methods considered to be industry standard and have the potential to be incorporated into portion(s) of the District's interceptor system. The methods discussed have all been successful in similar applications. The overview is subdivided into three categories as follows:

Liquid-Phase Treatment Methods

- Chlorine Gas
- Hypochlorite Solution
- Hydrogen Peroxide
- Iron Salts
- Nitrate Solution
- pH Adjustment
- Oxygen Injection (Superoxygenation)

Pipe Replacement, Physical Barriers, and Modifications

- Replacement
- Cured-In-Place Pipe (CIPP)
- Sliplining
- Plastic Lining
- Spiral Wound Liner
- Coatings

O&M Methods

- Caustic Slug Dosing
- Crown Spraying
- Cleaning

Of the methods listed above, three were eliminated from further consideration. Chlorine gas was not considered feasible for the District's interceptor applications due to high projected costs and safety concerns. It was determined that application of coatings for corrosion prevention did not have a sufficiently successful history for use in interceptor pipes (application in manholes does have some success in recent work). Finally, it was determined that cleaning of interceptor lines as an O&M method did not provide enough corrosion potential reduction to be recommended alone as a method.

3.2 Review of Corrosion Control Methods

Potential corrosion control methods for each potential hot spot were reviewed based on criteria that were agreed upon between BC, V&A, and the District. The criteria used included corrosion control effectiveness, constructability, community benefit/impacts, ease of maintenance, hazards/handling requirements, capacity impacts, projected operating cost, and projected capital cost.

Corrosion control methods were evaluated for each hot spot by assigning a rating from 1 to 5 for each criterion, with 5 being the best rating and 1 the worst. For example, for the criterion "Corrosion Control Effectiveness," a rating of 5 would indicate that the method is highly effective at keeping corrosion at a minimum over the course of the 50-year life cycle, whereas a rating of 1 would indicate the method is not effective. The detailed analysis of corrosion control methods for each hot spot is presented in TM B.2 Section 4.3, and the evaluation matrices are provided in Attachment D.

Following completion of the ratings evaluation for each hot spot, preliminary costs for each method were determined for the hot spots. The combination of those projected costs and the criteria evaluation produced preliminary corrosion control recommendations for hot spots not already associated with a rehabilitation project. Table 3-1 summarizes the preliminary corrosion control methods recommended for additional evaluation for each hot spot.

Table 3-1. Corrosion Hot Spots and Task B.2 Preliminary Recommendations

Hot Spot (HS)	Location (Nodes)		Corrosion Control Methods		Additional Sampling Locations
	Upstream	Downstream	Planned	Recommended	
North Interceptor					
HS1	N31	N35	None	Ferrous Chloride injection (near-term) Caustic slug dosing (near-term) Sliplining/Plastic Liner (future)	Manhole N34
Alameda Interceptor					
HS2	M01	M10	Corrosion barrier to be installed (FY14-16)	N/A	Manhole M02
HS3	A17	A21	Corrosion barrier to be installed (FY15-16)	N/A	Manhole A17
HS4	A21	A46a	Corrosion barrier to be installed between A40 and A41 (FY15-16)	Ferrous Chloride injection (near-term) Caustic Slug Dosing (near-term) Sliplining/ Plastic Liner (future) Crow Spraying (near-term) Oxygen Injection (near-term)	Manhole A39
HS5	A46a	S47	Corrosion barrier to be installed between A46a and A49 (FY15-16)	N/A	Manhole A48

Table 3-1. Corrosion Hot Spots and Task B.2 Preliminary Recommendations					
Hot Spot (HS)	Location (Nodes)		Corrosion Control Methods		Additional Sampling Locations
	Upstream	Downstream	Planned	Recommended	
South Interceptor					
HS6	S09	S16	None	Ferrous chloride injection (near-term) Caustic Slug Dosing (near-term) Sliplining/ Plastic Liner (future)	Manhole S09
HS7	S21	S31	None	Ferrous Chloride injection (near-term) Oxygen Injection (near-term) Caustic Slug Dosing (near-term) Sliplining/ Plastic Liner (future)	None
HS8	S47	S50	Corrosion barrier to be installed between S47 and S53 (FY15-16)	N/A	Manhole S48 or S49 Manhole A51 or A52
HS9	S54	S57	Corrosion barrier to be installed between S53 and S57 (FY15-16)	N/A	None

The table also includes additional sampling locations that were recommended in Task B.2 for each hot spot. The field sampling was set for September-October 2013, concurrent with field work associated with Task A. Liquid-phase sulfide sampling (grab samples tested using a field kit) and gas-phase H_2S monitoring (using OdaLog data loggers) were conducted to confirm the preliminary assessment of hot spot locations and to calibrate the updated sulfide accumulation model.

The results from Task B.2 matrix development and preliminary costing analysis directed the subsequent analysis in Task B.3. Each corrosion control method that was recommended for additional consideration, as shown in Table 3-1, was then evaluated for effectiveness using results of the updated sulfide accumulation model, corrosion calculations and assessment of remaining pipe life, and a life cycle conceptual cost analysis. This detailed final evaluation was completed as part of Task B.3.

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Section 4

Evaluation of Methods and Applications

This section summarizes the corrosion assessment process, modeling, and calculations discussed in detail in Section 4 of TM B.3.

4.1 Updated Sulfide Accumulation Model

To confirm areas of high corrosion potential and predict the effectiveness of corrosion control methods, a sulfide accumulation model was developed. The model was developed as an update to the CH2M HILL Interceptor Model, which was previously updated as part of the 2009 MWWTP Odor Control Master Plan Update. In Task B.3, the CH2M HILL model was imported into the BC model and expanded to predict the impact of the liquid-phase and O&M corrosion control methods identified for further evaluation on dissolved sulfide and gas-phase H_2S concentrations in the various hot spots.

The updated sulfide model is based on the Pomeroy-Parkhurst sulfide predictive equations for partially filled sewers. The model was calibrated using data collected in the Fall 2013 sampling, updated hydraulic data based on the CH2M HILL Interceptor Model inputs, the District's 2010 hydraulic model, and various historical data as listed in Appendix C of TM B.2. The model was calibrated to match the gas-phase H_2S data in particular, as it directly affects corrosion and more gas-phase H_2S data in the 2013 sampling program (using OdaLogs) than the grab liquid-phase samples. The model assumes a starting liquid-phase sulfide concentration at the furthest upstream node, which is used to calculate dissolved sulfides and gas-phase H_2S concentrations at each subsequent reach throughout each of the three interceptors.

The calibrated model was then used to predict the effectiveness of each potential liquid-phase chemical corrosion control method. Separate analyses were conducted for each corrosion control method as listed in TM B.2, Section 4.3. For each of these analyses, the model predicted liquid-phase sulfides and gas-phase H_2S production downstream and generated plots to help determine the effectiveness of the modeled corrosion control strategy. Each plot is shown in Attachment B of TM B.3. Figures 4-1 and 4-2 show examples of these plots for the South Interceptor.

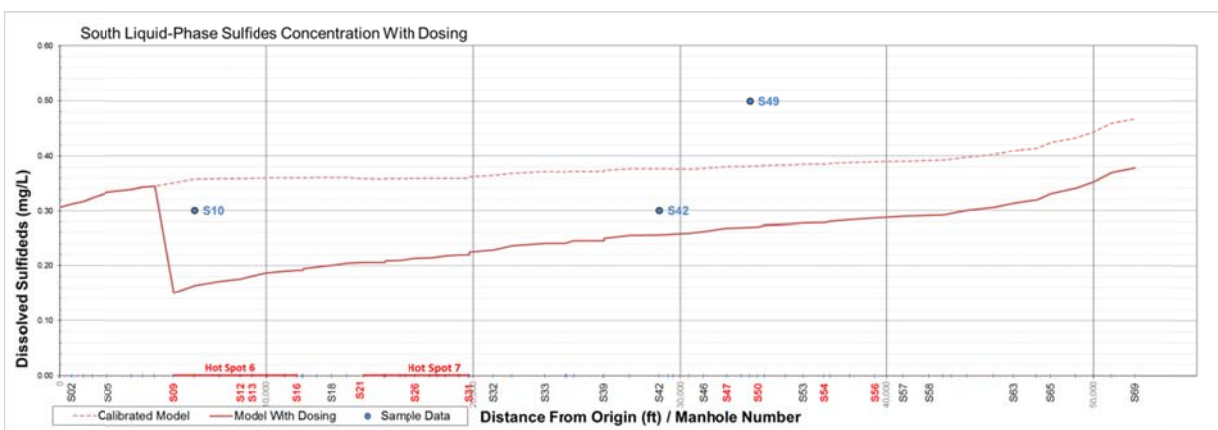

Figure 4-1. South Interceptor Liquid-Phase Sulfide Plot with Chemical Addition at Manhole S08

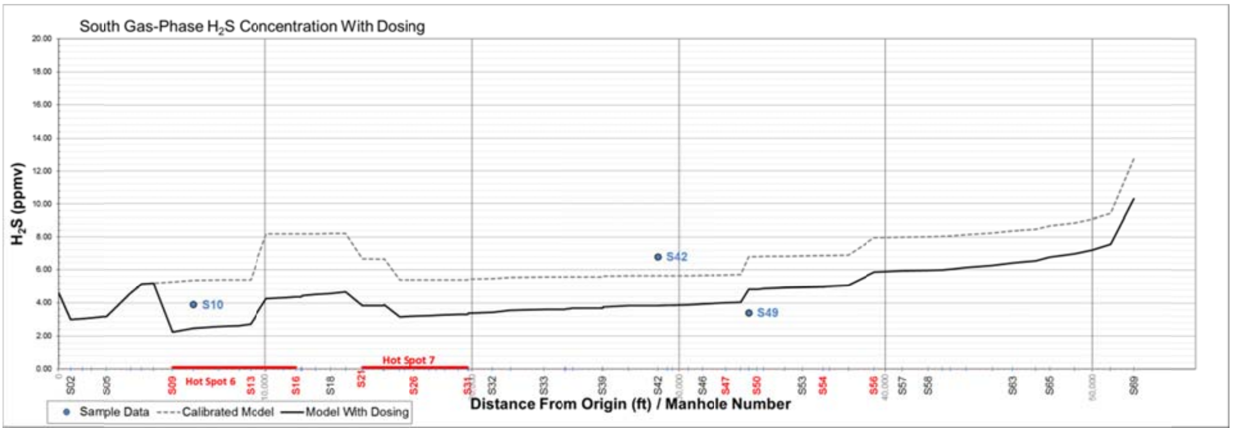

Figure 4-2. South Interceptor Gas-Phase H_2S Plot with Chemical Addition at Manhole S08

4.2 Corrosion Control Method Assessment Process

Of the nine identified hot spots, five have planned rehabilitation projects (as noted in Figure 2-3) to construct protective barriers for corrosion control. As discussed previously, these hot spots were not analyzed further. For each of the remaining four hot spots (HS1, HS4, HS6 and HS7) analyzed in this assessment, the following steps were used to calculate projected corrosion rates, pipe cover loss, and life cycle costs for alternative corrosion control methods:

1. Estimate the current (2013) remaining concrete cover (thickness over reinforcing steel) using the corrosion severity rating assessed in the 2010-2012 Condition Assessment and established thresholds from the 1997 IDAP.
2. Calculate the projected corrosion rate and remaining concrete cover reduction in a 50-year life cycle starting in 2013 using equations in the American Society of Civil Engineers (ASCE) Manual of Practice (MOP) 69.
3. Calculate the projected number of years to imminent pipe failure (corresponding to Pipe Severity Group "D" as defined in the 2010-2012 Condition Assessment) due to corrosion within the 50-year life cycle. For larger interceptor pipes, the Pipe Severity "D" rating corresponds with the time when the remaining pipe cover is reduced to 0.25 inches. A second calculation is also conducted for the less conservative approach of allowing the remaining pipe cover to be reduced to zero inches.
4. Calculate the extension of pipe life achieved by near-term corrosion control methods, which includes either liquid-phase treatment (chemical or oxygen addition) or O&M methods (caustic slug dosing or crown spraying).
5. Calculate life cycle costs of baseline (assuming rehabilitation at 0.25 inches of remaining pipe cover and zero pipe cover) and from applying the various alternative corrosion control options and determine the optimal corrosion control solution and timing of rehabilitation for the hot spot, if needed within the 50-year life cycle. O&M related expenses were assumed to continue until the midpoint of construction, which is assumed to be 5 years.

Section 4.2 of TM B.3 describes the assessment process and associated corrosion calculations and costing in detail. For each hot spot, each of the analyzed corrosion control methods was evaluated to determine the remaining useful life and present worth life cycle cost. These results are summarized in Section 5 of this report and presented in detail in TM B.3 Section 4.3.

Section 5

Findings

Table 5-1 presents an updated summary of potential and recommended (in red) corrosion control approaches for each hot spot based upon the analysis presented in TM B.3. Note that Hot Spots 2, 3, 5, 8 and 9 are not included in the table as they already have planned rehabilitation. A detailed comparison of alternative methods is presented in Section 4.3 of TM B.3.

Table 5-1. Interceptor System Hot Spot Corrosion Findings

Hot Spot (HS)	Remaining Useful Life[a] & Rehab Cost[b]	Corrosion Control Options or Alternative Rehabilitation			
		Option[c]	Description	Useful Life (Yr)	Life Cycle Cost[b]
HS1	9 Years $0.68 M	Rehabilitation	Slipline N34-N35 – Allow concrete cover to reduce to 0 in	17	$0.58 M
		Caustic Slug Dosing	Inject caustic into NF04 every 1-2 weeks for 19 years, then slipline N34-N35	30	$2.67 M
HS4	12 Years $6.82 M	Rehabilitation	Slipline Pipe Severity "C" reaches – Allow concrete cover to reduce to 0 in	23	$5.52 M
		Caustic Slug Dosing	Inject caustic into A21 every 1-2 weeks for 41 years, then slipline "C" reaches	41	$5.49 M
		Crown Spraying	Spray corrosion resistant material into sewer 1-2 times per year for 41 years, then slipline "C" reaches	41	$6.42 M
		Oxygenation	Install oxygen injection into upstream Pump Stations "C" and "M" for 28 years, then slipling "C" reaches.	28	$9.96 M
HS6	37 Years $2.74 M (plastic liner)	Rehabilitation	Install CIPP for pipe Severity "C" reaches instead of plastic liner rehabilitation	37	$2.44 M
		Rehabilitation	Slipline Pipe Severity "C" reaches – Allow concrete cover to reduce to 0 in	50+[d] (74)	None
		Chemical Injection	Inject ferrous chloride into Manhole S08 for 50-year life cycle	50+[d] (110)	$2.63 M
		Caustic Slug Dosing	Inject caustic into S08 every 1-2 weeks for 50-year life cycle	50+[d] (129)	$2.63 M
HS7	27 Years $2.66 M	Rehabilitation	Slipline Pipe Severity "C" reaches – Allow concrete cover to reduce to 0 in	50+[d] (55)	None
		Chemical Injection	Inject ferrous chloride into Pump Station "H" for 50-year life cycle	50+[d] (69)	$4.53 M
		Caustic Slug Dosing	Inject caustic into Pump Station "H" every 1-2 weeks for 50-year life cycle	50+[d] (96)	$5.47 M
		Oxygenation	Oxygen injection into PS "H" for 50-year life cycle	50+[d] (137)	$2.45M

[a]*Remaining life to 0.25 in concrete cover.*

[b]*Rehabilitation costs are in present value (M represents million); rehabilitation costs not included if outside of 50-year life cycle.*

[c]*Chemical injection not recommended for either HS1 or HS4 due to stringent land acquisition requirements and prohibitively high life cycle costs.*

[d]*Rehabilitation not required in 50-year life cycle. (xx) indicates estimated years to rehabilitation.*

Table 5-1 identifies the recommended alternatives for each hot spot, shown in red, and identifies the remaining useful life, after which rehabilitation will begin.

Additionally, for each hot spot, the extension of useful life and reduction in life cycle cost is noted for the rehabilitation options, assuming that rehabilitation is scheduled not upon reaching 0.25 inches of pipe cover (the standard used for the 1997 IDAP), but instead upon reaching 0 inches of pipe cover. This alternative rehabilitation option is presented in this report as part of a sensitivity analysis, where the District may see the greatest potential life extension and cost reduction achievable at a given hot spot, given the least conservative approach.

BC does not recommend allowing pipe cover to be reduced to zero before scheduling rehabilitation for any of the hot spots listed in Table 5-1, as exposure of the rebar that results would highly compromise the strength of the pipe, with greater potential for catastrophic failure. Section 7 provides alternate approaches for Hot Spots 4 and 7 where the pipe cover is allowed to be reduced not to zero, but to a point in between 0 and 0.25 inches which corresponds to a cost break as compared to other viable alternatives. This is presented to the District to provide a potential alternative means of scheduling rehabilitation, though at a higher degree of risk as compared to the recommended alternatives.

Section 6

Risk Assessment

An overview risk assessment has been completed based on the corrosion analysis and current condition assessment information. Figure 6-1 shows a risk assessment matrix for Hot Spots 1, 4, 6, and 7.

Consequence of Failure (Flow in MGD)				
	10 - 15		**HS 7** (13.5 million gallons per day [MGD], 27 years)	
	5 - 10	**HS 6** (5.5 MGD, 37 years)		**HS 1** (9.8 MGD, 9 years)
	<5			**HS 4** (3.8 MGD, 12 years)
		30 - 40+	15 - 30	< 15
		Likelihood of Failure (Years to Rehabilitation)		

Figure 6-1. Risk Assessment Matrix

In the figure, risk is defined by two parameters:

- **Consequence of Failure**: A simplified measure of consequence is based on the wastewater flow, through the hot spot that would have to be managed during a failure. Handling higher flow rates during a failure represents a higher consequence.
- **Likelihood of Failure**: A simplified measure of likelihood of failure is the number of years projected until pipe rehabilitation is needed due to corrosion without any corrosion prevention controls. For this analysis, the number of years is defined as the point when the most vulnerable pipe reach in the hot spot reaches Pipe Severity "D," defined as having 0.25 inches of pipe cover over the reinforcing steel remaining. Less time to rehabilitation is associated with higher risk.

Therefore, the top right box (red shading) in Figure 6-1 would be associated with the highest risk for combined consequence and likelihood, and the lower left box (green shading) would be associated with the lowest risk for combined consequence and likelihood. All four hot spots fall in the yellow boxes, which represent moderate risk. Figure 6-1 was developed using the average flow rate through each hot spot obtained from the District's hydraulic model and the corrosion assessments presented in TM B.3 Section 4. This matrix can be used to help prioritize the implementation of corrosion control strategies for each of the hot spots. Specifically, the matrix shows that considering corrosion control measures for Hot Spots1, 4 and 7 should be a priority of over Hot Spot 6.

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Section 7

Summary of Recommendations

This section presents a discussion of the recommended method of corrosion control for each of the four hot spots that currently do not have a rehabilitation project assigned to them. A preliminary scope, cost estimate, and schedule are provided for each recommendation. A detailed corrosion control calculation set and life cycle cost analysis for each hot spot is presented in TM B.3, Attachment C; total capital and annual O&M costs are summarized in this section. Note that the moderate level of hot spot monitoring costs, as defined in TM B.3 Section 5, have been included in the annual O&M cost calculations.

7.1 Hot Spot 1 – Rehabilitation (Sliplining)

The downstream section of the North Interceptor that passes through Emeryville (N31-N35) is Hot Spot 1. Table 7-1 presents a summary of the analyzed alternative methods for addressing corrosion, as discussed in Section 5 of this report. As noted in the table, chemical injection is not included in this summary, as that option has stringent land acquisition requirements and prohibitively high life cycle costs.

Table 7-1. Interceptor System Hot Spot Corrosion Findings for Hot Spot 1

Remaining Useful Life[a] & Rehab Cost[b]	Corrosion Control Options or Alternative Rehabilitation			
	Option[c]	Description	Useful Life (Yr)	Life Cycle Cost[b]
9 Years $0.68 M	Rehabilitation	Slipline N34-N35 – Allow concrete cover to reduce to 0 in	17	$0.58 M
	Caustic Slug Dosing	Inject caustic into NF04 every 1-2 weeks for 19 years, then slipline N34-N35	30	$2.67 M

[a]*Remaining life to 0.25 in concrete cover.*
[b]*Rehabilitation costs are in present value (M represents million); rehabilitation costs not included if outside of 50-year life cycle.*
[c]*Chemical injection not recommended for HS1 due to stringent land acquisition requirements and prohibitively high life cycle costs.*

As noted in red in Table 7-1, the recommended means of addressing corrosion in this hot spot is to rehabilitate the one Pipe Severity “C” reach (N34-N35) when that reach is projected to be a “D” rating for corrosion, which according to this analysis corresponds to a remaining pipe cover of 0.25 inches. No other corrosion prevention would be installed in Hot Spot 1 with this recommendation. This course of action was selected over the other two options shown in Table 7-1 because of the following:

- Scheduling rehabilitation upon designation of a reach as a Severity Group “D” for corrosion is the standard District protocol, as established in the Condition Assessment program.
- Scheduling rehabilitation in 9 years (with approximately 0.25 inches of pipe cover remaining) is preferred over scheduling rehabilitation in 17 years (with approximately 0 inches of pipe cover remaining) because the reduction in cost is approximately 14 percent, but that reduction comes with a significant risk. As noted in Figure 6-1, Hot Spot 1 is rated with the highest likelihood of failure (less than 15 years until projected failure) and has a moderate consequence of failure, as indicated by the average flow through the hot spot.

- Scheduling rehabilitation in 9 years is preferred over installation of caustic slug dosing upstream of the hot spot because of the much higher life cycle cost projected for corrosion control using caustic slug dosing. The cost of this approach is higher despite the projected extension of the need for scheduling rehabilitation in Reach N34-N35 from 9 years to 30 years.

Following are details on the recommended scope for addressing corrosion in the hot spot, the recommended monitoring program, and a projected schedule for implementation of the recommended action.

Recommended Scope

When Reach N34-N35 becomes Pipe Severity "D" status (0.25 inches of pipe cover remaining), the recommendation is to rehabilitate the reach by sliplining. The need for scheduling the rehabilitation work is projected to occur in approximately 9 years. Projected conceptual capital costs are estimated for sliplining based upon BC experience. No O&M costs are assumed for this recommended approach beyond the standard interceptor monitoring in accordance with the condition assessment recommendations.

Projected costs for the recommended course of action are summarized in Table 7-2. Note that costs are shown in millions (M) of dollars and are rounded from the values listed in TM B.3 Attachment C.

Table 7-2. Hot Spot 1 Recommended Approach Life Cycle Cost Elements

Description	Cost
Capital Cost (Slipline Reach N34-N35 in 9 years)	$0.68 M
Annual Operation and Maintenance Costs	-
Life Cycle Cost	$0.68 M

Recommended Monitoring

It is recommended that the District continue to monitor the hot spot in accordance with the District's current ongoing condition assessment program.

Schedule

Given the threshold of scheduling rehabilitation when the amount of remaining pipe cover is 0.25 inches over the reinforcing steel, the corrosion calculations indicate that the sliplining rehabilitation effort would need to be scheduled in 2022. No other corrosion control would be implemented at this hot spot prior to that time.

7.2 Hot Spot 4 – Caustic Slug Dosing and Rehabilitation (Sliplining)

The portion of the Alameda Interceptor between Manholes A21 and A46a is Hot Spot 4. Table 7-3 presents a summary of the analyzed alternative methods for addressing corrosion, as discussed in Section 5 of this report. As noted in the table, chemical injection is not included in this summary, as that option has stringent land acquisition requirements and prohibitively high life cycle costs. The approach of rehabilitating the Pipe Severity "C" reaches in either 12 years (corresponding to 0.25 inches of pipe cover remaining) or 23 years (corresponding to 0 inches of pipe cover remaining) is compared to three other corrosion control methods – caustic slug dosing, crown spraying, and oxygenation – followed by rehabilitation after extending the life of the pipe.

As indicated in red in Table 7-3, the recommended approach is caustic slug dosing, which is projected to extend the useful life of the Pipe Severity "C" rated reaches in the hot spot for 41 years. Following that period, the "C" rated reaches would be rehabilitated using sliplining.

Table 7-3. Interceptor System Hot Spot Corrosion Findings for Hot Spot 4

Remaining Useful Life[a] & Rehab Cost[b]	Corrosion Control Options or Alternative Rehabilitation			
	Option[c]	Description	Useful Life (Yr)	Life Cycle Cost[b]
12 Years $6.82 M	Rehabilitation	Slipline Pipe Severity "C" reaches – Allow concrete cover to reduce to 0 in	23	$5.52 M
	Caustic Slug Dosing	Inject caustic into A21 every 1-2 weeks for 41 years, then slipline "C" reaches	41	$5.49 M
	Crown Spraying	Spray corrosion resistant material into sewer 1-2 times per year for 41 years, then slipline "C" reaches	41	$6.42 M
	Oxygenation	Install oxygen injection into upstream Pump Stations "C" and "M" for 28 years, then sliping "C" reaches.	28	$9.96 M

[a]*Remaining life to 0.25 in concrete cover.*
[b]*Rehabilitation costs are in present value (M represents million); rehabilitation costs not included if outside of 50-year life cycle.*
[c]*Chemical injection not recommended for HS4 due to stringent land acquisition requirements and prohibitively high life cycle costs.*

This course of action was selected over the other options shown in Table 7-3 because of the following:

- Implementing a caustic slug dosing program for the hot spot extends the life of the pipe from needing rehabilitation after 12 years to needing it after 41 years. Because of this delay, the life cycle cost of implementing caustic slug dosing followed by slipline rehabilitation of the Pipe Severity "C" reaches is approximately 25 percent less than rehabilitation alone.
- The caustic slug dosing life cycle cost is effectively the same as the life cycle cost for scheduling rehabilitation of the Pipe Severity "C" reaches upon reaching zero cover. However, rehabilitating upon reaching zero cover assumes a much higher risk as there are several "C" reaches in this hot spot that could fail in that time. Therefore, the caustic slug dosing program is preferred over rehabilitation following zero cover due to risk.
- Given the approximation of costs based upon historical dose rates and current chemical costs, the life cycle cost of caustic slug dosing is approximately 17 percent less than the life cycle cost of crown spraying. Caustic slug dosing pilot testing is recommended to confirm this.
- The caustic slug dosing program is projected to extend the useful life of the hot spot reaches more than incorporation of an oxygenation system at the upstream pump station "C" and "M". Furthermore, the life cycle cost of the oxygenation system is approximately 55 percent higher than the caustic slug dosing program (both alternatives are followed with a slipline rehabilitation project).

Following are details on the recommended scope for addressing corrosion in the hot spot, the recommended monitoring program, and a projected schedule for implementation of the recommended action.

Recommended Scope

Implement a pilot study to inject 50 percent caustic solution for 60 minutes every 1 to 2 weeks (to be confirmed during pilot testing) to delay the need for rehabilitation of the Pipe Severity "C" reaches within the hot spot. Caustic solution would be injected at Manhole A21, or further upstream (as far upstream as Pump Station "M") provided that the pilot testing shows that the alternate location will not require significantly more chemical or produce other issues. The pilot testing will include coordination with MWWTP staff to monitor and assess potential pH impacts on plant processes from caustic dosing and to identify any potential long term operational changes that may be required at the MWWTP from caustic dosing at Hot Spot 4. Following completion of a successful pilot, caustic slug dosing of the hot spot could be incorporated on a regular basis for the hot spot.

This method assumes that rehabilitation of the Pipe Severity "C" reaches in the hot spot by sliplining will be scheduled in approximately 41 years. This cost is the only capital cost assumed for the recommended alternative. During the caustic slug dosing period, annual O&M costs would be incurred for chemical deliveries and associated labor, and for ongoing liquid-phase sulfide and gas-phase H_2S monitoring to confirm slug dosing effectiveness. Capital, O&M, and life cycle costs for the recommended alternative are summarized in Table 7-4.

Table 7-4. Hot Spot 4 Recommended Approach Life Cycle Cost Elements

Description	Cost
Capital Cost (Slipline Pipe Severity "C" reaches in 41 years)	$3.9 M
Annual Operation and Maintenance Costs	$1.6 M
Life Cycle Cost	$5.5 M

Note that caustic slug dosing pilot study costs are not included in the life cycle costs listed in the table. Pilot study costs are estimated to be between $100,000 and $200,000, with the actual cost dependent upon several factors, including the following:

- The number of pilot tests conducted
- Extent of support required from District MWWTP Operations staff and laboratory personnel
- Number of sampling locations, frequency of sampling, and timing of sample collection

Potential Alternative Corrosion Control Approaches

Because the recommended approach is dependent upon the caustic slug dosing pilot testing confirming the potential for success and confirming projected costs, an alternate approach may be considered if one or both of these items are not confirmed during the piloting process. In this case, the following two approaches, both described in Table 7-3, may be considered:

1. Incorporate a crown spraying program to reduce the corrosion rate within the pipe and extend the overall pipe life. Crown spraying consists of applying a high-pH chemical mixture onto the crown of a sewer in an effort to deactivate sulfur oxidizing bacteria and neutralize the acid produced on the crown that results in corrosion. Mixtures often used include magnesium hydroxide, sodium hydroxide, and sodium carbonate. Magnesium hydroxide was found to be most effective in the Los Angeles County Sanitation Districts sewer system. If enacted at the District interceptor system, the high-pH mixture would be applied onto the crown of all reaches within the hot spot 1-2 times per year. Similar to caustic slug dosing, this would extend the pipe life and delay the need to schedule rehabilitation of the Pipe Severity "C" reaches. Unlike caustic slug dosing, crown spraying would not require pilot testing, however, sulfide and H_2S monitoring would be needed during the course of the years of its application to demonstrate effectiveness. If crown spraying is required more frequently than twice per year, or if costs are considerably higher than is projected, an alternate approach may be more appropriate.

2. Do not implement a near-term corrosion control program and rehabilitate the Pipe Severity "C" reaches of the hot spot when the pipe cover is approaching zero. If rehabilitation were scheduled when the critical (most vulnerable) reach were at zero inches of cover, this would correspond to scheduling rehabilitation in 23 years, as shown in Table 7-5. However, given the number of Pipe Severity "C" reaches in this hot spot and the high likelihood of failure per the risk assessment matrix (Figure 6-1), BC recommends scheduling rehabilitation sooner than 23 years. If slipline rehabilitation were scheduled in 15 years (extended from the baseline of 12 years), the life cycle cost of the rehabilitation would be approximately the same as what is calculated for crown spraying ($6.4M). If this were the case, approximately 0.18 inches of pipe cover would remain in the critical reach.

Recommended Monitoring

OdaLog data loggers are recommended to be installed downstream of Hot Spot 4 for continuous gas-phase H_2S measurement. During each monitoring and analysis period, one week of collected data will be downloaded monthly and analyzed to determine if adjustments to the corrosion control system dosing rates should be considered. Continuous monitoring can also gives an approximation of season variations in chemical requirements for corrosion control. Chemical use is typically reduced in the winter due to colder temperatures and wet-weather flows.

These monitoring costs are included in the life cycle cost estimates shown in Table 7-4. Similar monitoring would be required for either of the two alternate corrosion control approaches listed above, which could be implemented if unacceptable results are found in the caustic slug dosing pilot testing.

Schedule

Following are the schedule milestone dates associated with corrosion control for this hot spot, assuming incorporation of the recommended approach (caustic slug dosing followed by slipline rehabilitation):

- Within 3 years: Conduct caustic slug dosing pilot program
- 2015: Continue caustic slug dosing or switch to crown spraying (pending results of pilot program)
- 2054: Rehabilitation (Sliplining) of Pipe Severity "C" reaches within hot spot

7.3 Hot Spot 6 – Rehabilitation (CIPP)

The segment of pipe in the upstream portion of South Interceptor between S09 and S16 is Hot Spot 6. Table 7-5 presents a summary of the analyzed alternative methods for addressing corrosion, as discussed in Section 5 of this report. The approach of rehabilitating the Pipe Severity "C" reaches in 37 years (corresponding to 0.25 inches of pipe cover remaining) is compared to two other corrosion control methods – chemical injection and caustic slug dosing – both of which are projected not to require rehabilitation of the Pipe Severity "C" reaches within the 50-year life cycle. Additionally, if the remaining pipe cover is allowed to be reduced to zero, no rehabilitation would be required in the 50-year life cycle, as is noted in Table 7-5. The table also compares the life cycle cost of rehabilitation using a plastic liner to that of using cured-in-place pipe (CIPP).

Table 7-5. Interceptor System Hot Spot Corrosion Findings for Hot Spot 6				
Remaining Useful Life[a] & Rehab Cost[b]	Corrosion Control Options or Alternative Rehabilitation			
	Option	Description	Useful Life (Yr)	Life Cycle Cost[b]
37 Years $2.74 M (plastic liner)	Rehabilitation	Install CIPP for Pipe Severity "C" reaches instead of plastic liner rehabilitation	37	$2.44 M
	Rehabilitation	Slipline Pipe Severity "C" reaches – Allow concrete cover to reduce to 0 in	50+[c] (74)	None
	Chemical Injection	Inject ferrous chloride into Manhole S08 for 50-year life cycle	50+[c] (110)	$2.63 M
	Caustic Slug Dosing	Inject caustic into S08 every 1-2 weeks for 50-year life cycle	50+[c] (129)	$2.63 M

[a]*Remaining life to 0.25 in concrete cover.*
[b]*Rehabilitation costs are in present value (M represents million); rehabilitation costs not included if outside of 50-year life cycle.*
[c]*Rehabilitation not required in 50-year life cycle. (xx) indicates estimated years to rehabilitation.*

As indicated in red in Table 7-5, the recommended approach is rehabilitation using CIPP, which would be scheduled approximately 37 years from the present day. Following are the recommended scope of corrosion control, monitoring program, and projected schedule for implementation at Hot Spot 6.

Recommended Scope

According to the corrosion calculations and life cycle cost estimates conducted in Task B.3, near-term corrosion control methods are not favorable as compared to rehabilitating the corroded hot spot reaches when necessary. Therefore, the recommended approach is for rehabilitation of the Pipe Severity "C" reaches in the hot spot when Critical Reach S09-S10 becomes Pipe Severity "D" status (0.25 inches of pipe cover remaining over the reinforcing steel). Rehabilitation is assumed to be done using CIPP, which was identified as the best corrosion control technology approach for this hot spot. Sliplining was determined not to be feasible in this location due to hydraulic constraints.

Table 7-6. Hot Spot 6 Recommended Approach Life Cycle Cost Elements	
Description	Cost
Capital Cost (Rehabilitation of Pipe Severity "C" reaches in 37 years)	$2.4 M
Annual Operation and Maintenance Costs	-
Life Cycle Cost	$2.4 M

Note that in Table 7-6 the annual O&M cost is listed as zero, although there will be some costs for labor and materials associated with monitoring the hot spot liquid-phase sulfide and gas-phase H_2S concentrations over the period of time prior to scheduling rehabilitation. Assuming monitoring is conducted as described below, using OdaLog data loggers and field sulfide test kits, the life cycle annual O&M cost is estimated at $15,000, which is small in comparison to the $2.4 million capital cost item listed in Table 7-3.

Recommended Monitoring

Since the required rehabilitation is projected not to be needed for 37 years, it is recommended that liquid-phase sulfide and gas-phase H_2S be monitored for any increases in liquid-phase sulfides or gas-phase H_2S until the rehabilitation of the pipe is completed. Significant increases, including those that are similar to historical records, could require rehabilitation in the hot spot much earlier than is currently projected. Monitoring should be conducted bi-annually for the first ten years, and then every five years after that. These monitoring costs are not included in the life cycle cost estimates shown in Table 7-6.

Schedule

Following are the schedule milestone dates associated with corrosion control for this hot spot:

- 2014-2040: Monitor liquid-phase sulfides and gas-phase H_2S within hot spot; conduct monitoring every two years for the first ten years and then every five years after that until rehabilitation begins.
- 2040: Rehabilitation (CIPP) of Pipe Severity "C" reaches within hot spot

7.4 Hot Spot 7 – Oxygen Injection

The reach of pipe downstream of the discharge pipeline for Pump Station "H" (Manhole S21) through the connection with the Pump Station "J" discharge point (Manhole S31) is Hot Spot 7. Table 7-7 presents a summary of the analyzed alternative methods for addressing corrosion, as discussed in Section 5 of this report. The approach of rehabilitating the Pipe Severity "C" reaches in 27 years (corresponding to 0.25 inches of pipe cover remaining) is compared to three other corrosion control methods – chemical injection, caustic slug dosing, and oxygenation – all of which are projected not to require rehabilitation of the Pipe Severity "C" reaches within the 50-year life cycle. Additionally, if the remaining pipe cover is allowed to be reduced to zero, no rehabilitation would be required in the 50-year life cycle, as is noted in Table 7-7.

As indicated in red in Table 7-7, the recommended approach is installing a superoxygenation system at Pump Station "H", which would correspond with no required rehabilitation within the hot spot throughout the 50-year life cycle. Oxygenation is significantly lower life cycle cost than both the chemical injection and caustic slug dosing alternatives, and is slightly lower life cycle cost than rehabilitation upon reaching 0.25 inches of remaining pipe cover. While the life cycle cost of rehabilitating the "C" reaches upon pipe cover reduced to zero inches is effectively zero, because rehabilitation would not be needed in the 50-year life cycle, this alternative is not recommended due to the additional risk.

Table 7-7. Interceptor System Hot Spot Corrosion Findings for Hot Spot 7

Remaining Useful Life[a] & Rehab Cost[b]	Corrosion Control Options or Alternative Rehabilitation			
	Option	Description	Useful Life (Yr)	Life Cycle Cost[b]
27 Years $2.66 M	Rehabilitation	Slipline Pipe Severity "C" reaches – Allow concrete cover to reduce to 0 in	50+[c] (55)	None
	Chemical Injection	Inject ferrous chloride into Pump Station "H" for 50-year life cycle	50+[c] (69)	$4.53 M
	Caustic Slug Dosing	Inject caustic into Pump Station "H" every 1-2 weeks for 50-year life cycle	50+[c] (96)	$5.47 M
	Oxygenation	Oxygen injection into PS "H" for 50-year life cycle	50+[c] (137)	$2.45M

[a]*Remaining life to 0.25 in concrete cover.*

[b]*Rehabilitation costs are in present value (M represents million); rehabilitation costs not included if outside of 50-year life cycle.*

[c]*Rehabilitation not required in 50-year life cycle. (xx) indicates estimated years to rehabilitation.*

Following are the recommended scope of corrosion control, monitoring program, and projected schedule for implementation at Hot Spot 7.

Recommended Scope

Install a system whereby pure oxygen is injected into the Pump Station "H" discharge pressure pipeline to elevate dissolved oxygen (DO) concentrations and lower the dissolved sulfide concentration to approximately zero at the pressure discharge point. Additionally a DO residual will be left at the pressure pipe discharge. A VSA on-site oxygen generator is assumed for the capital cost estimate. Estimated capital and annual O&M costs for the superoxygenation system are taken from a budgetary cost proposal provided by ECO2 (Eco Oxygen Technologies, LLC), which is included in TM B.3, Attachment D.

Projected conceptual capital costs would include procurement and construction of the superoxygenation system. Annual O&M costs would include associated labor, regular maintenance, and H_2S monitoring to confirm effectiveness. Costs are summarized in Table 7-8.

Table 7-8. Hot Spot 7 Recommended Approach Life Cycle Cost Elements

Description	Cost
Capital Cost	$1.8 M
Annual Operation and Maintenance Costs	$0.62 M
Life Cycle Cost	$2.5 M

Potential Alternative Corrosion Control Approach

An alternate approach may be considered for Hot Spot 7 for pipe rehabilitation planning, which would include not implementing a near-term corrosion control program and scheduling rehabilitation (by sliplining) of the Pipe Severity "C" reaches in 31 years (extended from the baseline of 27 years). If this is the selected course of action, the life cycle cost of the rehabilitation would be approximately the same as what is calculated for oxygenation ($2.5M). If this were the case, approximately 0.21 inches of pipe cover would remain in the critical reach.

While this alternative approach is reasonable economically from a corrosion control perspective, the recommended oxygenation alternative does have an important economic benefit in that it would reduce the total liquid-phase sulfide load to the MWWTP. As discussed in TM B.3, the approximate average reduction, per the sulfide accumulation model, would be from 0.48 mg/L to 0.26 mg/L. This reduction would equate to reduced hypochlorite use at the plant influent and associated reduced costs resulting in an estimated savings of approximately $200,000 annually in hypochlorite solution not used in the south interceptor just upstream of the MWWTP. This estimate is based on the projected average sulfide reduction and approximate chemical cost, and is dependent upon several variables, including the following:

- Stagnation in the surcharged interceptor during operational daily backups
- Impacts of the North Interceptor flows upon mixing with the South Interceptor flow at the MWWTP
- Variations in sulfide loads reflective of seasonal variations and upstream chemical dosing within the Alameda Interceptor
- The assumption that hypochlorite addition at the MWWTP influent is currently optimally reducing sulfides down to zero at all times.

Recommended Monitoring

The recommended monitoring program is to install OdaLogs within Hot Spot 7 for one week on a monthly basis to confirm that the superoxygenation system is working effectively. Additionally liquid-phase sulfide concentrations shall be measured, downloaded monthly, and analyzed to determine if adjustments to the superoxygenation system should be considered. Continuous monitoring also gives an approximation of season variations in chemical requirements for corrosion control (typically reduced in the winter due to colder temperatures and wet-weather flow events).

These monitoring costs are included in the life cycle cost estimates shown in Table 7-8. Similar monitoring would be required for the alternate corrosion control approach listed above.

Schedule

The recommendation is to install a superoxygenation system at Pump Station “H” within 3 years. Corrosion calculations indicate that if this is done, there will be no required rehabilitation for the hot spot within the 50-year life cycle.

7.5 Capital Improvement Program and O&M Summary

Table 7-9 provides a summary of the recommended capital improvement program costs and schedule along with potential alternative approaches for each hot spot. Though the alternate rehabilitation approaches are not recommended, as they would allow the pipe cover in the hot spot critical reaches to be reduced below the 0.25 inches threshold, the District may consider using the for scheduling purposes, assuming that continuous monitoring of the interceptors for corrosion parameters occurs throughout the life cycle.

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Table 7-9. Interceptor System Hot Spot Corrosion Control Recommendation Cost Summary and Schedule

Hot Spot	Option	Useful Life (yr)[a]	Total Life Cycle Cost [b]		Schedule (yr) 2–50
Recommended Options					
HS1	Slipline at 0.25-in Cover	9	$0.68 M	Capital: $0.68 M	
				O&M: $0.00 M	
HS 4	Caustic Slug Dosing	41	$5.49 M	Capital: $3.90 M	
				O&M: $1.60 M	$0.04 M/yr[d]
HS 6	Install CIPP at 0.25-in cover	37	$2.44 M	Capital: $2.44 M	
				O&M: $0.00 M	
HS 7	Oxygenation	50+[c]	$2.45 M	Capital: $1.80 M	
				O&M: $0.62 M	$0.01 M/yr[d]
Alternative Options					
HS 4	Crown Spraying	41	$6.42 M	Capital: $3.90 M	
				O&M: $2.52 M	$0.06 M/yr[d]
	Slipline at 0.18-in cover	15	$6.42 M	Capital: $6.42 M	
				O&M: $0.00 M	
HS 7	Slipline at 0.21-in cover	31	$2.45 M	Capital: $2.45 M	
				O&M: $0.00 M	

[a] Remaining life to 0.25 in concrete cover.

[b] Rehabilitation costs are in present value (M represents million) and include a 5-year window to allow for planning, design, and construction of rehabilitation; rehabilitation costs not included if outside of 50-year life cycle.

[c] Rehabilitation not required in 50-year life cycle and assumes a 25 year useful life for the mechanical and electrical components of the oxygenation equipment.

[d] Estimated average annual O&M costs are in present value; O&M costs are assumed to continue until the start of construction.

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Section 8

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CH2M HILL, *Odor Control Master Plan Update*, East Bay Municipal Utility District, 2009.

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Appendix A: Technical Memorandum B.2 - Initial Interceptor Corrosion Control Preliminary Assessment

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201 N Civic Drive
Walnut Creek, CA 94596

T: 925.937.9010
F: 925.937.9026

Technical Memorandum

FINAL

Prepared for: East Bay Municipal Utility District

Project Title: Wastewater Pump Station Discharge Pipeline Condition Assessment and Interceptor Corrosion Prevention Project

Project No.: 144408

Technical Memorandum

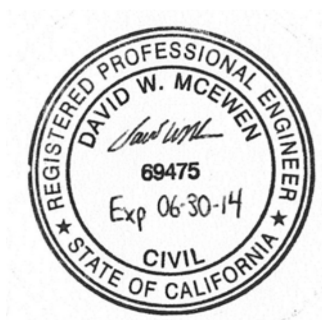
Subject: Initial Interceptor Corrosion Control Preliminary Assessment

Date: October 14, 2013

To: Diana Lee

From: Charlie Joyce

Copy to: Derek Wurst (V&A)



Prepared by:
David McEwen, CA License No.C69475

Reviewed by:
Charles Joyce, CA License No.C33166

Reviewed by: Jim Joyce (V&A), Mark Smith (BC)

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Section 1: Introduction and Background

This section presents background information on this technical memorandum (TM) for Task B.2 of the scope of work included in the agreement between Villalobos and Associates (V&A) and the East Bay Municipal Utility District (District) dated March 2013. An overview of the District's wastewater collection system and current corrosion prevention practices, a discussion of corrosion-related standard severity thresholds, and a review of the Task B.2 scope of services are included in this section.

1.1 Interceptor System Overview

The District owns and operates a wastewater interceptor system (Figure 1-1) that consists of approximately 30 miles of gravity pipelines, 7 miles of force mains, 15 pump stations, and three wet weather facilities. The original interceptor system was constructed in the 1950s along the East Bay shoreline and in Alameda to convey wastewater from the East Bay communities to the District's Main Wastewater Treatment Plant (MWWTP). The cities of Oakland, Berkeley, Alameda, Albany, Piedmont, and Emeryville, and the Stege Sanitary District provide local wastewater collection and discharge to the District interceptor system. The District provides wastewater conveyance, treatment, and discharge services. The interceptor system is divided into five main sections, which are shown in Figure 1-1:

- **North Interceptor**: serves the cities of Emeryville, Berkeley, Albany, and also receives flow from the Stege Sanitary District. Pump Stations "A", "N", and "Q" pump wastewater into the interceptor.
- **Alameda Interceptor**: serves the city of Alameda and includes discharges from Pump Stations "B", "C", "D", "E", "F", "M", and "R". Pump Stations "C", "M", and "R" have long discharge pipelines. Pump Stations "C", "F", "M", and "R" currently have sodium hypochlorite injection systems (see Section 1.2).
- **South Interceptor**: serves the city of Oakland and Piedmont also receives all flow from the Alameda Interceptor (flow enters the South Interceptor just beyond the Inner Harbor, as shown in Figure 1-1). Pump Stations "G", "H", "J", "K", and "L" all pump wastewater into the interceptor.
- **Adeline Interceptor**: serves the cities of Berkeley and Oakland.
- **South-Foothill Interceptor**: serves the city of Oakland.

In the 1960s, the Stege Sanitary District was added to the service area. It is served through an extension of the North Interceptor north of Albany. In the late 1980s, the interceptor system was expanded further to provide capacity for peak wet weather flows from the "satellite" communities. This was accomplished by adding the Adeline and South-Foothill Interceptors and three wet weather treatment facilities.

Most of the District's interceptor system is round gravity pipe ranging in diameter from 12 to 108 inches (in). Near the downstream end of the South Interceptor, the pipe contains thumbnail-shaped reaches that are 105 inches in height. The pipe material is primarily reinforced concrete, lined reinforced concrete, or lined ductile iron.

The interceptor system has a number of inverted siphons. One of the larger siphons is on the Alameda Interceptor under the Oakland Estuary between Alameda and Oakland (just upstream of the confluence with the South Interceptor). Several other siphons and D-shaped sections at creek crossings are located in the South Interceptor and on the gravity portion of the PS "Q" discharge line. Sulfide generation is a concern for these siphons. Additionally, sulfides can build up in the downstream end of the North Interceptor and South Interceptor when the MWWTP is operated to surcharge (back up) the influent flow in the interceptors as part of flow equalization efforts. This is a routine practice conducted by the District.

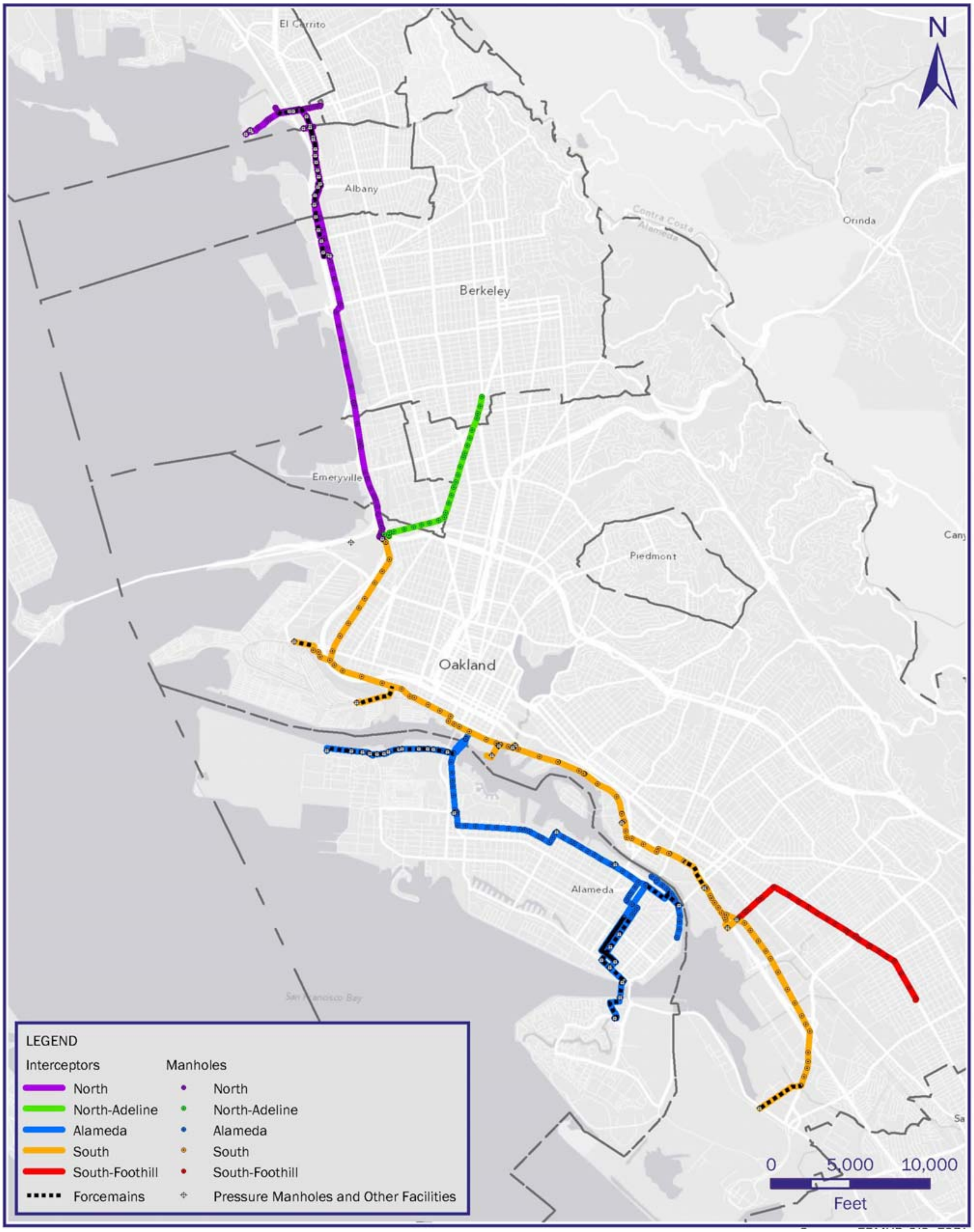


Figure 1-1. Overview of the District Interceptor System

The interceptors evaluated in this assessment include the North, Alameda, and South Interceptors. The Adeline Interceptor is not included in the study because it has had no evidence of severe corrosion to date. The South-Foothill Interceptor is not included because its entire length of pipe is PVC-lined.

1.2 Existing and Planned Corrosion Control

Sodium hypochlorite solution addition is currently implemented at Pump Stations “C”, “M”, “F”, and “R”. This chemical addition is for pump station and downstream interceptor odor control, not for corrosion control. While chemical injection in these locations does reduce sulfide generation somewhat, which is beneficial for limiting corrosion, a higher dose would be needed in these pump stations for complete corrosion control.

Figure 1-2 shows the monthly hypochlorite solution quantities (in gallons) injected into the various pump station wet wells from January 2012 through June 2013. Pump Stations “F” and “R” received the highest hypochlorite doses, with typical quantities generally ranging from 3,000 to 6,400 gallons per month in the dry season (generally between May and October), which equates to approximately 4 to 9 gallons per hour (gph) on average. During dry weather months in the same years, the District injected hypochlorite into Pump Stations “C” and “M” at a rate of approximately 800 to 2,700 gallons per month, which equates to approximately 1 to 4 gph on average.

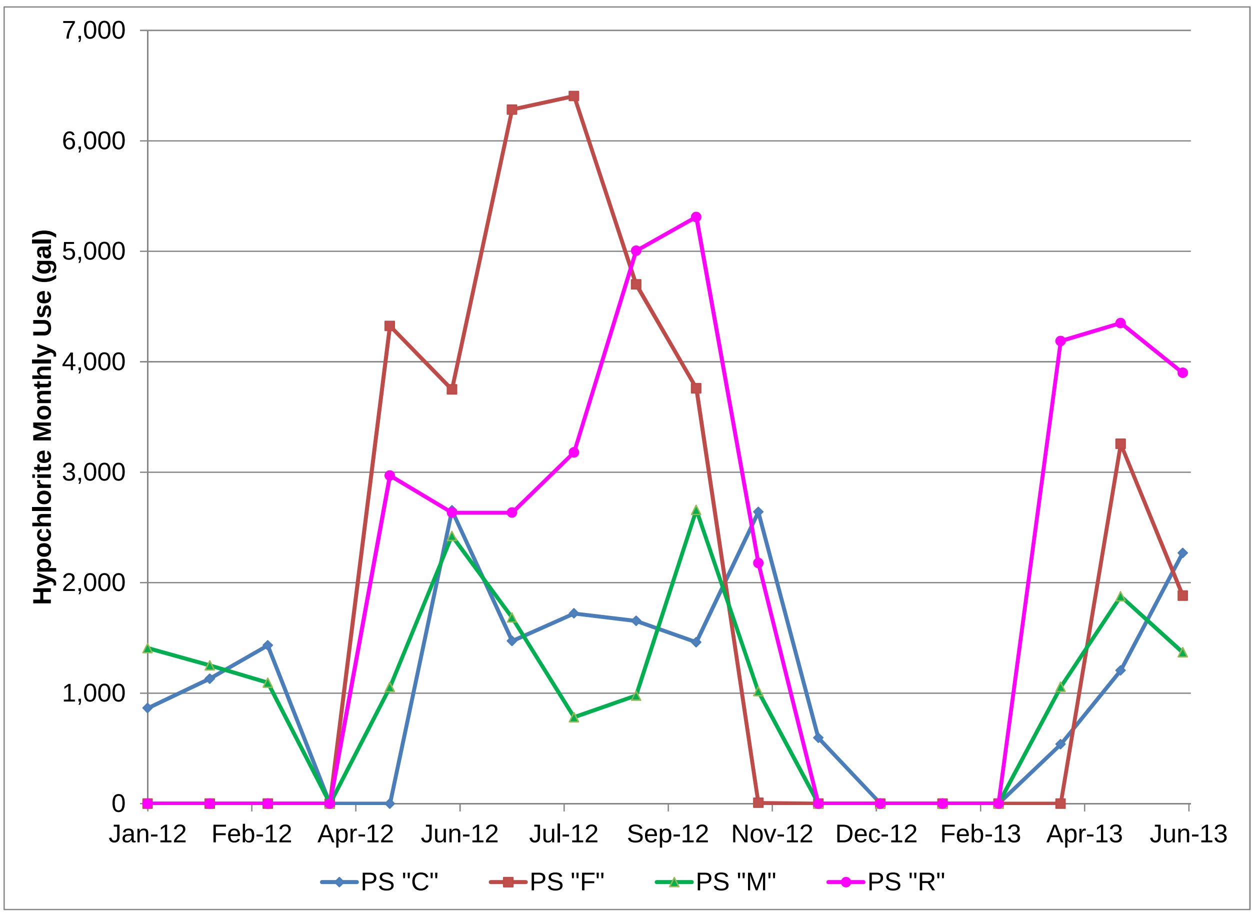


Figure 1-2. Historical Hypochlorite use in District Pump Stations (2012-2013)

Table 1-1 considers the hypochlorite dose rate at the four pump stations analyzed during weather as a proportion of average dry weather flow. For example, at Pump Station "F" in June 2012, on average hypochlorite was dosed into the flow at a rate of 6.3 gph per MGD of wastewater flow. The table indicates that Pump Station "R" is injected with a larger amount of hypochlorite, as a fraction of the total pump station wastewater flow, than the other three pump stations that regularly inject hypochlorite during dry weather.

Table 1-1. Ratio of Pump Station Hypochlorite Dose to Dry Weather Daily Flow

Pump Station	Ratio of Hypochlorite Dose to Dry Weather Daily Flow (gph/MGD)					
	Jun 2012	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Average
"F"	6.3	10.7	11.0	8.2	6.7	8.6
"R"	15.2	15.4	19.4	34.8	37.6	24.5
"C"	3.2	1.8	2.2	2.2	1.9	2.3
"M"	2.6	2.0	1.5	1.3	3.0	2.1

Historically, in most years no hypochlorite is injected into the pump stations in the winter months (generally between November and April). The winter of 2012 was an exception, as hypochlorite was injected into Pump Stations "C" and "M" (upstream portion of the Alameda Interceptor) in quantities ranging from 864 to 1,433 gallons per month (1.2 to 1.9 gph on average). This was an exception due to the dry winter and lower flows than is typical. Pump Stations "F" and "R" have not been dosed with hypochlorite during the winter months in recent years.

Physical barriers have also been installed in interceptor reaches to control the deterioration of the sewer pipe from corrosion, with additional installations planned through Fiscal Year 2018 (FY18). A summary of the interceptor rehabilitation projects in the current Capital Improvement Program (CIP) as provided by District staff is as follows:

- **Buchanan Street Interceptor Rehabilitation** (completed in FY13): Rehabilitation of 823 linear feet (LF) of pipe ranging from 24 to 48 inches in diameter. All work is on the North Interceptor between Manholes NF03 and N01a.
- **Wood Street Interceptor Rehabilitation** (ongoing, to be completed in FY16): Repair and rehabilitation of 9,133 LF of 105-in diameter pipe at the downstream end of the South Interceptor between Manholes S60a and S70.
- **3rd Street Interceptor Rehabilitation** (FY15-FY19): Rehabilitation of 10,447 LF of 105-in diameter pipe in the South Interceptor between Manholes S47 and S60. Also includes rehabilitation of 695 LF of pipe ranging from 30 to 84 inches in diameter. The work will be in several locations, all on the South Interceptor: (1) between Manholes S22 and S231, (2) between Manholes S22 and S232, (3) between Manholes S31 and S32, and (4) between Manholes S42 and S43.
- **Versailles Interceptor Rehabilitation** (FY14-FY16): Rehabilitation of 3,179 LF of 124-in diameter pipe at the upstream end of the Alameda Interceptor between Manholes M01 and M10.
- **Alameda Interceptor Rehabilitation** (FY14-FY16): Rehabilitation of 5,243 LF of pipe ranging from 42 to 60 inches in diameter. The work will be in several locations: (1) on the Alameda Interceptor between Manholes A17 and A21, (2) on the Alameda Interceptor between Manholes A40 and A41, (3) on the Alameda Interceptor between Manholes A46a and A49, and (4) on the South Interceptor between Manholes S08 and S09.

These projects are discussed further in the hot spot corrosion analysis and preliminary recommendations, which is presented in Section 4. Note that for simplicity, only the pipe rehabilitation work in the CIP is listed above; each of the projects also includes some manhole rehabilitation in the same area.

1.3 Corrosion Assessments and Severity Thresholds

In previous studies, condition assessments, and odor control master planning work completed by the District between 1998 and 2013, corrosion potential in the interceptor system has been quantified primarily using the following three parameters:

- **Liquid-phase sulfide** concentrations in milligrams per liter (mg/L): these were reported as total sulfides and/or dissolved sulfides in previous studies; in this TM, this parameter is referred to generically as liquid-phase sulfide concentration.
- **Liquid-phase hydrogen sulfide (H_2S)** concentrations in mg/L: this is the portion of the total sulfide concentration in the wastewater that is present as H_2S. The quantity of H_2S in the liquid phase is dependent upon pH. The H_2S species is the only one of the three ionic species of sulfide (H_2S, bisulfide, and sulfide) that can volatilize into the sewer headspace.
- **Gas-phase hydrogen sulfide (H_2S)** concentrations in the interceptor headspace in parts per million by volume (ppmv): measured either in single "snapshot" measurements by a portable H_2S analyzer or on an ongoing basis by an OdaLog data logger, which recorded concentrations every few minutes over the course of several days.

Corrosion severity thresholds have been identified for liquid phase sulfide concentration using the previous odor control master planning work and for headspace H_2S concentrations using research completed by the Water Environment Research Foundation (WERF) Project 04-CTS-1 entitled *Minimization of Odors and Corrosion in Collection Systems* (2007). Three ranges are shown in Table 1-2.

Table 1-2. Corrosion Severity Thresholds

Severity Level	Liquid-Phase Sulfide Concentration (mg/L)[a]	Gas-Phase H_2S Concentration (ppmv)[b]
Low	0-0.5	0-2
Moderate	>0.5-1.0	2-5
High	Greater than 1.0	Greater than 5

[a]Ranges used in 1999 District Odor Control Master Plan and 2009 Odor Control Master Plan Update

[b]Ranges established in WERF Project 04-CTS-1 Minimization of Odors and Corrosion in Collection Systems

This TM uses these previously designated thresholds as indications of potential corrosion issues in pipe reaches within the District interceptor system. Note that the gas-phase H_2S parameter is a more direct indication of corrosion potential, because H_2S in the sewer headspace is converted to sulfuric acid (H_2SO_4) which becomes corrosive to concrete sewer pipe. However, both liquid-phase sulfide and gas-phase H_2S are considered because H_2S in the sewer headspace can be highly variable at a given location in the collection system depending on water depth, turbulence, and velocity conditions caused by varying flow conditions. Liquid-phase sulfide concentrations are somewhat less variable and provide an indication of the potential quantity of H_2S that can be volatilized into the gas phase, which can be a source of both odor and corrosion issues if not controlled.

1.4 Corrosion Formation Mechanisms

The general principles of sulfide formation in wastewater collection systems by sulfate-reducing bacteria, and subsequent volatilization as H_2S and conversion to H_2SO_4 on the walls of sewer pipe, which results in corrosion, are not covered in detail in this TM. These mechanisms are well-established in the literature and in case studies. For a complete discussion of these principles, refer to guidance material and literature reviews in published research, including the Water Environment Federation (WEF) Manual of Practice 25 *Control of Odors and Emissions from Wastewater Treatment Plants* (2004) and the WERF Project 04-CTS-1 *Minimization of Odors and Corrosion in Collection Systems (2007)*.

1.5 Scope of Services

The goals of Task B.2 include: (1) providing a review of historical liquid-phase sulfide and gas-phase H_2S measurements in the District interceptors, (2) determining current corrosion “hot spots” in the interceptors and identifying the initial best means of controlling corrosion at those locations (3) providing a review of current methods and applications for corrosion control and prevention, and (4) developing justifications and recommendations for further evaluation of the best fit alternatives.

A review of historical liquid-phase sulfide and gas-phase H_2S measurements is provided in Section 2 of this TM. The analyzed data range is from 1996 through 2009, with data collected in two time periods: between 1995 and 1999 as part of Interceptor Damage Assessment Project (IDAP) and the MWWTP Odor Control Master Plan (1999), and in 2008 as part of the Odor Control Master Plan Update (2009). Historical measurements are compared in a trend analysis and correlations are identified with findings of pipe condition severity for corrosion in the 2010 through 2012 Interceptor Condition Assessment. No new modeling was performed for this TM.

Furthermore, Section 2 of the TM provides an assessment of data gaps that will be addressed with recommended additional field sampling as part of this project. In addition to the sampling at each pump station discharge manhole as part of the condition assessment work, ten manhole locations are identified where additional sampling (liquid-phase sulfide and gas-phase H_2S) was scheduled to be conducted in August-September 2013.

Section 2 of the TM also includes an analysis of the historical data and 2010-2012 Condition Assessment pipe severity ratings to identify corrosion “hot spots” – areas of either actual or potential corrosion in the interceptor system.

Section 3 of this TM includes a review of potential corrosion control methods, which are grouped as follows:

- Liquid-phase treatment methods (includes chemical addition and oxygen injection)
- Application of physical barriers (includes pipe lining and coatings) and pipe replacement
- Operation and maintenance (O&M) changes (includes interceptor cleaning, caustic slug dosing and crown spraying)

The advantages and disadvantages associated with potential corrosion control approaches are presented in Section 3, along with initial recommendations of which technologies appear to be most applicable to the District’s interceptor system.

In Section 4 of this TM, for each of the hot spot areas not already rehabilitated or planned for rehabilitation, potential corrosion control methods that could be installed to combat the corrosion potential are identified and evaluated on a weighted ratings basis, using criteria that were established by the District, V&A, and BC in a June 2013 meeting. Capital costs and yearly O&M costs are estimated for the highest scoring corrosion control methods in the liquid-phase treatment, physical barrier, and O&M categories, and a preliminary recommendation is made for implementation for each hot spot.

Preliminary recommendations for corrosion control measures will be confirmed in an August 2013 workshop with the District, V&A, and BC. In the workshop, District stakeholders will confirm the additional sampling locations and corrosion control technology evaluation criteria. Following incorporation of any changes in the hot spots corrosion control evaluation and/or recommended additional sampling locations that arise from the workshop, this TM will be finalized.

Following completion of this TM and the additional sampling, a liquid-phase sulfide model will be updated by BC to provide a current indication of sulfide accumulation in the interceptors. The updated sulfide model will be based on the hydraulic framework established in the CH2M HILL Interceptor Model (most recently updated in 2009 as part of the Odor Control Master Plan Update) and will incorporate results of the 2013 additional sampling, including the samples collected at each pump station discharge point. The model will also include flow data from the District's 2010 dynamic hydraulic model update. The sampling results and updated sulfide accumulation model will be used to refine the location of hot spot areas of corrosion potential and the recommended approaches to reduce corrosion in the interceptor system.

Section 2: Historical Data Analysis

This section presents an analysis of historical measured concentrations of liquid-phase total sulfides and sewer headspace gas-phase H_2S in the District's interceptor system. Field measurements are compared within the interceptors and fluctuations in measured concentrations over time are noted. Data gaps are indicated, particularly where conflicting measurements are noted and/or differ from results of previously completed sulfide accumulation and H_2S emissions models.

2.1 Historical Interceptor Liquid Sulfide and H_2S Concentrations

This section includes a review of previous direct measurements of liquid-phase sulfides and gas-phase H_2S in the three District interceptors analyzed in this study. Trends are noted where there are consistently high concentrations within a portion of a given interceptor, and fluctuations of liquid-phase sulfide and gas-phase H_2S measurements are noted as concentrations vary with time.

2.1.1 Data Sources

Historical data were reviewed from the following reports, each of which contains references to field measurements of either liquid-phase sulfide concentration and/or gas-phase H_2S concentration in the District's interceptor system:

- 1996 Interceptor Odor Control Study: included field sampling conducted in 1995 and an evaluation of various chemical treatment alternatives. The goal of the study was to minimize sulfide loading into the MWWTP influent pump station.
- 1997 Interceptor Damage Assessment Project (IDAP): included field sampling for liquid sulfides and a condition assessment of all manholes and pipe reaches in the District's interceptor system.
- 1998 MWWTP Odor Control Master Plan (OCMP): included new sulfide accumulation and H_2S emission modeling using the CH2M HILL Interceptor Model. Sampling data from the 1997 IDAP was used to calibrate the model.
- 2009 MWWTP Odor Control Master Plan Update: included limited sampling of wastewater for liquid sulfide concentrations and continuous H_2S monitoring at several manholes using OdaLog data loggers. Using the collected data, the 1998 CH2M HILL Interceptor model was updated.
- 2010-2012 Interceptor Condition Assessment: included an evaluation of manholes and pipe reaches on a severity of damage scale in which an "A" rating was given to a manhole or pipe reach that was in excellent condition, and a "D" rating was given to one that required immediate attention ("D" rated

locations are scheduled to be rehabilitated in the current CIP). Clear non-corrosion related damage to manholes and pipes were not included in this data review.

2.1.2 Data Compilation

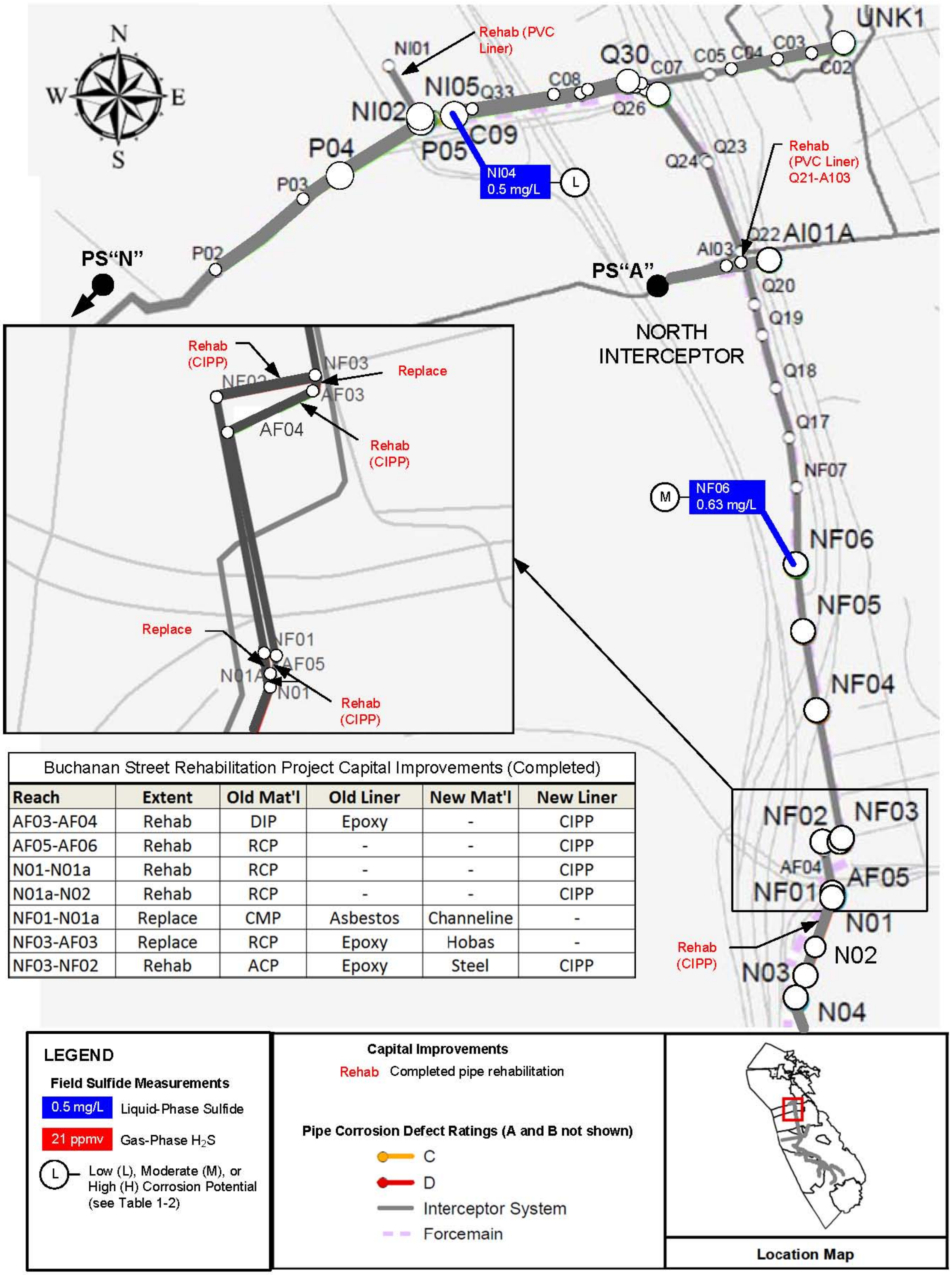
The data were used to compile pertinent historical liquid sulfide and H_2S measured concentrations, which have been noted in portions of the interceptor system provided in Figures 2-1 through 2-6. Note that the figures reflect available data for the analyzed interceptors, regardless of the data age. Furthermore, the figures also note the pipe reaches where either a "C" or "D" rating was given in the 2010-2012 Condition Assessment, disregarding those assets where the low rating was given for damage clearly unrelated to corrosion. A compilation of the most recently designated pipe severity ratings from the 2010-2012 Condition Assessment is provided in Attachment A. The interceptor maps in the attachment include all ratings ("A" through "D") for the pipe reaches and manholes. The data in Figures 2-1 through 2-6 were used to identify the hot spot areas of corrosion concern (Section 2.2).

2.1.3 Fluctuations with Time

This section reviews fluctuations in measured and previously modeled liquid sulfide and gas-phase H_2S concentrations within the historical period and notes interceptor locations where the values on average are either increasing or decreasing. Measurements are categorized into two distinctive timeframes:

- From 1995 to 1999: includes field measurements in 1995 and 1996 and concentrations as determined by the Interceptor Model as noted in the 1999 MWWTP Odor Control Master Plan.
- From 2008 to 2009: includes field measurements from 2008 and Interceptor Model results from the 2009 MWWTP Odor Control Master Plan Update.

Fluctuations were identified using the corrosion severity threshold ratings in Table 1-1. For those sections of the interceptors that generally remained the same severity level (low, medium, or high severity of corrosion potential) a yellow color is noted in Figures 2-7 and 2-8. For those segments in which measurements either increased or decreased by one group (for example, if liquid-phase sulfide concentrations went from "low" to "moderate") the pipe reaches are noted as such with orange for increasing and blue for decreasing. For reaches where corrosion potential increased or decreased by two groups (either going from low to high or from high to low), the reaches are noted as a large increase or large decrease (note that neither of these fluctuations occurred in the historical data analyzed).



Buchanan Street Rehabilitation Project Capital Improvements (Completed)					
Reach	Extent	Old Mat'l	Old Liner	New Mat'l	New Liner
AF03-AF04	Rehab	DIP	Epoxy	-	CIPP
AF05-AF06	Rehab	RCP	-	-	CIPP
N01-N01a	Rehab	RCP	-	-	CIPP
N01a-N02	Rehab	RCP	-	-	CIPP
NF01-N01a	Replace	CMP	Asbestos	Channeline	-
NF03-AF03	Replace	RCP	Epoxy	Hobas	-
NF03-NF02	Rehab	ACP	Epoxy	Steel	CIPP

Figure 2-1. Historical North Interceptor Liquid-Phase Sulfide and Gas-Phase H_2S Concentrations

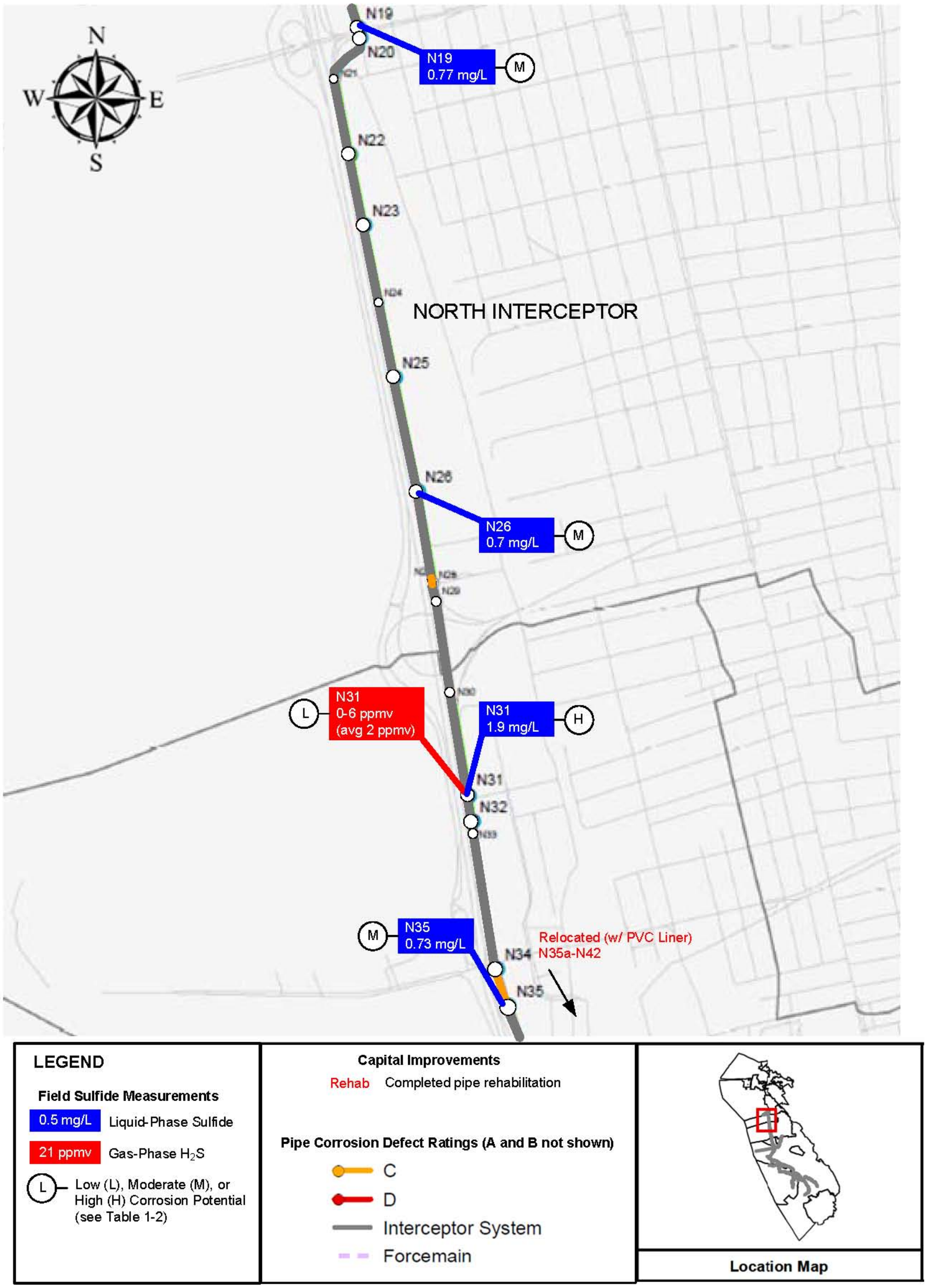


Figure 2-2. Historical North Interceptor Liquid-Phase Sulfide and Gas-Phase H_2S Concentrations

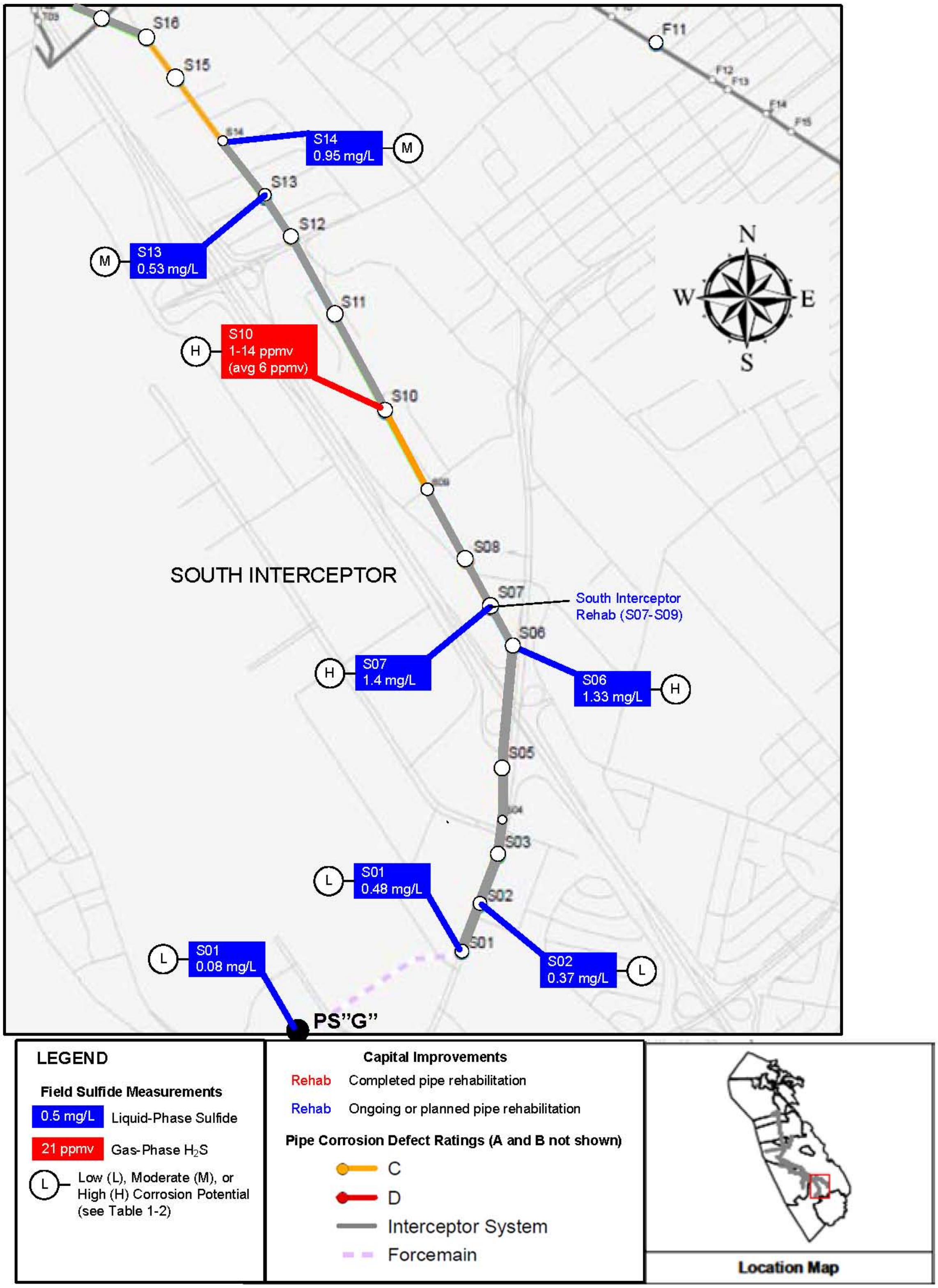


Figure 2-3. Historical South Interceptor Liquid-Phase Sulfide and Gas-Phase H_2S Concentrations

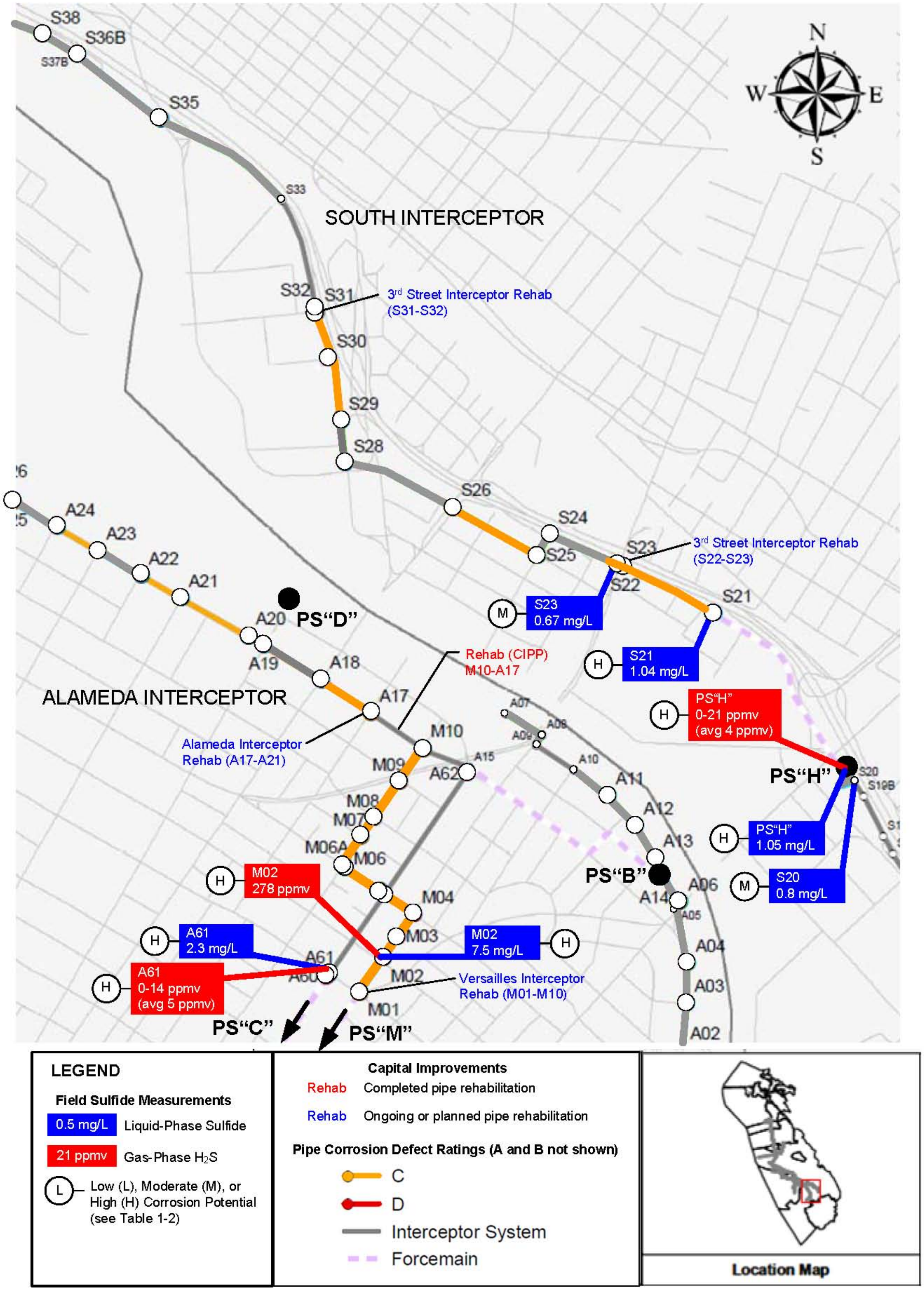


Figure 2-4. Historical Alameda and South Interceptors Liquid-Phase Sulfide and Gas-Phase H_2S Concentrations

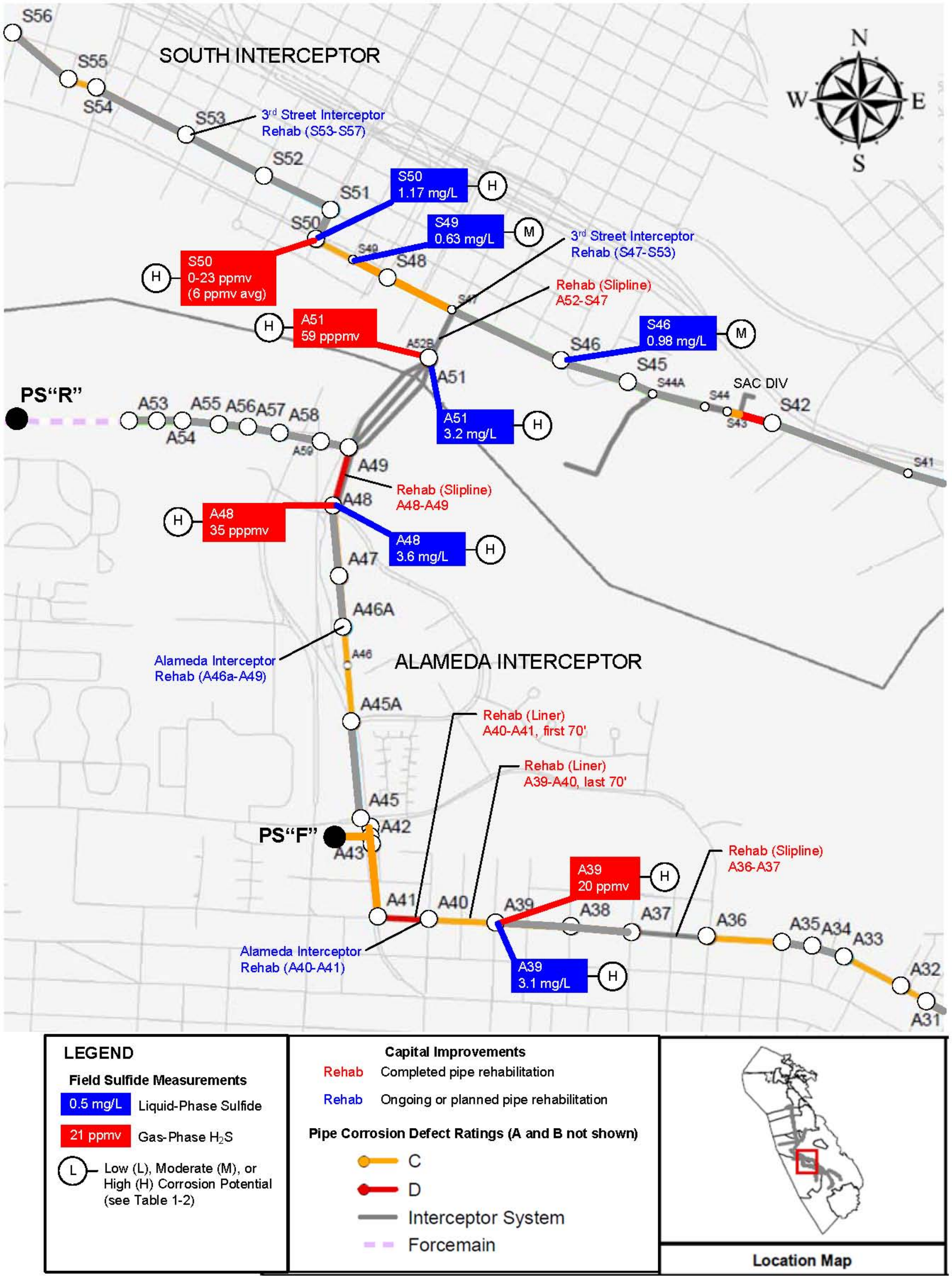


Figure 2-5. Historical Alameda and South Interceptors Liquid-Phase Sulfide and Gas-Phase H_2S Concentrations

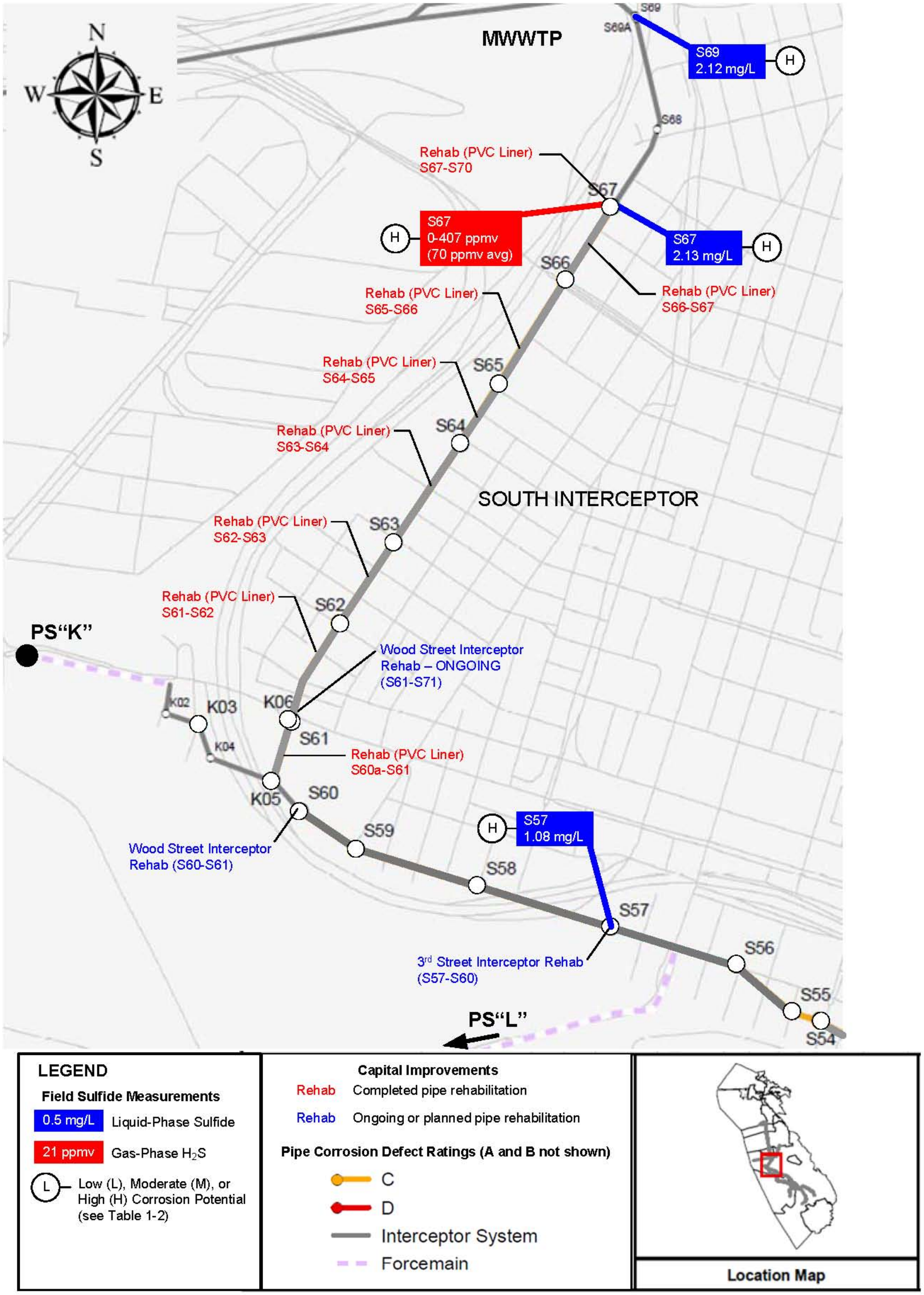


Figure 2-6. Historical South Interceptor Liquid-Phase Sulfide and Gas-Phase H_2S Concentrations

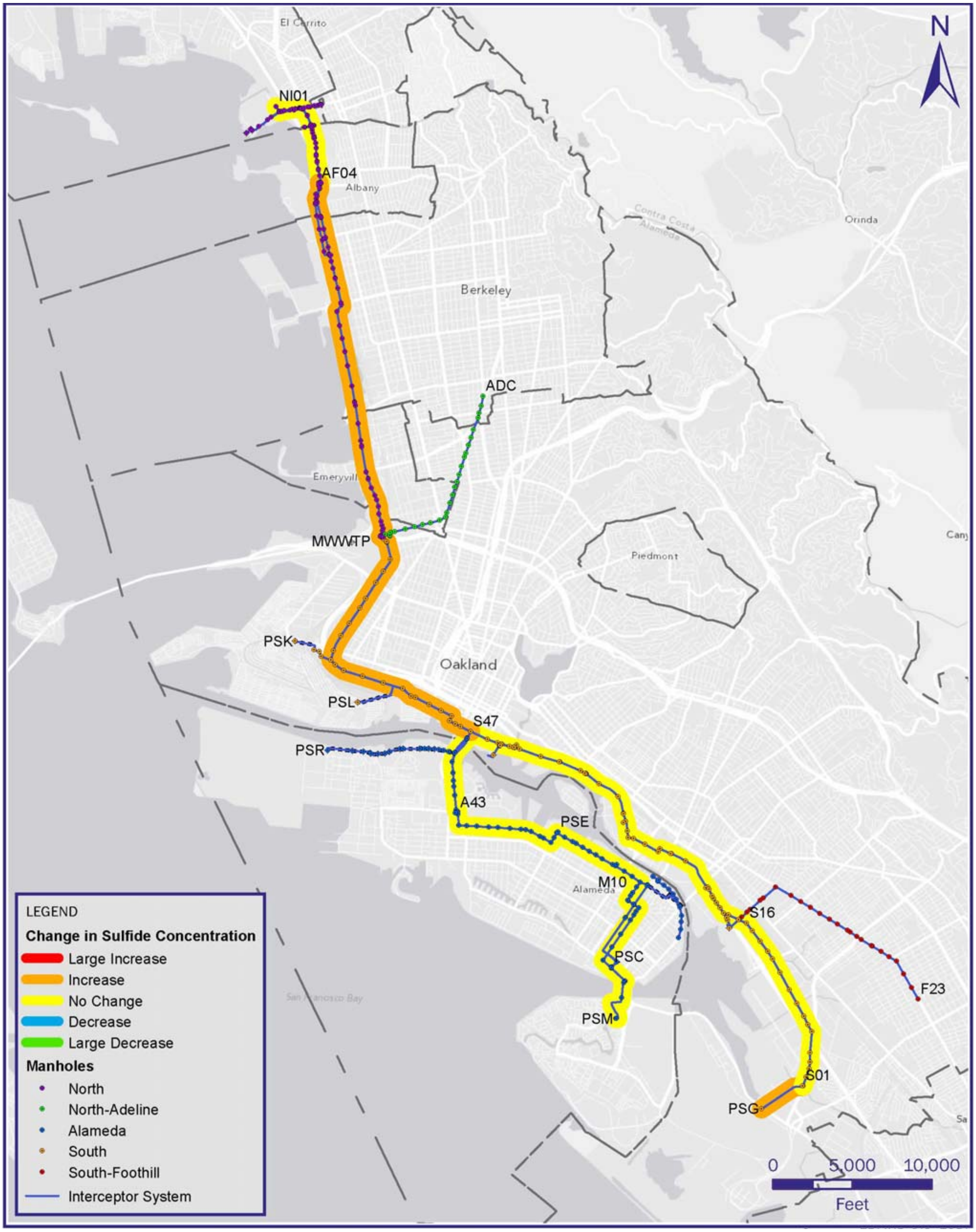


Figure 2-7. Interceptor Liquid-Phase Sulfide Concentration Fluctuations with Time

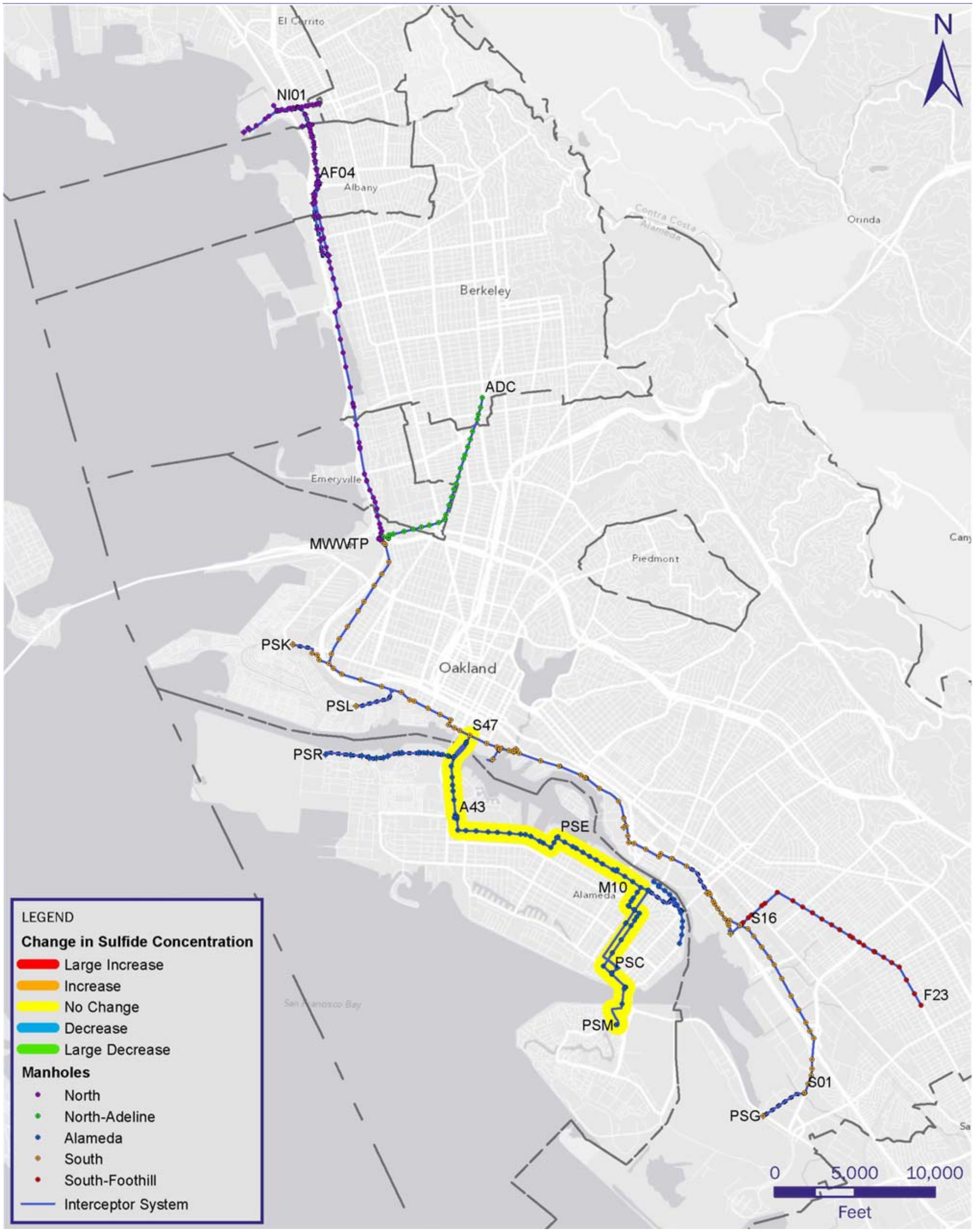


Figure 2-8. Interceptor Gas-Phase Hydrogen Sulfide Concentration Fluctuations with Time

The data supporting Figures 2-7 and 2-8 are shown in Table 2-1. Each of the three analyzed interceptors are broken up into logical segments that either correspond to interceptor transitions (for example, Manhole M10 is located at the confluence of a major side stream and the Alameda Interceptor) or significant changes in liquid-phase sulfide or gas-phase H_2S field measurements or modeled concentrations.

Table 2-1. Historical Corrosion Data Averages and Severity Levels

Interceptor Segment (Upstream Node-Downstream Node)	Liquid-Phase Sulfide Concentrations (mg/L)[a]				Gas-Phase H_2S Concentrations (ppmv)[a]			
	1995-1999 Data Average	Severity Level	2008-2009 Data Average	Severity Level	1995-1999 Data Average	Severity Level	2008-2009 Data Average	Severity Level
North Interceptor								
NI101-AF04	0.7	Moderate	0.8	Moderate	No Data[2]	-	0.3[b]	Low
AF04-MWWTP	0.7	Moderate	2.4	High	No Data[2]	-	1.7	Low
Alameda Interceptor								
PS"M"-M10	4.3	High	4.5	High	220	High	165[b]	High
M10-PS"E"	3.5	High	5.6	High	14	High	5[b]	High
PS"E"-A43	3.2	High	2.7	High	28	High	5[b]	High
A43-S47	3.4	High	2.7	High	54	High	5	High
South Interceptor								
PS"G"-S01	0.4	Low	0.7	Moderate	No Data[2]	-	0	Low
S01-S47	0.9	Moderate	1.0	Moderate	No Data[2]	-	7	High
S47-MWWTP	1.0	Moderate	1.9	High	No Data[2]	-	6	High

[a] Concentrations shown are reflective of overall average of measured data and modeled data within the various segments.

[b] No field-measured data are available. Values based on past modeling work (MWWTP Odor Control Master Plan Update, 2009).

In Table 2-1, the values in the "1995-1999 Data Average" and "2008-2009 Data Average" columns are representative of the average of the pertinent field-measured data and modeled data for the segments listed, as available. Field data is not available for all segments. In some segments where field data are not available, the concentrations from the corresponding CH2M HILL Interceptor Model are listed.

As shown in Figures 2-7 and 2-8 and in Table 2-1, the only significant changes in pipe corrosion severity level that occurred from the first timeframe to the second were in liquid-phase sulfide measurements – one in the downstream portion of the North Interceptor and two in the South Interceptor. In all three segments, the pipe corrosion severity levels increased. Note that while there were measured and modeled decreases in gas-phase H_2S concentrations throughout the Alameda Interceptor between the two timeframes, all measurements were still in the "high" range (greater than 2 ppmv).

2.2 Areas of Corrosion Concern

Based on the review of historical data, corrosion "hot spots" have been identified, which represent interceptor pipe locations (multiple reaches of sequential nodes) in the system in which significant corrosion has either already been identified in the 2010-2012 Condition Assessment (pipe severity groups C or D) or in which there is significant potential for future corrosion in the pipe based upon the historical measured liquid-phase sulfide and/or gas-phase H_2S concentrations. This section provides a summary of the hot spots and details of the field measurements that support their identification. Note that the list does not include two identified high-sulfide, high-corrosion areas that have either already been rehabilitated, or are currently undergoing rehabilitation with corrosion barriers. These areas include the South Interceptor in the vicinity of Wood Street and the North Interceptor in the vicinity of Buchanan Street. Also, note that the list includes some hot spots that have already been designated by the District for rehabilitation; this TM will not provide extended analyses of these hot spot areas.

2.2.1 Corrosion Hot Spots Summary

Table 2-2 presents a summary of the corrosion hot spots identified for this task. The hot spot locations are depicted on maps of the interceptors in Sections 2.2.2 through 2.2.4.

Table 2-2. Corrosion Hot Spots

Hot Spot (HS)	Location (Nodes)		Pipe Corrosion Severity Level[a]		Notes
	Upstream	Downstream	Liquid-Phase	Gas-Phase	
North Interceptor					
HS1	N31	N35	Moderate-High	Low	• 66-in diameter pipe (reinforced concrete pipe) • Length: 2,441 linear feet (LF). • Reach N34-N35 (432 LF) was assigned Pipe Severity Group “C” rating in 2011 inspections despite presence of PVC liner in this location. • Measured 1.9 mg/L liquid-phase sulfide concentration at Manhole N31 in 2008 sampling. • Low gas-phase H_2S concentrations at Manhole N31 in 2008 sampling do not match with high liquid-phase sulfide concentrations in historical record.
Alameda Interceptor					
HS2	M01	M10	High	High	• 24-in diameter pipe (ductile iron pipe) • Length: 3,165 LF • Currently has epoxy liner (M01-M10) • M01-M10 assigned Pipe Severity Group “C” rating in 2010-2012 Condition Assessment • High liquid-phase sulfide and gas-phase H_2S concentrations in historical record, but no measurements taken since 1997. • Upstream PS “M” currently dosed with hypochlorite for odor control. • Hot spot is being addressed with planned rehabilitation of M01-M10 as part of the Versailles Interceptor Rehabilitation Project (FY14-16).
HS3	A17	A21	High (upstream)	High (upstream)	• 42-in and 48-in diameter pipe (reinforced concrete pipe) • Length: 2,184 LF • High historical liquid-phase sulfide concentrations in upstream Versailles Segment. • Segment is downstream of confluence of three branches, each of which has a long pressure discharge pipeline (PS “B”, “C”, and “M”). • Hot spot is being addressed with planned rehabilitation of A17-A21 as part of the Alameda Interceptor Rehabilitation Project (FY15-16).

Table 2-2. Corrosion Hot Spots					
Hot Spot (HS)	Location (Nodes)		Pipe Corrosion Severity Level[a]		Notes
	Upstream	Downstream	Liquid-Phase	Gas-Phase	
HS4	A21	A46a	High	High	• 48-in to 60-in diameter pipe (reinforced concrete pipe) • 12,906 LF • High liquid-phase sulfides and gas-phase H_2S in historical record (at A39 and in upstream Versailles segment), but no measurements taken since 1997. • Several reaches designated with Pipe Severity Group "C" rating and one reach with Pipe Severity Group "D" (A40-A41) in 2010-2012 Condition Assessment • Reach A36-A37 (slipline) and portions of A39-A40 and A40-A41 (liner) rehabilitated previously. • Planned rehabilitation between Manholes A40 and A41 as part of the Alameda Interceptor Rehabilitation Project (FY15-16).
HS5	A46a	S47	High	High	• 30-in to 96-in pipe diameter (reinforced concrete pipe) • Length: 4,639 LF (includes both pipes that make up the Oakland Estuary Siphon) • Reach A48-A49 given Pipe Severity Group "D" rating in 2010-2012 Condition Assessment • High historical liquid-phase sulfide and gas-phase H_2S concentrations (A48, A51), but no measurements taken since 1997. • Reaches A48-A49 and A52-S47 were previously rehabilitated (slipline). • Hot spot area also includes contribution from segment that contains Pump Station "R" (no historical corrosion-related data but a potential additional hot spot, pending results from field sampling). • Hot spot is being addressed in the planned rehabilitation of A46a-A49 as part of the Alameda Interceptor Rehabilitation Project (FY15-16).
South Interceptor					
HS6	S09	S16	Moderate	High	• 63-in diameter pipe (reinforced concrete pipe) • 5,985 LF • High gas-phase H_2S concentrations in historical record, but no measurements taken since 1997. • S09-S10 and S14-S16 given Pipe Severity Group "C" rating in 2010-2012 Condition Assessment. • Not currently lined • Planned rehabilitation upstream (S07-S09) as part of the South Interceptor Rehabilitation Project (FY15-16).
HS7	S21	S31	Moderate-High	High	• 36-in to 66-in pipe diameter (reinforced concrete pipe in all but one vitrified clay pipe reach) • 5,724 LF • Moderate to high liquid-phase sulfide and gas-phase H_2S concentrations in historical record.

Table 2-2. Corrosion Hot Spots					
Hot Spot (HS)	Location (Nodes)		Pipe Corrosion Severity Level[a]		Notes
	Upstream	Downstream	Liquid-Phase	Gas-Phase	
					• Several reaches assigned Pipe Severity Group "C" ratings in 2010-2012 Condition Assessment. • Not currently lined • Planned rehabilitation of special structures at S22-S23 and S31-S32 as part of the 3rd Street Interceptor Rehabilitation Project (FY15-16).
HS8	S47	S50	Moderate-High	High	• 105-in diameter pipe (reinforced concrete pipe) • 1,498 LF • Moderate to high liquid-phase sulfide and gas-phase H_2S concentrations in historical record. • S47-S50 given Pipe Severity Group "C" rating in 2010-2012 Condition Assessment. • Of corrosion concern because the hot spot is downstream of the confluence of the Alameda and South Interceptors. • Not currently lined • Hot spot is being addressed in the planned rehabilitation of S47-S53 as part of the 3rd Street Interceptor Rehabilitation Project (FY15-16).
HS9	S54	S57	High	High (upstream)	• 105-in diameter pipe (reinforced concrete pipe) • 2,272 LF • High liquid-phase sulfide and gas-phase H_2S concentrations in historical record. • S54-S55 given Pipe Severity Group "C" rating in 2010-2012 Condition Assessment. • Not currently lined • Hot spot is being addressed in the planned rehabilitation of S53-S57 as part of the 3rd Street Interceptor Rehabilitation Project (FY15-16).

[a] *Determined using liquid-phase sulfide and gas-phase H_2S concentrations from the 2009 Odor Control Master Plan Update Interceptor Model.*

2.2.2 North Interceptor Corrosion Hot Spots

One hot spot for current and/or potential corrosion in the North Interceptor has been identified upon review of the historical data and the Interceptor Model completed as part of the 2009 MWWTP OCMP Update:

Hot Spot 1: The downstream section of the North Interceptor that passes through Emeryville (N31-N35) is a hot spot because of a high (per Table 1-2) measured liquid-phase sulfide concentration of 1.9 mg/L in Manhole N31 (2008 sampling) and the Severity "C" rating given to the N34-N35 reach in the 2010-2012 Condition Assessment. The corrosion in the N34-N35 reach could be related to the large sidestream input at Manhole N34, which increases turbulence and therefore could promote additional H_2S volatilization.

However, the high measured liquid-phase sulfide concentration at Manhole N31 does not correlate with the gas-phase H_2S measurements in the same location, whose average value corresponds to the "low" severity range per Table 1-2. In the 2009 MWWTP OCMP Update, it is noted that a possible reason for the lower-than-expected gas-phase H_2S concentrations was a positive dissolved oxygen concentration measured in the wastewater in the vicinity of the high liquid-phase sulfide area. Alternatively, the lower concentrations could result from a local high-pH discharge in the area, minimizing H_2S volatilization. Additional data is needed to confirm corrosion potential, and has been scheduled to be collected as part of the additional sampling discussed in Section 2.3. Sampling results will also impact dose calculations for the chemical treatment alternatives discussed in this TM.

The location of the hot spot is shown in Figure 2-9.

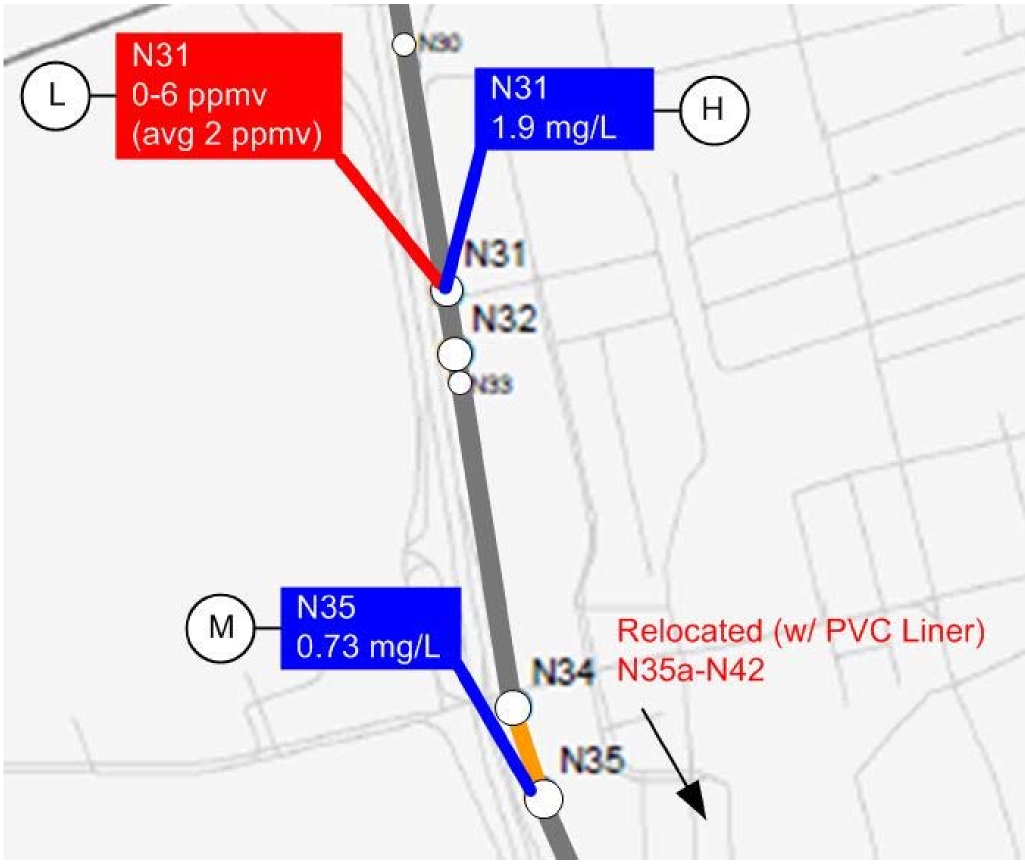


Figure 2-9. Hot Spot 1 (North Interceptor): N31-N35

See Figure 2-2 for legend

2.2.3 Alameda Interceptor Corrosion Hot Spots

Four corrosion hot spots in the Alameda Interceptor have been identified upon completion of a review of the historical data and the Interceptor Model completed as part of the 2009 MWWTP OCMP Update:

Hot Spot 2: The portion of the Alameda Interceptor downstream of the Pump Station "M" discharge outlet pipeline (M01 through M10) presents a corrosion concern because of historical high measured liquid-phase sulfide concentrations (as high as 7.5 mg/L), though recent liquid-phase sulfide data are not available (none have been collected since 1997). Additional sampling will be conducted to address this data gap (see Section 2.3). The 2010-2012 Condition Assessment gave a "C" rating to M01-M10, and a "D" rating to three of the manholes in this portion of the interceptor.

M01-M10 is planned for rehabilitation as part of the Versailles Interceptor Rehabilitation Project; therefore this TM will not discuss alternative means of controlling corrosion in this location. However, because construction of a physical barrier in this segment will not serve to reduce the high liquid-phase sulfide concentrations generated in the upstream force main, this rehabilitation will likely produce increased corrosion concerns for the reaches downstream of Manhole M10.

The location of the hot spot is shown in Figure 2-10.

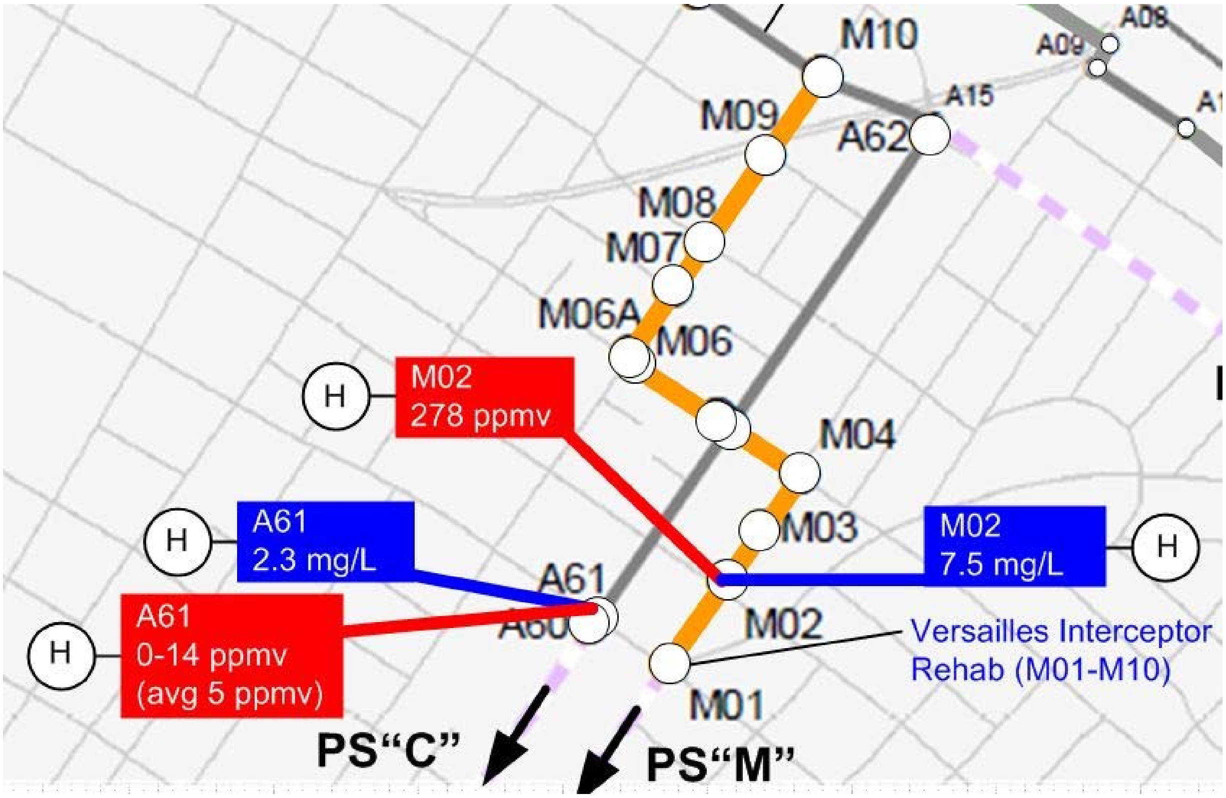


Figure 2-10. Hot Spot 2 (Alameda Interceptor): M01-M10

See Figure 2-4 for legend

Hot Spot 3: The portion of the Alameda Interceptor downstream of the confluence of the Pump Stations "M", "C", and "B" discharges (A17 through A21) is an area of corrosion concern primarily due the combination of three gravity lines, each of which contains a long discharge pressure pipeline upstream. Furthermore, high liquid-phase sulfide and gas-phase H_2S measurements in upstream areas are in the historical record. The 2010-2012 Condition Assessment gave a pipe severity "C" rating to the reach between A17 and A18, and between A20 and A21. Recent liquid-phase sulfide data between the confluence point and Manhole A19 are not available, which is noted in Section 2.3; an additional sampling location is recommended to provide an indication of current liquid-phase sulfide and gas-phase H_2S concentrations.

Similar to Hot Spot 2, the portion of the Alameda Interceptor between A17 and A21 is planned for rehabilitation as part of the Alameda Interceptor Rehabilitation Project; therefore this TM will not discuss alternative means of controlling corrosion in this location. However, because construction of a physical barrier in this segment will not serve to reduce the high liquid-phase sulfide concentrations generated in the upstream lines that come together at Manhole M10, this rehabilitation will likely produce increased corrosion concerns for the reaches downstream of this location.

The location of the hot spot is shown in Figure 2-11.

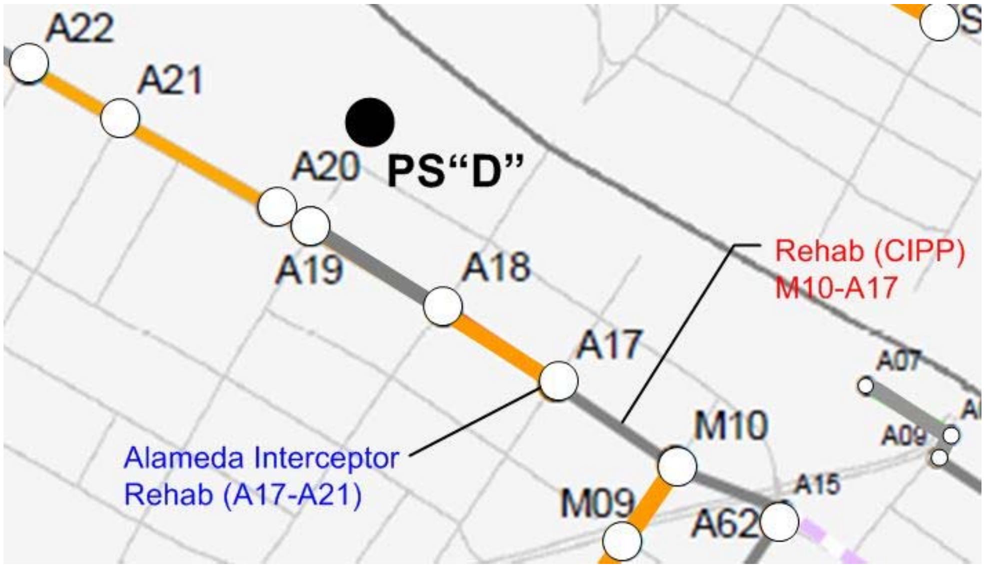


Figure 2-11. Hot Spot 3 (Alameda Interceptor): A17-A21

See Figure 2-4 for legend

Hot Spot 4: The portion of the Alameda Interceptor between A21 and A46a presents a corrosion concern due to high liquid-phase sulfide and gas-phase H_2S in the historical record at Manhole A39 and a severity rating of "C" given to several reaches in the 2010-2010 condition assessment, in addition to one severity rating "D" given to Reach A40-A41. This reach is planned for rehabilitation as part of the Alameda Interceptor Rehabilitation Project. Two other reaches in this hot spot have been lined or partially lined in previous rehabilitation projects. The location of the hot spot is shown in Figure 2-12.

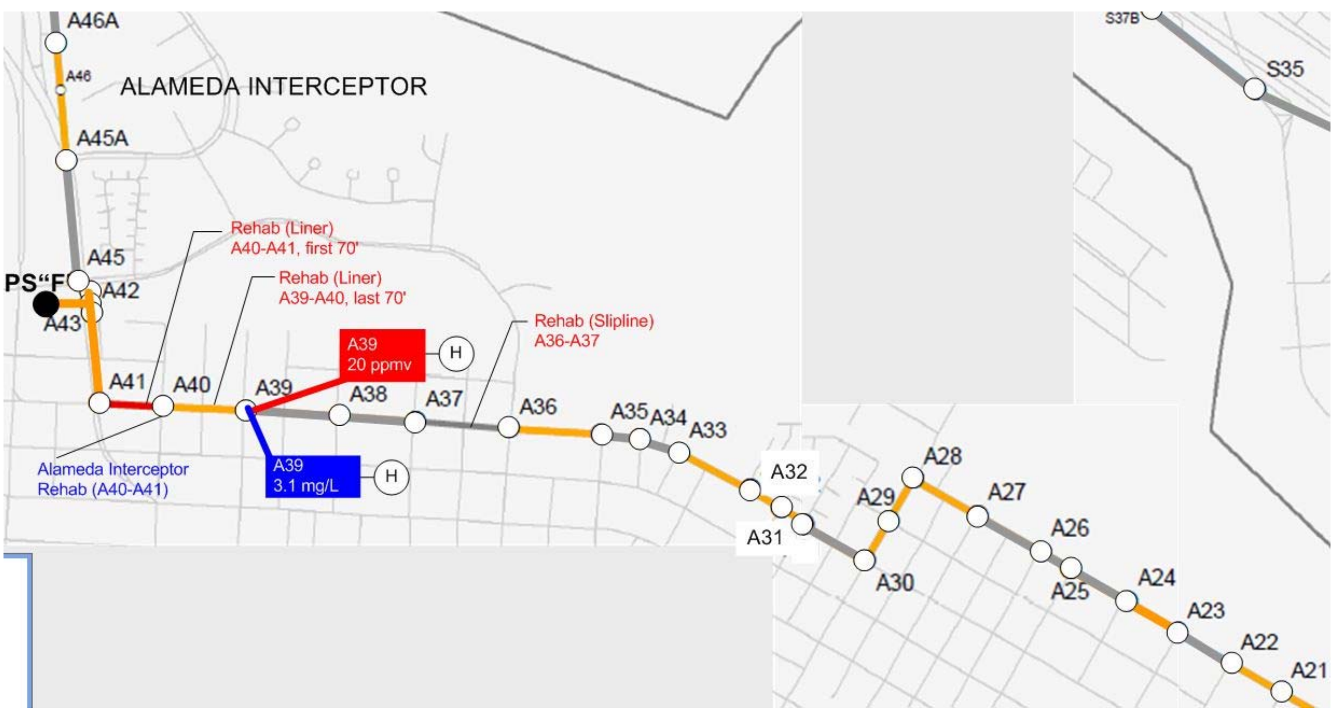


Figure 2-12. Hot Spot 4 (Alameda Interceptor): A21-A46a

See Figure 2-4 for legend

No data has been collected between Manholes A21 and A46a since 1997. Because of this, additional sampling will be conducted to address this data gap, as discussed in Section 2.3.

Hot Spot 5: This hot spot includes the area from A46a to the confluence of the Alameda Interceptor with the South Interceptor. This hot spot contains the Oakland Estuary siphon between A50 and A51. The hot spot limits are between Manhole A44 and Manhole S47. This location is a hot spot because high liquid-phase sulfide and gas-phase H_2S concentrations (per Table 1-2) were measured in Manholes A48 and A51 in the historical record. Additionally, the 2010-2012 Condition Assessment gave a “D” rating to the reach between A48 and A49. The location of the hot spot is shown in Figure 2-13.

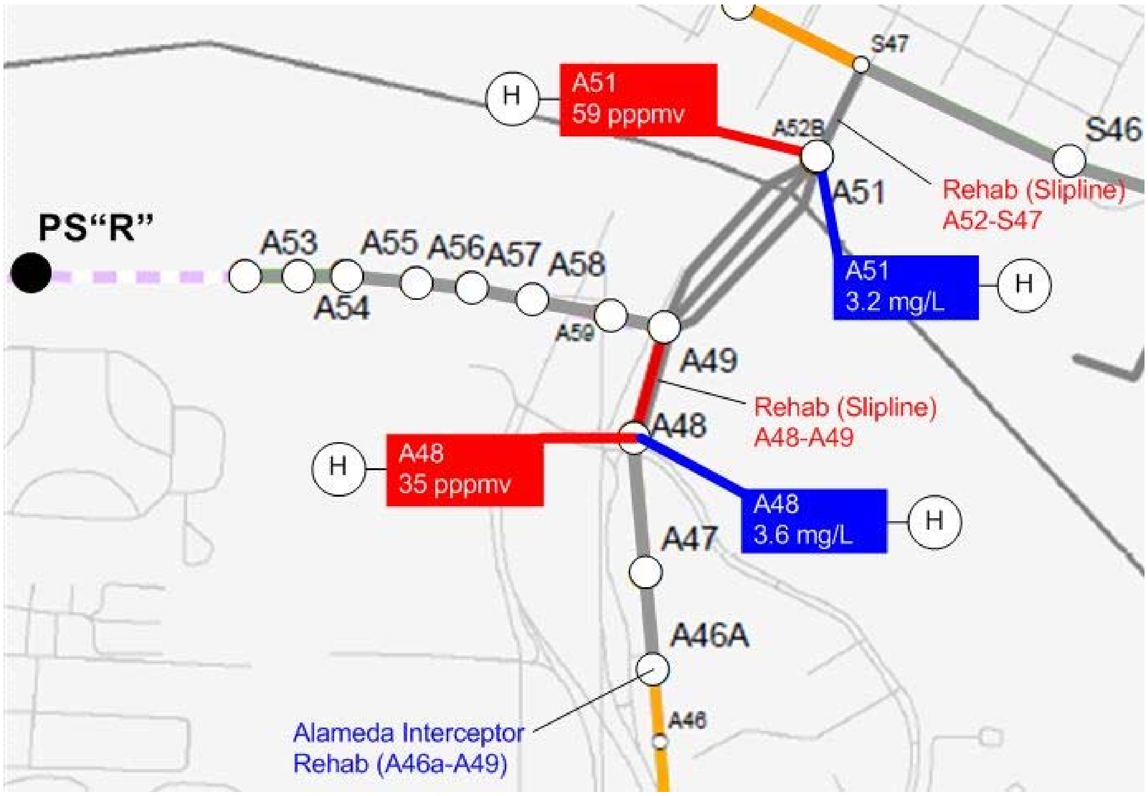


Figure 2-13. Hot Spot 5 (Alameda Interceptor): A46a-S47

See Figure 2-5 for legend

Recent liquid-phase sulfide and gas-phase H_2S data in this hot spot, including in the vicinity of the siphon, are not available. This is noted in the data gap section (Section 2.3), which also states the need for additional sampling in this area.

Similar to Hot Spots 2 and 3, A46a-A49 (ending just before the siphon) is planned for rehabilitation as part of the Alameda Interceptor Rehabilitation Project; therefore this TM will not discuss alternative means of controlling corrosion in this hot spot. However, because construction of a physical barrier in this segment will not serve to reduce the high liquid-phase sulfide concentrations downstream of the PS “F” input, this rehabilitation will likely produce increased corrosion concerns for the reaches downstream of this location, including the siphon itself and the downstream reaches following the confluence with the South Interceptor.

2.2.4 South Interceptor Corrosion Hot Spots

Four corrosion hot spots in the South Interceptor have been identified upon completion of a review of the historical data and the Interceptor Model completed as part of the 2009 MWWTP OCMP Update:

Hot Spot 6: The segment of pipe in the upstream portion of South Interceptor between S09 and S16 is designated as a hotspot due to moderate to high historical liquid-phase sulfide and gas-phase H_2S concentrations measured at Manholes S10, S13, and S14 and the Pipe Severity "C" rating given to the reach between Manholes S09 and S10 and S14-S16 in the 2010-2012 Condition Assessment. The upstream Reach S07-S09 is scheduled to be rehabilitated as part of the Alameda Interceptor Rehabilitation Project. The location of the hot spot is shown in Figure 2-14.

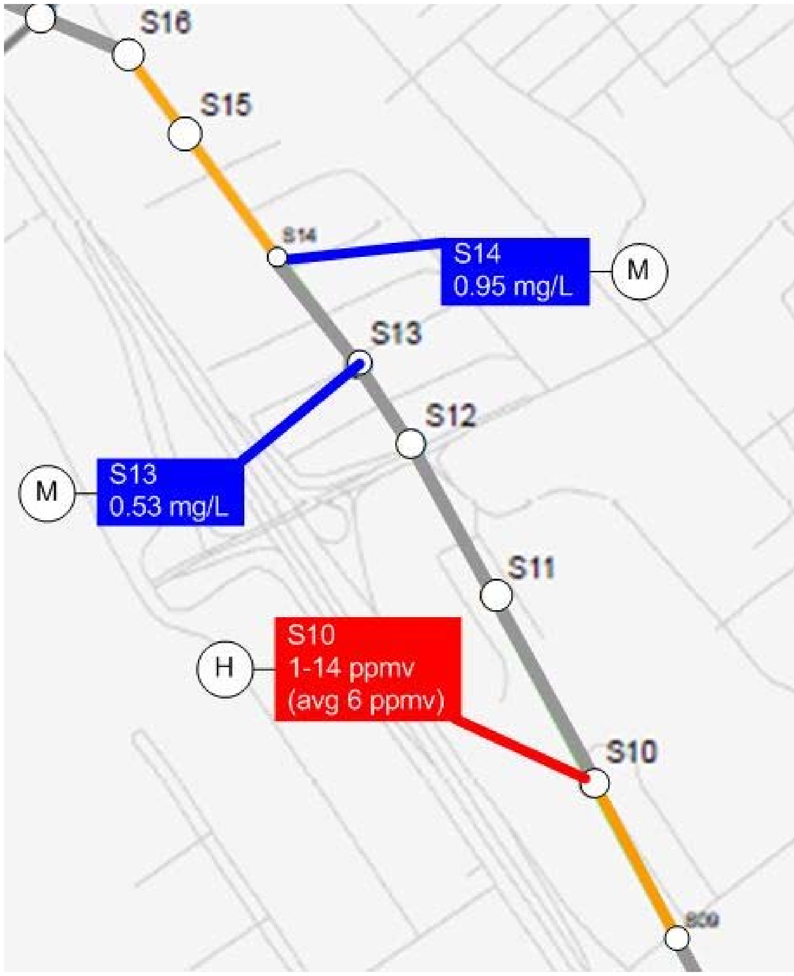


Figure 2-14. Hot Spot 6 (South Interceptor): S09-S16

See Figure 2-3 for legend

Because recent liquid-phase sulfide concentrations are not available for this area, additional sampling will be conducted to confirm this hot spot (see Section 2.3) and provide further basis for chemical injection liquid-phase treatment corrosion prevention methods.

Hot Spot 7: The reach of pipe downstream of the discharge line for Pump Station "H" (Manhole S21) through the connection with the Pump Station "J" discharge point (Manhole S31) represent a corrosion hot spot location due to moderate to high (per Table 2-1) liquid-phase sulfide concentrations in the historical record and because several reaches in the segment were designated as Pipe Severity "D" in the 2010-2012 Condition Assessment. The location of the hot spot is shown in Figure 2-15.

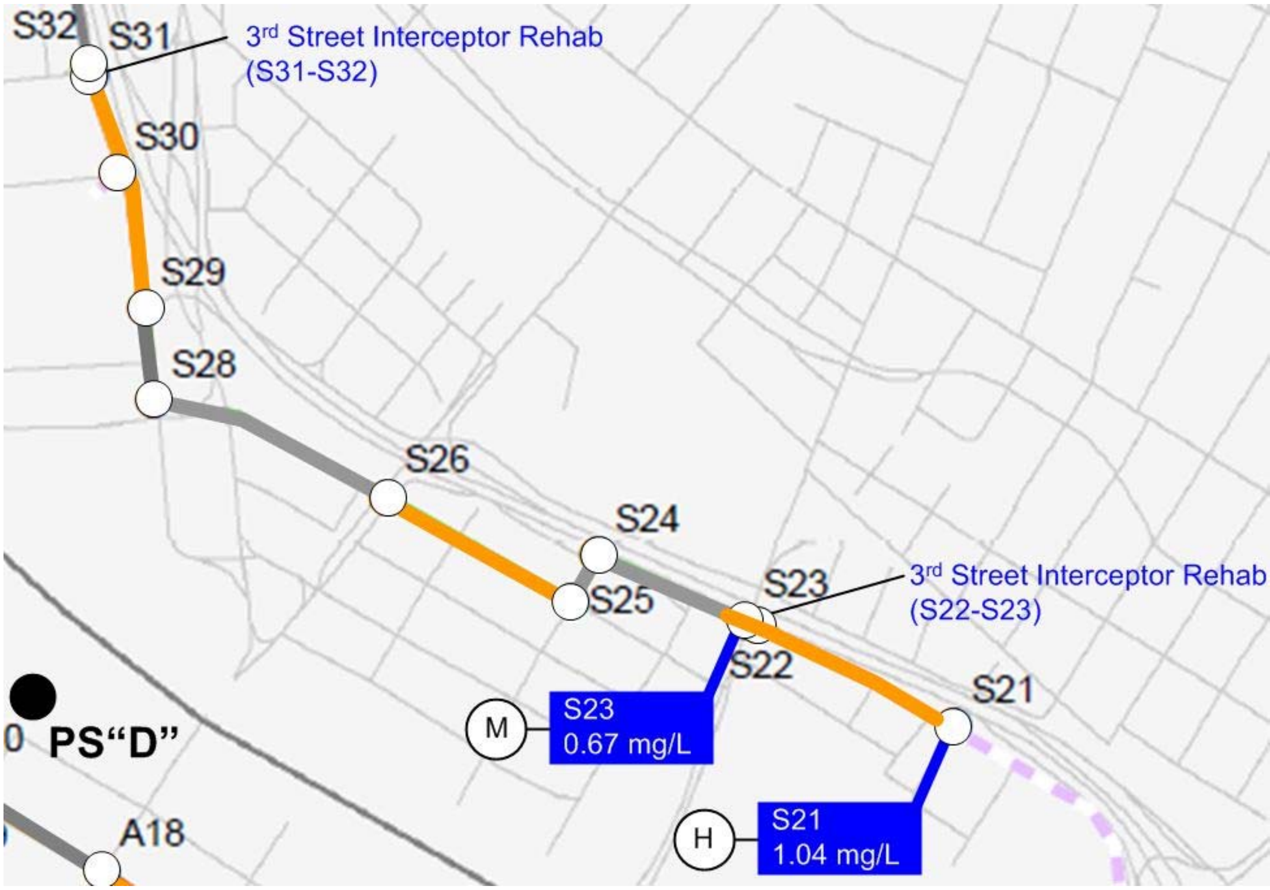


Figure 2-15. Hot Spot 7 (South Interceptor): S21-S31

See Figure 2-4 for legend

Two special structures (S22-S23 and S31-S32) have been designated for rehabilitation in the 3rd street Interceptor Rehabilitation Project. Other reaches within this hot spot have not yet been designated for improvements, including the four that were identified in the condition assessment as having pipe severity group "C". Additional liquid-phase sulfide sampling from the Pump Station "H" discharge will provide updated data that will be used as further basis for chemical injection liquid-phase treatment corrosion prevention methods in this hot spot.

Hot Spot 8: The pipe between Manhole S47 and Manhole S50 (just downstream of the confluence with the Alameda Interceptor) is designated as a hot spot area for corrosion potential due to moderate to high liquid-phase sulfide and gas-phase H_2S concentrations measured in the historical record. This area is of concern additionally because it is immediately downstream of a major sidestream input (the Alameda Interceptor), which historically has high-sulfide wastewater coming out of the Oakland Estuary Siphon. Additionally, sulfide concentrations are projected to increase in the future with rehabilitation to be completed in the downstream reaches of the Alameda Interceptor. The location of the hot spot is shown in Figure 2-16.

Additional sampling will be conducted (as described in Section 2.3) to update the liquid-phase sulfide and H_2S concentrations in this hot spot area and provide additional data for updating the Brown and Caldwell sulfide accumulation model. As discussed in Table 2-2, this TM will not provide further analysis of corrosion prevention methods in this hot spot because of the planned 3rd Street Interceptor Rehabilitation project for S47-S53.

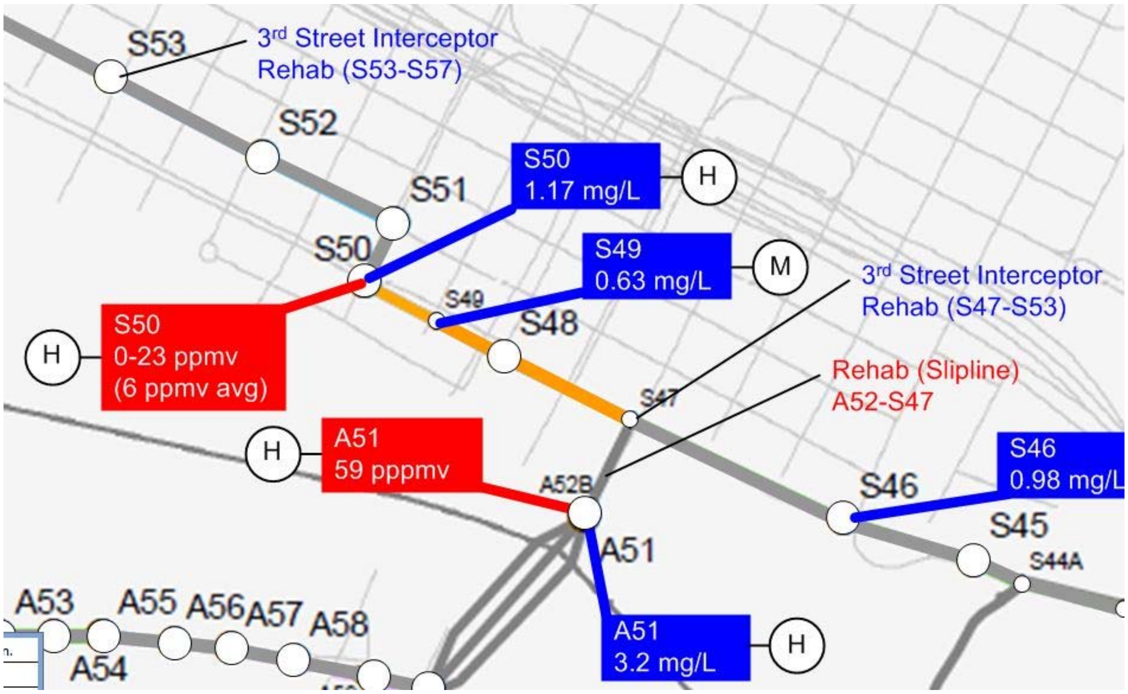


Figure 2-16. Hot Spot 8 (South Interceptor): S47-S50

See Figure 2-5 for legend

Hot Spot 9: The South Interceptor location between S54 and S57 is designated as a hot spot for corrosion potential due to high liquid-phase sulfide concentrations in the historical record and a determination of pipe severity group "C" for Reach S54-S55. The location of the hot spot is shown in Figure 2-17.

Figure 2-17. Hot Spot 9 (South Interceptor): S54-S57

See Figure 2-6 for legend

The segment of pipe between S54 and S57 is planned for rehabilitation as part of the 3rd Street Interceptor Rehabilitation Project; therefore this TM will not discuss alternative means of controlling corrosion in this location. However, because construction of a physical barrier in this segment and also downstream in the Wood Street segment will not serve to reduce the high liquid-phase sulfide historically measured, this rehabilitation could increase liquid-phase sulfide concentrations and sulfide loads to the MWWTP following installation of the barriers. This has an impact on downstream corrosion potential as well as on odor emissions and control at the MWWTP.

2.3 Data Gaps and Additional Sampling

Data gaps have been noted based on the review of sources listed in Section 2.1.1, in particular for liquid-phase sulfide and gas-phase H_2S concentrations in the three analyzed interceptors. Data gaps have been noted for areas where recent data has not been collected and/or where gas-phase data does not correlate with liquid-phase data, or with findings from the 2010-2012 Condition Assessment.

To address the data gaps a limited field sampling program is recommended as outlined in Table 2-3. Locations of the manholes listed in the table are shown on top of aerial photographs in Attachment B. This field sampling and testing is in addition to field work being conducted at the discharge points of all District pump stations, where liquid-phase sulfide concentrations will be measured. Results from the Task B additional sampling effort and the Task A pump station discharge sampling will be used to update and confirm hot spot locations as discussed in Section 2.3, and to calibrate a current sulfide accumulation and H_2S emissions model, which will be completed by BC using pipe hydraulic parameters (pipe diameter, slope, length, etc.) in the 2009 CH2M HILL Interceptor Model, flow data from the District's 2010 hydraulic modeling update, and parameters found in the historical literature (sources listed in Section 2.1.1).

Table 2-3. Proposed Additional Sampling Locations

Manhole(s)	Sample Type and Number		Rationale for Selection
	Liquid Sulfides[a]	Gas-Phase H_2S[b]	
North Interceptor			
NF05, NF04, or NF03[c]	1	1	Moderate concentrations of liquid-phase sulfides have been historically measured in this area, though pipe severity ratings in the 2010-2012 Condition Assessment were all "A" or "B". Liquid samples not collected since 1996 and no gas-phase H_2S data exists for this pipeline location.
N34 (Hot Spot 1)	1	1	This portion of the North Interceptor is a corrosion hot spot and Manhole N34 was given a severity rating of "C" in the 2010-2012 Condition Assessment; 2008 OdaLog H_2S data in Manhole N31 conflicts with CH2M HILL Interceptor Model predictions.
Alameda Interceptor			
M02 (Hot Spot 2)	1	1	Corrosion hot spot location with historical high liquid sulfide and gaseous H_2S at Pump Station "M" discharge; reach from M01 to M10 was designated as Pipe Severity Group "C" in the 2010-2012 Condition Assessment; no data collected in this reach since 1997.
A17 (Hot Spot 3)	1	1	Downstream of confluence of three segments; high historical liquid sulfide concentrations but no measurements since 1997.
A39 (Hot Spot 4)	1	1	High liquid sulfide measurement in 1997 (3.1 mg/L); no corrosion-related measurements between Pump Stations "E" and "F" since 1997.
A48 (Hot Spot 5)	1	1	Upstream of the Oakland Estuary Siphon, which historically has high liquid sulfides and gaseous H_2S; no data collected at A48 since 1997.

Table 2-3. Proposed Additional Sampling Locations			
Manhole(s)	Sample Type and Number		Rationale for Selection
	Liquid Sulfides[a]	Gas-Phase H_2S[b]	
A51 or A52[c] (Hot Spots 5 and 8)	1	1	Downstream of the Inner Harbor siphon which historically has high liquid sulfides and gaseous H_2S; pipe reaches following confluence with South Interceptor (Manhole S47) was identified as Pipe Severity Group "C" in 2010-2012 Condition Assessment and is a hot spot.
South Interceptor			
S09 (Hot Spot 6)	1	1	The Interceptor Model (2009) identifies the reach between Manholes S7 and S10 as having high liquid sulfides, but no data has been collected since 1997. Reach between Manholes S09 and S10 was identified as Pipe Severity Group "C" in 2010-2012 Condition Assessment.
S42 (Hot Spots 7 and 8)	1	1	Manhole S42 receives a large side stream input from Oakland; no historical liquid-phase sulfide or gas-phase H_2S data exists from Manhole S24 to Alameda Interceptor confluence (S47), therefore S42 was selected to characterize corrosion potential in this location.
S48 or S49[c] (Hot Spot 8)	1	1	Reach between Manholes S48 and S49 was identified as Pipe Severity Group "C" in 2010-2012 Condition Assessment; downstream of the confluence with Alameda Interceptor. Data to be collected to compare with results downstream of Inner Harbor siphon.

[a] *Two grab samples collected and analyzed for total liquid sulfides*

[b] *OdaLog installed and H_2S concentrations monitored for 1 week*

[c] *Field team to select whichever manhole can be most easily accessed*

2.4 Other Collected Interceptor Historical Data

Previous odor and corrosion studies on the District's interceptor system (Section 2.1.1.) were reviewed to obtain measurements of other water quality parameters that will also be needed to update the sulfide accumulation and H_2S emissions model (previously produced by CH2M HILL in its Interceptor Model and to be updated by BC for this work). The following wastewater parameters were reviewed:

- pH
- Biochemical oxygen demand (BOD)
- Dissolved oxygen (DO)
- Temperature

Average values for these parameters at interceptor nodes will be used to calibrate BC's updated sulfide accumulation and H_2S emissions model. Attachment C contains the retrieved data for each parameter. Where noted, the values are representative of the average of multiple measurements, either in the same study or in more than one study completed on different occasions.

Section 3: Corrosion Control Methods

This section presents an overview of corrosion control methods that have been deemed to be industry standard and have the potential to be incorporated into some portion(s) of the District's interceptor system. The overview is broken up into (1) liquid-phase treatment methods (chemical injection and oxygen addition), (2) pipe replacement and physical corrosion barriers that can be used to protect the existing sewer pipe against corrosion and (3) operational modifications intended to extend the sewer pipe life. The methods discussed in this section have all been successful in similar applications.

3.1 Liquid-Phase Treatment Methods

This section includes an overview of liquid-phase treatment alternatives that could be incorporated into the District's interceptor system for corrosion control. Treatment methods can be characterized as those that eliminate sulfide from the wastewater (or convert it to a non-volatile form) and those that prevent sulfide from forming. A summary of advantages and disadvantages associated with the methods discussed below is provided in Table 3-1 (Section 3.1.8). Further evaluation of viable hot spots where these methods could be installed to reduce sulfide concentrations in the downstream wastewater is provided in Section 4.

3.1.1 Chlorine Gas

Chlorination represents one of the oldest corrosion control practices for interceptor systems. Chlorine is effective in controlling corrosion because it acts as a strong oxidizing agent and an effective bactericide. When added to water, gaseous chlorine (Cl_2) immediately reacts to form hypochlorous acid (HOCl). This weak acid and the related hypochlorite ion (OCl^-) are the active agents in aqueous chlorination processes. Gaseous chlorine is toxic to sulfate-reducing bacteria present in the wastewater, but the dosage required to suppress sulfide formation is high. Therefore, it is more feasible to oxidize sulfide after it has formed, with the product of the reaction being colloidal sulfur or sulfate. Chlorine also reacts with organic material, which increases the dosage needed. In practice, Cl_2 to sulfide weight ratios of 7 to 10 are often required for light- to medium-strength wastewater. Higher ratios are needed for high-organic content wastewaters.

Typically, gaseous chlorine is only economical in comparison to hypochlorite solution when high dose rates are required (several hundred pounds per day). At these quantities, the presence of chlorine gas represents a significant hazard, as the chlorine is stored as a liquid under pressure and chlorine gas is drawn off of the storage tank headspace prior to injection into the wastewater. The need for a high-pressure storage facility combined with the fact that chlorine gas is poisonous makes this technology undesirable for being located in the District's interceptor system and it will be eliminated from consideration and further analysis.

3.1.2 Hypochlorite Solution

Sodium hypochlorite (NaOCl) solution is a high-strength version of the commercially available bleach used in domestic cleaning and disinfection. Calcium hypochlorite [$Ca(OCl)_2$] is another hypochlorite solution that can be used in corrosion control in interceptor systems. Similar to chlorine gas, HOCl and OCl^- are the active agents formed when hypochlorite solutions are used in chlorination. The advantage of using hypochlorite solution over chlorine gas is the lower toxicity of the chemical and the reduced hazard concern (though personal protective equipment is still required when handling the chemical).

Hypochlorite is a strong oxidant, reacting with sulfide in the liquid phase through the following reaction:

$4\ NaOCl + H_2S \rightarrow 4\ NaCl + H_2SO_4$

However, the agents of the hypochlorite solution reaction react indiscriminately with other compounds in the wastewater, which effectively exert a chlorine demand. Therefore, in practical applications the required dosage for effective sulfide reduction in wastewater typically ranges between 10 and 15 pounds of sodium hypochlorite per pound of hydrogen sulfide. This additional demand, which is consistently present in wastewater collection systems as organic matter (which can be measured as BOD), makes it difficult to establish a chlorine residual downstream much beyond the injection point of the chemical.

Therefore, hypochlorite addition is best implemented by injecting a sufficient quantity of chemical to reduce the liquid-phase sulfide concentration to zero at locations where high liquid-phase sulfide concentrations have accumulated, not attempting to inject large doses to combat chlorine demand further downstream and provide sulfide control. The District currently injects hypochlorite solution for (odor control purposes) at four of its pump stations (“C”, “”F”, “M”, and “R”).

The use of hypochlorite solution for sulfide control requires adequate mixing. However, the benefit of using locations of natural or induced turbulence as application points must be weighed against the probability of liberating H_2S gas in those locations. For this reason, it may be desirable to feed hypochlorite solution just upstream of areas where turbulence is created in the interceptor system, such as in areas where bends and/or changes in slope occur.

3.1.3 Hydrogen Peroxide

Hydrogen peroxide (H_2O_2) is a strong oxidant for converting sulfides in the liquid phase to a non-volatile form. The chemical oxidizes hydrogen sulfide to elemental sulfur according to the following equations:

$H_2S + H_2O_2 \rightarrow S + 2H_2O$ (for pH $\leq$ 8.5)

$S^- + 4H_2O_2 \rightarrow SO4^- + 4H_2O$ (for pH > 8.5)

However, much like hypochlorite, hydrogen peroxide is an indiscriminate oxidizer, meaning that additional compounds in the wastewater exert a demand on the chemical and cause effective dose rates to be higher than stoichiometric values. In practice, a range of 2 to 6 pounds of H_2O_2 is typically required to oxidize 1 pound of sulfide. Also similar to hypochlorite, it is recommended that hydrogen peroxide be added to the wastewater at a point where a significant amount of mixing will occur, to assure a complete reaction.

Hydrogen peroxide has been noted in some applications as being more effective than a comparable oxygen injection into the wastewater because it is capable of oxidizing the bisulfide ion (HS^-), whereas oxygen does not. Another advantage of hydrogen peroxide is that, upon injection, it decomposes into oxygen and water. The oxygen remaining in the wastewater after oxidation of the sulfide (and other compounds that exert a demand for oxidation) will increase the dissolved oxygen (DO) of the wastewater somewhat, and aid in preventing the formation of additional sulfide downstream. This is especially of value because a major disadvantage of hydrogen peroxide is that other than the DO increase, it provides no residual downstream for inhibiting further sulfide oxidation. This is because peroxide is both fast-acting and quickly consumed in raw wastewater. This fast-acting condition becomes a particular problem for corrosion control in long interceptors where high sulfide concentrations create issues in long reaches of the collection system.

3.1.4 Iron Salts

Iron salt solutions can be added to wastewater to precipitate sulfide as various iron-sulfide compounds. Four iron salt solutions are typically used for corrosion control:

- Ferric chloride, $FeCl_3$
- Ferrous chloride, $FeCl_2$
- Ferric sulfate, $Fe_2(SO_4)_3$
- Ferrous sulfate, $FeSO_4$

The simplest reactions of ferric (Fe^{2+}) and ferrous (Fe^{3+}) ions with dissolved sulfide are as follows:

$Fe^{2+} + HS^- \rightarrow FeS + H^+$

$2Fe^{3+} + 3HS^- \rightarrow Fe_2S_3 + 3H^+$

The stoichiometric quantity of iron required for each of these reactions is 1.6 and 1.1 lb. of ferrous and ferric ion, respectively, per pound of sulfide precipitated. In practice, the weight ratio ranges from 2:1 to 10:1, depending upon the final sulfide concentration obtained following the reaction. To lower sulfide concentrations below 0.5 mg/L, some previous similar applications have required disproportionately higher iron doses, in the upper part of the dose range (approximately 10:1).

The primary advantage of iron salts as compared to oxidants such as hypochlorite and hydrogen peroxide is that iron salts provide a residual in the wastewater downstream of the point of addition, which is advantageous for sulfide control in long interceptor segments. The residual iron that is in the system can also be used at a downstream treatment plant, producing improved odor control, increased primary sedimentation performance (solids removal) and H_2S control in the digesters, both of which could be beneficial for the MWWTP. In previous work, BC has estimated that an iron dose of approximately 3-4 mg/L as Fe is needed just upstream of the plant primary clarifiers to provide sufficient H_2S control in the digesters, and a dose of approximately 12 mg/L as Fe upstream of the primary clarifiers is needed for full chemically enhanced primary treatment (CEPT) at the MWWTP.

The primary disadvantages of injecting iron salts are the acidic (pH less than 2), corrosive, and hazardous nature of the chemical (resulting in stringent storage requirements) and the fact that, unlike oxidants, iron salt addition typically does not lower sulfide concentrations to zero. In previous applications, the resulting sulfide concentrations following the reaction with iron were not lower than approximately 0.4 mg/L. This concentration is still in the “low” range in the corrosion severity threshold distribution (Table 1-2).

3.1.5 Nitrate Solution

The bacteria that are responsible for sulfide production in wastewater systems typically reduce sulfate in the wastewater to sulfide after all dissolved oxygen in consumed. These bacteria prefer nitrate as an oxygen source over sulfate when it available, therefore when nitrate is added, the bacteria will use the nitrate compound as an electron acceptor, inhibiting sulfide production. The reaction of the nitrate solution with the bacteria produces nitrogen gas and other nitrogenous compounds rather than sulfide. Normally, raw wastewater does not contain any nitrate, therefore, it must be artificially added to achieve this preventative corrosion control measure.

Nitrate is available in a variety of dry and liquid forms, mostly as sodium nitrate ($NaNO_3$) or calcium nitrate [$Ca(NO_3)_2$]. Liquid solutions are commercially available containing between 2.0 and 3.5 pounds of nitrate-oxygen per gallon (40 to 60 percent by weight). One commercial nitrate product called Bioxide® is used throughout North America. Dry nitrate material is also available, but it is not recommended because it requires an additional step of mixing it with water and settling impurities prior to use.

Previous studies have indicated that a dose rate in the range of 4 to 15 pounds of calcium nitrate is needed to prevent one pound of sulfide from forming. This is a rather wide range, which emphasizes the importance of pilot testing nitrate addition prior to setting a dose rate. In the 1996 Interceptor Odor Study completed by the District, nitrate addition was pilot tested successfully in several locations, though ultimately hypochlorite addition was incorporated at four District pump stations, following recommendations from the 1997 IDAP.

A key advantage of using nitrate solution for corrosion control in wastewater collection is reduced handling requirements associated with this chemical as compared to the oxidants or the iron salt solutions, as nitrate solution is safe. However, an important disadvantage is the potentially high chemical cost of preventing sulfide formation through the entire extent of the long District interceptors. Because of this, it is likely to be more cost-effective to consider nitrate addition at the pump stations that have long discharge pressure pipelines immediately downstream.

3.1.6 pH Adjustment

The addition of alkaline chemicals to wastewater can be used to adjust pH and decrease the emission of H_2S gas to the atmosphere. Sulfide in wastewater takes the form of insoluble sulfide and dissolved sulfide. The dissolved sulfide is a mixture of H_2S and bisulfide ion (HS^-) existing in equilibrium with hydrogen ions (H^+), as shown in Figure 3-1. Sulfide ion (S^{2-}) does not exist in a significant fraction at typical wastewater pH. At a pH of approximately 5, nearly all the dissolved sulfide exists as H_2S while at pH 8.5 to 9.0, nearly all dissolved sulfide exists as HS^-. As the pH is elevated following addition of an alkaline chemical, more of the

H_2S is ionized and converted to HS^-. This is an important shift, as H_2S (aq) is the only dissolved sulfide species of the three that can be volatilized into the sewer headspace, where it deposits onto the sewer wall and is converted to sulfuric acid, resulting in corrosion.

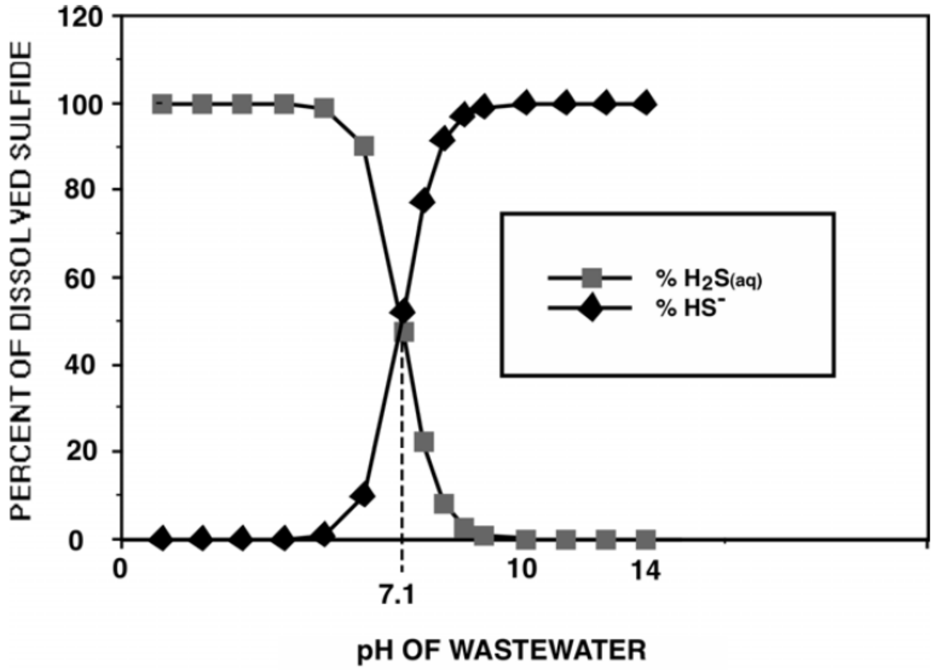


Figure 3-1. Dissolved sulfide speciation in solution with varying pH

From WERF Project 04-CTS-1 Minimization of Odors and Corrosion in Collection Systems

Increasing the pH of the wastewater into the range of 8.5 to 9.0 effectively minimizes off-gassing of hydrogen sulfide into the headspace of gravity sewers. Off-gassing at this pH range will typically maintain gas-phase H_2S concentrations to less than 5 ppmv and out of the "high" range as established in the thresholds listed in Table 1-1. Studies have also shown that at continuous operation in this pH range (8.5 to 9.0), there is also lower sulfide production in the slime layer since sulfate-reducing bacteria growth is significantly reduced at the higher pH.

Dosage rates of sodium hydroxide (NaOH) to reach this pH range are typically about 75 to 100 mg/L, which equates to very high chemical costs, and additionally continuous caustic addition would increase the pH to unnecessarily high levels. Magnesium hydroxide, therefore, is more commonly used, and is assumed for this analysis. Magnesium hydroxide is dosed into the interceptor as a slurry and raises the pH to a maximum of 9.0. Dose rate requirements are highly case specific; jar testing would identify the dose needed to maintain a constant pH of at least 8.5.

Note that unlike the other liquid-phase treatment alternatives, the dose rate requirement for magnesium hydroxide does not scale with sulfide concentration in the wastewater; the dose needed is whatever is required to maintain the entire flow at the appropriate pH. Also, pH adjustment would likely result in the treated wastewater exceeding the liquid-phase sulfide target concentration of 0.5 mg/L (the top of the "low" range in Table 1-1), however, the technology is acceptable because the sulfide is in a non-volatile form (HS^-).

3.1.7 Oxygen Injection (Superoxygenation)

Oxygen can be added through air injection or oxygen addition to force mains, resulting in aerobic conditions in the wastewater, which limits sulfide production. This analysis considers oxygen addition, specifically the "superoxygenation" process in which high DO concentrations are achieved in the force main. Oxygen addition also promotes biological oxidation of the dissolved sulfide that is already present in the wastewater. A manufacturer of a super-oxygenation system (ECO Oxygen Technologies LLC) has been consulted for analysis of this treatment technology. The ECO Oxygen system uses a speece cone unit to increase the DO of a wastewater sidestream to high levels, after which the wastewater is injected back into the system

Oxygen injection promotes the formation of numerous small bubbles which will readily dissolve under sufficient pressure in force mains (approximately between 5 and 10 ft. of static pressure). Greater force main pressures result in large amounts of oxygen being dissolved. Although stoichiometric quantities indicate that 1 pound of oxygen oxidizes 1 pound of sulfide, practical dosage rates are about 3 to 6 pounds of oxygen per pound of sulfide oxidized.

Oxygen addition is not typically effective in gravity interceptors because oxygen does not stay in solution for most of the gravity line due to insufficient pressures. Therefore, oxygen addition to gravity interceptors will not be considered for the District interceptor system. However, this technology may be applicable for sulfide control in the pressure pipe discharge lines that extend from the District pump stations. Pump stations that have been identified as potentially benefitting from superoxygenation include the following:

- **North Interceptor**: Pump Station “N”, which has a long discharge pipeline upstream of a pipe segment designated as Pipe Severity “C” and “D” in the 2010-2012 Condition Assessment.
- **Alameda Interceptor**: Pump Stations “B”, “C”, and “M” all discharge into the upstream gravity portion of the interceptor, which historically has had high liquid-phase sulfide and gas-phase H_2S concentrations. Pipe Severity “C” was also designated for the discharge of the Pump Station “M” line. Pump Station “R” is also considered for oxygenation because it conveys flow into the interceptor upstream of the Inner Harbor siphon, which has had historically high liquid-phase sulfide concentrations (final confirmation to be determined following the additional sampling at this pump station discharge). Pump Station “F” is also considered for superoxygenation, as the 2010-2012 Condition Assessment indicated Pipe Severity “C” in the lines in the vicinity of this pump station.
- **South Interceptor**: Pump Station “H”, which has a long discharge pipeline upstream of a pipe segment (Manhole S21 to S26) designated as Pipe Severity “C” and “D” in the 2010-2012 Condition Assessment

3.1.8 Summary of Liquid-Phase Treatment Methods

Table 3-1 provides a comparison of the liquid-phase corrosion control technologies discussed in Section 3.1. Of the technologies evaluated, chlorine gas injection has been eliminated from further consideration and the evaluation of oxygen injection will be limited to the already identified pump station discharge lines.

Table 3-1. Comparison of Liquid-Phase Corrosion Control Technologies

Treatment	Advantages	Disadvantages	Potential District Application
Chlorine Gas Injection	• Highly effective in oxidizing liquid-phase sulfide • Quick reaction time	• Extremely hazardous application • Organic material in the wastewater exerts a chlorine demand, increasing dose requirements • Potential chlorinated organic byproducts may be regulated • Toxic byproducts may inhibit downstream biological processes	This technology is not recommended for the District interceptor system due to hazard concerns and a projected lack of cost-effectiveness as compared to other corrosion-prevention technologies.

Table 3-1. Comparison of Liquid-Phase Corrosion Control Technologies			
Treatment	**Advantages**	**Disadvantages**	**Potential District Application**
Hypochlorite Addition	• Effective in oxidizing liquid-phase sulfide • Quick reaction time • Less hazardous than gaseous chlorine	• Most effective at the point of application; high doses required to achieve any residual downstream • Oxidation of compounds is non-discriminant; other compounds in wastewater will exert a chlorine demand, increasing dose Chemical breaks down after extended storage time • Potential toxic byproducts • Hazard concerns require a secure storage tank and injection system area	Hypochlorite is currently used at four District pump stations and at the MWWTP for odor control. It is a viable approach for corrosion control, provided that sufficient mixing is available and there is available footprint for storage tanks and containment areas. It is best used at a point of high sulfide accumulation, where injection of the chemical can reduce the liquid-phase sulfide concentration to zero.
Hydrogen Peroxide Addition	• Effective in oxidizing liquid-phase sulfide • No toxic byproducts • Relatively simple storage and dosing system • Reaction adds oxygen to the wastewater, which can reduce sulfide concentrations further	• Most effective at the point of application; chemical is quickly consumed following addition • Oxidation of compounds is non-discriminant, increasing dose • Can require disproportionately high dosages and high associated cost to reduce sulfide to less than 0.5 mg/L • Hazard concerns require a secure storage tank and injection system area	There are limited potential applications of hydrogen peroxide to the District interceptor system due to concerns of potentially high chemical costs and for multiple dosing locations. The chemical will be evaluated from a cost and potential effectiveness perspective at the corrosion hot spots.
Iron Salts Addition	• Effective precipitant for liquid-phase sulfide • Often is more cost-effective than other chemicals • Dosing excess iron provides downstream sulfide removal benefits with an iron residual • Potential downstream benefits at the MWWTP	• Highly acidic and potentially hazardous • Sometimes requires higher doses to produce low (less than 0.5 mg/L) sulfide concentrations • Typically cannot reduce liquid-phase sulfide concentration to zero, even at high iron doses	Because the iron salts are effective at precipitating sulfide specifically, they are a good fit for corrosion control in District interceptor system, particularly in long pipe segments. The application is likely to be highly cost-effective provided that an appropriate chemical storage and dosing location can be identified for individual hot spots.
Nitrate Addition (Sulfide Inhibition)	• Relatively simple feed system • Relatively safe to handle • Efficient choice when storage space is available at the upstream end of an interceptor	• Variable performance has been reported in case studies, particularly with gravity sewers • Dosing station must be located upstream of corrosion-prone areas with 3 to 5 minutes of detention time • Issues when treatment plant has effluent nitrate limits as it impacts denitrification	Nitrate solution addition is a reasonable treatment technology for consideration in the District interceptor system with a potential to replace hypochlorite addition where it currently exists at pump stations and in other pump stations where downstream corrosion is a concern. Note that historically it has been noted that nitrate addition works more consistently in force mains than in gravity lines.

Table 3-1. Comparison of Liquid-Phase Corrosion Control Technologies			
Treatment	Advantages	Disadvantages	Potential District Application
pH Adjustment (Magnesium Hydroxide Addition)	• Provides consistent sulfide control when structured to keep the pH high through varying wastewater conditions • Economical for high sulfide concentrations (greater than 10 mg/L) compared to other chemical addition • In one case study, a time-release effect was noted, enabling highly efficient chemical addition • Adds alkalinity to the wastewater	• Does not remove sulfide from the system but converts it to bisulfide, which cannot volatilize from the wastewater into the sewer headspace • Requires a mixer to keep the slurry in suspension • Potential negative impacts at downstream treatment plant processes	While there are fewer applications of magnesium hydroxide addition in collection systems than other treatment technologies, there have been some significant successes. The key unknown is identification of an appropriate dose rate, as this is highly case-specific. Too high of a dose requirement could make this technology not cost-competitive. However, it will be considered in this preliminary analysis, particularly for areas of historically high liquid sulfide concentrations.
Oxygen Injection	• Typically is lower long-term cost than other technologies • Super-oxygenation applications will maintain a residual oxygen level well downstream of the injection point	• Typically is best applied to force mains and pump station discharge pressure lines • Hazard storage requirements for pressurized oxygen • Higher capital cost investment than chemical treatment systems • Potential corrosion in pressure pipes at crown bubble locations (concern for several District pump station discharge lines, such as PS “M” and PS “H”).	BC’s experience has been that gravity sewer lines are not effective applications of superoxygenation because the oxygen does not stay in solution without the pressures from a force main or pump station discharge pipeline. However, this technology will be considered for the longer pump station discharge lines in the District interceptor system (Pump Stations “B”, “C”, “H”, “M”, “N”, and “R”) as well as PS “F”, which has a history of corrosion in the immediate downstream area.

3.2 Physical Corrosion Barriers and Modifications

This section presents an overview of alternatives available to protect concrete sewer pipes and manholes against corrosion through the application of physical barriers. Also included in this section is replacement of pipes with corrosion-resistant materials. A summary of advantages and disadvantages associated with the methods discussed below is provided in Table 3-3 (Section 3.2.8). Further evaluation of viable hot spots where these methods could be installed is provided in Section 4.

3.2.1 Replacement

Replacement entails constructing a new pipeline along a parallel alignment or replacing an existing pipeline with new pipes and manholes. Replacement is typically used when the existing pipeline has hydraulic constraints that prevent rehabilitation by other means, the pipeline needs to be realigned, or the existing pipeline is very short and replacement is the easiest rehabilitation method to apply. If the existing pipeline is replaced with a new pipeline along the same alignment, flow bypassing is required.

A replacement pipeline would be installed primarily by traditional open trench excavation. However, highway, railroad track and storm drain culvert crossings would likely need to be by bore-and-jack or micro-tunneling. These construction methods are not proprietary; local contractors would be available to perform the construction. Replacement pipeline materials would be corrosion-resistant, typically high-density polyethylene (HDPE), polyvinyl chloride (PVC), fiberglass-reinforced polymer (FRP), reinforced plastic mortar (RPM), or plastic-lined reinforced concrete pipe (RCP).

Replacement is typically the most expensive alternative for corrosion protection and often used as either a last resort when other methods are impractical or when corrosion levels of the existing pipe are very high. These conditions are not currently noted in any of the hot spot areas listed in Section 2, and as such, pipe replacement will not be considered further in this analysis.

3.2.2 Cured-In-Place Pipe (CIPP)

The CIPP process involves inserting a flexible, resin-impregnated liner into the sewer, filling the liner with water, and then heating the water to cure the resin. The resulting cured-in-place pipe forms a permanent corrosion barrier. The liner is typically composed of layers of polyester felt or woven fiberglass fabric that are saturated with a thermosetting or epoxy resin immediately before installation. The lining may be manufactured to accommodate small deformations and changes in alignment or diameter of the sewer. The liner can be designed to provide structural rehabilitation if the integrity of the host pipe is compromised.

Full bypassing of all flow is necessary to install and cure the liner, which makes CIPP a less desirable option for large-diameter (30 inches in diameter and greater) pipelines. Continuous bypassing is typically required for three to seven days for each liner insertion. During this period, the interceptor invert would need to be cleaned of debris, but the walls do not require extensive cleaning. If needed, structural repairs could also be performed during bypassing. In some cases, the tops of manholes typically need to be removed because the liner is too large to fit through the existing manhole frames

An advantage of CIPP over sliplining (Section 3.2.3) is CIPP does not reduce the hydraulic capacity significantly. A general rule-of-thumb approximation is that CIPP reduces the hydraulic capacity of a 36-in pipe by 3 to 5 percent.

Although the CIPP process is most commonly used for pipe rehabilitation, it has also been used successfully in manholes. CIPP for manhole rehabilitation is available from SunCoast and its California installer, Tajon Constructors, Inc. The SunCoast system is called the Poly-triplex Liner System. Tajon has rehabilitated large manholes in Los Angeles County. Manhole liners are typically only 90 mils thick. Rehabilitation typically takes one to two days per manhole.

The District used CIPP for a portion of the Buchanan Street Interceptor Rehabilitation Project (completed in FY13). Feedback from the District on the technology has been generally positive.

3.2.3 Sliplining

Sliplining is the process of inserting a new pipe within an existing pipe. The slipliner pipe is manufactured from corrosion-resistant material, and provides long-term protection of the existing pipe from additional deterioration. The slipliner pipe can also be specified to provide additional structural capacity to the interceptor where needed. Common slipliner pipe materials include HDPE, PVC, and RPM pipe. The process works best on straight pipe runs, but some manufacturers allow slight deflections (less than 5 degrees per joint) to accommodate pipe curves. The District has used this method successfully in portions of the Alameda Interceptor.

The main advantage of sliplining is that bypass pumping is not needed. However, the sliplining operation cannot be performed with deep flows, such as during sewer surcharge conditions in the downstream structures to the North and South Interceptors. This is because of the need to monitor the joining and jacking of the slipliner pipe. A noted disadvantage of sliplining is that the process reduces the cross-sectional interceptor pipe area and hydraulic capacity of the pipeline. A general rule-of-thumb approximation is that sliplining reduces the hydraulic capacity of a 36-in pipe by 25 to 50 percent.

Before sliplining, the pipe invert needs to be cleaned of debris, but the pipe walls do not require water blasting to remove corroded concrete. A slipliner pipe is placed into an existing pipe via an insertion pit. Pits for large diameter (30 inches diameter and larger) slipliner insertion would need to be 20 to 30 feet long.

Slipliner pipe sections are typically joined together at the insertion pit and jacked into place. This process works best when some wastewater remains in the interceptor to provide flotation to the slipliner pipe while it is being inserted. Insertion pits extend down to about the spring line of the pipe, and the top half of the existing interceptor pipe is removed.

After the slipliner pipe is inserted, a reinforced concrete cap is constructed over the interceptor pipe to prevent overloading the slipliner pipe. After the slipliner pipe is in place, the annular space between the existing pipe and the slipliner pipe is filled with grout to anchor it. The grouting process must be carefully performed to prevent damaging the slipliner pipe or leaking grout into the new pipe.

Two types of slipliner pipe are available for the different shapes of the interceptor pipes:

- **Round Pipe.** Round RPM pipe is available from Hobas and Ameron in large sizes, up to 96-inch-diameter. The exterior diameter of the pipe is about 100 inches. This is the largest size that would be required anywhere in the District's interceptor system. Large-diameter RPM slipliner pipe would have gasketed joints and would be jacked into place. The maximum jacking length is 1,000 to 1,500 linear feet (LF). For smaller diameter pipe (less than 30 inches diameter), Hobas pipe, HDPE pipe and PVC pipe are available.
- **Non-Round Pipe.** For sliplining non-round interceptor pipes, Ameron makes Bondstrand®, a non-circular FRP mortar pipe. Bondstrand® is available in arched, elliptical, circular and egg shapes. The largest non-circular Bondstrand® pipe made by Ameron is a 99-inch arch pipe. Standard Bondstrand® pipe lengths are 20 feet with the thickness estimated at 1.5 to 2 inches. Other manufacturers have used custom fabrications to produce thumb nail and egg-shaped liner pipe.

Manhole inserts are the manhole equivalent of sliplining. Manholes can be rehabilitated by inserting precast sections made of corrosion-resistant material. This construction method avoids excavating around the manhole and demolishing the walls. Several Interceptor manholes have connecting local sewers that penetrate the manhole walls above the top of the manhole base. The connecting sewers would need to be extended to penetrate the inserts. Like sliplining, inserts reduce the manhole diameter. Reducing the size of small precast manholes is not recommended because of potential impacts on maintenance activities.

3.2.4 Plastic Lining

Bonded plastic lining systems consist of plastic sheets and a bonding compound such as epoxy, mastic, or polyurethane. For mechanical bonds, the sheets are mechanically or chemically bonded to the bonding compound, which in turn adheres by mechanical bonding to the substrate surface. The sheets are also bonded or welded to one another where they overlap. The sheets provide the barrier to sulfuric acid attack. Plastic lining is currently being installed in the Wood Street Interceptor Rehabilitation Project.

Plastic lining requires installers to enter the sewer; therefore, it is only suitable for larger-diameter portions of an interceptor. A temporary platform is anchored to the pipe wall in the interceptor above the water surface during early morning low-flow conditions for workers to stand on, which facilitates wall cleaning and liner installation. While the platform limits how low the liner can be installed on the interceptor walls, it likely would be low enough to protect the interceptor in locations of the North and South Interceptors where wastewater levels are kept high for flow equalization in the MWWTP.

Extensive cleaning of the sewer wall surfaces is required prior to installation of plastic liners. Cleaning is performed with high-pressure water to remove corroded concrete. During previous District lining projects, water blasting of the severely corroded interceptor pipe resulted in considerable amounts of debris dropping from the interceptor crown and walls. The debris consisted of soft concrete and aggregate up to three inches in size. The debris dropped onto the temporary working platform and was removed from the interceptor.

The plastic liner covers the area where the concrete is susceptible to corrosion, and would not need to extend to the lower portions of the pipe wall or invert where the concrete is always submerged. Therefore, thorough cleaning of existing debris from the invert would not be required. Because the liner does not extend to the invert, flow bypassing would also not be required.

The following proprietary plastic bonded liner systems have a sufficient history of successful applications:

- **Danby Self-Forming Grouted Plastic Sheets:** The Danby system uses semi-rigid PVC sheets with ribbed or "T" backs. The sheets are installed concentrically and are connected to each other with joiner strips. The sheets are attached to the walls of the pipe to form a self-supporting arch. The space between the arch and the existing pipe wall is then grouted with a cementitious grout in lifts that are limited by the load of the arch liner. The District used the Danby system in its 1993 rehabilitation of 350 LF of the South Interceptor (downstream of Manhole S61). A negative aspect of the Danby system is that the grouting in lifts may take more time. Additionally, after the first day, the concrete surface of the pipe could become contaminated with oil and grease from the wastewater as the level rises during the day. This could adversely impact the development of a secure mechanical bond between the cementitious grout and the existing interceptor wall. The Danby installed in 1993 is in good condition; however, changes to details used in 1993 may be needed to be made based on the manufacturer's recommendations to ensure the grout and plastic sheets are firmly anchored.
- **Linabond Structural Polymer Plastic Sheets:** The Linabond system consists of spraying proprietary urethane foam on the existing concrete pipe and then chemically bonding PVC sheets to the foam. The foam adheres and mechanically anchors to the concrete and provides a smoother surface for adhering the plastic sheeting. Recent system enhancements to the system include using semi-rigid PVC sheets to provide a smoother interior surface and less potential for air pocket formation and blistering and modifying the technique for bottom edge termination with the goal of mitigating the potential for voids, blistering and detachment along the springline. The Linabond structural polymer and PVC system was installed in portions of the District's South Interceptor, including the ongoing Wood Street Interceptor Rehabilitation Project. To date, District feedback on the technology has been successful with some local blistering of lined sections that required repair after follow up inspections. Applications of the Linabond system are numerous internationally, but domestically, the number of Linabond installations in pipelines is limited. King County, Washington, appears to be the most consistent user of Linabond, has sole-sourced Linabond in the past, and gave a strong endorsement of the system. King County conducts regular inspection of Linabond liner and reports that no significant problems have developed.
- **Ameron T-Hab Flexible Plastic Sheets:** The T-Hab system is similar to the Danby system, but it uses portable forms to hold T-lock PVC sheets in place during grouting. An experienced local contractor (JR Pipeline) believes that this method would not be viable for applications where high flows are expected during the construction process. Their primary concerns are related to the temporary platform and potential movement of the forms when flow depths increase each day during the construction period. The T-Hab plastic sheets can be used in either pipes or manholes.
- **Ameron Arrowlock Flexible Plastic Sheets:** The Arrowlock system is acceptable for manhole rehabilitation but is not recommended for pipeline rehabilitation due to the unrestrained edge that can be snagged by passing debris. Installation consists of applying a thick coat of mastic to the manhole walls and then pressing PVC sheets into the mastic. The backs of the sheets are studded with arrow-shaped projections that become embedded into the mastic. The seams between sheets are then sealed with weld strips to produce a continuous gas-impermeable barrier.

3.2.5 Spiral Wound Liner

The spiral wound liner (SWL) method involves constructing a plastic pipe inside of the existing interceptor pipe. This is essentially the same concept as sliplining, except that the liner pipe is field-fabricated inside of the host pipe from a continuous strip of PVC or HDPE that is fed into position through a manhole and manually wound into the desired shape using a winding machine that can either sit stationary in the manhole (stationary installation equipment) or travel through the pipeline (travelling installation equipment). SWLs are formed circumferentially from a continuous strip, so they cover the complete interior of the host pipe. Structural SWLs have steel bands embedded into the plastic in a radial orientation.

SWL can be installed under partial wastewater flow conditions (typically 6 to 8 inches), so some bypass pumping would likely be required in all hot spots. In addition, the invert needs to be relatively free of debris for the equipment to traverse along the interceptor.

An SWL can be made in either circular or custom shapes (for non-circular pipes). Following is a description of available configurations:

- **Circular, Fixed Diameter:** Fixed-diameter, circular SWL strips have smooth interior walls and profile exterior walls that become embedded into cementitious grout that is injected into the annular space. The HDPE strips can contain a continuous, embedded steel strip to provide structural strength. Like slipliners, fixed-diameter SWLs require that the outside diameter of the liner pipe be slightly smaller than the inside diameter of the host pipe to allow for grouting in the annular space. This causes some loss of pipe diameter, but the smoother interior may make up for some of the lost hydraulic capacity. Fixed diameter lines are offered in PVC and HDPE. Sekisui SPR Americas, LLC provides the fixed-diameter SWL, as does Danby; however, with the Danby process, the PVC liner is joined manually, so the pipeline must be large enough for man-entry.
- **Circular, Expanding Liner**: Expanding SWL strips fit snugly against the host pipe after installation, and are not grouted into place. The loss of inner diameter is typically less than that of the fixed-diameter configuration. Expanding strips are formed into a circular shape with a diameter smaller than the host pipe diameter. After forming, the “pulling” wire is removed, which allows the pipe to expand and fit snugly against the host pipe wall. Expanding SWLs are not appropriate for non-circular pipes or pipes with highly irregular, corroded surfaces. Expanding liner SWL is only offered in PVC and is provided by Sekisui SPR Americas, LLC. It is also limited in size range to a 33-in or 36-in diameter host pipe.
- **Custom-Shaped:** For non-circular pipes, the Sekisui SPR installation method can be adapted to field-fabricate a new pipe that closely matches the shape of a host pipe with interior diameters between 32 and 197 inches. This system uses a traveling jig and winding machine to fabricate the SWL from a steel-reinforced PVC profile strip. The jig is custom built to the desired shape and dimensions. During installation, the winding machine is mounted on the traveling jig and winds the interlocking strips into the custom shape. After winding, the annular space between the SWL and host pipe is filled with high compressive strength grout. This method would be appropriate for large-diameter interceptor pipes, depending on the resulting finished interior dimensions and corresponding effect on hydraulic capacity. The manufacturer claims that the smooth PVC improves hydraulics since it has a Manning’s ‘n’ roughness factor of 0.010. This method requires man-entry into the interceptor pipe during winding and grouting, so it is not appropriate for small-diameter pipes.

3.2.6 Segmented Liner

Segmented liners are manufactured by Channeline International, located in Dubai, United Arab Emirates. Initial contact with Channeline is primarily made through approved contractors within the United States. The liners are constructed of glass-reinforced plastic (GRP) panels that are assembled in the pipe and grouted in place, forming a continuous tight-fitting reconstruction product.

Segmented liners are custom-made in various sizes and shapes using site-specific, survey data; shapes include egg, elliptical, circular, and arched. The liners are available in 3- to 4-foot segments that are transported into the pipe in two pieces using a crane. The pipe is then joined using a socket and spigot method that allows small directional changes and offsets. If large curves are present in the sewer, special pieces may be fabricated to traverse the curves. The liner’s thickness and resin formula are selected to determine the best type of liner for the service conditions.

Prior to installation, the host pipe requires cleaning and surveying to determine the specific design dimensions for manufacturing. Therefore, a significant amount of bypass pumping is required. Access pits are required during installation, followed by removal of the crown of the pipe within the pit to allow placement of the pipe segments. Due to the weight of large-diameter segments, they must be transported down the pipeline using a hydraulic trolley unit for placement at the correct location. This requires that the sewer be large enough for man entry. The liner is then positioned in place using wood pieces and connected utilizing a socket and spigot joint. The joints are injected with an epoxy filler to provide sealing. Lastly, the annular space is filled with a low-viscosity, high-strength grout. Typically, the grout is applied in a minimum of two lifts, with the first lift installed between the 5 to 7 o'clock pipe positions to secure the base of the liner at the invert. Subsequent lifts are completed to grout to the top of the pipe.

The product has been installed in large-diameter applications in several areas of the United States, with approximately 6,000 LF of pipe rehabilitated with the product in Los Angeles, CA. The District recently rehabilitated a small-diameter portion of the Buchanan Interceptor with an elliptical cross-section Channeline pipe, and feedback has been positive.

3.2.7 Coatings

Coating systems that are sprayed or troweled onto pipe and manhole walls have been problematic because of their high rate of failure in highly corrosive environments. Coating systems are typically spray- or trowel-applied epoxy, urethane, or another polymer. While these materials are highly corrosion-resistant, coating systems are typically applied at a thickness of less than 100 mils (less than 0.1 inches), and tend to have pinholes that allow corrosion to occur behind the coating. Several coating systems have been used in the District's interceptor system manholes, and all of them have failed.

The District's experience with coatings is similar to results of testing performed by the Los Angeles County Sanitation Districts (LACSD). That testing allowed a manufacturer to apply its coating to corroded concrete, which is then inserted into a concentrated sulfuric acid bath to simulate corrosive conditions in sewers in an accelerated manner. Coatings typically failed quickly, while plastic lining systems performed well.

One coating system developed by SprayRoq utilizes polyurethane that is applied at thicknesses of greater than 1 inch. This thickness is designed to overcome the typical pinhole problem associated with coatings. SprayRoq indicates that its coatings need to be applied in several layers of approximately 300 mil thicknesses each, with about an hour window between coats to build up to the required design thickness. The minimum thicknesses for non-structural and structural applications are 125 mil and 250 mil, respectively. According to SprayRoq, the resulting coating can protect concrete from corrosion and also will provide structural rehabilitation. SprayRoq took part in the LACSD long-term performance testing and has been determined to be one of the "successful" coating systems utilizing the LACSD testing method.

SprayRoq indicates that existing concrete must be completely dry before application of its product, typically recommending the use of portable heaters. SprayRoq indicated that due to the humid conditions generated by live flow conditions, it should not be used unless flows are completely bypassed. The District used SprayRoq for manhole rehabilitation during the 2012 Buchanan Interceptor Rehabilitation Project.

3.2.8 Summary of Physical Corrosion Barriers

Table 3-2 provides a summary of applications of the physical corrosion barriers discussed in Section 3.2 and how they might be applied to the District's interceptor system.

Table 3-2. Applications of Pipeline Physical Corrosion Barriers and Modifications					
Physical Corrosion Barrier or Modification	Applicable Pipe Sizes		Bypass Pumping Required	Hydraulic Capacity Reduction[a]	District Experience (+, -, TBD)[b]
	Large Diameter (> 30 in)	Small Diameter (≤ 30 in)			
Replacement	X	X	Yes	None	+
CIPP	X	X	Yes	5%	+
Sliplining	X	X	No	25-50%	+
Plastic Lining					
Danby	X		No	None	+
Linabond	X		No	None	TBD[c]
T-Hab	X		No	None	TBD
Spiral Would Liner	X[d]	X[e]	Yes	8%	TBD
Segmented Liner	X	X	Yes	8%	+
Coatings (Sprayroq)	X	X	Yes	None	+/-[f]

[a]*Approximate capacity reduction for a 36-in diameter pipe*

[b]*Symbology definitions: + indicates a positive District experience, - indicates a negative District experience, TBD indicates to be determined*

[c]*Mixed feedback on installations in the South Interceptor (ongoing construction in the Wood Street Interceptor)*

[d]*For non-expanding SWL*

[e]*For expanding SWL*

[f]*Positive experience for Sprayroq in manhole rehabilitation only, negative experience for other coatings*

Table 3-3 provides a summary of the advantages and disadvantages associated with the physical corrosion protection methods discussed in Section 3.2.

Table 3-3. Comparison of Physical Corrosion Barriers and Modifications			
Treatment	Advantages	Disadvantages	Potential District Application
Replacement	• New pipe segment will have corrosion-resistant material • Potential capacity increases • Lower yearly inspection costs	• High capital cost • Extensive excavation and site restoration are required • Requires full bypass pumping	Replacement is considered to be a reasonable corrosion mitigation option only in cases where significant corrosion and damage has occurred and other methods are not feasible. Because this is not the case for any of the hot spots, this method will not be considered further.
Cured-in-Place Pipe (CIPP)	• Minimal excavation requirements • Minimal hydraulic capacity reduction	• High capital cost for small-diameter (less than 30-in diameter) pipe • Requires full bypass pumping	The most likely potential applications for CIPP are smaller diameter pipe, such as what was previously installed in the Buchanan Street Interceptor. Larger pipes and associated flows would require a significant and costly bypass pumping operation, for which there may be limited available footprint.

Table 3-3. Comparison of Physical Corrosion Barriers and Modifications			
Treatment	Advantages	Disadvantages	Potential District Application
Sliplining	• Can be performed on live sewers (no bypassing) • Manholes can be added at insertion pit locations • Can be used on non-round pipes • Lower capital cost than other barrier alternatives	• Significant hydraulic capacity reduction • Cannot be installed in deep flows (such as a surcharged South Interceptor near the MWWTP) • Some open trench excavation required for insertion pits	The significant hydraulic capacity reduction that occurs with sliplining will be a major factor in decisions regarding corrosion protection. In locations where sufficient capacity will be available in the life of the installation, this alternative is reasonable.
Plastic Lining	• Effectively no reduction in hydraulic capacity • Can be used on non-round pipes • No excavation required	• Only suitable for large-diameter pipelines (large enough for man entry) • Significant pipe wall cleaning effort required prior to liner application • Requires repair of any exposed rebar prior to liner installation	The District has used the Linabond technology in portions of the South Interceptor and in the ongoing Wood Street Interceptor Rehabilitation Project. To date, District feedback has been mixed, but the technology is considered to be appropriate for potential future corrosion mitigation applications.
Spiral Wound Liner	• Smooth PVC decreases friction, which compensates for capacity reduction • Can be used on non-round pipes • No excavation required	• Requires bypass pumping • Some hydraulic capacity reduction • Mostly applicable to large-diameter (30-in diameter and larger) pipe • Higher capital cost than sliplining	Several products and manufacturers are available for SWL, but costs are higher than sliplining. It will be difficult to find a suitable application of this technology in the District interceptor system, due to it primarily being appropriate for large-diameter pipe and the fact that it requires bypass pumping.
Segmented Liner	• Smooth PVC decreases friction, which compensates for capacity reduction • Can be used on non-round pipes • No excavation required	• Requires bypass pumping • Some hydraulic capacity reduction • Mostly applicable to large-diameter (30-in diameter and larger) pipe • Significant cleaning and survey effort prior to installation	The only provider for this product is Channeline. The product was installed in the Buchanan Street Interceptor Project (for a lower-diameter pipe). It will be difficult to find a suitable application of this technology in the District interceptor system, due to it primarily being appropriate for large-diameter pipe and the fact that it requires bypass pumping.
Coatings	• Typically is lower installation cost than other technologies • Sprayroq claims structural rehabilitation in addition to corrosion protection can be achieved	• Poor corrosion prevention performance in LACSD testing • Full bypassing is required and pipe walls must be dry prior to application • Pinholes in many coatings have led to failures, including in the District interceptor system	Coatings have not performed well in pipeline corrosion prevention projects, including some at the District's interceptor system. This track record makes this technology less reliable and it will not be considered further in this study. The Sprayroq technology will continue to be considered for manhole rehabilitation.

3.3 Operations and Maintenance Strategies

Operations and maintenance strategies for corrosion control would involve periodic activities geared towards temporarily changing the conditions in localized areas of the interceptor system to reduce the corrosion potential. This section describes three strategies that could be employed in the District's interceptor system. Potential applications of these strategies to hot spot locations are discussed in Section 4.

3.3.1 Caustic Slug Dosing

An O&M strategy that is commonly used by utilities for short- and mid-term sulfide control is the injection of an alkaline solution (typically caustic), producing a temporary high-pH "slug" that passes downstream within the sewer. By maintaining the wastewater pH at 12 to 12.5 for about 20 minutes, inactivation of the slime layer that grows along the wetted surface of the sewer can be achieved through microbial sterilization.

The length of time during which sulfide production is slowed varies with wastewater temperature and the intensity of treatment (quantity of caustic used). In general, this period is typically less than two weeks. On the basis of dollars spent per pound of sulfide eliminated, however, this technique is often attractive. Downstream handling of the high-pH wastewater produced following the slug treatment is needed in some cases. If possible, the slug is diverted to a spare tank (e.g., an off-line primary clarifier), stored, and recycled back into the system over the next 2 to 3 days.

While caustic slug dosing has been noted in similar applications to extend the life of the pipe, it does not eliminate corrosion in the manner that the liquid-phase treatment and barrier/replacement options discussed in Sections 3.1 and 3.2 are designed to do. Therefore, it is recommended that this O&M strategy not be employed in hot spot locations where corrosion is already problematic or liquid-phase sulfide and/or gas-phase H_2S concentrations are routinely high. Doing so in those areas would not sufficiently address the corrosion problems at present. However, in areas where corrosion is a potential concern in the future, and where corrosion damage is currently not significant, caustic slug dosing is a reasonable maintenance approach for extending the life of the pipe.

3.3.2 Crown Spraying

Crown spraying entails applying a thick, sacrificial coat of caustic material to the interior of unlined reinforced concrete pipe (RCP) above the water line. Magnesium hydroxide [$Mg(OH)_2$] slurry is typically used. The coating sticks to the pipe surface and effectively soaks up H_2S gas acidity, protecting the underlying concrete from acid attack. Like caustic slug dosing, crown spraying does not prevent concrete corrosion, but it has been shown to slow it down considerably, thereby extending the life of the treated sewer pipes. Crown spraying with a 50-percent solution of $Mg(OH)_2$ can elevate the pH along the inner walls of the sewer pipe to 9 or above for as long as 9 to 12 months. However, repeated high wet weather flows will tend to wash off the chemical, which could require reapplication in a shorter timeframe.

Crown spraying would be effective in areas of the interceptor that do not experience high peak water levels. It would not be an effective corrosion control strategy in segments that experience very wide daily water level fluctuations, such as the downstream ends of the North and South Interceptors, where surcharging of the MWWTP influent flow regularly occurs. Should surcharging the downstream ends of those interceptors be ceased as an operational practice, the crown spraying technology would become a feasible solution. Ending the practice would also be beneficial for downstream sulfide control in the MWWTP, as surcharging the influent sewers promotes wastewater stagnation, which increases the time during which anaerobic conditions exist and increases liquid-phase sulfide concentrations.

Similar to caustic slug dosing, crown spraying can be a less costly alternative than the permanent corrosion barriers discussed previously. Typically, utility owners contract with service companies to spray specific segments of pipeline on an annual or semi-annual basis. A number of local sewer service companies have the capability to provide this service to the District. Regularly scheduled inspections of the adherence of the chemical to the pipe walls are necessary to confirm that the treatment is working sufficiently.

3.3.3 Cleaning

Sediment accumulation in the bottom of interceptors is a source of increased sulfide production, and when disturbed sulfides can be released into the liquid. Interceptor cleaning could reduce sediment accumulation and minimizing this occurrence. However, this phenomenon appears to be a localized event that produces a short-term impact on liquid-phase sulfide concentrations and minimal effect on corrosion. Therefore, interceptor cleaning is not recommended for long-term corrosion control because it is labor-intensive and disposal of solids removed can be costly. Interceptor cleaning will not be discussed further in this study.

Section 4: Corrosion Hot Spot Analysis

This section presents a preliminary list of potential solutions for minimizing corrosion at key hot spot areas in the District's interceptor system, given the historical sulfide and H_2S data discussed in Section 2 (combined with recent condition assessment results) and the alternatives discussed in Section 3. Solutions will be analyzed further upon completion of the additional sampling and production of an updated sulfide accumulation model, which will use the hydraulic data in the 2009 Interceptor Model with the sampling data and flow rates. Refined corrosion hot spot locations and recommended solutions will be provided in a subsequent TM.

4.1 Evaluation Process

Table 4-1 provides the design criteria used to evaluate the various liquid-phase treatment and corrosion barrier alternatives for each corrosion hot spot location.

Table 4-1. Corrosion Mitigation Methods Evaluation Criteria

Criterion Number	Criterion	Application to District Interceptor System
1	Corrosion Control Effectiveness	How easily does the method provide corrosion control? As an example: what is the relative amount of chemical needed to provide corrosion control for the hot spot?
2	Constructability	How easily can the method be implemented, given the site constraints? Is there land acquisition needed to implement the method?
3	Community Benefit / Impacts	What level of community impacts, both real and perceived, are associated with the method? Both temporary and long-term impacts should be considered.
4	Ease of Maintenance	How easily can the method be maintained over a 50-year life cycle? Does it have a sufficient track record of long-term reliability?
5	Hazards / Handling Requirements	Are hazardous materials involved in the method, both during installation and in the long-term operation?
6	Capacity Impacts	To what degree is the hydraulic capacity of the pipe compromised in the project area as a result of implementation of the method?
7	Operating Costs[a]	What are the projected relative long-term operating costs for the method? Costs include yearly chemical, power, and labor-rated items.
8	Draft Project Capital Cost[a]	What are the projected initial costs for construction and implementation of the method? Cost includes materials, labor, engineering, and project management.

[a] *In this initial review, costs are rated separately. Final review of alternatives will include integrated life cycle cost analyses.*

The design criteria are placed in a matrix that provides ratings for the corrosion control methods for the hot spots that do not already have planned rehabilitation associated with them (refer to Attachment D for complete matrices). The methods are grouped into the three categories (liquid-phase treatment, corrosion barriers, and O&M modifications) discussed in this TM. For each corrosion control method, a rating from 1 to 5 is given for each criterion, with 5 being given to the best rating and 1 the worst. For example, for the criterion "Corrosion Control Effectiveness," a rating of 5 would indicate that the method is highly effective at keeping corrosion at a minimum over the course of the 50-year life cycle. These ratings are indicated in the white columns in each matrix.

The matrix evaluation process also includes a weighting system for each of the 9 criteria. Representatives from the District, V&A, and BC met in June 2013 to discuss the criteria and agree on an appropriate weighting for each. The weighting is on a scale of 1 to 10, where 10 represents the most important criterion and 1 the least. For example, "Corrosion Control Effectiveness" is one of the three criteria that were given a weighting of 10. The weighting is multiplied by the raw rating to come up with a weighted value for each method and criterion in the matrix. These weighted ratings are indicated in the blue columns in the matrix.

The final column in each matrix provides the total weighted rating for each method. Section 4.3 presents these totals and provides supporting information on the calculations and the basis for the evaluation.

4.2 Sulfide Control Calculations

To calculate chemical dose rates for addressing corrosion in hot spot areas, a liquid-phase sulfide and H_2S mass loading must be calculated. This calculation is summarized in Table 4-2, which includes wastewater flow rates and historical liquid-phase sulfide concentrations in the hot spot areas and shows the conversion to H_2S mass loading using a speciation curve for sulfide in wastewater as a function of pH. Liquid-phase sulfide concentrations are taken from the historical data in a representative manhole, with a 20-percent safety factor increase included to account for peak loads.

Table 4-2. Corrosion Hot Spots Sulfide and H_2S Mass Flow Rate Calculations

Hot Spot Number	Manhole Range	Wastewater Flow Rate (mgd)[a]	Liquid Sulfide Concentration (mg/L)	Sulfide Mass Flow Rate (lb/day)	Wastewater pH[b]	Fraction of H_2S at Equilibrium[c]	H_2S Mass Flow Rate (lb/day)
North Interceptor							
HS1	N31-N35	9.48	2.28	180.4	6.8	0.55	99.2
Alameda Interceptor							
HS2	M01-M10	1.05	9.00	78.9	7.2	0.45	35.5
HS3	A17-A21	2.53	2.04	43.1	7.2	0.45	19.4
HS4	A21-A46a	4.08	3.72	126.6	7.2	0.45	57.0
HS5	A46a-S47	5.23	4.32	188.5	7.2	0.45	84.8
South Interceptor							
HS6	S09-S16	3.17	0.89	23.5	7.0	0.5	11.7
HS7	S21-S31	11.61	1.24	120.9	7.0	0.5	60.5
HS8	S47-S50	27.52	1.18	270.1	7.0	0.5	135.0
HS9	S54-S57	28.55	1.40	334.5	7.0	0.5	167.2

[a]*Flow rates taken from District's 2010 flow model update (daily average dry weather flow averaged over listed manhole range)*

[b]*From historical data (see Attachment C)*

[c]*Taken from plot of sulfide speciation with pH*

Table 4-3 provides the assumed parameters associated with the liquid-phase treatment methods in this TM. Typical densities and solution strengths are noted, and the midpoint of the assumed range of sulfide or H_2S removal efficiency is assumed. Note that for pH adjustment (magnesium hydroxide), the quantity dosed is not a function of sulfide concentration but wastewater flow rate. For oxygen injection, the required dose is also a function of flow rate and pipe hydraulic parameters of the downstream force main.

Table 4-3. Liquid-Phase Treatment Parameters			
Liquid-Phase Treatment Method	Density (lb/gal)	Strength	Projected Dose Ratio
Sodium Hypochlorite	9.7	15%	13 lb/lb H_2S
Hydrogen Peroxide	10	50%	4 lb/lb S
Ferrous Chloride	10	30%	8 lb/lb S
Calcium Nitrate	12.1	60%	10 lb/lb S formed
Magnesium Hydroxide	N/A	N/A	75 L/ML wastewater
Oxygen Injection	N/A	N/A	1.9 lb / lb H_2S (stoichiometric)

4.3 Corrosion Solutions Analysis

This section provides an analysis of potential solutions that would address corrosion issues at the hot spots discussed in this TM. As discussed previously, the analysis in this section is limited to hot spots that do not already have a planned rehabilitation project associated with that location (Hot Spots 1, 4, 6, and 7). For each of these hot spots, an evaluation of each corrosion control method is provided using the criteria listed in Table 4-1 and a short list of optimal solutions is provided. A preliminary recommendation is made for each hot spot based upon applicability and the overall rating considering all criteria categories. The ratings tables are provided in Attachment D. Conceptual cost breakdowns are provided in Attachment E.

4.3.1 North Interceptor Hot Spot Analysis

The following is the assessment of corrosion prevention alternatives for the one remaining hot spot identified in the North Interceptor:

Hot Spot 1 (N31-N35, 66-in diameter pipe, 2,441 LF): this section of the North Interceptor that passes through Emeryville presents a corrosion concern because of a high measured liquid-phase sulfide concentration of 1.9 mg/L in Manhole N31 (2008 sampling) and the severity group "C" rating given to Reach N34-N35 in the 2010-2012 Condition Assessment.

Table 4-4 summarizes the ratings given to the potential corrosion prevention methods for this hot spot (highlighted methods are the highest scoring for each category). Based on this evaluation, the highest rated liquid-phase treatment technology is ferrous chloride addition and the highest rated physical barrier is sliplining (plastic liner would be the highest if sliplining is eliminated by the District due to hydraulic capacity impacts). Crown spraying is not considered feasible in this location due to the downstream end of the interceptor being surcharged as part of routine operational practices.

Table 4-4. Hot Spot 1 (North Interceptor N31-N35) Ratings Summary				
Method	Type	Injection Location	Rating[a]	Notes
Hypochlorite	Liquid-Phase Treatment	Upstream Manhole	150	Unclear how effective the chemical would be in the last reaches given the length of the segment.
Hydrogen Peroxide	Liquid-Phase Treatment	Upstream Manhole	138	Unclear how effective the chemical would be in the last reaches given the length of the segment.
Ferrous Chloride	Liquid-Phase Treatment	Upstream Manhole	180	Benefits from being able to establish a residual for further downstream sulfide treatment.
Calcium Nitrate	Liquid-Phase Treatment	Upstream Manhole	164	Reasonable solution if an upstream chemical storage location can be identified.
CIPP	Physical Barrier	N/A	180	Higher projected capital cost primarily due to bypass pumping requirements.

Table 4-4. Hot Spot 1 (North Interceptor N31-N35) Ratings Summary				
Method	Type	Injection Location	Rating[a]	Notes
Sliplining	Physical Barrier	N/A	226	Hydraulic capacity impacts must be overcome for design life to recommend rehabilitation of one reach.
Plastic Liner	Physical Barrier	N/A	208	No capacity reduction issues.
Spiral Would Liner	Physical Barrier	N/A	200	Some loss in capacity.
Segmented Liner	Physical Barrier	N/A	200	Some loss in capacity.
Caustic Slug Dosing	O&M	Manhole N31	180	Unknown whether would be effective at keeping corrosion under control, particular in pipe severity "C" reach (N34-N35).

[a]*Total weighted rating using criteria in Table 4-1 (see Attachment D for full ratings sheets)*

For this preliminary assessment, pH adjustment and oxygen injection were not considered an appropriate solution for this hot spot. This is because the liquid-phase sulfide concentration in this hot spot area is not high enough to make pH adjustment cost-effective, and oxygen injection is not projected to be effective within gravity lines. Additionally, all chemical addition methods are limited in that there is no clear location in the upstream portion of the hot spot that would be sufficient for a new chemical dosing facility.

Table 4-5 presents conceptual estimates of capital and annual costs for the highest-rated liquid-phase treatment, physical barrier, and O&M methods (plastic liner is included in addition to sliplining if it is determined that the hydraulic capacity reduction associated with sliplining creates too much of a concern). The physical barrier alternatives assume rehabilitation of the one reach given a "C" severity rating (N34-N35), which makes them less costly than the highest rated liquid-phase treatment alternative. Note that these costs are for conceptual comparisons only. A full breakdown of conceptual costs for all methods is provided in Attachment E.

Table 4-5. Hot Spot 1 (North Interceptor N31-N35) Comparative Cost Estimate Summary								
Method	Interceptor Length (LF)	Barrier Cost ($/LF)	Construction Cost	Engineering[a]	Capital Cost	Chemical Cost ($/gal)	Chemical Dose (gal/day)	Annual Cost[b]
Ferrous Chloride	-	-	$300,000[c]	$135,000	$435,000	0.75	439	$156,000
Sliplining	432[d]	$540	$233,300	$105,000	$338,300	-	-	-
Plastic Liner	432[d]	$720	$311,000	$140,000	$451,000	-	-	-
Caustic Slug Dosing		-	-	-	-	-	-	$17,000[b,e]

[a]*Includes planning, design, and construction management (estimated at 45% of construction cost)*

[b]*Yearly chemical costs only*

[c]*Land acquisition costs are not included*

[d]*Assumes rehabilitation of Pipe Severity "C" reach (2010-2012 Condition Assessment) only*

[e]*Special monitoring costs and wastewater treatment plant modifications may be needed to refine caustic dosage amount and frequency, along with determination of any impacts to the wastewater treatment processes.*

<u>Preliminary Recommendation</u>: Although siting issues exist for the ferrous chloride alternative, and capacity needs for potential sliplining locations need to be confirmed, both options should be considered further in Task B.3. In addition, it is recommended that a pilot test of caustic slug dosing for the North Interceptor at N31, or further upstream, be conducted to confirm its effectiveness and identify dose rates.

4.3.2 Alameda Interceptor Hot Spot Analysis

Following is the assessment of corrosion prevention alternatives for the one hot spot in the Alameda Interceptor that does not already have a rehabilitation project designated:

Hot Spot 4 (A21-A46a, 48-in to 60-in diameter pipe, 12,906 LF): this portion of the Alameda Interceptor is a hot spot due to high liquid-phase sulfide and gas-phase H_2S in the historical record at Manhole A39 (liquid-phase sulfide concentration of 3.1 mg/L) and a severity rating of "C" for several reaches. The one "D" rated reach of this hot spot (A40-A41) is planned for rehabilitation as part of the Alameda Interceptor Rehabilitation Project, and three other reaches have been either fully or partially lined in the past.

Table 4-6 summarizes the ratings given to the potential corrosion prevention methods for this hot spot. The highest rated liquid-phase treatment technology is ferrous chloride injection. The highest rated physical barrier is sliplinng, with a plastic liner being the next highest if it is determined that capacity impacts from sliplining cannot be overcome. Caustic slug dosing is an economical O&M alternative, though pilot testing is needed to confirm its effectiveness.

Table 4-6. Hot Spot 4 (Alameda Interceptor A21-A46a) Ratings Summary

Method	Type	Injection Location	Rating[a]	Notes
Hypochlorite	Liquid-Phase Treatment	3 manholes	142	Long segment of pipe reduces constructability and cost ratings due to need to construct multiple chemical dosing stations.
Hydrogen Peroxide	Liquid-Phase Treatment	3 manholes	130	Long segment of pipe reduces constructability and cost ratings due to need to construct multiple chemical dosing stations.
Ferrous Chloride	Liquid-Phase Treatment	2 manholes	186	Benefits from being able to establish a residual for further downstream sulfide treatment; reduces the projected number of dosing stations.
Calcium Nitrate	Liquid-Phase Treatment	2 manholes	178	Reasonable solution but high chemical cost.
pH Adjustment	Liquid-Phase Treatment	2 manholes	164	Long distance and high sulfide concentrations make the alternative more attractive; handling requirements are an issue.
CIPP	Physical Barrier	N/A	180	High projected capital cost primarily due to bypass pumping requirements.
Sliplining	Physical Barrier	N/A	196	Hydraulic capacity impacts must be overcome for design life to recommend.
Plastic Liner	Physical Barrier	N/A	188	High capital cost but no capacity reduction issues.
Spiral Would Liner	Physical Barrier	N/A	180	High capital cost and some loss in capacity.
Segmented Liner	Physical Barrier	N/A	180	High capital cost and some loss in capacity.
Caustic Slug Dosing	O&M	Manhole A21 and Manhole A33	180	Long segment projected to require multiple injection locations; should be pilot tested to confirm effectiveness.
Crown Spraying	O&M	N/A	170	Long segment requires a significant investment, even if only "C" rated reaches are crown sprayed.

[a]*Total weighted rating using criteria in Table 4-1 (see Attachment D for full ratings sheets)*

Table 4-7 shows conceptual cost estimates of the highest rated liquid-phase treatment, barrier, and O&M methods (costs are for conceptual comparisons only). Both O&M methods are included for consideration in Task B.3, as the cost of caustic slug dosing could ultimately be much higher given the potential higher dose or frequency requirements that could become necessary after pilot testing. A full breakdown of conceptual costs for all methods is provided in Attachment E.

Preliminary Recommendation: The capital cost of installing a protective barrier inside all reaches identified as pipe severity "C" in the 2010-2012 Condition Assessment (a total of 6,277 LF) is high. Furthermore, the annual cost of operating a ferrous chloride injection system is significant, and would likely require two dosing stations within the total 12,906 LF of the hot spot alignment. Because of this, the hot spot is a good candidate for caustic slug dosing as a near-term solution, potentially at two locations along the alignment. As was recommended for Hot Spot 1, caustic slug dosing would need to be pilot tested to confirm success at reducing liquid-phase sulfide and gas-phase H_2S concentrations between Manhole A21 and A46a. Caustic slug dosing is the preferred O&M method as it is projected to be lower cost than crown spraying (pending confirmation using pilot testing); if costs are projected to be significantly higher following the pilot testing, crown spraying may be the optimal O&M solution. All four alternatives (ferrous chloride, sliplining, caustic slug dosing, and crown spraying) should be considered further in Task B.3.

Table 4-7. Hot Spot 4 (Alameda Interceptor A21-A46a) Comparative Cost Estimate Summary

Method	Interceptor Length (LF)	Barrier Cost ($/LF)	Construction Cost	Engineering[a]	Capital Cost	Chemical Cost ($/gal)	Chemical Dose (gal/day)	Annual Cost
Ferrous Chloride	-	-	$600,000[b]	$270,000	$870,000	0.75	640[c]	$228,000[d]
Sliplining	6,277[e]	$446	$2,802,000	$1,261,000	$4,063,000	-	-	-
Plastic Liner	6,277[e]	$648	$4,068,000	$1,830,000	$5,898,000	-	-	-
Caustic Slug Dosing	12,906	-	-	-	-	-	-	$17,000[d,f]
Crown Spraying	6,277	$3.60						$46,000

[a]Includes planning, design, and construction management (estimated at 45% of construction cost)

[b]Land acquisition costs are not included

[c]Assumes construction of two chemical injection stations along hot spot alignment

[d]Yearly chemical cost only

[e]Assumes rehabilitation of Pipe Severity "C" reaches (2010-2012 Condition Assessment) only

[f]Special monitoring costs and wastewater treatment plant modifications may be needed to refine caustic dosage amount and frequency, along with any impacts to the wastewater treatment processes.

4.3.3 South Interceptor Hot Spot Analysis

Following is the assessment of corrosion prevention alternatives for the two hot spots in the South Interceptor that do not already have a rehabilitation project designated:

Hot Spot 6 (S09-S16, 63-in diameter pipe, 5,985 LF): this segment is an area of corrosion concern due to moderate to high historical liquid-phase sulfide and high gas-phase H_2S concentrations and the pipe severity "C" rating given to three reaches in the 2010-2012 Condition Assessment. Table 4-8 summarizes the ratings given to the potential corrosion prevention methods for this hot spot. The highest rated liquid-phase treatment technology is ferrous chloride injection, with the optimal location for chemical injection being PS "G", which is further upstream, but if dosed at a high enough concentration would provide a residual for treatment in the hot spot area. The highest rated physical barrier was sliplinng, with a plastic liner being the next highest if it is determined that capacity impacts from sliplining cannot be overcome. Caustic slug dosing was the highest rated O&M alternative.

Table 4-8. Hot Spot 6 (South Interceptor S09-S16) Ratings Summary				
Method	**Type**	**Injection Location**	**Rating[a]**	**Notes**
Hypochlorite	Liquid-Phase Treatment	Upstream manhole	168	Constructability rating downgraded due to need to procure new dosing location.
Hydrogen Peroxide	Liquid-Phase Treatment	Upstream manhole	166	Constructability rating downgraded due to need to procure new dosing location.
Ferrous Chloride	Liquid-Phase Treatment	PS "G"	216	Benefits from being able to establish a residual for further downstream sulfide treatment.
Calcium Nitrate	Liquid-Phase Treatment	PS "G"	200	High chemical cost.
Oxygen Injection	Liquid-Phase Treatment	PS "G"	204	Less desirable solution given historical low liquid-phase sulfide concentration in PS "G" pressure discharge outlet (0.48 mg/L).
CIPP	Physical Barrier	N/A	180	High projected capital cost primarily due to bypass pumping requirements.
Sliplining	Physical Barrier	N/A	204	Hydraulic capacity impacts must be overcome for design life to recommend.
Plastic Liner	Physical Barrier	N/A	192	High capital cost but no capacity reduction issues.
Spiral Would Liner	Physical Barrier	N/A	184	High capital cost and some loss in capacity.
Segmented Liner	Physical Barrier	N/A	184	High capital cost and some loss in capacity.
Caustic Slug Dosing	O&M	Manhole S09	190	Needs pilot testing to confirm sufficient corrosion control.
Crown Spraying	O&M	N/A	156	Reasonable approach to extend pipe life but relatively expensive yearly cost.

[a] Total weighted rating using criteria in Table 4-1 (see Attachment D for full ratings sheets)

Table 4-9 shows conceptual cost estimates for the highest rated liquid-phase treatment, barrier, and O&M corrosion prevention methods. Note that these costs are for conceptual comparisons only. A full breakdown of conceptual costs for all methods is provided in Attachment E.

Table 4-9. Hot Spot 6 (South Interceptor S09-S16) Comparative Cost Estimate Summary								
Method	**Interceptor Length (LF)**	**Barrier Cost ($/LF)**	**Construction Cost**	**Engineering[a]**	**Capital Cost**	**Chemical Cost ($/gal)**	**Chemical Dose (gal/day)**	**Annual Cost[b]**
Ferrous Chloride	-	-	$300,000[b]	$135,000	$435,000	0.75	49	$17,000[c]
Sliplining	2,439[d]	$490	$1,194,000	$537,000	$1,731,000	-	-	-
Plastic Liner	2,439[d]	$684	$1,668,000	$751,000	$2,419,000	-	-	-
Caustic Slug Dosing	5,985	-	-	-	-	-	-	$8,000[c,f]

[a]Includes planning, design, and construction management (estimated at 45% of construction cost)

[b]Land acquisition costs are not included

[c]Yearly chemical cost only

[d]Assumes rehabilitation of Pipe Severity "C" reaches (2010-2012 Condition Assessment) only

[e]Special monitoring costs and wastewater treatment plant modifications may be needed to refine caustic dosage amount and frequency, along with any impacts to the wastewater treatment processes.

Preliminary Recommendation: From a conceptual perspective, the high capital cost associated with the barrier methods are such that it is more cost-effective to install a ferrous chloride dosing system, which could be constructed at PS "G" to take advantage of the fact that ferrous chloride leaves a residual in the wastewater for continued treatment downstream. Chemical treatment would also have the benefit of keeping liquid-phase sulfide concentrations relatively low throughout the first portion of the South Interceptor, whereas installation of a barrier would allow sulfide concentrations to increase and potentially lead to corrosion further downstream. While caustic slug dosing is a lower annual cost than ferrous chloride, injection, the projected cost is approximate and could increase following pilot testing. As was recommended for Hot Spot 1, caustic slug dosing pilot tested is recommended to confirm success at reducing liquid-phase sulfide and gas-phase H_2S concentrations between Manhole S09 and S16 and to identify projected dose requirements. Therefore, the preliminary recommendation for this hot spot is to further consider the following alternatives: a ferrous chloride injection system at PS "G" or at Manhole S09, whichever is more easily installed; sliplining of the 2,439 LF of pipe severity "C" reaches if sufficient capacity is available; and caustic dosing if a pilot program shows it to be effective.

Hot Spot 7 (S21-S31, 36-66-in diameter pipe, 5,724 LF): the portion of the South Interceptor downstream of the discharge line for PS "H" (Manhole S21) through the connection with the Pump Station "J" discharge point (Manhole S31) represent a corrosion hot spot location due to high liquid-phase sulfide concentrations in the historical record and because several reaches in the segment were given either a pipe severity "C" in the 2010-2012 Condition Assessment.

Table 4-10 summarizes the ratings given to the potential corrosion prevention methods for this hot spot. Of the liquid-phase treatment alternatives, oxygen injection receives the highest rating due to the ease of implementation at PS "H" and projected effectiveness in controlling sulfide formation in the downstream pressure discharge pipeline. The goal of the oxygen injection at the pump station would be to keep liquid-phase sulfide concentrations at or near zero through the PS "H" discharge pipeline, such that the sulfide concentration starts at zero in Manhole S21, as compared to the 1.04 mg/L that was measured in the historical record. Because ferrous chloride injection received a similar rating, it will also be considered in the next phase of analysis in TM B.3.

Table 4-10. Hot Spot 7 (South Interceptor S21-S31) Ratings Summary

Method	Type	Injection Location	Rating[a]	Notes
Hypochlorite	Liquid-Phase Treatment	PS "H"	166	Effectiveness rating downgraded due to need to inject chemical into an upstream pump station.
Hydrogen Peroxide	Liquid-Phase Treatment	PS "H"	174	Effectiveness rating downgraded due to need to inject chemical into an upstream pump station.
Ferrous Chloride	Liquid-Phase Treatment	PS "H"	222	Benefits from being able to establish a residual for further downstream sulfide treatment, plus lowest projected chemical cost.
Calcium Nitrate	Liquid-Phase Treatment	PS "H"	206	Would not lower sulfide concentration for the wastewater entering the hot spot (only would inhibit additional sulfide from forming).
Oxygen Injection	Liquid-Phase Treatment	PS "H"	224	Ideal application for keeping sulfide concentrations low within the segment by reducing sulfide formation in the pressure discharge pipeline.
CIPP	Physical Barrier	N/A	180	High projected capital cost primarily due to bypass pumping requirements.
Sliplining	Physical Barrier	N/A	216	Hydraulic capacity impacts must be overcome for design life to recommend.

Table 4-10. Hot Spot 7 (South Interceptor S21-S31) Ratings Summary				
Method	Type	Injection Location	Rating[a]	Notes
Plastic Liner	Physical Barrier	N/A	198	High capital cost but no capacity reduction issues.
Spiral Would Liner	Physical Barrier	N/A	190	High capital cost and some loss in capacity.
Segmented Liner	Physical Barrier	N/A	190	High capital cost and some loss in capacity.
Caustic Slug Dosing	O&M	PS "H"	176	Needs pilot testing to confirm sufficient corrosion control and identify dose rate.
Crown Spraying	O&M	N/A	166	Reasonable approach to extend pipe life but relatively expensive projected yearly cost.

[a]*Total weighted rating using criteria in Table 4-1 (see Attachment D for full ratings sheets)*

The highest-rated physical barrier method for this hot spot is sliplining, though a plastic liner or CIPP would be recommended if hydraulic impacts present an issue at this location. Caustic slug dosing is the O&M method recommended for further consideration, though as discussed previously for other hot spots, pilot testing would be needed.

Table 4-11 shows conceptual cost estimates for the two top-rated liquid-phase treatment alternatives (ferrous chloride and oxygen injection), the top two rated alternatives for physical barrier alternatives (sliplining and plastic liner), and the top-rated O&M method (caustic slug dosing).

Table 4-11. Hot Spot 7 (South Interceptor S21-S31) Comparative Cost Estimate Summary								
Method	Interceptor Length (LF)	Barrier Cost ($/LF)	Construction Cost	Engineering[a]	Capital Cost	Chemical Cost ($/gal)	Chemical Dose (gal/day)	Annual Cost
Ferrous Chloride	-	-	$300,000[b]	$135,000	$435,000	0.75	271	$96,000[c]
Oxygen Injection	-	-	$415,000	$187,000	$602,000[e]	-		$17,000[d]
Sliplining	3,793[e]	$490	$1,857,000	$835,000	$2,693,000	-	-	-
Plastic Liner	3,793[e]	$684	$2,594,000	$1,167,000	$3,761,000	-	-	-
Caustic Slug Dosing	5,724	-	-	-	-	-	-	$25,000[c,f]

[a]*Includes planning, design, and construction management (estimated at 45% of construction cost)*

[b]*Land acquisition costs are not included*

[c]*Yearly chemical cost only*

[d]*Oxygen injection annual cost is for power only*

[e]*Assumes rehabilitation of Pipe Severity "C" reaches (2010-2012 Condition Assessment) only*

[f]*Special monitoring costs and wastewater treatment plant may be needed to refine caustic dosage amount and frequency, along with any impacts to the wastewater treatment process.*

<u>Preliminary Recommendation</u>: While oxygen injection is projected to have a higher capital cost than the ferrous chloride alternative, the lower annual cost may make it more cost-effective overall. Oxygen addition is also projected to be more reliable at a lower annual cost than caustic slug dosing in this hot spot location. Ferrous Chloride addition, oxygen injection, and caustic slug dosing (with a pilot to establish effectiveness) should be considered further in Task B.3. The sliplining and plastic liner rehabilitation methods will also be considered further in Task B.3.

Section 5: Summary of Findings and Recommendations

Table 5-1 lists the corrosion hot spots identified in this TM as well as the preliminary recommendations for corrosion control for the four hot spots that do not have a planned rehabilitation project scheduled for them. The preliminary recommendations are based on historical liquid-phase sulfide and gas-phase H_2S data, the matrix rating analysis, and projected conceptual costs of the highest rated liquid-phase treatment, barrier, and O&M methods, as discussed in Section 4.

Preliminary recommendations listed in Table 5-1 include liquid-phase treatment and O&M corrosion control methods for near-term improvements and a future rehabilitation effort. The table also indicates where additional sampling will be conducted, which will be used to refine chemical dose rate requirements, projected costs, and recommendations, as part of the next task in the project.

In addition to the sampling locations listed in the last column of Table 5-1, liquid-phase and gas-phase samples will also be collected at Manhole S42, which is the location of a major side stream input to the South Interceptor from Oakland. The sampling effort will also include liquid-phase sulfide sampling at each of the pump station pressure discharge lines. Sampling results will be incorporated into the Task B.3 TM and into the updated Brown and Caldwell sulfide accumulation model.

Table 5-1. Corrosion Hot Spots and Preliminary Recommendations

Hot Spot (HS)	Location (Nodes)		Corrosion Control Methods		Additional Sampling Locations[a]
	Upstream	Downstream	Planned	Recommended	
North Interceptor					
HS1	N31	N35	None	Ferrous Chloride injection (near term) Caustic slug dosing (near-term) Sliplining/Plastic Liner (future)	Manhole N34
Alameda Interceptor					
HS2	M01	M10	Corrosion barrier to be installed (FY14-16)	N/A	Manhole M02
HS3	A17	A21	Corrosion barrier to be installed (FY15-16)	N/A	Manhole A17
HS4	A21	A46a	Corrosion barrier to be installed between A40 and A41 (FY15-16)	Ferrous Chloride injection (near term) Caustic Slug Dosing (near-term) Sliplining/ Plastic Liner (future)	Manhole A39
HS5	A46a	S47	Corrosion barrier to be installed between A46a and A49 (FY15-16)	N/A	Manhole A48
South Interceptor					
HS6	S09	S16	None	Ferrous chloride injection (near-term) Caustic Slug Dosing (near-term) Sliplining/ Plastic Liner (future)	Manhole S09
HS7	S21	S31	None	Ferrous Chloride injection (near term) Oxygen Injection (near-term) Caustic Slug Dosing (near-term) Sliplining/ Plastic Liner (future)	None

Table 5-1. Corrosion Hot Spots and Preliminary Recommendations					
Hot Spot (HS)	Location (Nodes)		Corrosion Control Methods		Additional Sampling Locations[a]
	Upstream	Downstream	Planned	Recommended	
HS8	S47	S50	Corrosion barrier to be installed between S47 and S53 (FY15-16)	N/A	Manhole S48 or S49[b] Manhole A51 or A52[b]
HS9	S54	S57	Corrosion barrier to be installed between S53 and S57 (FY15-16)	N/A	None

[a]*Each location includes liquid-phase sulfide testing and gas-phase H2S monitoring (OdaLog) for one week.*

[b]*Field team to select whichever manhole can be most easily accessed.*

BC, V&A and the District completed a workshop in August 2013 to discuss the findings of this TM and the following key items:

- Additional sampling needs to address data gaps (liquid-phase sulfide and gas-phase H_2S monitoring, as discussed in this section and in Section 2.3).
- Discussion of the corrosion hot spots in the interceptor system that need to be addressed with liquid-phase treatment, barrier protection, O&M modifications, or some combination of these.
- Preliminary recommendations for corrosion control in the hot spots identified. Preliminary recommendations will be refined following completion of additional field sampling and updating the sulfide accumulation and emissions model (BC's model to update the 2009 Interceptor Model).

In Task B.3, an updated sulfide accumulation and H_2S emission model will be produced by BC, using the most recent 2009 Interceptor Model and sampling results as a basis. This model is projected to confirm that the approaches selected for each hot spot will be effective. Final alternatives analysis and evaluations, in Task B.3 will build from the work in this TM and updated model results, and will include projections of timing of completion of near-term (liquid-phase treatment or O&M) corrosion control methods and ultimate rehabilitation efforts for hot spots. The timing will be based upon a life cycle cost analysis and projected remaining pipe life given calculations of corrosion impacts.

References

Brown and Caldwell, *Interceptor Damage Assessment Project*, East Bay Municipal Utility District, 1997.

CH2M HILL, *Odor Control Master Plan*, East Bay Municipal Utility District, 1999.

CH2M HILL, *Odor Control Master Plan Update*, East Bay Municipal Utility District, 2009.

Water Environment Federation Manual of Practice 25 *Control of Odors and Emissions from Wastewater Treatment Plants*, 2004.

Water Environment Research Foundation Project 04-CTS-1 *Minimization of Odors and Related Corrosion in Collection Systems*, 2007.

Attachment A: Condition Assessment Corrosion Maps

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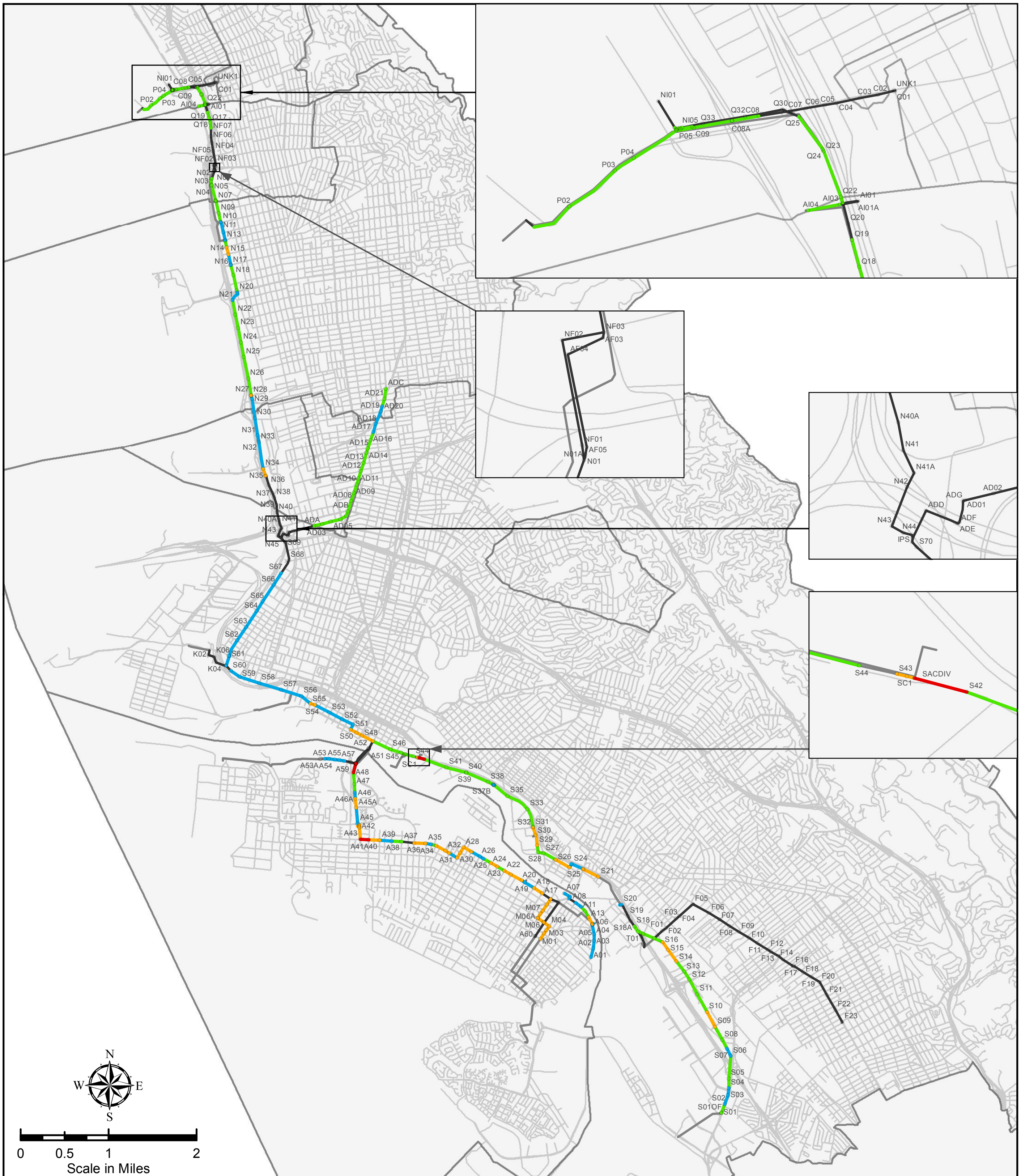
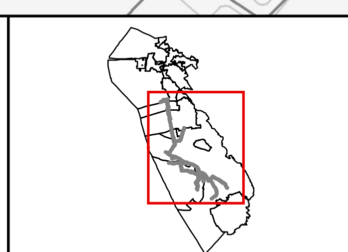


LEGEND

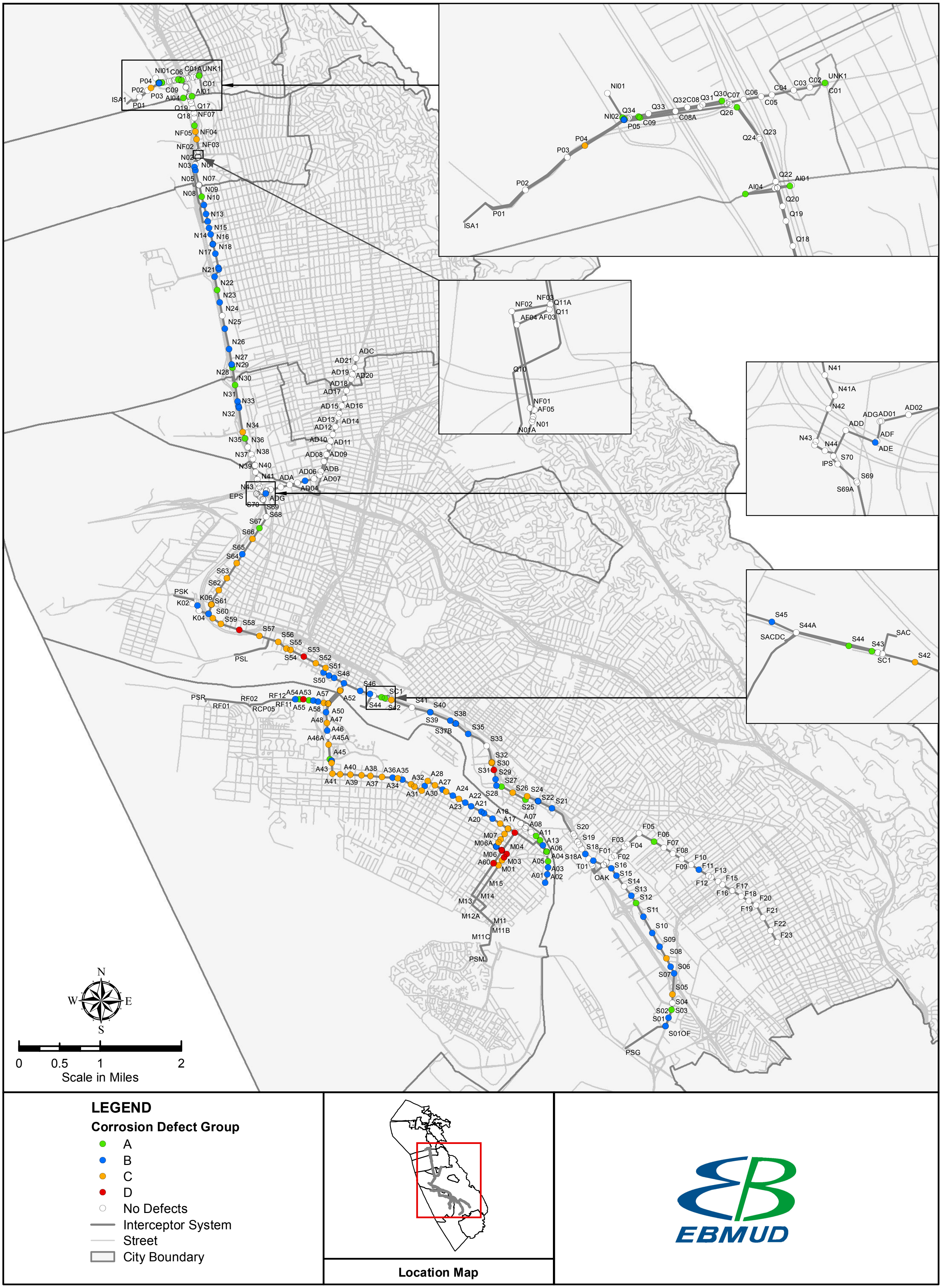
Corrosion Defect Group

- A
- B
- C
- D
- No Defects
- Interceptor System
- Street
- City Boundary



Location Map

EBMUD



N
E
S
W
0
0.5
1
2
Scale in Miles
LEGEND
Corrosion Defect Group
A
B
C
D
No Defects
Interceptor System
Street
City Boundary
Location Map
EBMUD

Attachment B: Sampling Locations

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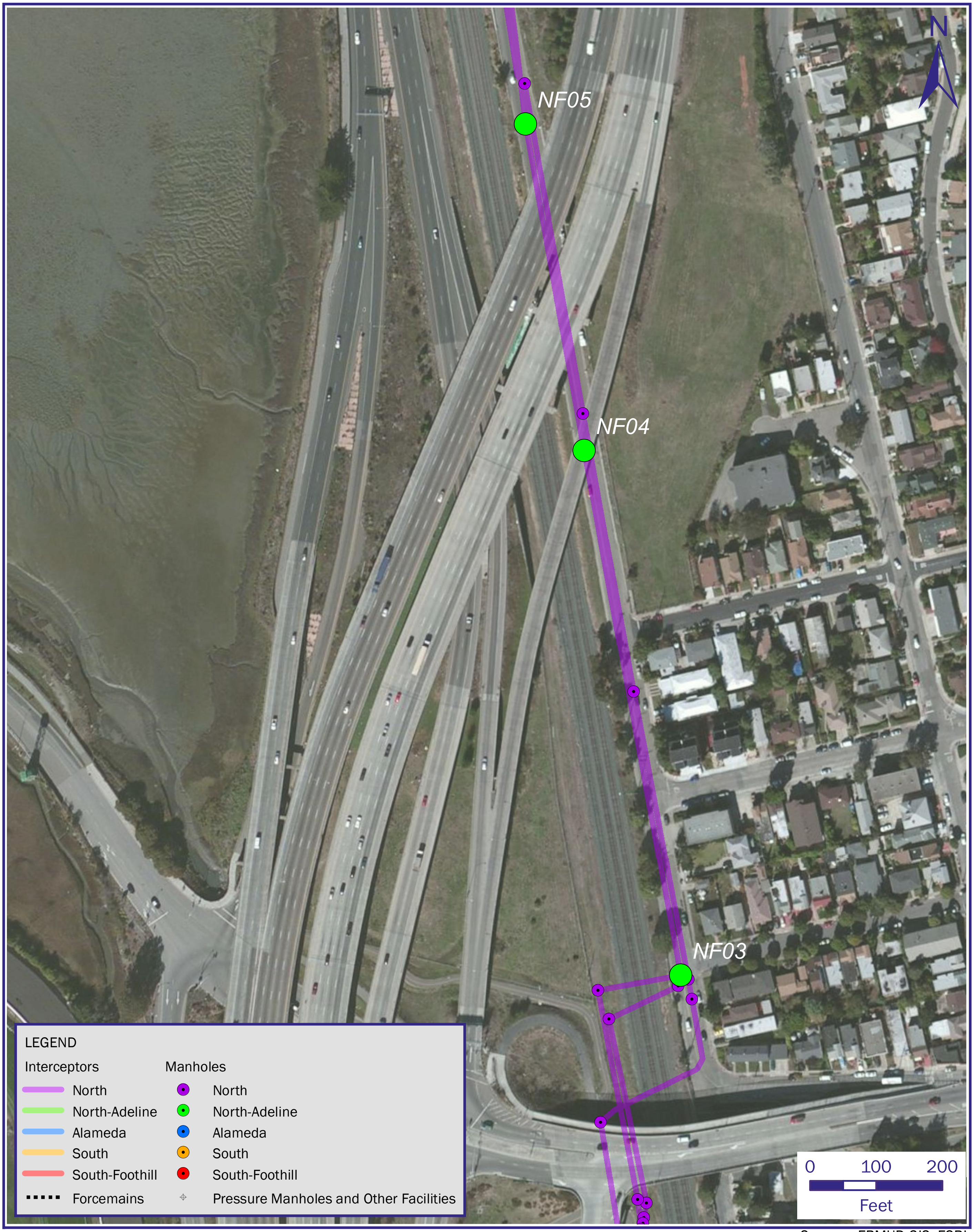

Sources: EBMUD GIS, ESRI

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Brown AND Caldwell

FIGURE 1
INTERCEPTOR SYSTEM

EBMUD

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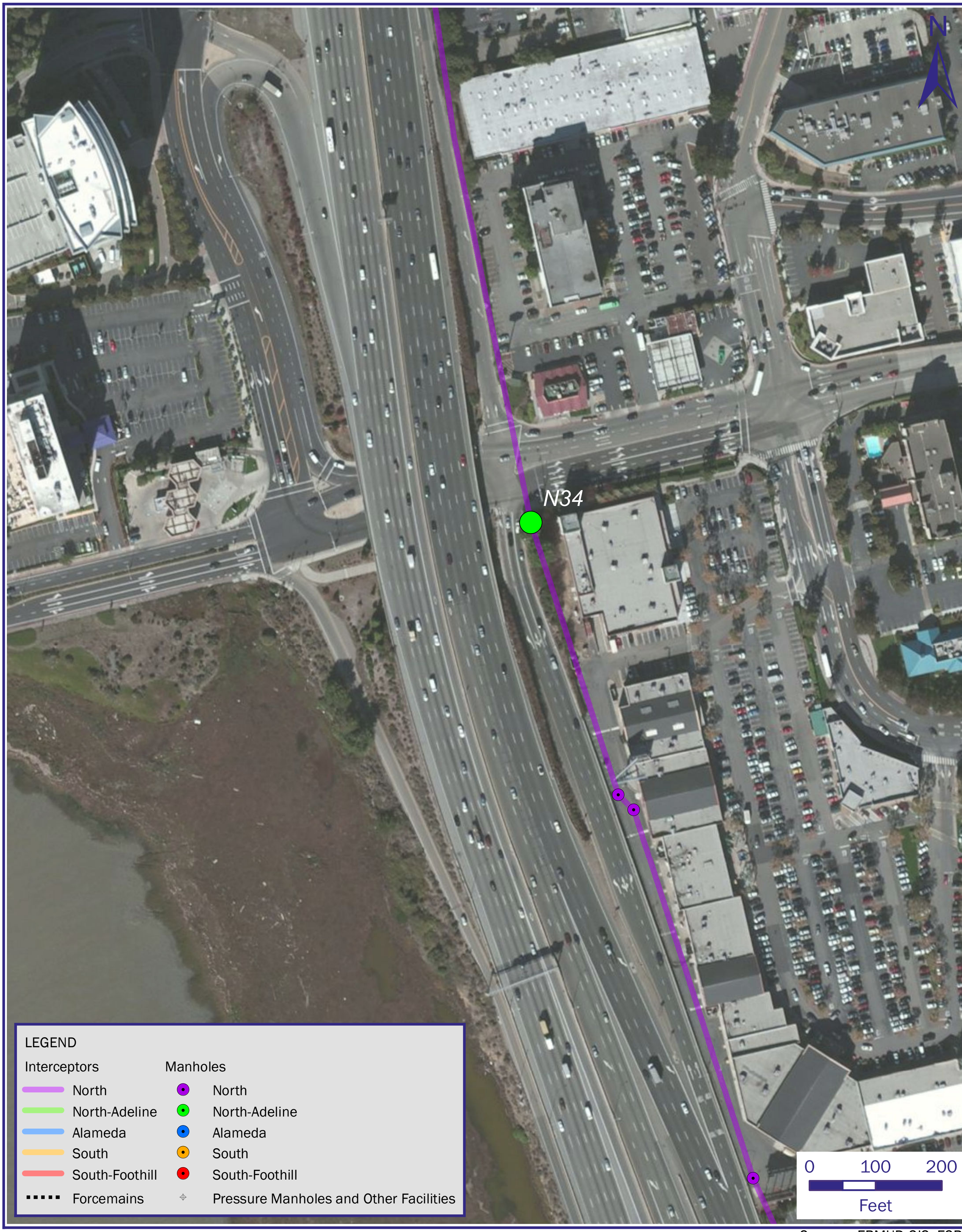

Sources: EBMUD GIS, ESRI

Brown AND Caldwell

FIGURE 1
INTERCEPTOR SYSTEM

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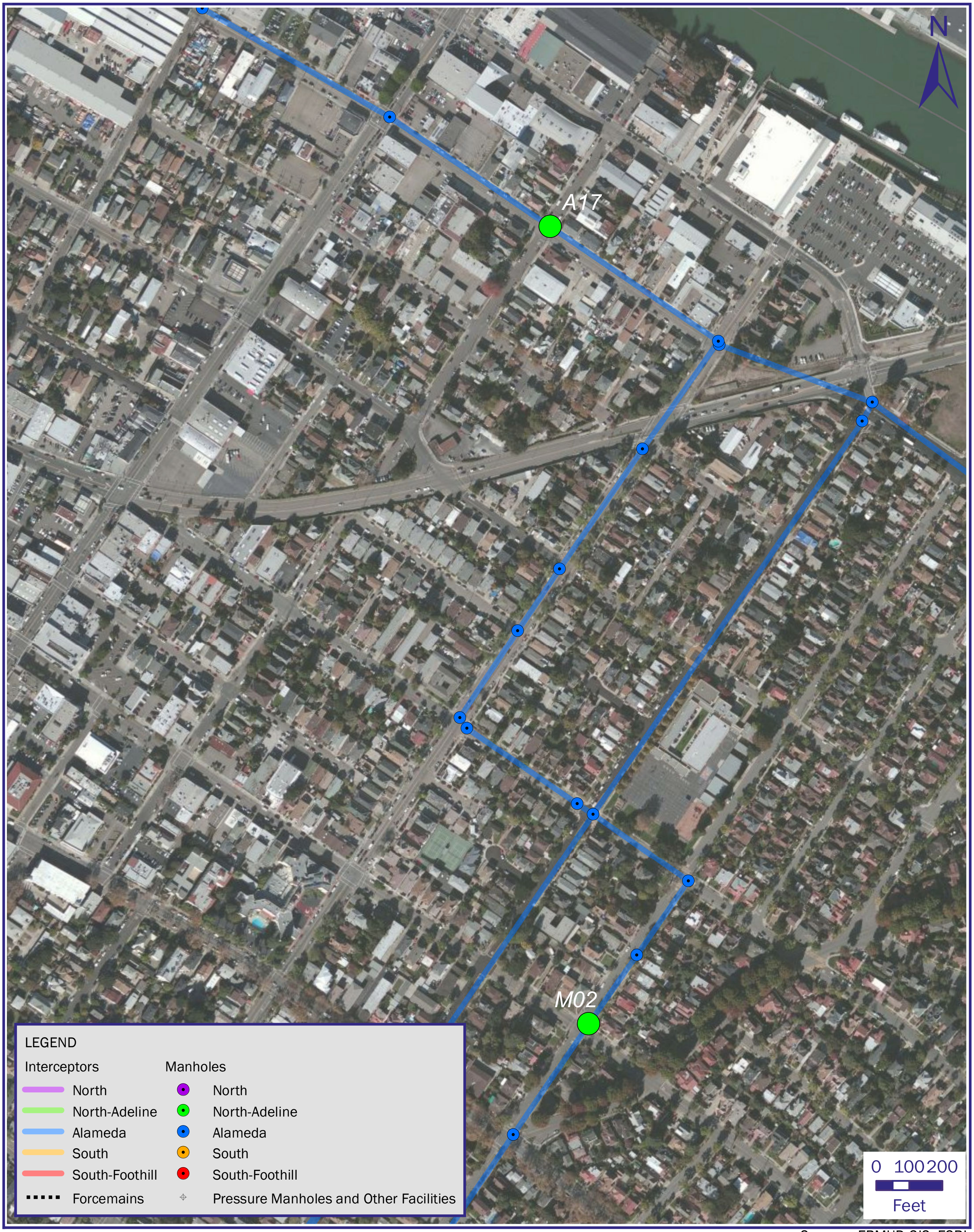

Sources: EBMUD GIS, ESRI

Brown AND Caldwell

FIGURE 1
INTERCEPTOR SYSTEM

EBMUD

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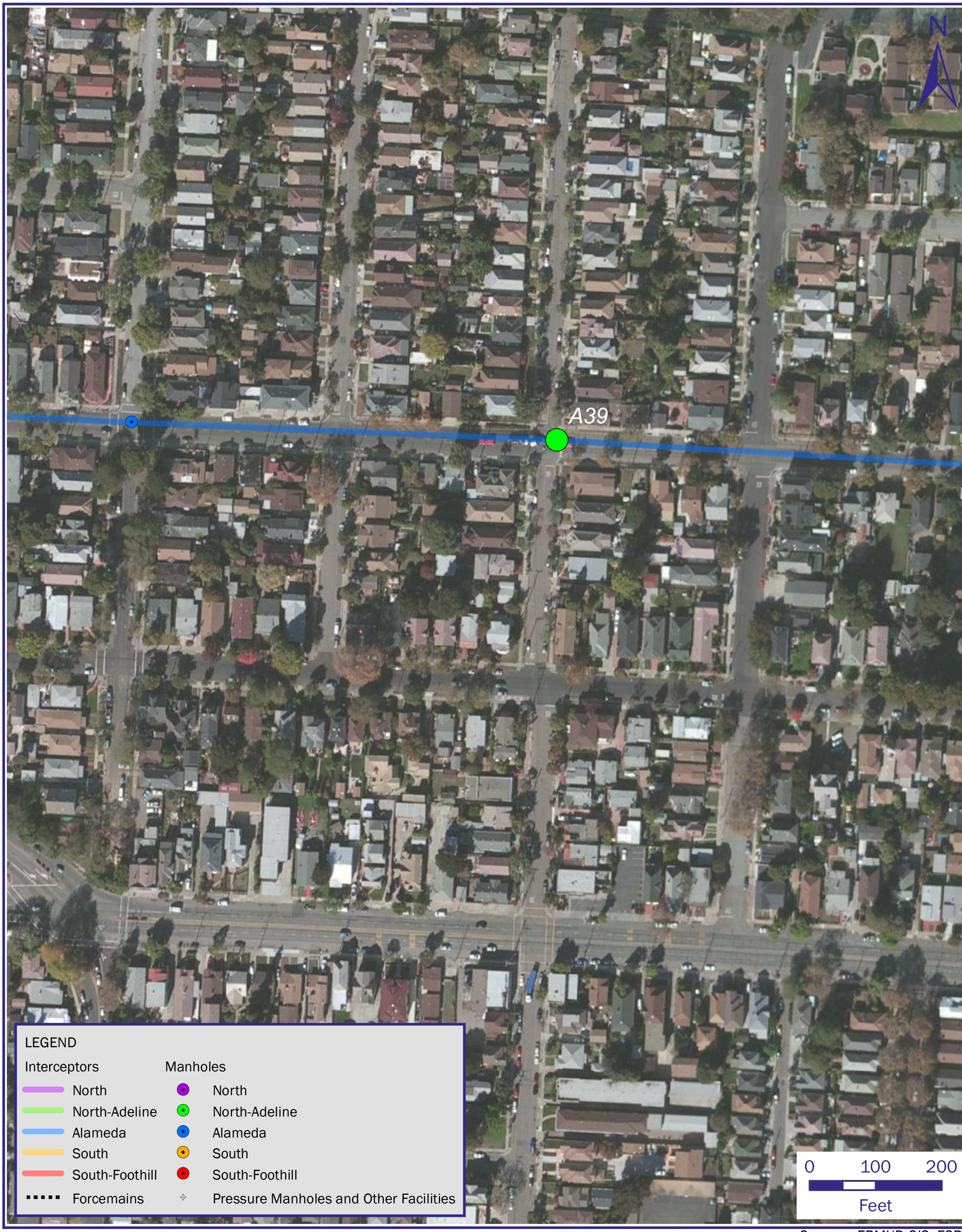
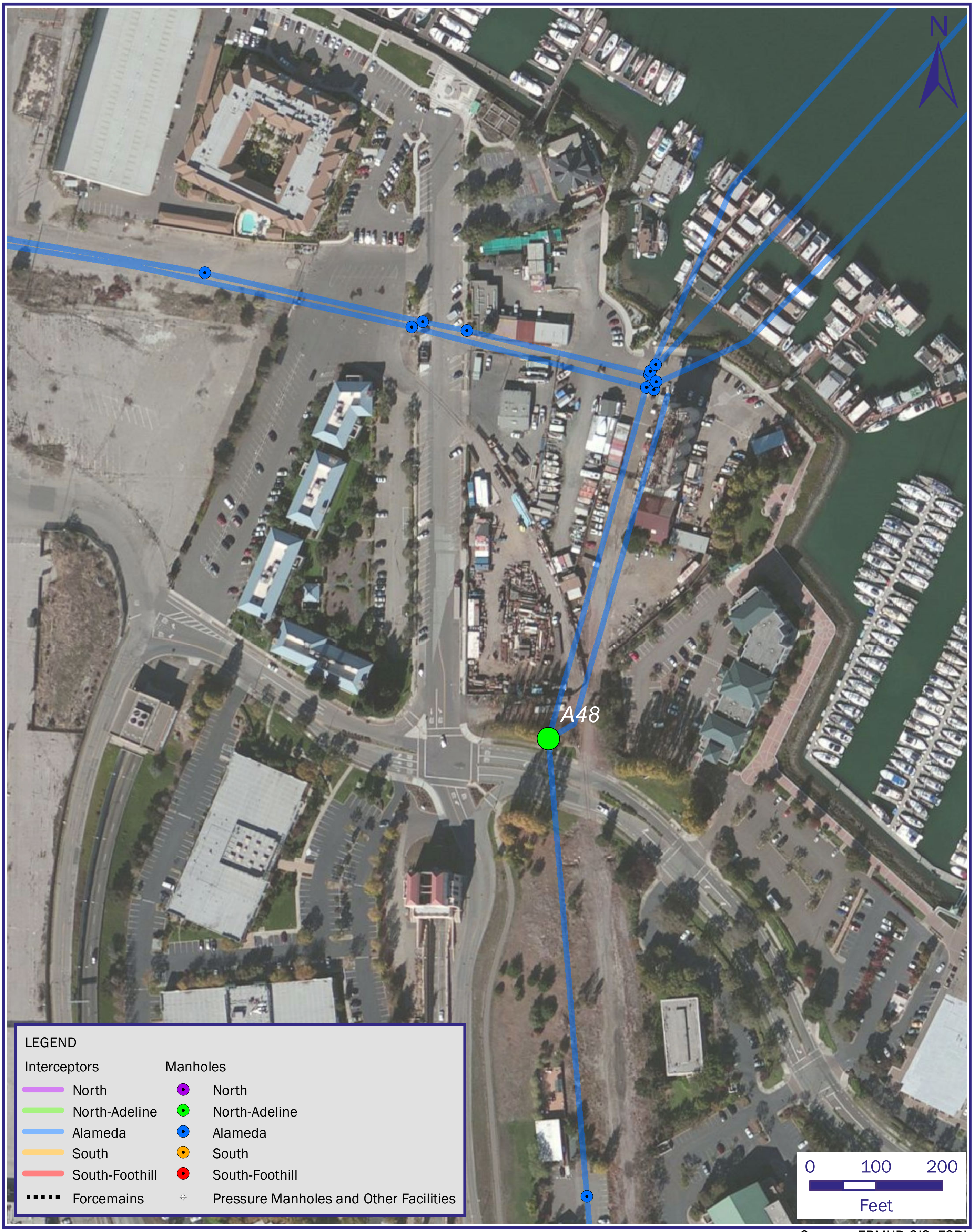


Sources: EBMUD GIS, ESRI

Brown AND Caldwell

FIGURE 1
INTERCEPTOR SYSTEM

EBMUD



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Sources: EBMUD GIS, ESRI

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FIGURE 1
INTERCEPTOR SYSTEM

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Sources: EBMUD GIS, ESRI

Brown AND Caldwell

FIGURE 1
INTERCEPTOR SYSTEM

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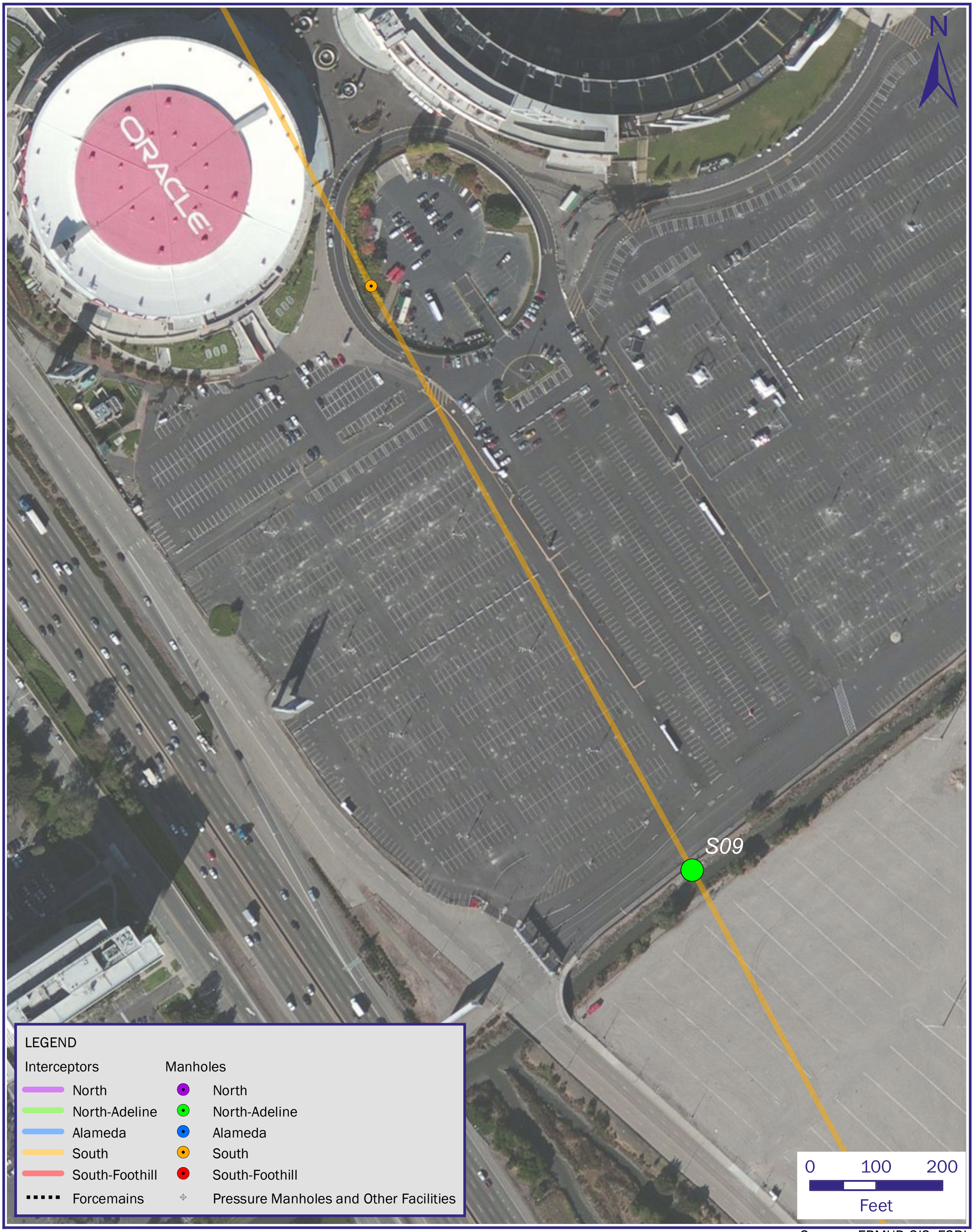

Sources: EBMUD GIS, ESRI

Brown AND Caldwell

FIGURE 1
INTERCEPTOR SYSTEM

EBMUD

Sources: EBMUD GIS, ESRI

Brown AND Caldwell

FIGURE 1
INTERCEPTOR SYSTEM

EBMUD

Attachment C: Historical Data Compilation

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Attachment C
Exisiting Measured Data Compilation
EBMUD Interceptor System - North Interceptor Data

Node or Reach	Dissolved Oxygen (mg/L)			pH		Temperature (°C)				
						Source 2				
	Source 3	Source 7	Average	Source 7	Average	Minimum	Maximum	Source 7	Average	Comments
NI01-NI02						19.4	20.0		19.4	
NI02 to NI03						20.0	20.0		20.0	
NI04		0.35		7				19		
NI04		0		6				22		
NI04		0.96		7				24		
NI04		0.04		7				20.1		
NI04		0.1		7				19.6		
NI04 (avg)			0.29		6.8				20.9	
NF06		0		7				20.7		
NF06		0		7				21.6		
NF06		0		7				21.3		
NF06		0.55		7.5				20.9		
NF06		0.4		7				26.1		
NF06		0.4		6				22.5		
NF06		0.4		6				24.1		
NF06		0.25		7				21.1		
NF06 (avg)			0.25		6.8				22.3	
N09				7				21.7		
N09		0.3		6				21.4		
N09		0.2		6.5				21.6		
N09		0		6				23.6		
N09		0		6				25.3		
N09		0.2		7				24.3		
N09		0		7				20.4		
N09 (avg)			0.12		6.50				22.6	
N19		0		7				20.2		
N19		0.4		6.5				20.9		
N19		0.2		7				23.1		
N19		0		6				23.6		
N19		0.3		6				23.1		
N19		0		6				22.5		
N19 (avg)			0.2		6.4				22.2	
N26		0		7				20		
N26		0.2		7.5				20.9		
N26		0.3		6				21.3		
N26		0.4		6.5				22.9		
N26		0.25		6				22.9		
N26		0		6				19.5		
N26 (avg)			0.19		6.5				21.3	
N31	2.85									
N35		0		7				21.7		
N35		0		6				20.5		
N35		0.3		7				22.4		
N35		0.55		6				26.1		
N35		0		7				28.6		
N35		0		7				22.4		
N35 (avg)			0.14		6.7				23.6	
N39-N40						19.4	20.6		20.0	
N40-N40A						18.3	18.9		18.9	
N40A-N41						17.2	18.3		17.8	
N41-N41A						15.6	16.7		16.1	
N41A-N42						19.4	20.0		20.0	
N42-N42A						19.4	20.0		20.0	
N42A-N43						20.0	20.0		20.0	

Sources:
1 - 2011 Interceptor Inspections and Condition Assessment
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Attachment C
Exisiting Measured Data Compilation
EBMUD Interceptor System - Alameda Interceptor Data

Node or Reach	Dissolved Oxygen (mg/L)			pH		Temperature (°C)				
						Source 2				
	Source 3	Source 7	Average	Source 7	Average	Minimum	Maximum	Source 7	Average	Comments
M101					7.30				24.5	Only avg temps given for Source 5
M02					7.20				24.5	
PS "C"										
C101					7.30				25.3	
A17					7.30				25.0	
A39					7.00				24.8	
A48					7.10				25.0	
A51					6.90				25.0	
A61					7.40				24.8	
A17-A18						20.0	20.6		20.0	
A18-A19						19.4	20.0		19.4	
A19-A20						19.4	19.4		19.4	
A20-A21						17.8	19.4		18.9	
A21-A22						18.9	19.4		19.4	
A22-A23						17.8	18.9		18.3	
A23-A24						18.9	19.4		19.4	
A24-A25						19.4	19.4		19.4	
A25-A26						19.4	19.4		19.4	
A26-A27						19.4	20.0		19.4	
A30-A31						18.9	18.9		18.9	
A31-A32						18.9	18.9		18.9	
A32-A33						18.3	18.9		18.9	
A33-A34						16.7	18.3		17.8	
A34-A35						14.4	16.7		15.6	
A35-A36						17.8	18.9		18.3	
A36-A37						18.3	18.9		18.9	
A37-A38						18.9	18.9		18.9	
A38-A39						15.6	17.2		16.1	
A39-A40						17.2	18.3		17.8	
A40-A41						17.8	18.9		18.3	
A44-A45						15.6	16.1		15.6	
A45-A45A						16.1	19.4		17.8	
A45a-A46						18.9	19.4		19.4	
A46-A46a						19.4	19.4		19.4	

Sources:
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7 - 1997 Interceptor Damage Asssessment Project
8 - 1996 Evaluation of Influent Pump Station Odor Control Alternatives

Attachment C
Exisiting Measured Data Compilation
EBMUD Interceptor System - South Interceptor Data

Node or Reach	Dissolved Oxygen (mg/L)			pH		Temperature (°C)				
	Source 3	Source 7	Average	Source 7	Average	Source 2 Minimum	Source 2 Maximum	Source 7	Average	Comments
Inlet to PSG		0.9		6				26.8		
Inlet to PSG		0.3		8				25.5		
Inlet to PSG		2.5		8				21.5		
Inlet to PSG		0.25		8				27.6		
Inlet to PSG (avg)			0.99		7.5				25.4	
S01		1.5		7				21.8		
S01		1		7				22.6		
S01		2.7		7				22.1		
S01		1.27		7						
S01		0.8		7				22.6		
S01		0.75		7				24.6		
S01		3		7				25.2		
S01		1.75		7				20.8		
S01		1.5		7				20.7		
S01		1		7				21.5		
S01				7				24.6		
S01		1.25		7				24.8		
S01 (avg)			1.50		7				22.8	
S02		1.2		7				21.6		
S02		0		7				27.9		
S02		0		8				26.9		
S02 (avg)			0.4		7.3				25.5	
S06		0		7				21.5		
S06		0		7				21.6		
S06		0		8				24.6		
S06		0.1		7				25.1		
S06		0		7				21.6		
S06		0.2		7				23.7		
S06		1.3		7				24.3		
S06		0.4		7				26.4		
S06				7				25.3		
S06		0.25		7				27.5		
S06		0		7				22.8		
S06		0		7				20.6		
S06 (avg)			0.2		7.1				23.8	
S07		0		7				24.9		
S07		0.1		7				26.1		
S07		0.3		7				28.1		
S07		0.6		7				27		
S07		0.6		7				27.6		
S07 (avg)			0.3		7.0				26.7	
S13		0		7				23.6		
S13		0.2		7				25.9		
S13		0.25		7				25.7		
S13 (avg)			0.15		7.0				25.1	
S14		0.75		6				23.8		
S14		0.2		7				26.4		
S14 (avg)			0.48		6.5				25.1	
S20		0.45		7				23.5		
S20		0.2		6				20.1		
S20		1.1		7				26.7		
S20		0.5		7				23.4		
S20		1		7				27.3		
S20		0.2		7				25.5		
S20		1.1		7				23		
S20 (avg)			0.65		6.9				24.2	

Sources:
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Attachment C
Exisiting Measured Data Compilation
EBMUD Interceptor System - South Interceptor Data

Node or Reach	Dissolved Oxygen (mg/L)			pH		Temperature (°C)				
	Source 3	Source 7	Average	Source 7	Average	Source 2		Source 7	Average	Comments
						Minimum	Maximum			
S21		0		7				20.6		
S21		0		7				19.7		
S21		0.25		6.5				24.9		
S21		0.55		6				22.8		
S21		0.15		7				26.1		
S21		0		7				26.8		
S21		0.25		7				23.6		
S21 (avg)			0.17		6.8				23.5	
S24		0.25		7				22.2		
S24		0		6				21.7		
S24		0.2		8				22.7		
S24		0.45		7				22.6		
S24		0.4		7				26.4		
S24		0.25		7				23.1		
S24		0.1		7				22.5		
S24 (avg)			0.24		7.0				23.0	
S46		0		7				25.3		
S46		0		7						
S46		0.5		8				26.4		
S46		0.7		6				27.3		
S46		0.25		7				25.7		
S46		0		7				23.3		
S46 (avg)			0.24		7.0				25.6	
S49		0		7				20.9		
S49		0		6				22.7		
S49		2.6		7				25.1		
S49		0.4		7				28.5		
S49		0		7				22.3		
S49		0		7				23.5		
S49 (avg)			0.5		6.8				23.8	
S57		0		6				27.1		
S57		2		6				26.6		
S57		0		7				23.7		
S57		0.3		7				26.3		
S57		0		7				23.1		
S57		0		7				23.8		
S57 (avg)			0.4		6.7				25.1	
S69		0.3		6				21.6		
S69		0		6				21.4		
S69		0.4		6				24.1		
S69		0		6						
S69		0		6				19.4		
S69 (avg)			0.1		6.0				21.6	
S05a-S06						17.8	17.8		17.8	
S06-S07						17.2	17.8		17.8	
S07-S08						15.6	17.2		16.1	
S08-S09						14.4	18.3		17.2	
S16a-S17						18.3	18.3		18.3	
S17-S18						18.3	18.9		18.3	
S61-S62						18.9	19.4		19.4	
S62-S63						18.9	18.9		18.9	
S63-S64						18.9	19.4		19.4	
S64-S65						20.6	21.7		21.1	
S65-S66						20.6	21.1		20.6	
S66-S67						20.6	21.1		20.6	
S67-S68						19.4	20.0		20.0	
S68-S69						17.8	19.4		18.9	

Sources:
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Attachment D: Hot Spot Corrosion Control Evaluation Matrices

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EBMUD Interceptor System Corrosion Control Evaluation

Corrosion Control Methods Evaluation

North Interceptor - HS1 (N31-N35)	Selection Criteria: Corrosion Control Effectiveness (1)		Constructability (2)		Community Benefit/Impacts (3)		Ease of Maintenance (4)		Hazards/Handling Requirements (5)		Capacity Impacts (6)		Operating Costs (7)		Draft Capital Project Cost (8)		Total Weighted Rating (higher value is preferred)
Weighting Factor Importance		**10**		**6**		**2**		**8**		**2**		**4**		**10**		**10**	
	R	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	
Liquid-Phase Treatment																	
Hypochlorite Solution	2	20	1	6	2	4	3	24	3	6	5	20	2	20	5	50	150
Hydrogen Peroxide	2	20	1	6	2	4	3	24	2	4	5	20	1	10	5	50	138
Iron Salts	4	40	1	6	2	4	3	24	3	6	5	20	3	30	5	50	180
Nitrate Solution	4	40	1	6	3	6	3	24	4	8	5	20	1	10	5	50	164
Physical Corrosion Barriers																	
CIPP	5	50	1	6	3	6	4	32	5	10	4	16	5	50	1	10	180
Sliplining	5	50	4	24	3	6	4	32	5	10	1	4	5	50	5	50	226
Plastic Lining	4	40	3	18	4	8	4	32	5	10	5	20	5	50	3	30	208
Spiral Wound Liner	4	40	3	18	4	8	4	32	5	10	3	12	5	50	3	30	200
Segmented Liner	4	40	3	18	4	8	4	32	5	10	3	12	5	50	3	30	200
Operations and Maintenance Strategies																	
Caustic Slug Dosing	2	20	3	18	3	6	3	24	1	2	5	20	4	40	5	50	180

R = Rating and WR = Weighted Rating

Rating values are based on known factors for the different options. Rating values range from 1 (least desirable) to 5 (most desirable).

EBMUD Interceptor System Corrosion Control Evaluation

Corrosion Control Methods Evaluation

Alameda Interceptor - HS4 (A21-A46a)	Selection Criteria: Corrosion Control Effectiveness (1)		Constructability (2)		Community Benefit/Impacts (3)		Ease of Maintenance (4)		Hazards/Handling Requirements (5)		Capacity Impacts (6)		Operating Costs (7)		Draft Capital Project Cost (8)		Total Weighted Rating (higher value is preferred)
Weighting Factor Importance		**10**		**6**		**2**		**8**		**2**		**4**		**10**		**10**	
	R	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	
Liquid-Phase Treatment																	
Hypochlorite Solution	3	30	1	6	2	4	2	16	3	6	5	20	2	20	4	40	142
Hydrogen Peroxide	3	30	1	6	2	4	2	16	2	4	5	20	1	10	4	40	130
Iron Salts	4	40	2	12	2	4	3	24	3	6	5	20	3	30	5	50	186
Nitrate Solution	3	30	2	12	3	6	4	32	4	8	5	20	2	20	5	50	178
pH Adjustment	4	40	2	12	2	4	2	16	1	2	5	20	2	20	5	50	164
Physical Corrosion Barriers																	
CIPP	5	50	1	6	3	6	4	32	5	10	4	16	5	50	1	10	180
Sliplining	5	50	4	24	3	6	4	32	5	10	1	4	5	50	2	20	196
Plastic Lining	4	40	3	18	4	8	4	32	5	10	5	20	5	50	1	10	188
Spiral Wound Liner	4	40	3	18	4	8	4	32	5	10	3	12	5	50	1	10	180
Segmented Liner	4	40	3	18	4	8	4	32	5	10	3	12	5	50	1	10	180
Operations and Maintenance Strategies																	
Caustic Slug Dosing	2	20	3	18	3	6	3	24	1	2	5	20	4	40	5	50	180
Crown Spraying	3	30	2	12	4	8	2	16	2	4	5	20	3	30	5	50	170

R = Rating and WR = Weighted Rating

Rating values are based on known factors for the different options. Rating values range from 1 (least desirable) to 5 (most desirable).

EBMUD Interceptor System Corrosion Control Evaluation

Corrosion Control Methods Evaluation

South Interceptor - HS6 (S09-S16)	Selection Criteria																
	Corrosion Control Effectiveness (1)		Constructability (2)		Community Benefit/Impacts (3)		Ease of Maintenance (4)		Hazards/Handling Requirements (5)		Capacity Impacts (6)		Operating Costs (7)		Draft Capital Project Cost (8)		Total Weighted Rating (higher value is preferred)
Weighting Factor Importance		**10**		**6**		**2**		**8**		**2**		**4**		**10**		**10**	
	R	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	
Liquid-Phase Treatment																	
Hypochlorite Solution	4	40	1	6	2	4	4	32	3	6	5	20	2	20	4	40	168
Hydrogen Peroxide	4	40	1	6	2	4	4	32	2	4	5	20	2	20	4	40	166
Iron Salts	4	40	4	24	2	4	4	32	3	6	5	20	4	40	5	50	216
Nitrate Solution	4	40	4	24	3	6	4	32	4	8	5	20	2	20	5	50	200
Oxygen Injection	3	30	5	30	3	6	4	32	3	6	5	20	4	40	4	40	204
Physical Corrosion Barriers																	
CIPP	5	50	1	6	3	6	4	32	5	10	4	16	5	50	1	10	180
Sliplining	5	50	2	12	3	6	4	32	5	10	1	4	5	50	4	40	204
Plastic Lining	4	40	2	12	4	8	4	32	5	10	5	20	5	50	2	20	192
Spiral Wound Liner	4	40	2	12	4	8	4	32	5	10	3	12	5	50	2	20	184
Segmented Liner	4	40	2	12	4	8	4	32	5	10	3	12	5	50	2	20	184
Operations and Maintenance Strategies																	
Caustic Slug Dosing	2	20	3	18	3	6	3	24	1	2	5	20	5	50	5	50	190
Crown Spraying	3	30	3	18	4	8	2	16	2	4	5	20	1	10	5	50	156

R = Rating and WR = Weighted Rating

Rating values are based on known factors for the different options. Rating values range from 1 (least desirable) to 5 (most desirable).

EBMUD Interceptor System Corrosion Control Evaluation

Corrosion Control Methods Evaluation

South Interceptor - HS7 (S21-S31)	Selection Criteria: Corrosion Control Effectiveness (1)		Constructability (2)		Community Benefit/Impacts (3)		Ease of Maintenance (4)		Hazards/Handling Requirements (5)		Capacity Impacts (6)		Operating Costs (7)		Draft Capital Project Cost (8)		Total Weighted Rating (higher value is preferred)
Weighting Factor Importance		**10**		**6**		**2**		**8**		**2**		**4**		**10**		**10**	
	R	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	**R**	**WR**	
Liquid-Phase Treatment																	
Hypochlorite Solution	2	20	4	24	2	4	4	32	3	6	5	20	1	10	5	50	166
Hydrogen Peroxide	2	20	4	24	2	4	4	32	2	4	5	20	2	20	5	50	174
Iron Salts	4	40	5	30	2	4	4	32	3	6	5	20	4	40	5	50	222
Nitrate Solution	4	40	5	30	3	6	4	32	4	8	5	20	2	20	5	50	206
Oxygen Injection	4	40	5	30	3	6	4	32	3	6	5	20	5	50	4	40	224
Physical Corrosion Barriers																	
CIPP	5	50	1	6	3	6	4	32	5	10	4	16	5	50	1	10	180
Sliplining	5	50	4	24	3	6	4	32	5	10	1	4	5	50	4	40	216
Plastic Lining	4	40	3	18	4	8	4	32	5	10	5	20	5	50	2	20	198
Spiral Wound Liner	4	40	3	18	4	8	4	32	5	10	3	12	5	50	2	20	190
Segmented Liner	4	40	3	18	4	8	4	32	5	10	3	12	5	50	2	20	190
Operations and Maintenance Strategies																	
Caustic Slug Dosing	1	10	4	24	3	6	3	24	1	2	5	20	4	40	5	50	176
Crown Spraying	1	10	3	18	4	8	2	16	2	4	5	20	4	40	5	50	166

R = Rating and WR = Weighted Rating

Rating values are based on known factors for the different options. Rating values range from 1 (least desirable) to 5 (most desirable).

Attachment E: Corrosion Control Method Conceptual Costs

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North Interceptor Chemical Dose Requirements

Hot Spot 1 (N31-N35)

Chemical	Liquid Sulfide Concentration (mg/L)		Target Sulfide Flow Rate (lb/day)	Dose Ratio		Dose Requirement		Cost ($/gal)	Cost ($/lb)	Annual Chemical Cost	Chemical Properties	
	Initial	Target				lb/day	gal/day				Density (lb/gal)	Strength
Hypochlorite	2.28	0.0	0.0	13	lb / lb H2S	1,290	886	0.75	0.40	$188,000	9.7	0.15
Hydrogen Peroxide	2.28	0.0	0.0	4	lb / lb S	721	144	4.00		$211,000	10	0.5
Ferrous Chloride	2.28	0.2	15.8	8	lb / lb S	1,316	439	0.75	0.33	$156,000	10	0.3
Calcium Nitrate	2.28	0.0	0.0	10	lb / lb S formed	1,804	248	3.00		$272,000	12.1	0.6

Pipe Diameter 66 in

Rehab N34-N35

Method	Interceptor Length (LF)	Construction Cost ($/ LF)	Construction Cost	Planning, Design, CM (45% of Construction Cost)	Capital Cost	Capital Cost (Rounded)
Ferrous Chloride	-	-	$300,000	$135,000	$435,000	$435,000
Sliplining	432	$540	$233,280	$104,976	$338,256	$338,300
Plastic Liner	432	$720	$311,040	$139,968	$451,008	$451,000

O&M	Segment Length (LF)	Cost ($/ LF)	Cost	Times/Yr	Yearly Cost	Yearly Cost (Rounded)
Caustic Slug Dosing	4,917		$317	52.1	$16,545	$17,000

Caustic slug dosing calculations

9.48	Mgal/day
0.006583333	Mgal/min
60	mins dosing time
0.395	Mgal
3000	lb/Mgal dose rate caustic
1185	lb caustic required
102.7	gal caustic required
110	gal drums (2) assumed
1269	lb caustic in drums
$500	/ton
$317.31	each treatment

Alameda Interceptor Chemical Dose Requirements

Hot Spot 4 (A21-A46a)

Chemical	Liquid Sulfide Concentration (mg/L)		Target Sulfide Flow Rate (lb/day)	Dose Ratio		Dose Requirement		Cost ($/gal)	Cost ($/lb)	Number of Dosing Stations	Annual Chemical Cost	Chemical Properties	
	Initial	Target				lb/day	gal/day					Density (lb/gal)	Strength
Hypochlorite	3.72	0.0	0.0	13	lb / lb H2S	741	509	0.75	0.40	3	$324,000	9.7	0.15
Hydrogen Peroxide	3.72	0.0	0.0	4	lb / lb S	507	101	4.00		3	$444,000	10	0.5
Ferrous Chloride	3.72	0.2	6.8	8	lb / lb S	959	320	0.75	0.33	2	$228,000	10	0.3
Calcium Nitrate	3.72	0.0	0.0	10	lb / lb S formed	1,266	174	3.00		2	$382,000	12.1	0.6
Magnesium Hydroxide	3.72	N/A	N/A	75	L / ML wastewater	N/A	306	1.50		2	$336,000		

Method	Interceptor Length (LF)	Construction Cost ($/ LF)	Construction Cost	Planning, Design, CM (45% of Construction Cost)	Capital Cost	Capital Cost (Rounded)
Ferrous Chloride			$600,000	$270,000	$870,000	$870,000
Hypochlorite			$900,000	$405,000	$1,305,000	$1,305,000
Sliplining	6,277	$446	$2,802,100	$1,260,900	$4,063,000	$4,063,000
Plastic Liner	6,277	$648	$4,067,500	$1,830,400	$5,897,900	$5,898,000

O&M	Segment Length (LF)	Cost ($/ LF)	Cost	Times/Yr	Yearly Cost	Yearly Cost (Rounded)
Caustic Slug Dosing	12,906		$317	52.14	$16,545	$17,000
Crown Spraying	6,277	$ 3.60	$22,597	2	$45,194	$45,000

Caustic slug dosing calculations

4.08	Mgal/day
0.002833333	Mgal/min
60	mins dosing time
0.17	Mgal
3000	lb/Mgal dose rate caustic
2	dosing locations assumed
1020	lb caustic required
88.4	gal caustic required
110	gal drum assumed (2 55-gallon drums)
1269	lb caustic in drum
$500	/ton
$317.31	each treatment

South Interceptor Chemical Dose Requirements

Hot Spot 6 (S09-S16)

Chemical	Liquid Sulfide Concentration (mg/L)		Target Sulfide Flow Rate (lb/day)	Dose Ratio		Dose Requirement		Cost ($/gal)	Cost ($/lb)	Annual Chemical Cost	Chemical Properties	
	Initial	Target				lb/day	gal/day				Density (lb/gal)	Strength
Hypochlorite	0.89	0.0	0.0	13	lb / lb H2S	153	105	0.75	0.40	$22,000	9.7	0.15
Hydrogen Peroxide	0.89	0.0	0.0	4	lb / lb S	94	19	4.00		$27,000	10	0.5
Ferrous Chloride	0.89	0.2	5.3	8	lb / lb S	146	49	0.75	0.33	$17,000	10	0.3
Calcium Nitrate	0.89	0.0	0.0	10	lb / lb S formed	235	32	3.00		$35,000	12.1	0.6
Magnesium Hydroxide	0.89	N/A	N/A	75	L / ML wastewater	N/A	238	1.50		$130,000		

Method	Interceptor Length (LF)	Construction Cost ($/ LF)	Construction Cost	Planning, Design, CM (45% of Construction Cost)	Capital Cost	Capital Cost (Rounded)
Ferrous Chloride			$300,000	$135,000	$435,000	$435,000
Sliplining	2,439	$490	$1,194,000	$537,300	$1,731,300	$1,731,000
Plastic Liner	2,439	$684	$1,668,000	$750,600	$2,418,600	$2,419,000

O&M	Segment Length (LF)	Cost ($/ LF)	Cost	Times/Yr	Yearly Cost	Yearly Cost (Rounded)
Crown Spraying	5,985	$ 3.60	$21,546	2	$43,092	$43,000
Caustic Slug Dosing	5,985		$159	52.14	$8,273	$8,000

Caustic slug dosing calculations

3.17	Mgal/day
0.002201389	Mgal/min
60	mins dosing time
0.132083333	Mgal
3000	lb/Mgal dose rate caustic
1	dosing location assumed
396.25	lb caustic required
34.3	gal caustic required
55	gal drum assumed
635	lb caustic in drum
$500	/ton
$158.65	each treatment

South Interceptor Chemical Dose Requirements

Hot Spot 7 (S21-S31)

Chemical	Liquid Sulfide Concentration (mg/L)		Target Sulfide Flow Rate	Dose Ratio		Dose Requirement		Cost		Annual Chemical or	Chemical Properties	
	Initial	Target	(lb/day)			lb/day	gal/day	($/gal)	Cost ($/lb)	Power Cost	Density (lb/gal)	Strength
Hypochlorite	1.25	0.0	0.0	13	lb / lb H2S	786	540	0.75	0.40	$115,000	9.7	0.15
Hydrogen Peroxide	1.25	0.0	0.0	4	lb / lb S	484	97	4.00		$141,000	10	0.5
Ferrous Chloride	1.25	0.2	19.4	8	lb / lb S	812	271	0.75	0.33	$96,000	10	0.3
Calcium Nitrate	1.25	0.0	0.0	10	lb / lb S formed	1,209	167	3.00		$182,000	12.1	0.6
Magnesium Hydroxide	1.25	N/A	N/A	75	L / ML wastewater	N/A	871	1.50		$477,000		
Oxygen Addition	1.25	N/A	N/A							$17,400		

Method	Interceptor Length (LF)	Construction Cost ($/ LF)	Construction Cost	Planning, Design, CM (45% of Construction Cost)	Capital Cost	Capital Cost (Rounded)
Oxygen Addition			$415,000	$186,750	$601,750	$601,800
Sliplining	3,793	$490	$1,857,000	$835,700	$2,692,700	$2,693,000
Plastic Liner	3,793	$684	$2,594,000	$1,167,300	$3,761,300	$3,761,000

O&M	Segment Length (LF)	Cost ($/ LF)	Cost	Times/Yr	Yearly Cost	Yearly Cost (Rounded)
Caustic Slug Dosing	5,724		$476	52.14	$24,818	$25,000
Crown Spraying	3,793	$ 3.60	$13,655	2	$27,310	$27,000

Caustic slug dosing calculations

11.61	Mgal/day
0.0080625	Mgal/min
60	mins dosing time
0.48375	Mgal
3000	lb/Mgal dose rate caustic
1	dosing location assumed
1451.25	lb caustic required
125.8	gal caustic required
165	gal drum assumed (3 55-gal drums)
1904	lb caustic in drum
$500	/ton
$475.96	each treatment

Appendix B: Technical Memorandum B.3 - Interceptor Corrosion Prevention Methods and Applications Evaluation

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Brown AND Caldwell

201 North Civic Drive, Suite 115
Walnut Creek, CA 94563

T: 925-937-9010
F: 925-937-9026

Technical Memorandum

FINAL

Prepared for: East Bay Municipal Utility District

Project Title: Wastewater Pump Station Discharge Pipeline Condition Assessment and Interceptor Corrosion Prevention Project

Project No.: 144408

Technical Memorandum

Subject: Interceptor Corrosion Prevention Methods and Applications Evaluation

Date: February 7, 2014

To: Diana Lee, East Bay Municipal Utility District

From: Charlie Joyce, Brown and Caldwell

Copy to: Jose Villalobos, Villalobos and Associates
Derek Wurst, Villalobos and Associates
Evan Geer, Brown and Caldwell

Prepared by: David W McEwen

David McEwen, Brown and Caldwell
California License No. C 69475

Reviewed by: Charles W. Joyce

Charlie Joyce, Brown and Caldwell
Engineer in Responsible Charge
California License No. C 33166

REGISTERED PROFESSIONAL ENGINEER
CHARLES W JOYCE
No. C33166
Exp. 06-30-14
CIVIL
STATE OF CALIFORNIA

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List of Abbreviations

^{0}C	degrees Celsius
Ave Day	average day
BOD	biochemical oxygen demand
BC	Brown and Caldwell
CIPP	cured in place pipe
DO	dissolved oxygen
District	East Bay Municipal Utility District
ft	feet
ft/s	feet per second
FY	fiscal year
g/m2-hr	grams per square meter per hour
gal/week	gallons per week
HS	Hot Spot
H_2S	hydrogen sulfide
in/yr	inches per year
LF	linear feet
m/hr	meters/hour
mg/L/hr	milligrams/liter/hour
MWWTP	Main Wastewater Treatment Plant
MOP-69	Manual of Practice Number 69
m/hr	meters per hour
MGD	million gallons per day
mg/L	milligrams per liter
OCMP	Odor Control Master Plan
O&M	operation and maintenance
ppmv	part per million by volume
TM	technical memorandum
V&A	Villalobos and Associates
VCP	vitrified clay pipe

Section 1: Introduction

1.1 Summary of Previous Work

This Technical Memorandum (TM) follows up work completed in TM B.2 “Initial Interceptor Corrosion Control Preliminary Assessment” (October 10, 2013). In the previous TM, the following items were addressed:

- Compilation of historical data associated with corrosion-related parameters, including liquid-phase sulfide concentration, gas-phase hydrogen sulfide (H_2S) concentration, pH, biochemical oxygen demand (BOD), temperature, and dissolved oxygen (DO).
- Identification of corrosion “hot spots” (interceptor areas of either high historical liquid-phase sulfide or gas-phase H_2S concentration and/or areas where pipe reaches were designated as Pipe Severity Group “C” or “D” in the 2010-2012 Condition Assessment).
- Compilation of additional sampling needs to further confirm or evaluate candidate hot spot areas; sampling included liquid-phase sulfide and gas-phase H_2S analyses and was completed in September 2013.
- Comparison of corrosion control technologies, including liquid-phase treatment and operation and maintenance (O&M) near-term activities and rehabilitation efforts, which would include either installation of a physical barrier or pipe replacement.
- Preliminary analysis of the hot spots that do not have a designated rehabilitation effort planned for them and recommendations of near-term and rehabilitation corrosion control options that were to be evaluated in TM B.3.

1.2 Task B.3 Scope of Services

Following are the major scope items that are addressed in this TM B.3:

- Discussion of the sampling results and how they differ from the historical data (Section 2).
- Completion of an updated sulfide accumulation model and calibration to the 2013 field sampling results (Section 3).
- Updating the list of hot spots based on results of the sampling and from the baseline sulfide accumulation model (Section 4).
- Final analysis of the hot spots that do not have a designated rehabilitation effort planned for them and recommendations of near-term and rehabilitation corrosion control options; analysis includes comparison of remaining pipe life within the hot spots and life cycle costs of corrosion control options (Section 4).
- Discussion of recommended means for monitoring the effectiveness of the recommended system for corrosion control (Section 5).
- Listing of recommended corrosion control approaches for each of the hot spots analyzed as part of this Task B.3 (Section 5).

The recommendations associated with this TM will be discussed in a review meeting that will include East Bay Municipal Utility District (District), Brown and Caldwell (BC), and Villalobos and Associates (V&A) on November 5, 2013. Comments from that meeting will be incorporated into the final version of this TM.

Section 2: Field Data Collection and Results

This section discusses the September 2013 field sampling program that supports the sulfide model development and corrosion assessment discussed in this TM.

2.1 Sampling Protocol

This section discusses the means by which samples were collected for use in preparing the sulfide accumulation model and the corrosion assessment.

2.1.1 Sampling Locations

Liquid-phase and gas-phase samples were taken at locations along each interceptor as shown in Figure 2-1. The locations are consistent with the recommendations made in TM B.2. In some locations, the V&A field team determined in the field which of 2 or 3 manholes identified in TM B.2 was most easily accessible. Refer to the previous TM for this discussion.

2.1.2 Data Collection Methods

At each location, an OdaLog recorded gas-phase H_2S data in manhole headspaces continuously for one week and liquid-phase grab samples were taken at OdaLog installation and removal and analyzed for liquid-phase sulfides. Following are descriptions of the methodology and equipment used in the data collection.

Liquid-Phase Sulfide Testing

A LaMotte test kit was used to measure the following liquid-phase sulfide concentrations in the two grab samples collected at each location (Figure 2-1):

- Total liquid-phase sulfides, in milligrams per liter (mg/L).
- Dissolved liquid-phase sulfides, in mg/L, which is the parameter used in the sulfide modeling and in calculations for quantifying initial chemical dose requirements for corrosion control in a hot spot.

Note that the liquid-phase sulfide concentrations in the various locations are assumed to be variable over the course of the day, and the concentrations measured in the two samples may not correspond to the daily maximum. Calibration of the sulfide accumulation model is therefore completed primarily with the gas-phase H_2S data, which is more comprehensive in that the sample data was measured continuously for one week as opposed to the grab samples associated with the liquid-phase sampling. However, the liquid-phase data collected as discussed in this section is used to compare various interceptor locations with similar grab samples collected in previous work conducted in the 1990's and 2000's, such as in the Main Wastewater Treatment Plant (MWWTP) Odor Control Master Plan (OCMP) (CH2M HILL, 1999) and OCMP Update (CH2M HILL, 2009).

In addition to the sampling locations in Figure 2-1, V&A also collected similar liquid-phase data at the discharge of each pump station discharge pipeline downstream of a pump station. This was added to the scope because historically high concentrations of sulfides can develop in long force mains, which can accelerate concrete corrosion.

Gas-Phase H_2S Monitoring

Continuous H_2S concentrations were measured and logged by OdaLog data loggers, which were inserted in the manhole headspaces in the locations shown in Figure 2-1. These data loggers measured the ambient H_2S concentration every 5 minutes continuously for a period of one week and record the measured concentration in a data file that is downloaded onto a personal computer and analyzed. The OdaLogs measure H_2S to a resolution of 1 part per million by volume (ppmv).

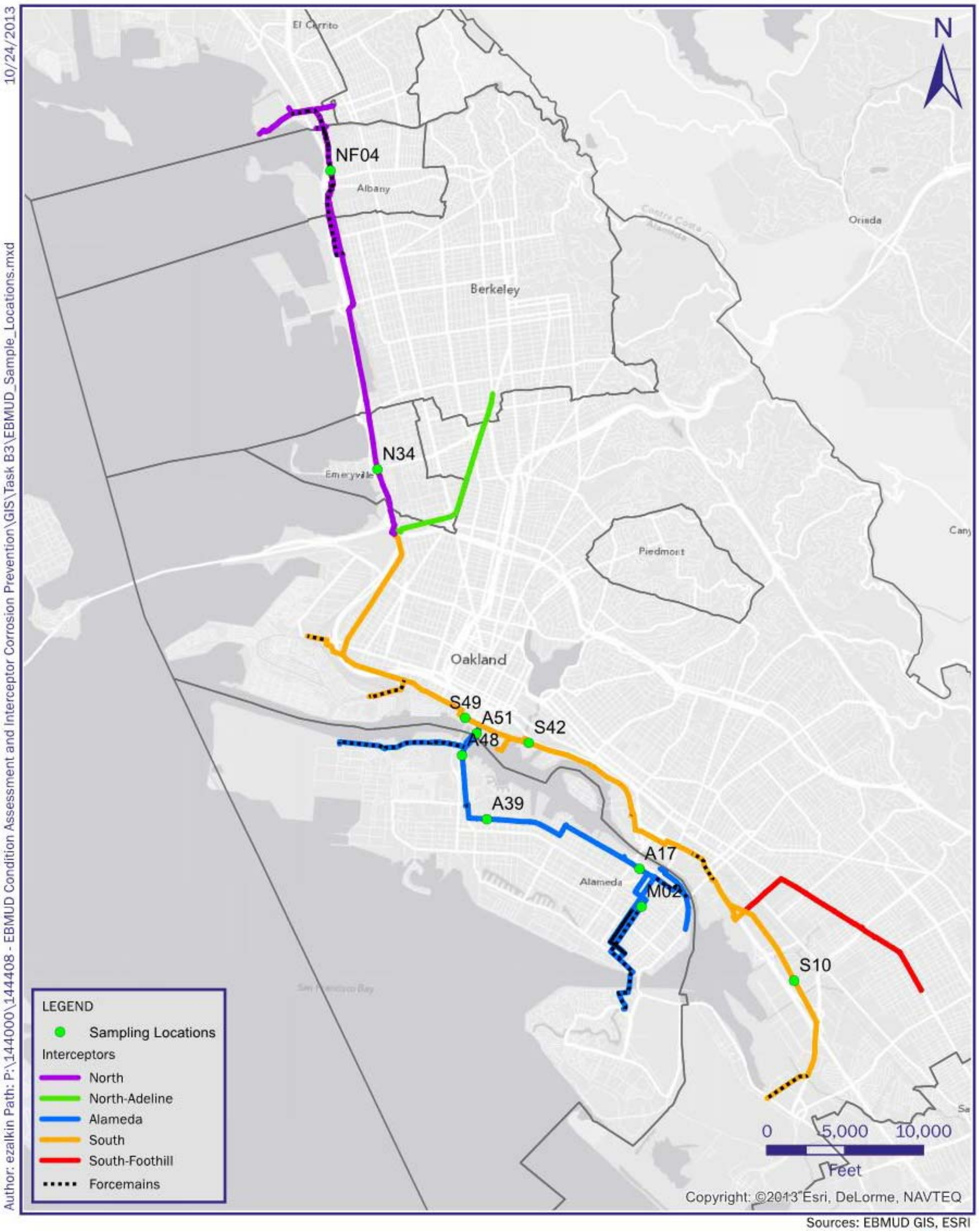

Figure 2-1. Sulfide, Liquid and Gas Phase, Sampling Locations

2.1.3 Data Collection Results

Table 2-1 provides a summary of the liquid-phase sampling results. A compilation of the raw data from the sampling is provided in Attachment A, including additional details not shown in the table.

Table 2-1. Liquid-Phase Sulfide Analysis 2013 Sampling Results

Manhole	During OdaLog Installation			During OdaLog Removal		
	Date	Total Sulfides (mg/L)	Dissolved Sulfides (mg/L)	Date	Total Sulfides (mg/L)	Dissolved Sulfides (mg/L)
North Interceptor						
N34	9/3	1.5	1.2	9/10	0.6	0.4
NF04	9/3	3.6	3.2	9/10	0.6	0.5
Alameda Interceptor						
M02	9/3	3	2	9/11	3.2	2.2
A17	9/3	0.9	0.8	9/11	1.1	0.9
A39	9/4	2.3	2	9/10	1	1
A48	9/3	0.7	0.7	9/11	1.2	1
A51	9/4	1.2	1	9/11	2	1.6
South Interceptor						
S10	9/3	0.6	0.3	9/11	0.4	0.3
S42	9/4	0.1	ND	9/11	0.3	0.3
S49	9/4	0.1	ND	9/11	0.7	0.5

Table 2-2 provides a summary of the gas-phase sampling results. Note that there were numerous data points for each location, and each day included a diurnal variation in concentrations. Because average values are of primary importance in corrosion assessments, daily and weekly averages are shown.

Table 2-2. Gas-Phase H_2S 2013 Sampling Results

Manhole	Daily Average (ppmv)								Week Average (ppmv)
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	
North Interceptor									
N34	9.5	11.2	10.9	7.5	6.2	7.4	8.1	-	8.7
NF04	122.0	155.0	137.0	127.0	107.0	115.0	140.0	-	129
Alameda Interceptor									
M02	35.2	52.6	63.1	58.1	62.0	62.5	75.6	-	62.3
A17	25.1	24.9	24.4	22.4	18.7	19.4	20.4	-	22.2
A39	11.9	13.1	13.1	16.1	10.7	11.9	12.2	-	12.7
A48	6.9	4.0	5.1	4.6	6.9	8.2	7.0	-	6.1
A51	6.5	22.6	26.3	41.5	32.7	35.4	33.0	48.7	30.8
South Interceptor									
S10	2.7	3.5	4.2	4.4	4.3	4.3	4.1	-	3.9
S42	6.8	8.6	7.4	8.9	10.3	6.9	6.2	2.8	7.2
S49	4.8	5.0	3.7	3.9	3.6	2.7	2.7	0.9	3.4

Table 2-3 provides a comparison of the September 2013 liquid-phase and gas-phase sampling results to the range of historical data in the same location, or in a manhole in the vicinity (within 1,000 feet) of the manhole tested in 2013. The data indicates that liquid-phase and gas-phase concentrations in the Alameda and South Interceptor were generally lower than the historical data. A marked increase has occurred, however, in the upper portion of the North Interceptor, just downstream of the Pump Station “N” discharge pipeline, where the average H_2S concentration was the highest of all locations sampled and the larger liquid-phase sulfide concentration was five times what was measured in the historical data. However, this location will not be analyzed as a hot spot as this section is constructed of vitrified clay pipe (VCP).

Table 2-3. Comparison of Current Sampling Results to Historical Data

Manhole	Current (Sep 2013) Sampling		Historical Data	
	Total Sulfide Concentration (mg/L)	Average H_2S Concentration (ppmv)	Total Sulfide Concentration (mg/L)	Average H_2S Concentration (ppmv)
North Interceptor				
N34	0.6-1.5	8.7	0.73-1.9	2
NF04	0.6-3.6	129	0.63	None
Alameda Interceptor				
M02	3.0-3.2	62.3	7.5	278
A17	0.9-1.1	22.2	None	None
A39	1.0-2.3	12.7	3.1	20
A48	0.7-1.2	6.1	3.6	35
A51	1.2-2.0	30.8	3.2	59
South Interceptor				
S10	0.4-0.6	3.9	0.53-1.4	6
S42	0.1-0.3	7.2	0.98	None
S49	0.1-0.7	3.4	0.63-1.17	6

The data in Tables 2-1 through 2-3 should be compared against the corrosion severity thresholds established for this project, which were identified in TM B.2 and provided in Table 2-4.

Table 2-4. Corrosion Severity Thresholds

Severity Level	Liquid-Phase Sulfide Concentration (mg/L)[a]	Gas-Phase H_2S Concentration (ppmv)[b]
Low	0-0.5	0-2
Moderate	>0.5-1.0	2-5
High	Greater than 1.0	Greater than 5

[a]*Ranges used in 1999 District Odor Control Master Plan and 2009 Odor Control Master Plan Update.*

[b]*Ranges established in WERF Project 04-CTS-1 Minimization of Odors and Corrosion in Collection Systems.*

The following observations are made regarding the three interceptors and current levels of corrosion severity for the sampled locations:

- The North Interceptor locations had moderate to high liquid-phase corrosion severity levels, similar to the historical data. Gas-phase concentrations were both in the high range and a significant increase from historical measurements.
- The Alameda Interceptor locations had moderate to high liquid-phase corrosion severity levels, which is lower than the historical data, where all measurements where in the high range. However, some of those historical measurements were taken prior to hypochlorite injection commencing at Pump Station “M”. Gas-phase concentrations were in the 2013 sampling were all in the high range, similar to the historical measurements.
- The South Interceptor locations had low to moderate liquid-phase corrosion severity levels, a significant decrease in comparison to the historical data, where all measurements were in the high range. A similar trend was present for the gas-phase concentrations where, all 2013 measurements were in the low range, a significant decrease from historical measurements, both of which were in the high corrosion severity range.

In addition to the sampling locations discussed in Tables 2-1 and 2-2, liquid-phase sulfide samples were also collected at all pump station discharge pipeline outlets (where the pressure line transitions to the gravity line). Table 2-5 provides a summary of this data.

Table 2-5. Discharge Manhole 2013 Sampling Data

Pump Station		Discharge Manhole	Grab Sample		Sulfide Concentration (mg/L)		Notes
			Date	Time	Total	Dissolved	
A		AF01	-	-	N/A	N/A	Pressure manhole; no sampling
B		A15	10/2/2013	6:27	1	0.3	
C	C_A	A60	8/19/2013	14:20	5.3	N/A	
C	C_B	A61	9/19/2013	4:26	2	1.6	
D		A19	10/2/2013	2:20	0	0	
E		A28	10/2/2013	2:45	0	0	
F		FF01	9/10/2013	8:23	0.2	0.1	
G		S01	10/2/2013	5:54	0.2	0.1	
H		S21	9/26/2013	15:30	0.2	0.1	
J		S30	9/26/2013	16:10	0	0	
K		KE01	9/26/2013	14:25	0	0	
L		LE01	9/26/2013	14:55	0	0	
M		M01	8/20/2013	12:25	4.2		
N		NF07	9/18/2013	23:32	0	0	Inconsistent with NF04 sampling
Q		Q16	-	-	N/A	N/A	No flow; no sampling conducted
R		A49/A50	10/2/2013	13:21	4.3	2.1	

A notable difference in the discharge manhole sampling data is measurement of zero liquid-phase sulfides in the NF07 manhole, which is much different from the liquid-phase and gas-phase results in Manhole NF04, as discussed above. This sample appears to be an anomaly, as it is unlikely that Manhole NF04 is a location of high turbulence, which would result in high gas-phase H_2S concentrations at that location. As discussed previously, this area of the North Interceptor will not be addressed further in this TM, as the segment of pipe between NF07 and NF03 is VCP, which is not impacted by H_2S corrosion, and reaches downstream of NF03 have already been rehabilitated in the Buchanan Street Interceptor Rehabilitation Project.

Section 3: Sulfide Generation Model

This section discusses the development of an updated sulfide generation model to support the corrosion analysis in this work. The model was developed by BC as an update to the CH2M HILL Interceptor Model last developed as part of the 2009 MWWTP Odor Control Master Plan.

3.1 Model Summary

This section provides a summary of the basic sulfide accumulation model theory concepts and model input parameters. The 2013 sampling data is used to calibrate the model; this section provides an explanation of that calibration process.

3.1.1 Model Theory

A sulfide generation model based on the Pomeroy-Parkhurst sulfide predictive equations for partially filled sewers was prepared to assist with determining the impact of potential solutions on gas- and liquid- phase sulfide concentrations in the District interceptor system. Predictive equations are based on a 1989 USEPA Document (Contract No. 68-03-3412) and on equations from the *ASCE Manual of Practice Number 69* (MOP-69)*, Sulfide in Wastewater Collection and Treatment Systems*. MOP-69 is the industry standard for analytical methods used to quantify sulfides accumulation in a municipal collection system.

The Pomeroy-Parkhurst equation (1) is the main equation used to calculate sulfide generation in the sulfide accumulation model. Following are definitions of the variables in the equation:

$$\frac{d[S]}{dt} = M' \, [EBOD] \, r^{-1} - m \, (sv)^{0.375} \, [S] \, d_m^{-1} \qquad (1)$$

where :

$\frac{d[S]}{dt}$ = sulfide concentration change during time t, milligrams/liter/hour (mg/L/hr)

M' = empirical sulfide flux coefficient, meters/hour (m/hr)

$EBOD$ = effective BOD

r = hydraulic radius, feet (ft)

m = dimensionless, empirical sulfide loss coefficient

s = hydraulic slope, ft/ft

v = flow velocity, ft/second (ft/s)

$[S]$ = total sulfide concentration, mg/L

d_m = mean hydraulic depth, ft

Modeling parameters, including empirical constants specific to sulfide generation and loss potential of the interceptors, were established based on the results of the 2013 field sampling and are discussed in Section 3.1.2. Furthermore, the field sampling data were used to calibrate the model such that the projections align to the field-measured data. Once calibrated, the model is used to estimate sulfide production under a variety of flow and loading conditions and also under varying forms of liquid-phase treatment.

Liquid-phase sulfide concentration estimates from the model are used to:

- Size chemical dosing facilities that can be used to reduce liquid-phase sulfide concentrations in the collection system.
- Predict gas-phase H_2S generation in the interceptors, which is linked to corrosion potential.

3.1.2 Model Input Summary

The sulfide accumulation model uses data from the following sources:

- Interceptor pipe characteristics including length, diameter, slope and were retrieved from CH2M HILL's Interceptor Model inputs. The most recent version of the Interceptor Model completed as part of the MWWTP Odor Control Master Plan Update was used. This pipe information was also compared against the current InfoNet database. Some discrepancies were discovered and addressed.
- Flow rate, velocity, and Manning's "n" roughness coefficients were taken from the District's 2010 hydraulic modeling update as supplied by District staff. The average dry weather flow was used.
- Dissolved oxygen and pH data were compiled from various sources in the historical record as provided in Appendix C of Technical Memorandum B.2.
- The sulfide flux coefficient, M', was initially assumed to be 3.2×10^{-4} meters per hour (m/hr). This is a typical recommended value in the Pomeroy-Parkhurst equation; the coefficient was modified through the calibration process.
- The empirical sulfide loss coefficient, m, was initially assumed to be 0.96 (typical recommended value) and then was modified in the calibration process; increasing the m value assumes a greater amount of turbulence in the system at that location and decreasing the m value assumes a less turbulent flow.
- Liquid-phase total and dissolved sulfide concentrations were taken from the September 2013 sampling. The average ratio of dissolved to total sulfide from the sampling was calculated for each interceptor and that ratio was used in all reaches throughout the interceptor to estimate dissolved sulfide concentrations in the model. These averages were similar to each other – 75 percent in the North Interceptor, 83 percent in the Alameda Interceptor, and 82 percent in the South Interceptor – and similar to ratios calculated in other sulfide accumulation modeling projects.

Table 3-1 summarizes some of the inputs used to develop the model. The listed data are the parameters assumed at the most upstream node in the model in the particular interceptors.

Table 3-1. Sulfide Generation Model Input

Interceptor	Average pH	BOD (mg/L)	Dissolved Oxygen (mg/L)	Temperature (°C)
North	6.6	358	0.19	23.5
Alameda	6.9	209	0.45	24.4
South	7.2	390	-	24.5

3.1.3 Model Calibration

Following completion of the baseline models for all three interceptors, the model runs for the individual interceptors were then calibrated using the appropriate tuning constants (the M' and m values) to achieve an approximate alignment to the field-collected data summarized in Tables 2-1 and 2-2. The model was calibrated to match the gas-phase H_2S data in particular, as it directly affects corrosion. The model assumes a starting liquid-phase sulfide concentration at the furthest upstream node. The model uses this data point to calculate dissolved sulfides and gas-phase H_2S concentrations at each subsequent reach throughout each of the three interceptors.

The sulfide flux coefficient, M' and the empirical sulfide loss coefficient, m, were adjusted to generate two curves that encompassed the gas-phase H_2S sample data. These two curves assumed that 2 percent or 30 percent of the equilibrium concentration of H_2S were present in the sewer headspace, which are assumed minimum and maximum values respectively and are based on similar percentages of equilibrium from previous project experience. Then a percent of equilibrium headspace H_2S concentration was chosen to generate a curve that closely matched the sample data. This percentage of equilibrium was assumed to change in some reaches to represent changes in turbulence due to pipe geometry and incoming side stream. Linear interpolation was also used between assumed changes.

3.2 Baseline Model Results

The calibrated model was used to produce representative generation curves throughout each interceptor systems. This section reviews the liquid-phase sulfide and gas-phase H_2S outputs. Liquid-phase sulfide and gas-phase H_2S plots are provided in Attachment B.

Figures B-1, B-2, and B-3 show the liquid-phase sulfides results generated by the calibrated sulfide model. The North and Alameda Interceptors both have a high amount of dissolved sulfides immediately downstream of the pump station discharge pipes that feed the systems. Concentrations decay quickly within the first mile of both interceptors. This decaying trend is often seen in gravity interceptors downstream of long pressure discharge pipelines, as the high concentrations of liquid-phase sulfides promote significant potential for H_2S volatilization throughout the gravity line. The South Interceptor, unlike the North and Alameda Interceptors, has a relatively constant amount of dissolved sulfides, with an increase in the first mile of the interceptor.

Figures B-4, B-5, and B-6 show the gas-phase H_2S generated by the calibrated model. The gas-phase plots showing similar trends to the liquid phase sulfide accumulation plots. The gas-phase plots were calibrated to match the average H_2S concentrations in the various sampling locations since H_2S in the gas phase is the critical element in identifying corrosion potential and liquid-phase sulfide concentrations tend to vary significantly over the course of a typical day. Additionally, the OdaLog gas-phase monitoring provided a much greater amount of data (H_2S measurements every five minutes for one week of monitoring) than the two liquid-phase grab samples at each location. Because of these factors, the gas-phase calibration plots (Figures B-4, B-5, and B-6) match the gaseous H_2S sampling data more closely than the liquid-phase calibration plots (Figures B-1, B-2, and B-3) match the liquid-phase dissolved sulfide sampling data.

The North and South Interceptor baseline model plots reflect the operational condition employed on a daily basis during dry weather by the District in which the MWWTP influent flow is effectively equalized within the interceptors. The backup increases the flow depth and reduces the headspace within both interceptors, which increases the wastewater detention time. Additional detention time tends to increase the accumulation of liquid-phase sulfide in the system, which also can lead to increase H_2S volatilization and ultimately to increases in corrosion rates.

Following are comparisons of the above sulfide accumulation model output plots to those produced using the Interceptor Model as part of the 2009 MWWTP Odor Control Master Plan:

- **North Interceptor**: current liquid-phase sulfide plot starts at a much higher concentration (greater than 2.5 mg/L) and then concentrations reduce, whereas in the previous model the concentrations start at approximately 0.5 mg/L and generally rise. This indicates either an increase in the sulfides generated in Pump Station "N" and its associated pressure discharge pipeline or a more accurate model in this assessment. Similar observations with the gas-phase H_2S plots regarding the trends in the plots. Also, throughout the interceptor the gas-phase H_2S concentrations are much higher in the 2013 model than in the 2009 model – most values are in the "high" corrosion potential range.
- **Alameda Interceptor:** the shapes of the plots for both the liquid-phase sulfide and gas-phase H_2S outputs are similar for the two models, though in general the concentrations were higher in the 2009 model. In both models, large sulfide accumulation and associated emissions result from the Pump Station "M" discharge into a gravity line. The current model has an increase in gas-phase H_2S emissions at Oakland Estuary Siphon that is not present in the previous model.
- **South Interceptor**: both sets of plots for the two models are similar in the first half of the interceptor in that concentrations do not vary much and are generally speaking on the same order of magnitude. However, in the second half of the interceptor, including all of the Wood Street Interceptor, both the liquid-phase sulfide and gas-phase H_2S concentrations increase significantly in the 2009 model while they both generally remain flat in the current model.

Section 4: Corrosion Assessment

This section presents the corrosion assessment for the interceptor system. The list of hot spots from TM B.2 is confirmed. Note that this list does not include three high-sulfide areas due to the following reasons:

1. The section of the North Interceptor from NF07 to NF04 is constructed from VCP.
2. The Buchanan Street segment of the North Interceptor from Manhole NF04 to Manhole NF01 was rehabilitated in 2012.
3. The section of the South Interceptor from Manhole S60 to the MWWTP is currently undergoing rehabilitation.

Corrosion calculations are provided for each of the hot spots that do not have a rehabilitation project associated with them. The corrosion calculations are used as a basis for life cycle cost comparisons of various corrosion control approaches.

4.1 Updated Hot Spots

Table 4-1 presents a summary of the corrosion hot spots in the District interceptor system as updated following completion of the following tasks:

- September 2013 field sampling and H_2S monitoring, as discussed in Section 2.
- Completion of the updated baseline sulfide generation model, as discussed in Section 3, which incorporates and is calibrated to the field data.

All hot spot locations from TM B.2 remain in the analysis with additional information now available from the sampling and baseline modeling. The field data and modeling results have also been incorporated into the into the corrosion analysis as discussed in Section 4.

Table 4-1. Updated Corrosion Hot Spots

Hot Spot (HS)	Location (Nodes)		Pipe Corrosion Severity Level[a]		Notes
	Upstream	Downstream	Liquid-Phase	Gas-Phase	
North Interceptor					
HS1	N31	N35	Moderate-High	High	• 66-in diameter pipe (reinforced concrete pipe) • Length: 2,441 linear feet (LF). • Reach N34-N35 (432 LF) was assigned Pipe Severity Group "C" rating in 2010-2012 Condition Assessment.
Alameda Interceptor					
HS2	M01	M10	High	High	• 24-in diameter pipe (ductile iron pipe). • Length: 3,165 LF. • Currently has epoxy liner (M01-M10). • M01-M10 assigned Pipe Severity Group "C" rating in 2010-2012 Condition Assessment. • Upstream PS "M" currently dosed with hypochlorite only for odor control. • Hot spot is being addressed with planned rehabilitation of M01-M10 as part of the Versailles Interceptor Rehabilitation Project (FY14-16).
HS3	A17	A21	Moderate - High	High	• 42-in and 48-in diameter pipe (reinforced concrete pipe). • Length: 2,184 LF. • High historical liquid-phase sulfide concentrations in upstream Versailles Segment. • Segment is downstream of confluence of three branches, each of which has a long pressure discharge pipeline (PS "B", "C", and "M"). • Hot spot is being addressed with planned rehabilitation of A17-A21 as part of the Alameda Interceptor Rehabilitation Project (FY15-16).
HS4	A21	A46a	High	High	• 48-in to 60-in diameter pipe (reinforced concrete pipe). • Length: 12,906 LF. • Several reaches designated with Pipe Severity Group "C" rating and one reach with Pipe Severity Group "D" (A40-A41) in 2010-2012 Condition Assessment. • Reach A36-A37 (slipline) and portions of A39-A40 and A40-A41 (liner) rehabilitated previously. • Planned rehabilitation between Manholes A40 and A41 as part of the Alameda Interceptor Rehabilitation Project (FY15-16).
HS5	A46a	S47	High	High	• 30-in to 96-in pipe diameter (reinforced concrete pipe). • Length: 2,938 LF (sulfide model includes all three pipes that make up the Oakland Estuary Siphon). • Reach A48-A49 given Pipe Severity Group "D" rating in 2010-2012 Condition Assessment. • Reaches A48-A49 and A52-S47 were previously rehabilitated (slipline). • Hot spot area also includes contribution from segment that contains Pump Station "R", which had a high liquid-phase sulfide concentration in the 2013 sampling. • Hot spot is being addressed in the planned rehabilitation of A46a-A49 as part of the Alameda Interceptor Rehabilitation Project (FY15-16).

Table 4-1. Updated Corrosion Hot Spots					
Hot Spot (HS)	Location (Nodes)		Pipe Corrosion Severity Level[a]		Notes
	Upstream	Downstream	Liquid-Phase	Gas-Phase	
South Interceptor					
HS6	S09	S16	Moderate	Moderate	• 63-in diameter pipe (reinforced concrete pipe). • Length: 5,985 LF. • S09-S10 and S14-S16 given Pipe Severity Group "C" rating in 2010-2012 Condition Assessment. • Not currently lined. • Planned rehabilitation upstream (S07-S09) as part of the South Interceptor Rehabilitation Project (FY15-16).
HS7	S21	S31	Low	High	• 36-in to 66-in pipe diameter (reinforced concrete pipe in all but one vitrified clay pipe reach). • 5,724 LF. • Several reaches assigned Pipe Severity Group "C" ratings in 2010-2012 Condition Assessment. • Not currently lined. • Planned rehabilitation of special structures at S22-S23 and S31-S32 as part of the 3rd Street Interceptor Rehabilitation Project (FY15-16).
HS8	S47	S50	Moderate-High	High	• 105-in diameter pipe (reinforced concrete pipe). • Length: 1,498 LF. • S47-S50 given Pipe Severity Group "C" rating in 2010-2012 Condition Assessment. • Of corrosion concern because the hot spot is downstream of the confluence of the Alameda and South Interceptors. • Not currently lined. • Hot spot is being addressed in the planned rehabilitation of S47-S53 as part of the 3rd Street Interceptor Rehabilitation Project (FY15-16).
HS9	S54	S57	High	High	• 105-in diameter pipe (reinforced concrete pipe). • Length: 2,272 LF. • S54-S55 given Pipe Severity Group "C" rating in 2010-2012 Condition Assessment. • Not currently lined. • Hot spot is being addressed in the planned rehabilitation of S53-S57 as part of the 3rd Street Interceptor Rehabilitation Project (FY15-16).

[a]*Determined using liquid-phase sulfide and gas-phase H_2S concentrations from the updated sulfide accumulation model produced for this work,*

4.2 Corrosion Assessment Process

Of the nine identified hot spots, five have planned rehabilitation projects to install protective barriers and will not be analyzed further in this TM. For each of the remaining four hot spots (HS1, HS4, HS6 and HS7) to be analyzed in this assessment, the following steps were used to calculate projected corrosion rates, pipe cover loss, and life cycle costs for alternative corrosion control methods:

- Estimate the current (2013) remaining concrete cover (thickness over reinforcing steel) using the corrosion severity rating assessed in the 2010-2012 Condition Assessment and established thresholds from the 1997 IDAP. Table 4-2 provides the ranges used in the 1997 IDAP. The maximum concrete cover is 1 inch, corresponding to the length of cover to the rebar at the crown of the pipe for an elliptical rebar reinforced concrete pipe, which is a characteristic of all Pipe Severity Group "C" reaches considered in the four hot spots.

Table 4-2. Relationship of Remaining Concrete Cover to Pipe Severity Group

Severity Group	Remaining Concrete Cover	
	Pipe Diameter < 57 inch	Pipe Diameter ≥ 57 inch
A or B	≥0.75 in	≥0.5 in
C	>0.5- 0.75 in	>0.25- 0.5 in
D	≤0.5 in	≤0.25 in

The assumptions made for the corrosion analysis in this TM are that for Pipe Severity "C" reaches with pipe diameters less than 57 in, the current remaining concrete cover is **0.75 inch** and for Pipe Severity "C" reaches with pipe diameters greater than or equal to 57 in, the current remaining concrete cover is **0.5 inch**.

- Calculate the projected corrosion rate and remaining concrete cover reduction in a 50-year life cycle starting in 2013 using equations in ASCE MOP 69. The liquid-phase sulfide concentrations used in these calculations reflect the September 2013 sampling.
- Calculate the projected number of years to imminent pipe failure (corresponding to Pipe Severity Group "D" as defined in the 2010-2012 Condition Assessment) due to corrosion within the 50-year life cycle. If the calculated number of years is greater than 50, the quantity is referred to as 50 in the corrosion calculations. A sensitivity analysis is also conducted for large diameter (≥ 57 inch) pipes where the number of years to imminent pipe failure is calculated assuming that the concrete cover is allowed to be reduced to zero. This sensitivity analysis was inserted into the corrosion calculations to identify whether recommendations for corrosion control options would change if the threshold were lowered from 0.25 inch remaining concrete cover to zero.
- Calculate the extension of pipe life achieved by near-term corrosion control methods, which includes either liquid-phase treatment (chemical and/or oxygen addition) or O&M methods (caustic slug dosing and/or crown spraying). The reductions in liquid-phase sulfide concentrations used in the calculations are based on the sulfide generation model results (plots provided in Attachment B).
- Calculate life cycle costs of baseline (no corrosion control) and from applying the various corrosion control options and determine the optimal corrosion control solution and timing of rehabilitation for the hot spot, if needed within the 50-year life cycle.

The point where rehabilitation (installation of a physical barrier or replacement, as discussed in TM B.2) is needed is a function of the remaining concrete cover over the reinforcing steel. Pipe cover thresholds used in this analysis are consistent with those used in the 1997 IDAP:

- For pipe diameters < 57 inch, pipe rehabilitation must be planned when the remaining pipe cover over reinforcing steel is **0.5 inch**. This is assumed to be equivalent to a Pipe Severity "D" rating.
- For pipe diameters ≥ 57 inch, pipe rehabilitation must be planned when the remaining pipe cover over reinforcing steel is **0.25 inch**. This is assumed to be equivalent to a Pipe Severity "D" rating.

In summary, for smaller diameter (< 57 inch) Pipe Severity "C" reaches, the estimated current remaining concrete cover is 0.75 inch, and rehabilitation must be scheduled in the future when the remaining concrete cover is 0.5 inch (equivalent to a Pipe Severity "D" rating). Similarly, for larger diameter (≥ 57 inch) Pipe Severity "C" reaches, the estimated current remaining concrete cover is 0.5 inch, and rehabilitation must be scheduled in the future when the remaining concrete cover is 0.25 inch (equivalent to a Pipe Severity "D" rating for the pipe reach).

Corrosion calculations, including an assessment of remaining pipe life, are based on these estimated current pipe covers. Calculations supporting the corrosion analysis are provided in Attachment C. Section 4.3 provides a summary of the findings and recommendations for each of the four hot spots analyzed.

4.3 Alternative Corrosion Control Evaluations

This section presents an analysis of the four hot spots identified for assessment, with cost projections and recommended corrosion control approaches provided for each.

4.3.1 Hot Spot 1 (North Interceptor N31-N35)

Hot Spot 1 is located in the downstream portion of the North Interceptor. It was designated as a hot spot due to confirmed high liquid-phase sulfide and gas-phase H_2S concentrations and a Pipe Severity "C" designated for Reach N34-N35. According to the updated sulfide accumulation model, liquid-phase sulfides are in the "moderate" range of corrosion severity and gas-phase H_2S concentrations are in the "high" range.

Corrosion Control Options

Three corrosion control options are evaluated for Hot Spot 1. Each requires calculations to determine the impact on pipe cover in the one "C" rated reach (N34-N35). The options are described in Table 4-3 and full conceptual scopes are provided in Attachment C. Note the estimated year requiring rehabilitation is based on the corrosion control calculations discussed below.

Table 4-3. Hot Spot 1 Corrosion Control Options Summary

Corrosion Control Option	Description	Chemical Injection Location and Rate	Estimated Year Requiring Rehabilitation[a]
Rehabilitation Only	No corrosion control implemented; rehabilitation of Reach N34-N35 upon reaching Pipe Severity "D" status.	None	2022
Chemical Injection	Ferrous chloride dosing facility to control liquid-phase sulfides and therefore reduce corrosion in hot spot. Delays required pipe rehabilitation.	Location: N31 Rate: 562 gal/day	2044
Caustic Slug Dosing	Injection of 50 percent caustic solution for 60 minutes weekly to inactivate slime layer and reduce sulfide production. Delays required pipe rehabilitation.	Location: NF04 Rate: 630 gallons per week (gal/week)	2043

[a]*Year when corrosion calculations indicate pipe will reach "D" status, meaning rehabilitation must be scheduled.*

Aerial and street views of the proposed chemical (ferrous chloride) and caustic injection locations are provided in Figure 4-1 and Figure 4-2, respectively. Note that, as shown in Figure 4-1, there is minimal available area to construct a chemical dosing station in the vicinity of Manhole N31, which makes the chemical injection option less desirable. There is no space for a chemical dosing station at Manhole N30, and manholes upstream of N30 are too far upstream for there to be sufficient sulfide reduction in the hot spot, including Reach N34-N35.

The Manhole NF04 location for caustic slug dosing was intentionally selected in an upstream location so as to provide sulfide and corrosion control further upstream in the North Interceptor, which includes an additional short Pipe Severity "C" reach upstream of Hot Spot 1. An alternate location for caustic slug addition is Pump Station "N", which can be used in particular if access to Manhole NF04 is an issue. Using Pump Station "N" would also provide the benefit of lowering liquid-phase sulfide concentrations throughout the entire North Interceptor. However, a higher caustic dose rate could be needed at the upstream pump station location to provide effectiveness throughout the interceptor, which would increase costs somewhat. Pilot testing of both caustic slug dosing locations (NF04 and Pump Station "N") is recommended to confirm projected dose rates and associated costs.

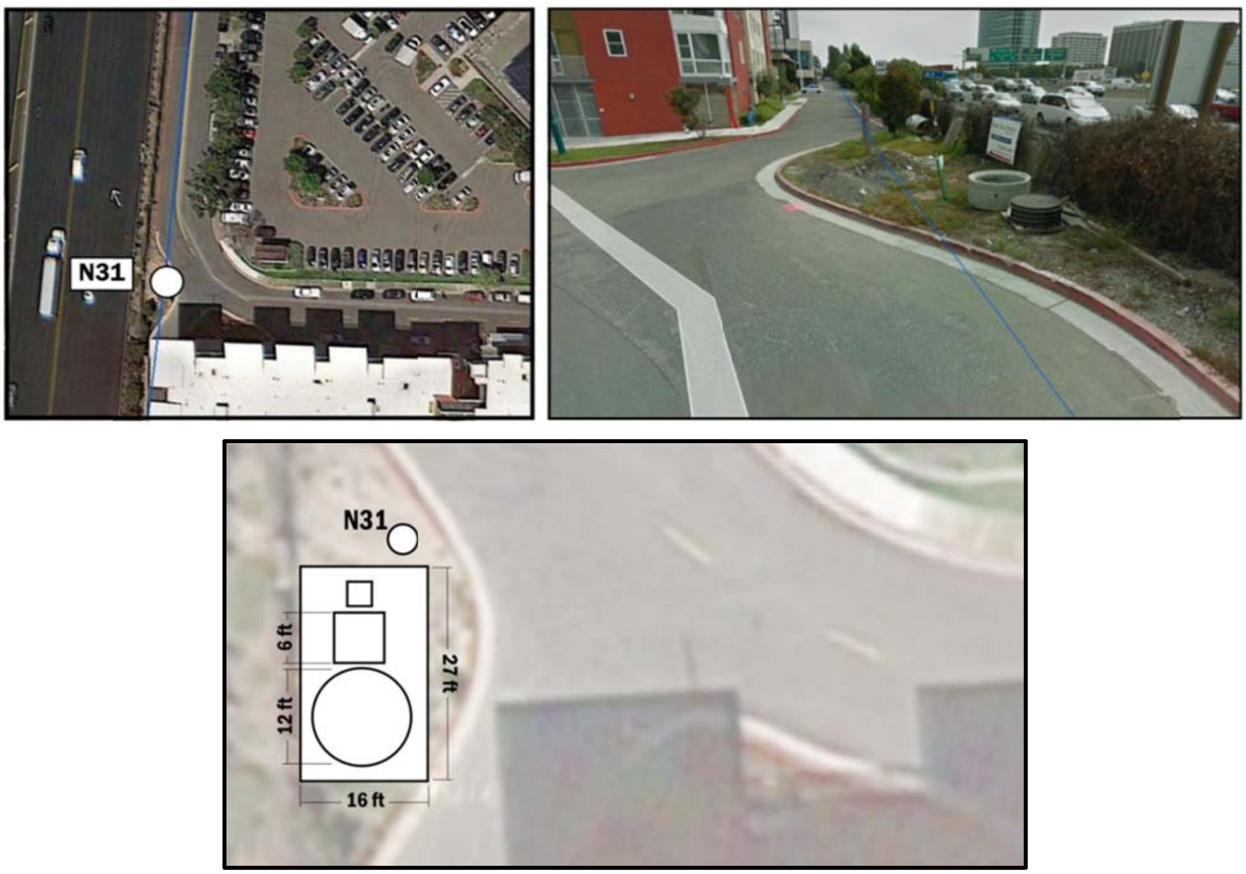

Figure 4-1. Potential Hot Spot 1 Ferrous Chloride Injection Location (Manhole N31)

Figure 4-2. Potential Hot Spot 1 Caustic Slug Injection Location (Manhole NF04)

Corrosion Calculations

Corrosion calculations were completed to identify the number of years before Reach N34-N35 reaches the "critical pipe cover" of 0.25 in, which would correspond in this analysis to Pipe Severity "D" and require rehabilitation. The calculations are provided in Attachment C. Without any corrosion control implemented, the calculations indicate that rehabilitation of the pipe would be needed in approximately 9 years under the criteria that rehabilitation shall be scheduled with 0.25 inches of concrete cover remaining (17 years if it is assumed that rehabilitation is scheduled with zero concrete cover remaining). Critical parameters associated with the three options for corrosion control are summarized in Table 4-4.

Table 4-4. Hot Spot 1 (Reach N34-N35, 66-in Pipe) Corrosion Calculations Summary

Corrosion Control Option	Flow (MGD)	Current Pipe Wall Cover (in)	2013 Dissolved Sulfide Concentration (mg/L)	H_2S Flux (g/m^2-hr)	Average Corrosion Rate (in/yr)	Time before Critical Pipe Cover (yr)
Rehabilitation Only (Time to 0.25 in Cover)	9.83	0.5	1.1	0.0216	0.0296	9
Rehabilitation Only (Time to Zero Cover)	9.83	0.5	1.1	0.0216	0.0296	17
Chemical Injection	9.83	0.5	0.3[a]	0.0059	0.0081	31
Caustic Slug Dosing	9.83	0.5	1.1	0.0062[b]	0.0084	30

[a] *Estimated Reach N34-N35 concentration is based on sulfide model output, assuming ferrous chloride addition at Manhole N31.*

[b] *Calculated by reducing overall H2S flux rate resulting from assuming no sulfide generation activity in 10 of 14 days.*

The impact of liquid-phase treatment (ferrous chloride injection) on the liquid-phase sulfides and gas-phase H_2S is shown in Attachment B, Figures B-7 and B-8. Both curves show that levels are reduced to the "low" corrosion potential range (less than 0.5 mg/L liquid-phase sulfides and less than 2 ppmv gas-phase H_2S) with chemical dosing at Manhole N31.

A similar reduction is shown with two curves that project decreases in liquid-phase sulfide and gas-phase H_2S upon incorporation of caustic slug dosing (Figures B-9 and B-10, respectively). The curves in these figures identify model-projected sulfide and H_2S concentrations in the reaches downstream of the Manhole NF04 dose location immediately following addition of the caustic slug dose (Day 0), in two interim days (Day 7, and 11) and in Day 14, which would be coincident with a new slug dose. These curves show how the impact of the dose decreases over time due to regrowth of the slime layer.

The average day (Ave Day) curve in each caustic slug dosing plot in this TM represents the overall net effect of caustic slug dosing curves taking into account an entire 14-day cycle. This curve represents the projected net effect of the chemical treatment and inactivation of the slime layer in the interceptor, in which inactivation is assumed to effectively occur for 10 out of every 14 days on average. This series of plots is presented for each of the hot spots where caustic slug dosing is an option.

Life Cycle Cost Analysis

Table 4-5 presents a comparison of life cycle costs for the baseline (rehabilitation only), alternate baseline (rehabilitation only but allowing for reduction of the concrete cover over the rebar to zero as opposed to 0.25 inches) and the two near-term corrosion control options (ferrous chloride injection and caustic slug dosing) for Hot Spot 1. Details of the cost calculations are provided in Attachment C. For this and all hot spots in this analysis, a 5 percent interest rate is assumed and a 3 percent cost escalation of rehabilitation options capital costs to the midpoint of construction is assumed. For the chemical injection option, a land acquisition cost of $925,000 per acre is assumed. For Hot Spot 1, acquisition of 0.02 acres adjacent to Manhole N31 is estimated. However, suitability of placing chemical dosing facilities at this location is poor.

Table 4-5. Hot Spot 1 Life Cycle Cost Calculations Summary

Corrosion Control Option	Present Worth Capital Cost	Present Worth Annual Cost	Present Worth Life Cycle Cost
Rehabilitation Only [a]	$680,000	-	$680,000
Rehabilitation Only [b] (Additional Time to Zero Cover)	$583,000	-	$583,000
Chemical Injection[c]	$1,094,000	$4,160,000	$5,254,000
Caustic Slug Dosing [d]	$454,000	$2,210,000	$2,665,000

[a]*Assumes installation of slipline barrier in 9 years when concrete cover is estimated to be at 0.25 inch.*

[b]*Assumes installation of slipline barrier in 17 years when concrete cover is estimated to be at 0 inch.*

[c]*Assumes ferrous chloride addition then installation of slipline barrier in 31 years.*

[d]*Assumes caustic slug dosing then installation of slipline barrier in 30 years.*

Note that the chemical injection option does include an estimate of land acquisition costs at $925,000 per acre, as discussed in Attachment C. This unit cost is applied to all chemical injection options for all hot spots.

Of the three recommended options, the lowest cost is to rehabilitate Reach N34-N35 upon reaching the critical concrete cover rather than installing chemical dosing or caustic slug dosing. The life cycle cost of the chemical and caustic slug dosing options are significantly higher than the rehabilitation option. Additionally, site constraints for the chemical injection equipment are significant for the chemical injection option.

As indicated in Table 4-4 and in Attachment C, at the current rate of corrosion, the N34-N35 would need to be scheduled for rehabilitation in 9 years. However, if the District accepts allowing the remaining concrete cover in the reach to be reduced to zero, rehabilitation of the reach would need to be scheduled in 17 years.

Recommended Approach

Because of a significant difference in life cycle cost, the recommended approach for Hot Spot 1 is to schedule the one Pipe Severity “C” reach (N34-N35) for rehabilitation upon that reach being classified as Pipe Severity “D”. As indicated in Table 4-4 and in Attachment C, at the current rate of corrosion, the reach would need to be scheduled for rehabilitation in 9 years. Alternatively, if the District accepts allowing the remaining concrete cover in the reach to be reduced to zero, rehabilitation of the reach would need to be scheduled in 17 years (a lower life cycle approach, as indicated in Table 4-5, but representing a greater risk of failure based on a projection that rehabilitation would be scheduled when no concrete cover over the rebar remains for the critical pipe reach). Furthermore, when N34-N35 is scheduled for rehabilitation, it would be appropriate to rehabilitate the small reach from N28 to N29, which also was designated as Pipe Severity "C" in the 2010-2012 Condition Assessment. This would represent a small increase in capital cost.

4.3.2 Hot Spot 4 (Alameda Interceptor A21-A46a)

Hot Spot 4 is located in the middle of the Alameda Interceptor and was designated as a hot spot due to confirmed high measured liquid-phase sulfide and H_2S concentrations and several reaches that were identified as Pipe Severity "C" for corrosion in the 2010-2012 Condition Assessment. According to the updated sulfide accumulation model, liquid-phase sulfides and gas-phase H_2S concentrations are in the "high" range of corrosion severity throughout this hot spot.

Corrosion Control Options

Five corrosion control options are evaluated for Hot Spot 4. For each of the options, calculations have been produced that ascertain the impact on pipe cover in the Pipe Severity Group "C" rated reaches, which include: A21-A22, A23- A24, A27-A28, A28-A29, A29-A30, A31-A32, A32-A33, A35-A36, A39-A40, A41-A42, A43-A44, A44-A45, A45a- A46, and A46-A46a.

The corrosion control options, which were identified in TM B.2, are described in Table 4-6 and full conceptual scopes are provided in Attachment C. The estimated years requiring rehabilitation is based on the corrosion control calculations discussed below.

Table 4-6. Hot Spot 4 Corrosion Control Options Summary

Corrosion Control Option	Description	Chemical Injection Location and Rate	Estimated Year Requiring Rehabilitation[a]
Rehabilitation Only	No corrosion control implemented; rehabilitation of "C" rated pipe reaches (see list in Section 4.3.2) upon reaching Pipe Severity "D" status.	None	2025
Chemical Injection	Ferrous chloride dosing facility at two locations to control liquid-phase sulfides and therefore reduce corrosion in hot spot. Delays required pipe rehabilitation.	Location: A21 and A36 Rate: 405 gal/day (each)	2052
Caustic Slug Dosing	Injection of 50 percent caustic solution for 60 minutes weekly to inactivate slime layer and reduce sulfide production. Delays required pipe rehabilitation to out of the life cycle.	Location: A21 Rate: 435 gal/week	2054
Crown Spraying	Applying a high-pH coating to the exposed pipe surface in the "C" rated reaches of the hot spot (see list in Section 4.3.2). Delays required pipe rehabilitation to out of the life cycle.	None (assumes application two times per year)	2054
Oxygen Injection	Installation of a superoxygenation system at upstream Pump Stations "C" and "M" to reduce downstream liquid-phase sulfide concentrations.	No chemicals Oxygen injection is 500 lb/day at each location	2041

[a]*Year when corrosion calculations indicate pipe will reach "D" status, meaning rehabilitation must be scheduled.*

Because of the length of the hot spot, which extends from Manhole A21 to Manhole A46a, the chemical injection alternative would require two separate dosing stations within the hot spot to keep liquid-phase sulfide concentrations in the low range, as confirmed using the sulfide accumulation model. Caustic slug dosing upstream of the hot spot is projected to be sufficient for the entire extent of the hot spot (only one dosing location needed). The oxygenation alternative would require injection at both upstream Pump

Stations “C” and “M” to reduce liquid-phase sulfide concentrations within the gravity lines in an effort to minimize sulfides and H_2S in the hot spot.

Aerial and street views of the proposed chemical (ferrous chloride) and caustic injection locations are provided in Figure 4-3 and Figure 4-4, respectively. Note that both of the locations would likely require land acquisition to construct a new chemical dosing facility, which makes the chemical injection option less desirable. The Manhole A21 location for caustic slug dosing is a reasonable choice as the manhole is located in a relatively low-volume traffic area of Alameda. Alternatively, caustic slug dosing could be conducted in upstream Pump Station “M”, provided that a similar dose rate could be applied with similar H_2S-reduction benefits in the hot spot. The final injection location and dose rate and frequency is best determined using full-scale pilot testing.

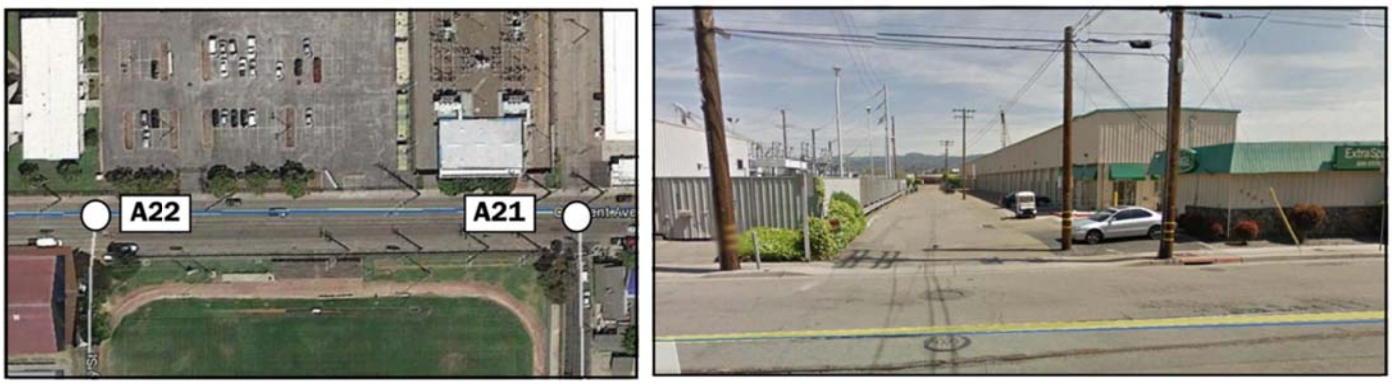

Figure 4-3. Potential Chemical Injection and Caustic Slug Dosing Location for Hot Spot 4 (A21)

Figure 4-4. Potential Second Chemical Injection Location for Hot Spot 4 (A36)

Corrosion Calculations

Corrosion calculations (Attachment C) were completed to identify the number of years before Pipe Severity "C" reaches are reduced to the critical pipe cover, which would correspond in this analysis to Pipe Severity "D" and require scheduling of rehabilitation. Table 4-7 presents a summary of critical parameters associated with the baseline (no corrosion control) and near-term corrosion control options in Reach A41-A42. This reach was selected as a conservative choice (identified as the "critical reach"), as the corrosion calculations indicate that it would reach Pipe Severity "D" status first of all "C" reaches in the hot spot.

Table 4-7. Hot Spot 4 (Reach A41-A42, 60-in Pipe) Corrosion Calculations Summary

Condition	Flow (MGD)	Current Pipe Wall Cover (in)	2013 Dissolved Sulfide Concentration (mg/L)	H_2S Flux (g/m^2-hr)	Average Corrosion Rate (in/yr)	Time before Critical Pipe Cover (yr)
Rehabilitation Only (Time to 0.25 in Cover)	4.28	0.5	1.68	0.0157	0.0215	12
Rehabilitation Only (Time to Zero Cover)	4.28	0.5	1.68	0.0157	0.0215	23
Chemical Injection[a]	4.28	0.5	0.5[a]	0.0047	0.0064	39
Caustic Slug Dosing [b]	4.28	0.5	1.68	0.0045[b]	0.0061	41
Crown Spraying [c]	4.28	0.5	1.68	0.0045[c]	0.0061	41
Oxygenation[d]	4.28	0.5	0.7[d]	0.0066	0.0090	28

[a]*Estimated Reach A41-A42 concentration is based on sulfide model output, assuming ferrous chloride addition at Manhole N31.*

[b]*Calculated by reducing overall H_2S flux rate resulting from assuming no sulfide generation activity in 10 of 14 days.*

[c]*For corrosion calculations, assumes a reduction in H_2S flux similar to the effect of caustic slug dosing.*

[d]*For corrosion calculations, assumes liquid-phase sulfide concentration in Reach A41-A42 per sulfide model results.*

Without any corrosion control implemented, the calculations indicate that rehabilitation of Reach A41-A42 would be needed in approximately 12 years under the criteria that rehabilitation is scheduled with 0.25 inches of concrete cover remaining (23 years if it is assumed that rehabilitation is scheduled with zero concrete cover remaining). At the time of rehabilitation of A41-A42, it is assumed that the other reaches in the hot spot would also be rehabilitated.

The impact of liquid-phase treatment (ferrous chloride injection) on the liquid-phase sulfides and gas-phase H_2S is shown in Attachment B, Figures B-11 and B-12. This assumes injection of ferrous chloride at the two locations within the hot spot identified in Table 4-6. The first curve shows that levels are reduced to the low corrosion potential range (less than 0.5 mg/L) throughout the hot spot, and the second curve shows that H_2S concentrations are reduced to the low (below 2 ppmv) and moderate (2 to 5 ppmv) range throughout the hot spot.

A similar reduction into the low liquid-phase and low-moderate gas-phase ranges is shown with two curves that project decreases in liquid-phase sulfide and gas-phase H_2S upon incorporation of caustic slug dosing (Figures B-13 and B-14, respectively). A similar distribution of curves plotted as a function of number of days after the caustic slug dose is applied as was generated for Hot Spot 1.

Figures B-15 and B-16 show the reductions in liquid-phase sulfides and gas-phase H_2S for the oxygen injection option, where systems would be installed at Pump Stations "C" and "M". The liquid-phase sulfide concentrations are in the low and moderate range, but H_2S concentrations in the downstream portion of the hot spot remain in the "high" range (greater than 5 ppmv). This indicates that oxygen injection in the upstream locations is projected to be only partially effective at reducing corrosion in the hot spot.

Life Cycle Cost Analysis

Table 4-8 presents a comparison of life cycle costs for the rehabilitation only and near-term corrosion control options for Hot Spot 4. Details on the calculations are provided in Attachment C. The lowest cost option is to use caustic slug dosing to reduce sulfide generation in the hot spot for 41 years followed by scheduling installation of a slipline barrier in 2054.

Table 4-8. Hot Spot 4 Life Cycle Cost Calculations Summary

Condition	Present Worth Capital Cost	Present Worth Annual Cost	Present Worth Life Cycle Cost
Rehabilitation Only [a] (Time to 0.25 Cover)	$6,820,000	-	$6,820,000
Rehabilitation Only [b] (Time to Zero Cover)	$5,520,000	-	$5,520,000
Chemical Injection [c]	$5,574,000	$6,597,000	$12,172,000
Caustic Slug Dosing [d]	$3,906,000	$1,588,000	$5,494,000
Crown Spraying [e]	$3,906,000	$2,516,000	$6,422,000
Oxygenation [f]	$8,450,000	$1,508,000	$9,957,000

[a]Assumes installation of slipline barrier in 12 years when concrete cover is estimated to be at 0.25 inch.

[b]Assumes installation of slipline barrier in 23 years when concrete cover is estimated to be at 0 inch.

[c]Assumes ferrous chloride addition for 39 years followed by installation of a slipline barrier.

[d]Assumes weekly caustic slug dosing for 41 years followed by installation of a slipline barrier.

[e]Assumes crown spraying for 41 years followed by installation of a slipline barrier.

[f] Assumes oxygen injection at Pump Stations "C" and "M" for 41 years followed by installation of a slipline barrier.

Recommended Approach

The lowest life cycle cost approach is to incorporate caustic slug dosing into the entire length of the hot spot, which is projected to delay the need for rehabilitation from 12 years to 41 years from the present day, assuming rehabilitation is scheduled upon reaching 0.25 in of remaining concrete cover over the existing rebar in the critical pipe reach. Caustic slug dosing is recommended for pilot testing to confirm effectiveness and to identify actual projected chemical dose rates and costs. Should pilot testing indicate significantly higher dose rates and associated costs, crown spraying may prove to be a more cost-effectively solution.

Note that the life cycle cost of the rehabilitation only option is approximately 20 percent higher than the caustic slug dosing option, given a threshold of scheduling the rehabilitation upon reaching 0.25 in of concrete cover in the critical pipe reach. However, when allowing the concrete cover to be reduced to zero, the additional delay in scheduling rehabilitation reduces the life cycle costs to be effectively the same as caustic slug dosing. This allows for adaptation of the rehabilitation option, at higher risk, but at a projected cost more comparable to the recommended option of caustic slug dosing.

Because of the high life cycle cost and because there would need to be two new sites for new chemical dosing stations (which may present site constraints), chemical injection is not desirable for this hot spot. Additionally, the oxygenation option projected life cycle cost is significantly higher than either the rehabilitation only or caustic slug dosing alternatives, plus the upstream location of injection facilities (Pump Stations "C" and "M") result in gas-phase H_2S concentrations in the downstream reaches of the hot spot that remain in the "high" category for corrosion potential. Therefore, oxygen addition as a corrosion prevention measure alone is not recommended for Hot Spot 4. However, the oxygen injection technology could prove to be a reasonable replacement for the existing chemical injection systems at the two pump stations (both hypochlorite injection systems), which do not appear to be removing liquid-phase sulfides in the downstream discharge pipelines efficiently, as is evidenced by discharge manhole sulfide data collected in August-September 2013 (Table 2-5).

4.3.3 Hot Spot 6 (South Interceptor S09-S16)

Hot Spot 6 is located in the upstream portion of the South Interceptor and was designated as a hot spot due to confirmed high liquid-phase sulfide and gas-phase H_2S concentrations and several reaches that were designated at Pipe Severity "C" in the 2010-2012 Condition Assessment. According to the updated sulfide accumulation model, liquid-phase sulfides and gas-phase H_2S concentrations are in the moderate range of corrosion severity throughout this hot spot.

Combined Hot Spot 6 and 7 Analysis

Because of the proximity of Hot Spot 6 to Hot Spot 7, potential corrosion control options were considered for both Hot Spot 6 and 7 simultaneously. This was because two options (chemical addition and caustic slug dosing) potentially could be implemented with facilities upstream of Hot Spot 6 that would benefit both hot spots. However, after further analysis, it was determined that though there was some benefit in Hot Spot 7, the effect is projected not to be enough to reduce corrosion in Hot Spot 7 to the extent that a separate facility would provide. Therefore, Hot Spots 6 and 7 are analyzed separately in this TM.

Corrosion Control Options

Four corrosion control options are evaluated for Hot Spot 6. For each option, calculations project the impact of corrosion on pipe cover in the Pipe Severity "C" rated reaches from the 2010-2012 Condition Assessment. These reaches include S09-S10, S14-S15, and S15-S16

The three options considered are described in Table 4-9 and full conceptual scopes are provided in Attachment C. The estimated years requiring rehabilitation is based on the corrosion control calculations.

Table 4-9. Hot Spot 6 Corrosion Control Options Summary

Corrosion Control Option	Description	Chemical or Oxygen Injection Location and Rate	Estimated Year Requiring Rehabilitation[a]
Rehabilitation Only	No corrosion control implemented; rehabilitation of "C" rated reaches in both hot spots upon reaching Pipe Severity "D" status.	None	2050
Chemical Injection	Ferrous chloride dosing facility to control liquid-phase sulfides and therefore reduce corrosion in the hot spot using a dosing station upstream of Hot Spot 6. Delays required pipe rehabilitation in both hot spots to out of the 50-year life cycle.	Location: S08 Rate: 65 gal/day	Not in 50-Year Life Cycle
Caustic Slug Dosing	Injection of 50 percent caustic solution upstream of Hot Spot 6 for 60 minutes weekly to inactivate slime layer and reduce sulfide production. Delays required pipe rehabilitation to out of the 50-year life cycle.	Location: S08 Rate: 555 gal/week	Not in 50-Year Life Cycle

[a]*Year when corrosion calculations indicate pipe will reach "D" status, meaning rehabilitation must be scheduled.*

Aerial and street views of the proposed chemical (ferrous chloride) and caustic injection location are provided in Figure 4-5. Note that there is sufficient available area to construct a chemical dosing station in the vicinity of Manhole S08. Manhole S08 is also a sufficient location for caustic slug dosing.

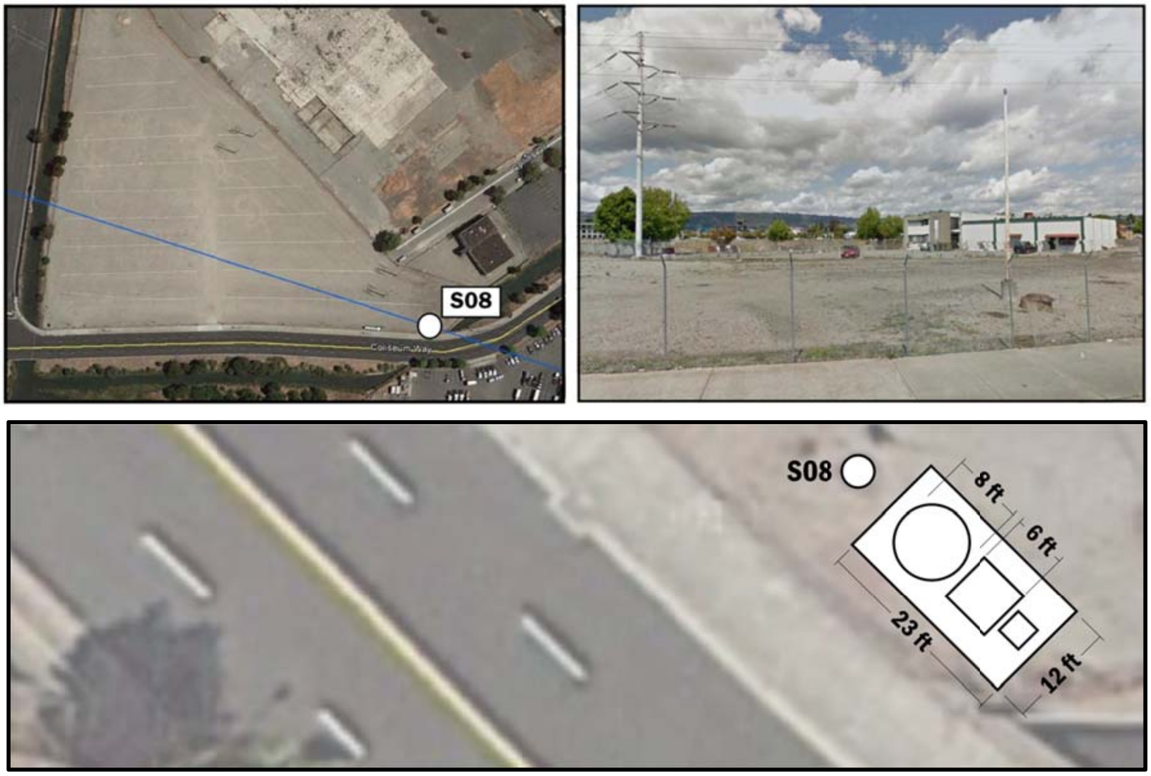

Figure 4-5. Potential chemical injection and caustic slug dosing location for Hot Spot 6

Corrosion Calculations

Corrosion calculations were completed to identify the number of years before the Pipe Severity "C" reaches are reduced to the critical pipe cover, which would correspond in this analysis to Pipe Severity "D" and require rehabilitation. Table 4-10 presents a summary of critical parameters associated with the baseline (no corrosion control, rehabilitation only) and two near-term options for corrosion control within Hot Spot 6. Details of these calculations and scope summaries are provided in Attachment C.

Table 4-10 Hot Spot 6 (Reach S09-S10, 63-in Pipe) Corrosion Calculations Summary

Condition	Flow (MGD)	Current Pipe Wall Cover (in)	2013 Dissolved Sulfide Concentration (mg/L)	H_2S Flux (g/m^2-hr)	Average Corrosion Rate (in/yr)	Time before Critical Pipe Cover (yr)
Rehabilitation Only (Time to 0.25 in Cover)	5.00	0.5	0.6	0.0050	0.0068	37
Rehabilitation Only (Time to Zero Cover)	5.00	0.5	0.6	0.0050	0.0068	50+
Chemical Injection	5.00	0.5	0.2[a]	0.0007	0.0023	50+
Caustic Slug Dosing	5.00	0.5	0.6	0.0007[b]	0.0019	50+

[a]*Estimated Reach S09-S10 concentration is based on sulfide model output, assuming ferrous chloride addition at Manhole S08.*

[b]*Calculated by reducing overall H_2S flux rate resulting from assuming no sulfide generation activity in 10 of 14 days.*

The corrosion control analysis and Table 4-10 use Reach S09-10 as an indication of corrosion potential in the hot spot. This reach was selected as a conservative choice, as the corrosion calculations (Attachment C) indicate that it would reach Pipe Severity “D” status first of all “C” reaches in Hot Spot 6. Without any corrosion control implemented, the calculations indicate that rehabilitation of the Hot Spot 6 critical reach would be needed in approximately 37 years.

Similar to what was done for previous hot spots, a corrosion analysis was also conducted for the condition where the remaining amount of concrete cover is allowed to be reduced to 0 in, as opposed to 0.25 in. If this less conservative threshold is chosen, rehabilitation is not needed for the Pipe Severity “C” rated reaches within the 50-year life cycle. Therefore, the District could opt not to complete rehabilitation in the hot spot if the amount of remaining concrete cover is allowed to approach zero; this would dramatically reduce projected costs but would do so at an increased level of risk.

Either injecting ferrous chloride or incorporating caustic slug dosing upstream of Hot Spot 6 (Manhole S08) is projected to eliminate the need for rehabilitation in either hot spot within the 50-year life cycle. The impact of liquid-phase treatment (ferrous chloride injection) on the liquid-phase sulfide and gas-phase H_2S concentrations is shown in Attachment B, Figures B-17 and B-18. The first curve shows that liquid-phase sulfide concentrations remain in the low corrosion potential range (less than 0.5 mg/L) throughout the hot spot, and the second curve shows that H_2S concentrations are reduced into moderate corrosion potential range (between 2 and 5 ppmv) within the hot spot. This represents a minimal change in corrosion potential.

A projection of the impact of caustic slug dosing on the accumulation plots is provided in Attachment B, Figures B-19 and B-20. This assumes injection of 50 percent caustic solution into Manhole S08 every 14 days. The projected reductions in liquid-phase sulfide (Figure B-19) and gas-phase H_2S (Figure B-20) are similar to what is projected to be accomplished using chemical addition, with the exception that more than half of Hot Spot 6 is projected to have gas-phase H_2S concentrations in the “low” corrosion potential range of less than 2 ppmv with caustic slug dosing.

Life Cycle Cost Analysis

Table 4-11 presents a comparison of life cycle costs for the baseline (rehabilitation only) and two near-term corrosion control options for Hot Spot 6. Details on the calculations are provided in Attachment C. The lowest cost option is to use chemical (ferrous chloride) injection into Manhole S08 for corrosion control in both hot spots through the 50-year life cycle.

Table 4-11 Hot Spot 6 Life Cycle Cost Calculations Summary

Condition	Present Worth Capital Cost	Present Worth Annual Cost	Present Worth Life Cycle Cost
Rehabilitation Only (Plastic Liner)[a]	$2,744,000	-	$2,744,000
Rehabilitation Only Cured in Place Pipe (CIPP)[a]	$2,438,000	-	$2,438,000
Rehabilitation Only (Cover goes to zero)[b]	-	-	None
Chemical Injection[c]	$781,000	$1,851,000	$2,632,000
Caustic Slug Dosing [d]	-	$2,625,000	$2,625,000

[a]Assumes installation of a plastic liner or CIPP barrier in 37 years for the Hot Spot 6 Pipe Severity “C” reaches.

[b]Assumes cover allowed to progress to zero. Rehabilitation required outside of 50 year window for the Hot Spot 6 Pipe Severity “C” reaches.

[c]Assumes ferrous chloride addition into Manhole S08 for entire 50-year life cycle.

[d]Assumes caustic slug dosing into Manhole S08 for entire 50-year life cycle.

For the Hot Spot 6 corrosion analysis, chemical injection has a lower life cycle cost than the previous hot spots analyzed. This is primarily due to the fact that chemical requirements are projected to be relatively low to control sulfide formation in the South Interceptor, given the results of the 2013 sampling, where liquid-phase sulfide concentrations were generally in the low range (a reduction from the historical values). Caustic slug requirements, and associated costs, however, do not scale with the liquid-phase sulfide concentration in the wastewater, but instead are a function of flow, alkalinity, and other water quality parameters.

Recommended Approach

The life cycle costs of all options are essentially within a reasonable margin of error. Therefore, the recommendation for corrosion control at Hot Spot 6 is to schedule rehabilitation of the Pipe Severity "C" reaches in the hot spot in the long-range District plans (scheduling rehabilitation in 2050 is projected in the analysis). Because installation of a CIPP barrier is projected to be lower cost, this approach is recommended. However, given that current liquid-phase sulfide and gas-phase H_2S concentrations are lower than historical values, it is possible that the District may only need to monitor this hot spot for corrosion-related parameters and may not need to complete any rehabilitation efforts within the 50-year life cycle.

4.3.4 Hot Spot 7 (South Interceptor)

Hot Spot 7 is located in the South Interceptor immediately downstream of Pump Station "H". It was designated as a hot spot due to confirmed high gas-phase H_2S concentrations and several reaches that were designated at Pipe Severity "C" in the 2010-2012 Condition Assessment. According to the updated sulfide accumulation model, liquid-phase sulfide concentrations are in the low to moderate range and gas-phase H_2S concentrations are in the high range of corrosion severity throughout this hot spot.

Corrosion Control Options

Four corrosion control options, which were identified in TM B.2, are evaluated for Hot Spot 7. The corrosion control options are described in Table 4-12. For each of the options, calculations have been produced that ascertain the impact on pipe cover in the Pipe Severity Group "C" rated reaches.

Table 4-12. Hot Spot 7 Corrosion Control Options Summary

Corrosion Control Option	Description	Chemical or Oxygen Injection Location and Rate	Estimated Year Requiring Rehabilitation[a]
Rehabilitation Only	No corrosion control implemented; rehabilitation of "C" rated pipe reaches upon reaching Pipe Severity "D" status.	None	2040
Chemical Injection	Ferrous chloride dosing facility to control liquid-phase sulfides and therefore reduce corrosion in hot spot. Delays required pipe rehabilitation to out of the life cycle.	Location: Pump Station "H" Rate: 355 gal/day	Not in 50-Year Life Cycle
Caustic Slug Dosing	Injection of 50% caustic solution for 60 minutes weekly to inactivate slime layer and reduce sulfide production. Delays required pipe rehabilitation to out of the life cycle.	Location: Pump Station "H" Rate: 1,617 gal/week	Not in 50-Year Life Cycle
Oxygen Injection	Applying a high-pH coating to the exposed pipe surface within the "C" rated reaches of the hot spot. Delays required pipe rehabilitation to out of the life cycle.	No chemicals Oxygen injection is 1,100 lb/day at Pump Station "H"	Not in 50-Year Life Cycle

[a] *Year when corrosion calculations indicate pipe will reach "D" status, meaning rehabilitation must be scheduled.*

Aerial and street views of the proposed ferrous chloride and caustic injection location are in Figure 4-6. The advantage of using Pump Station "H" for oxygen injection is that it would not require land acquisition. However, the available footprint for additional facilities at Pump Station "H" is limited, and there is a strong potential that there is insufficient space for installation of a chemical dosing station. A general indication of available footprint and the size the oxygen injection facilities would be at Pump Station "H" is provided in Attachment D, along with the budgetary proposal from ECO2 for an oxygenation installation, which includes an estimate of annual O&M requirements and associated costs.

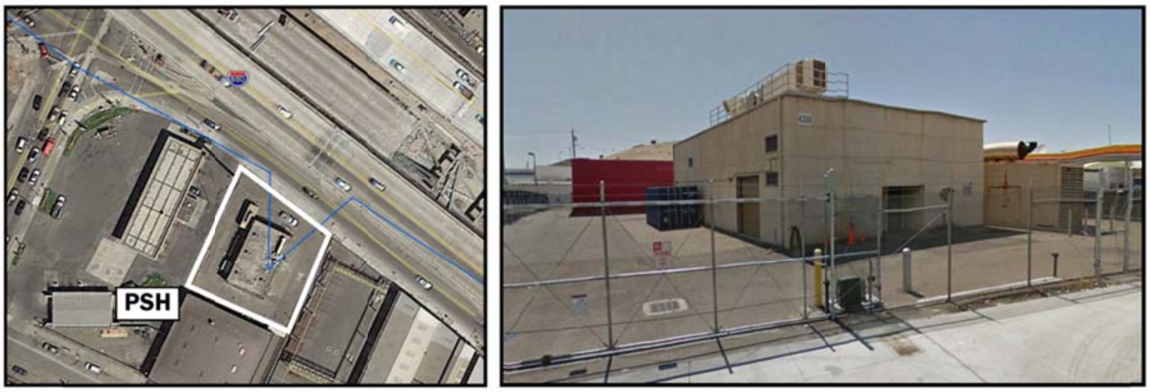

Figure 4-6. Pump Station "H" Available Footprint

Corrosion Calculations

Corrosion calculations were completed to identify the number of years before the Pipe Severity "C" reaches with the projected least amount of remaining life (Reach S21-S22) is reduced to the critical pipe cover, which would correspond in this analysis to Pipe Severity "D" and require rehabilitation. Table 4-13 presents a summary of critical parameters associated with the rehabilitation only (no corrosion control) and the three near-term options for corrosion control in Reach S21-S22. Details of these calculations are provided in Attachment C.

Table 4-13 Hot Spot 7 (Reach S21-S22, 57-in Pipe) Corrosion Calculations Summary

Condition	Flow (MGD)	Current Pipe Wall Cover (in)	2013 Dissolved Sulfide Concentration (mg/L)	H_2S Flux (g/m^2-hr)	Average Corrosion Rate (in/yr)	Time before Critical Pipe Cover (yr)
Rehabilitation Only (Time to 0.25 Cover)	12.08	0.5	0.5	0.0067	0.0091	27
Rehabilitation Only (Time to zero Cover)	12.08	0.5	0.5	0.0067	0.0091	50+
Chemical Injection	12.08	0.5	0.2[a]	0.0027	0.0036	50+
Caustic Slug Dosing	12.08	0.5	0.5	0.0019[b]	0.0026	50+
Oxygen Injection	12.08	0.5	0.1[c]	0.0013	0.0018	50+

[a]*Estimated Reach S21-S22 concentration is based on sulfide model output, assuming ferrous chloride addition at Pump Station "H".*

[b]*Calculated by reducing overall H_2S flux rate resulting from assuming no sulfide generation activity in 10 of 14 days.*

[c]*Goal is zero dissolved sulfide in the reach; using 0.1 mg/L for calculation purposes.*

Without any corrosion control implemented, the calculations indicate that rehabilitation of the pipe would be needed in approximately 27 years, during which time it is assumed that the other currently designated Pipe Severity “C” reaches in the hot spot would also be rehabilitated. Any of the near-term options (ferrous chloride addition, caustic slug dosing, or oxygen addition) is projected to eliminate the need for rehabilitation of the hot spot within the 50-year life cycle.

Plots of projected modified liquid-phase sulfide and gas-phase H_2S accumulation in the hot spot following chemical addition are shown in Attachment B, Figures B-21 and B-22. As shown in the figures, chemical addition at Pump Station “H” would result in liquid-phase sulfide in the low corrosion potential range (note that for liquid-phase sulfides, the untreated accumulation plot also has low corrosion potential in the hot spot). Gas-phase H_2S concentrations are reduced using chemical addition from the high into the moderate range (less than 2 ppmv).

Plots of projected modified liquid-phase sulfide and gas-phase H_2S accumulation in the hot spot following regular caustic slug injections addition in Pump Station “H” are shown in Attachment B, Figures B-23 and B-24. The liquid-phase sulfides remain in the low range of corrosion potential, similar to the chemical addition plot, but Figure B-24 indicates that caustic slug dosing would be more effective than chemical treatment, reducing gas-phase H_2S concentrations into the low range throughout the hot spot.

Plots of projected modified liquid-phase sulfide and gas-phase H_2S accumulation in the hot spot following installation of a superoxygenation system in Pump Station “H” are shown in Attachment B, Figures B-25 and B-26. The liquid-phase sulfides remain in the low range of corrosion potential, similar to the previous plots, and Figure B-26 indicates that oxygen addition would have a significant benefit in reducing gas-phase H_2S concentrations into the low range throughout the hot spot to concentrations below 1 ppmv, entirely within the low corrosion-potential range.

Life Cycle Cost Analysis

Table 4-14 presents a comparison of life cycle costs for the baseline and two near-term corrosion control options for Hot Spot 7. Details on the calculations are provided in Attachment C. The lowest cost option is to use oxygen injection into Pump Station “H” for the hot spot through the 50-year life cycle.

Table 4-14. Hot Spot 7 Life Cycle Cost Calculations Summary

Condition	Present Worth Capital Cost	Present Worth Annual Cost	Present Worth Life Cycle Cost
Rehabilitation Only [a]	$2,662,000	-	$2,662,000
Chemical Injection [b]	$803,000	$3,732,000	$4,534,000
Caustic Slug Dosing	-	$5,473,000	$5,473,000
Oxygen Injection[c]	$1,835,000	$617,000	$2,452,000

[a]Assumes installation of slipline barrier in 27 years.

[b]Assumes ferrous chloride addition into PS “H” for entire 50-year life cycle.

[c]Assumes oxygen injection into PS “H” for entire 50-year life cycle.

Recommended Approach

The lowest life cycle cost approach is to install an oxygen injection (superoxygenation) system into Pump Station “H”, which is projected reduce liquid-phase sulfide concentrations at the end of the discharge pipeline to near zero. This would delay the need for rehabilitation from 27 years from the present day to out of the 50-year life cycle. Therefore, oxygen injection is recommended for this hot spot.

Evaluation of Benefits for MWWTP Sulfide Loading

Sulfide reduction associated with corrosion control using oxygen addition at Pump Station "H" would also have a beneficial reduction in the sulfide load to the MWWTP, which would produce an odor control benefit by reducing chemical requirements at the plant influent point and potentially reducing the load on gas-phase odor control systems. With much of the Wood Street segment of the South Interceptor lined, the sulfide load to the MWWTP is projected to increase in time. Oxygen injection into Pump Station "H" is projected to reduce plant influent sulfide loads from the current load of approximately 0.48 mg/L to 0.26 mg/L (Figure B-25).

An alternative approach that was also considered for reducing the sulfide load to the MWWTP would be to install a new chemical dosing system at Pump Station "R". The chemical dosing facility could be sized to reduce the liquid-phase sulfide concentration in the Alameda Interceptor prior to the confluence with the South Interceptor, thus reducing the overall sulfide load further downstream in the South Interceptor and at the MWWTP. A general site plan of chemical dosing facilities that could be constructed at Pump Station "R" is provided in Attachment E.

The impact of constructing this chemical dosing facility is shown using the sulfide accumulation model, and the resulting South Interceptor plots are shown in Attachment B, Figures B-27 and B-28. The benefit of this strategy would not be as significant as oxygen injection into Pump Station "H", as injecting ferrous chloride into Pump Station "R" would reduce sulfide loads from approximately 0.48 mg/L to 0.43 mg/L. Therefore, installation of a new chemical dosing facility at Pump Station "R" is not recommended.

Section 5: Monitoring Recommendations

This section provides a recommended monitoring program for the corrosion control program and also identifies reaches within the interceptors that warrant close monitoring in the future. Table 5-1 presents options for establishing a corrosion control monitoring program. Monitoring can be conducted assuming one of three levels of complexity and cost. The District will ultimately need to determine which level of monitoring to perform. The cost analysis utilized the Medium Complex monitoring option as part of calculating the long term costs.

Table 5-1. Corrosion Control Monitoring Options Summary

Monitoring Option	Summary	Advantages	Disadvantages	Cost
Most Complex	Installation of real-time liquid-phase sulfide monitors at downstream locations just beyond each of the hot spots where either liquid-phase treatment or caustic slug dosing are implemented. These systems can set up to be read by MWWTP SCADA and can provide input as to whether the recommended program is effective. At the most advanced level of control, these monitors can be installed in existing quality monitoring stations and connected to chemical dosing systems where doses can be actively increased or decreased depending on sulfide measurements.	Greatest level of control over chemical treatment optimizes chemical use.	Highest cost and strictest O&M requirements.	Equipment cost is approximately $30,000 for each location plus electrical installation costs; yearly maintenance.
Moderately Complex	Installation of OdaLogs downstream of the hot spot areas where either liquid-phase treatment or caustic slug dosing is being implemented. One week of collected data are downloaded monthly and analyzed to determine if adjustments to the corrosion control system dosing rates should be considered. Continuous monitoring gives an approximation of season variations in chemical requirements for corrosion control (typically reduced in the winter due to colder temperatures and wet-weather flow events).	OdaLog measurements of gas-phase H_2S provide a direct measurement of the most important factor in corrosion potential (H_2S in the headspace).	Monitoring frequency is less than the most complex option and chemical adjustment are less frequent.	OdaLog rental is approximately $250 for one week for each hot spot, plus labor to install and download data.
Least Complex	Provide a brief (two weeks to one month) initial monitoring of gas-phase H_2S concentrations using OdaLogs downstream of the hot spots where either liquid-phase treatment or caustic slug dosing is enacted. This brief monitoring period is focused on identifying an optimal initial chemical dose that will either reduce sulfide concentrations sufficiently (for liquid-phase treatment) or inactivated the slime layer (caustic slug dosing). Then the District can on occasion bring back OdaLogs to determine corrosion control effectiveness every 1-2 years to refine the dosing rate or frequency of caustic slug dosing.	Least costly of the three options	Presents the greatest potential for either overdosing or underdosing chemicals	One time cost of OdaLog rental: approximately $750 for one month for each hot spot, plus labor to install and download data

Attachment F contains catalog information for a monitoring station provided by S::CAN that could be installed for continuous dissolved sulfide monitoring (most complex option in Table 5-1). The recommended system for corrosion monitoring is the moderately complex system of monthly OdaLog data collection and optimizing the chemical injection or caustic slug dosing accordingly. This monitoring system provides needed year-round continuous data and can provide some optimization of chemical use during winter wet-weather months, but avoids the high equipment and maintenance costs associated with the continuous monitoring system. The continuous monitoring system could be more effective if there were several “D” rated reaches that were not being addressed in the near future with rehabilitation projects but instead were being controlled by liquid-phase treatment. However, all “D” rated reaches in the District interceptor system are being addressed with near-term rehabilitation projects.

Scopes and approximate costs for implementing the moderately complex monitoring system discussed in Table 5-1 have been included in Attachment C.

Section 6: Summary of Recommendations

Table 6-1 summarizes findings from the corrosion and cost analyses, including consideration of alternate scenarios that may be considered which may represent higher cost or risk of failure. For each hot spot, the option in red is the recommended option.

Table 6-2 presents an updated summary recommended corrosion control approaches for each hot spot based upon the analysis conducted in Task B.3.

Table 6-1. Interceptor System Hot Spot Corrosion Findings

Hot Spot (HS)	Location (Nodes)		Pipe Corrosion Severity Level		Remaining Useful Life[a] and Rehabilitation Cost[b]	Corrosion Control Options or Alternative Rehabilitation			
	Upstream	Downstream	Liquid-Phase	Gas-Phase		Option[c]	Description	Remaining Useful Life (Yr)	Life Cycle Cost[b]
HS1	N31	N35	Moderate-High	High	9 Years $0.68 M	Rehabilitation	Slipline N34-N35. Allow concrete cover to reduce to 0 inches.	17	$0.58 M
						Caustic Slug Dosing	Inject caustic into NF04 every 1-2 weeks for 19 years, then slipline N34-N35.	30	$2.67 M
HS4	A21	A46a	High	High	12 Years $6.82 M	Rehabilitation	Slipline Pipe Severity "C" reaches. Allow concrete cover to reduce to 0 inches.	23	$5.52 M
						Caustic Slug Dosing	Inject caustic into A21 every 1-2 weeks for 41 years, then slipline "C" reaches.	41	$5.49 M
						Crown Spraying	Spray corrosion resistant material into sewer 1-2 times per year for 41 years, then slipline "C" reaches.	41	$6.42 M
						Oxygenation	Install oxygen injection into upstream Pump Stations "C" and "M" for 28 years, then sliplining "C" reaches.	28	$9.96 M
HS6	S09	S16	Moderate	Moderate	37 Years $2.74 M (plastic liner)	Rehabilitation	Install CIPP for pipe Severity "C" reaches instead of plastic liner rehabilitation.	37	$2.44 M
						Rehabilitation	Install CIPP Pipe Severity "C" reaches. Allow concrete cover to reduce to 0 inches.	50+[d] (74)	None
						Chemical Injection	Inject ferrous chloride into Manhole S08 for 50-year life cycle.	50+[d] (110)	$2.63 M
						Caustic Slug Dosing	Inject caustic into S08 every 1-2 weeks for 50-year life cycle.	50+[d] (129)	$2.63 M
HS7	S21	S31	Low	High	27 Years $2.66 M	Rehabilitation	Slipline Pipe Severity "C" reaches. Allow concrete cover to reduce to 0 inches.	50+[d] (55)	None
						Chemical Injection	Inject ferrous chloride into Pump Station "H" for 50-year life cycle.	50+[d] (69)	$4.53 M
						Caustic Slug Dosing	Inject caustic into Pump Station "H" every 1-2 weeks for 50-year life cycle.	50+[d] (96)	$5.47 M
						Oxygenation	Oxygen injection into PS "H" for 50-year life cycle.	50+[d] (137)	$2.45M

[a]Remaining life to 0.25 in concrete cover.
[b]Rehabilitation costs are in present value (M represents million); rehabilitation costs not included if outside of 50-year life cycle.
[c]Chemical injection not recommended for either HS1 or HS4 due to stringent land acquisition requirements and prohibitively high life cycle costs.
[d]Rehabilitation not required in 50-year life cycle. (xx) indicates estimated years to rehabilitation.

Table 6-2. Corrosion Hot Spots and Recommendations					
Hot Spot (HS)	Location (Nodes)		Corrosion Control Methods		Dosing Location (Liquid-Phase Treatment or Caustic Slug) and Estimated Chemical Rate
	Upstream	Downstream	Planned	Recommended	
North Interceptor					
HS1	N31	N35	None	Hot spot monitoring (near-term) Slipline "C" reaches (future) – estimated year of scheduled rehabilitation 2022	None
Alameda Interceptor					
HS4	A21	A46a	Corrosion barrier to be installed between A40 and A41 (FY15-16)	Caustic Slug Dosing (near-term) Slipline "C" reaches (future) – estimated year of scheduled rehabilitation 2054	Location: A21 Rate: 435 gal/week
South Interceptor					
HS6	S09	S16	None	Hot spot monitoring (near-term) CIPP "C" reaches (future) – estimated year of scheduled rehabilitation 2050	None
HS7	S21	S31	None	Oxygen Addition (near-term) No rehabilitation in 50-year life cycle	Location: Pump Station "H" Rate: 1,100 lb/day oxygen

References

American Society of Civil Engineers – Manual and Reports on Engineering Practice – No. 69, *Sulfide in Wastewater Collection and Treatment Systems*, 1989.

Brown and Caldwell, *Interceptor Damage Assessment Project*, East Bay Municipal Utility District, 1997.

CH2M HILL, *Odor Control Master Plan*, East Bay Municipal Utility District, 1999.

CH2M HILL, *Odor Control Master Plan Update*, East Bay Municipal Utility District, 2009.

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Attachment A: Field Data Collection Reports

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		Installation		Sulfide		Removal		Sulfide	
Manhole	Serial Number	Date	Time	Total	Dissolved	Date	Time	Total	Dissolved
S10	OL45066341	9/3/2013	11:33 AM	0.6	0.3	9/11/2013	3:22 PM	0.4	0.3
M02	OL02031357	9/3/2013	1:16 PM	3.0	2.0	9/11/2013	3:45 PM	3.2	2.2
A17	LL05304947	9/3/2013	1:37 PM	0.9	0.8	9/11/2013	4:11 PM	1.1	0.9
A48	OL45066342	9/3/2013	2:00 PM	0.7	0.7	9/11/2013	5:28 PM	1.2	1.0
NF04	OL45066345	9/3/2013	2:40 PM	3.6	3.2	9/10/2013	12:25 PM	0.6	0.5
N34	OL45066343	9/3/2013	3:09 PM	1.5	1.2	9/10/2013	1:30 PM	0.6	0.4
A39	OL0201307	9/4/2013	4:30 AM	2.3	2.0	9/10/2013	7:45 AM	1.0	1.0
S42	OL45021309	9/4/2013	5:10 AM	0.1	ND	9/11/2013	4:46 PM	0.3	0.3
S49	OL45066318	9/4/2013	5:46 AM	0.1	ND	9/11/2013	5:12 PM	0.7	0.5
A51		9/4/2013	10:25 AM	1.2	1.0	9/11/2013	5:04 PM	2.0	1.6
	OL45066345	9/12/2013	8:24 PM						

Rich Rivera
510-774-7786

V&A
Oakland, San Diego, Houston, Seattle
155 Grand Avenue, Suite 700, Oakland, CA 94612
Phone (510) 903-6600 Fax (510) 903-6601
www.vaengineering.com

Project: EBMUD
Project No. 13-0028 **Date** 9/3/13
Work Description Odalogger Installations
Engineer Initials ______ **Sheet** 1 **of** 1

Manhole	Time	Odalog I.D.	Total H2S
S10	11:33 AM	05304948 LL-H2S-1000	0.6 mg/L 0.3 mg/L DISSOLVED
M02	1:16 PM	OL 02031357	3.0 mg/L 2.0 mg/L Dissolved
A17	1:31 PM	LL-H2S-1000 05304947	0.9 mg/L 0.8 mg/L Dissolved
A48	2:01 PM	OL 45066342	0.7 mg/L 0.7 mg/L Dissolved
NF04	2:40 PM	OL 45066345	3.6 mg/L 3.2 mg/L Dissolved
N34	3:09 AM	OL 45066343	1.5 mg/L 1.2 mg/L Dissolved
9/4/13 A39	4:30 Am	OL 02093307	2.3 mg/L 2.0 mg/L DISSOLVED
S42	5:10 Am	OL 45021309	0.1 mg/L ND DISSOLVED
S49	5:46 Am	OL 45066313	≈0.1 mg/L ND DISSOLVED
9/4/13 A61 double barrel siphon	10:25 AM	OL 45087077	1.2 mg/L 1.0 mg/L Dissolved

no change 1.0 to 1.2 mg/L
still matches No. 1 test tube

Manhole	Serial Number	Installation Date	Installation Time	Sulfide Total	Sulfide Dissolved	Removal Date	Removal Time	Sulfide Total	Sulfide Dissolved	Daily Ave H_2S (PPM) 9/3	9/4	9/5	9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	9/16	9/17	9/18	9/19	Average	Std dev	%of AVE
S10	OL45066341	41520	0.48125	0.6	0.3	41528	0.640278	0.4	0.3	2.7	3.5	4.2	4.4	4.3	4.3	4.1											3.9	0.620	0.2
M02	OL02031357	41520	0.552778	3	2	41528	0.65625	3.2	2.2	35.2	52.6	63.1	58.1	62.0	62.5	75.6											58.4	12.4	0.2
A17	LL05304947	41520	0.567361	0.9	0.8	41528	0.674306	1.1	0.9	25.1	24.9	24.4	22.4	18.7	19.4	20.4											22.2	2.7	0.1
A48	OL45066342	41520	0.583333	0.7	0.7	41528	0.727778	1.2	1	6.9	4.0	5.1	4.6	6.9	8.2	7.0											6.1	1.5	0.2
NF04	OL45066345	41520	0.611111	3.6	3.2	41527	0.517361	0.6	0.5	122	155	137	127	107	115	140											129	16.3	0.1
N34	OL45066343	41520	0.63125	1.5	1.2	41527	0.5625	0.6	0.4	9.5	11.2	10.9	7.5	6.2	7.4	8.1											8.7	1.9	0.2
A39	OL0201307	41521	0.1875	2.3	2	41527	0.322917	1	1		11.9	13.1	13.1	16.1	10.7	11.9	12.2										12.7	1.7	0.1
S42	OL45021309	41521	0.215278	0.1	ND	41528	0.698611	0.3	0.3		6.8	8.6	7.4	8.9	10.3	6.9	6.2	2.8									7.2	2.2	0.3
S49	OL45066318	41521	0.240278	0.1	ND	41528	0.716667	0.7	0.5		4.8	5.0	3.7	3.9	3.6	2.7	2.7	0.9									3.4	1.3	0.4
		41521	0.434028	1.2	1	41528	0.711111	2	1.6																				
A51	OL45066345	41529	0.85																6.5	22.6	26.3	41.5	32.7	35.4	33.0	48.7	30.8	12.8	0.4

Manhole	Daily Water Temp (^oF) 9/3	9/4	9/5	9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	9/16	9/17	9/18	9/19	Average	Std dev	%of ave
S10	75.4	73.5	73.5	73.4	73.3	73.1	73.0											73.6	0.795	1.1%
M02	80.4	79.0	78.9	78.9	79.1	79.1	79.1											79.2	0.5	0.7%
A17	78.1	77.8	77.6	77.8	77.9	78.0	78.0											77.9	0.2	0.2%
A48	77.9	76.8	76.7	76.6	76.5	75.8	75.8											76.6	0.7	0.9%
NF04	73.9	72.9	72.8	72.9	73.1	73.0	72.9											73	0.4	0.5%
N34	76.2	75.5	75.5	75.5	75.5	75.4	75.3											75.6	0.3	0.4%
A39		74.1	74.7	74.8	74.8	74.8	74.7	74.6										74.7	0.2	0.3%
S42		77.8	78.4	78.4	78.5	78.3	78.3	78.4	78.5									78.3	0.2	0.3%
S49		75.7	75.7	76.0	76.7	76.5	76.3	76.3	76.0									76.1	0.4	0.5%
A51										73.4	70.7	70.5	71.5	71.6	71.7	71.3	71.3	71.5	0.9	1.2%

Manhole	Daily Ave Temp (^oC) 9/3	9/4	9/5	9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	9/16	9/17	9/18	9/19	Average	Std dev	%of ave
S10	24.09	23.04	23.04	23	22.97	22.84	22.8											23.11125	0.441	1.9%
M02	26.92	26.11	26.08	26.06	26.17	26.18	26.16											26.23934	0.3	1.2%
A17	25.64	25.42	25.35	25.42	25.5	25.54	25.55											25.48665	0.1	0.4%
A48	25.47	24.88	24.85	24.76	24.71	24.33	24.32											24.7608	0.4	1.6%
NF04	23.26	22.71	22.69	22.72	22.83	22.79	22.72											22.81902	0.2	0.9%
N34	24.55	24.15	24.17	24.17	24.14	24.1	24.08											24.19603	0.2	0.7%
A39		23.41	23.74	23.77	23.8	23.78	23.75	23.68										23.70479	0.1	0.6%
S42		25.47	25.77	25.76	25.81	25.71	25.71	25.77	25.86									25.73269	0.1	0.5%
S49		24.27	24.26	24.43	24.84	24.74	24.6	24.59	24.43									24.52096	0.2	0.9%
A51										23	21.51	21.37	21.93	22	22.04	21.82	21.84	21.9385	0.5	2.2%

North Ave	**23.51**	^oC
Alameda Ave	**24.43**	^oC
South Ave	**24.45**	^oC

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Attachment B: Sulfide Accumulation Model Plots

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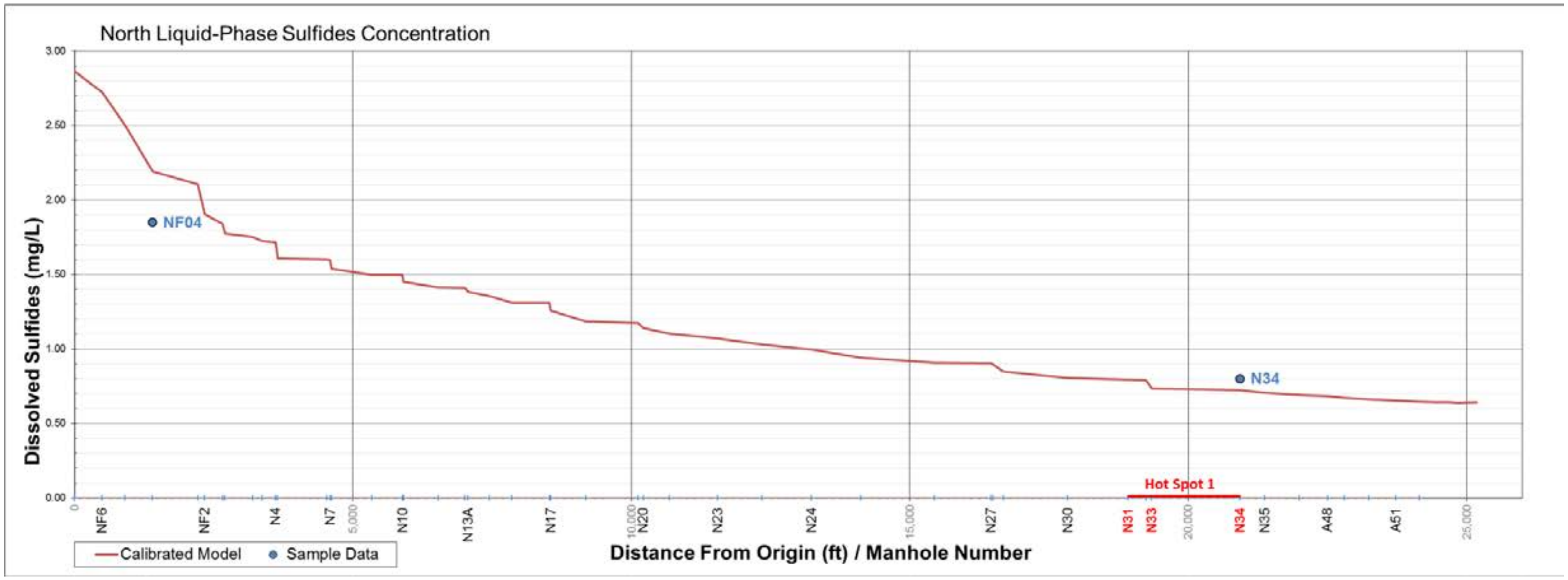

Figure B-1. North Interceptor Liquid-Phase Sulfide Accumulation Plot

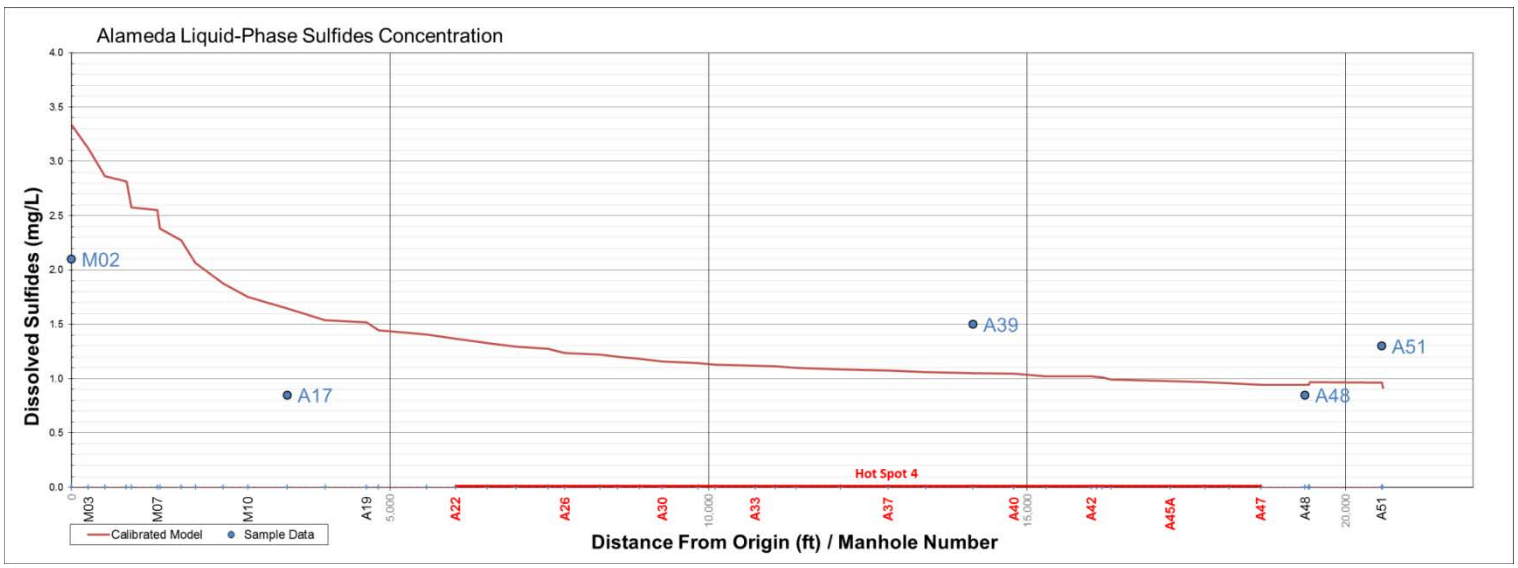

Figure B-2. Alameda Interceptor Liquid-Phase Sulfide Accumulation Plot

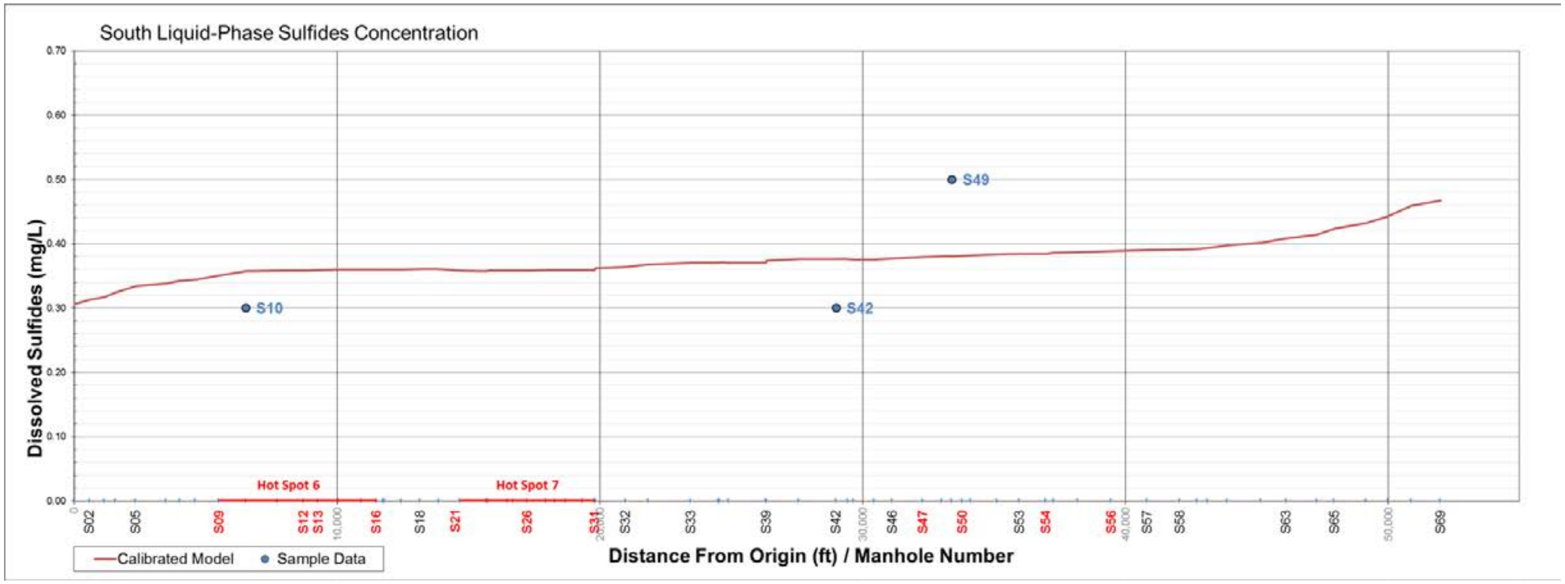

Figure B-3. South Interceptor Liquid-Phase Sulfide Accumulation Plot

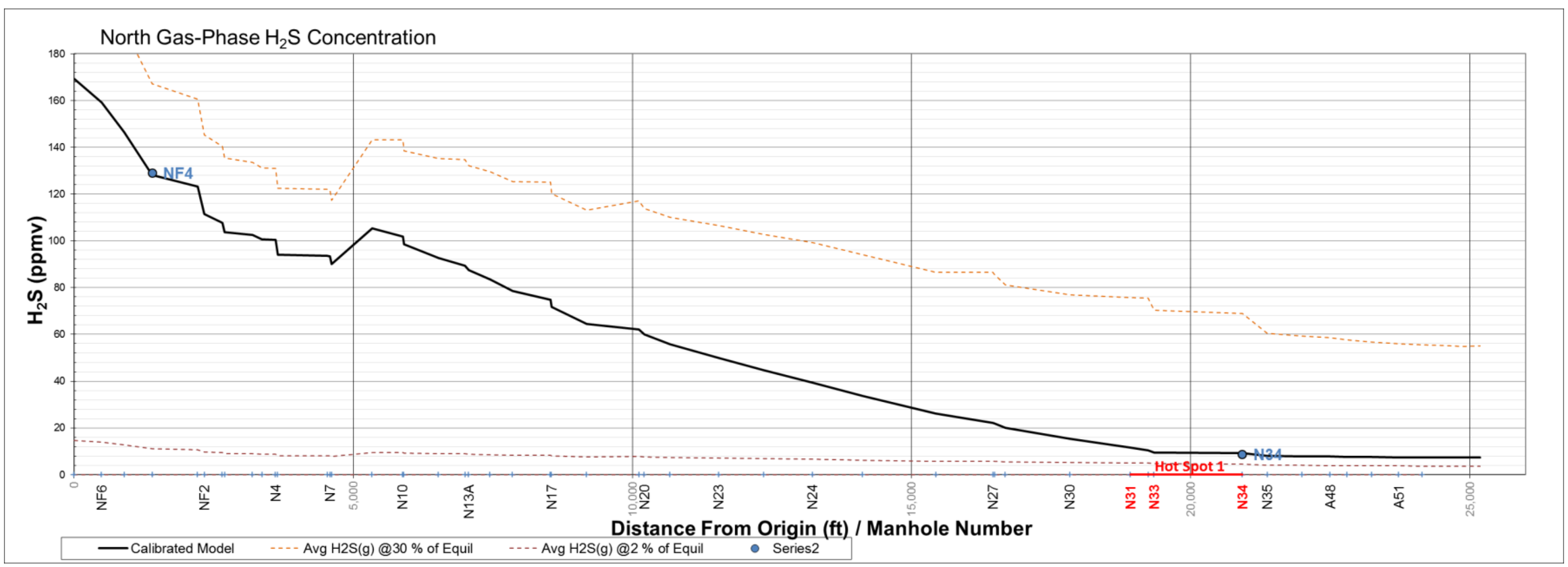

Figure B-4. North Interceptor Gas-Phase H_2S Accumulation Plot

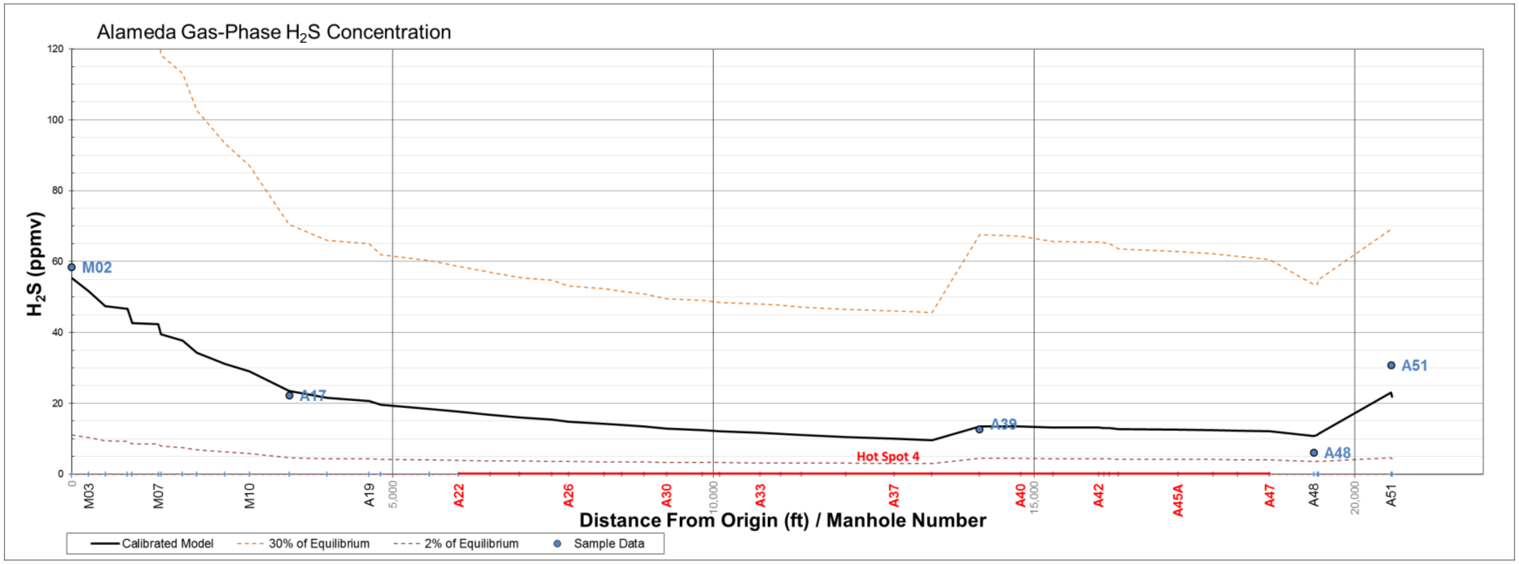

Figure B-5. Alameda Interceptor Gas-Phase H_2S Accumulation Plot

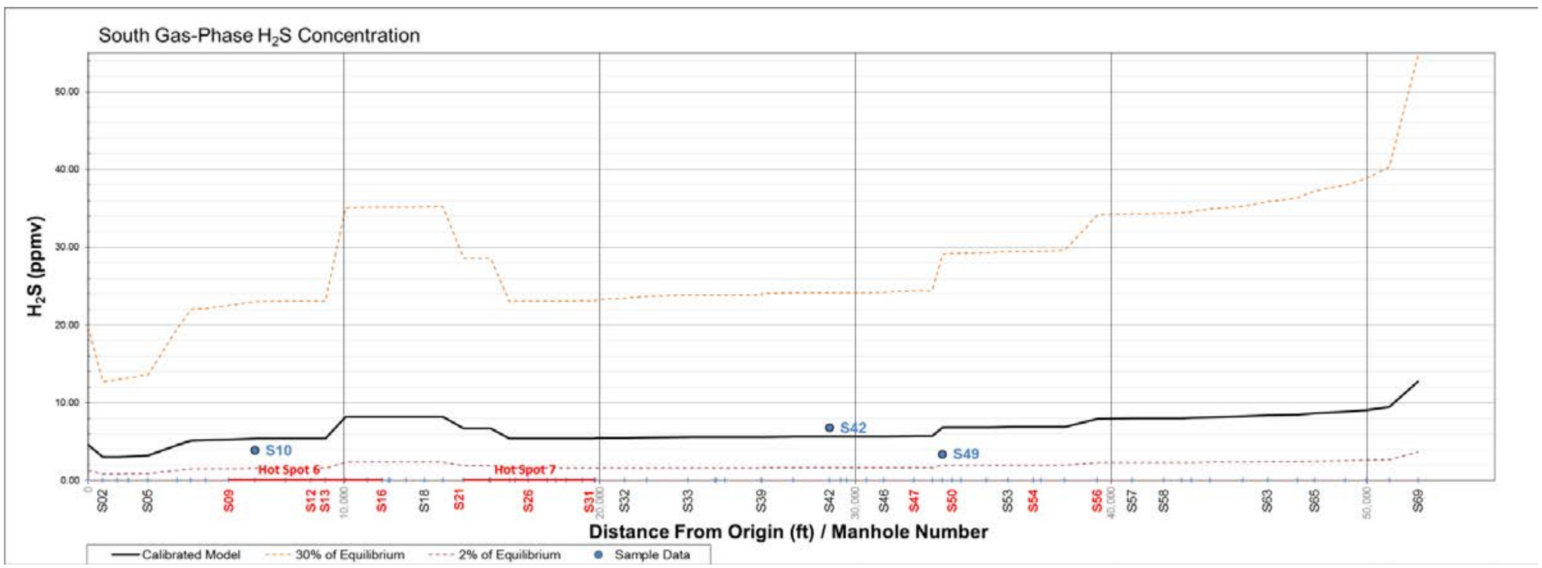

Figure B-6. South Interceptor Gas-Phase H_2S Accumulation Plot

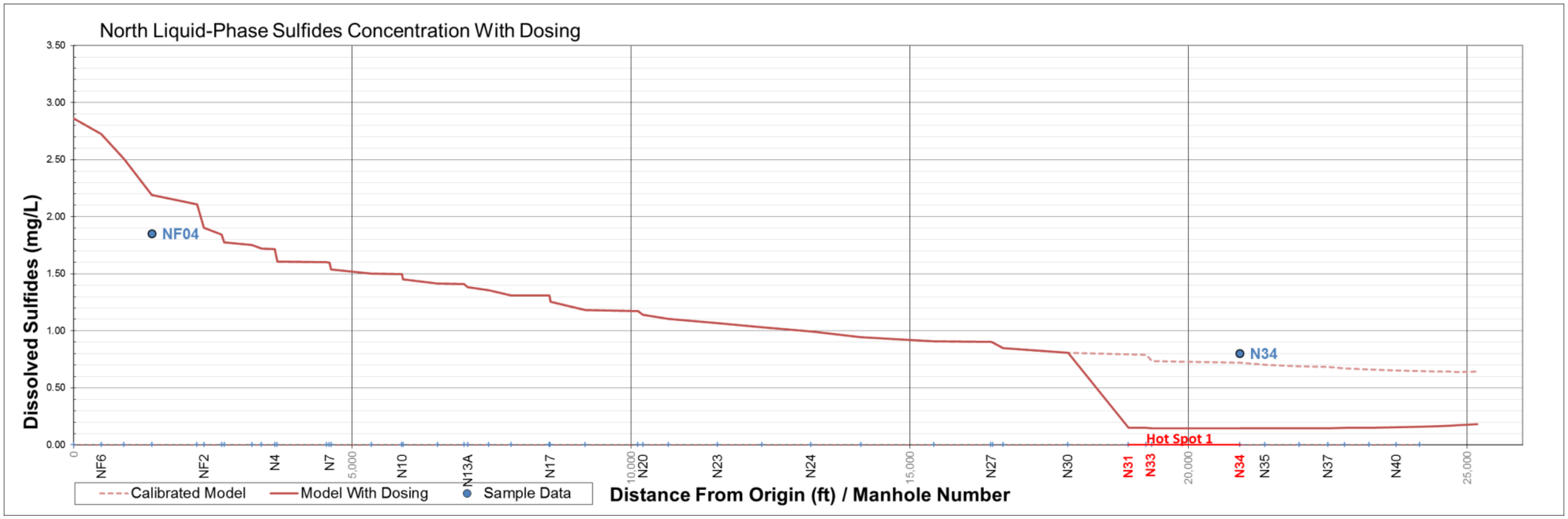

Figure B-7. North Interceptor Liquid-Phase Sulfide Plot with Chemical Addition at Manhole N30

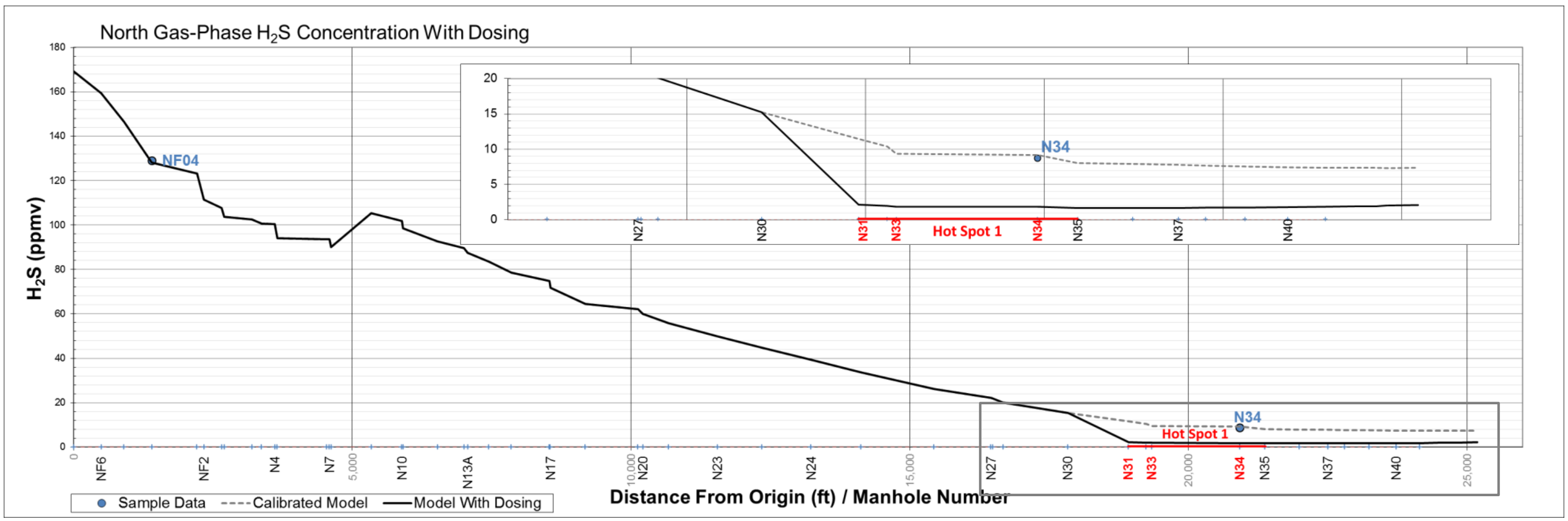

Figure B-8. North Interceptor Gas-Phase H_2S Plot with Chemical Addition at Manhole N30

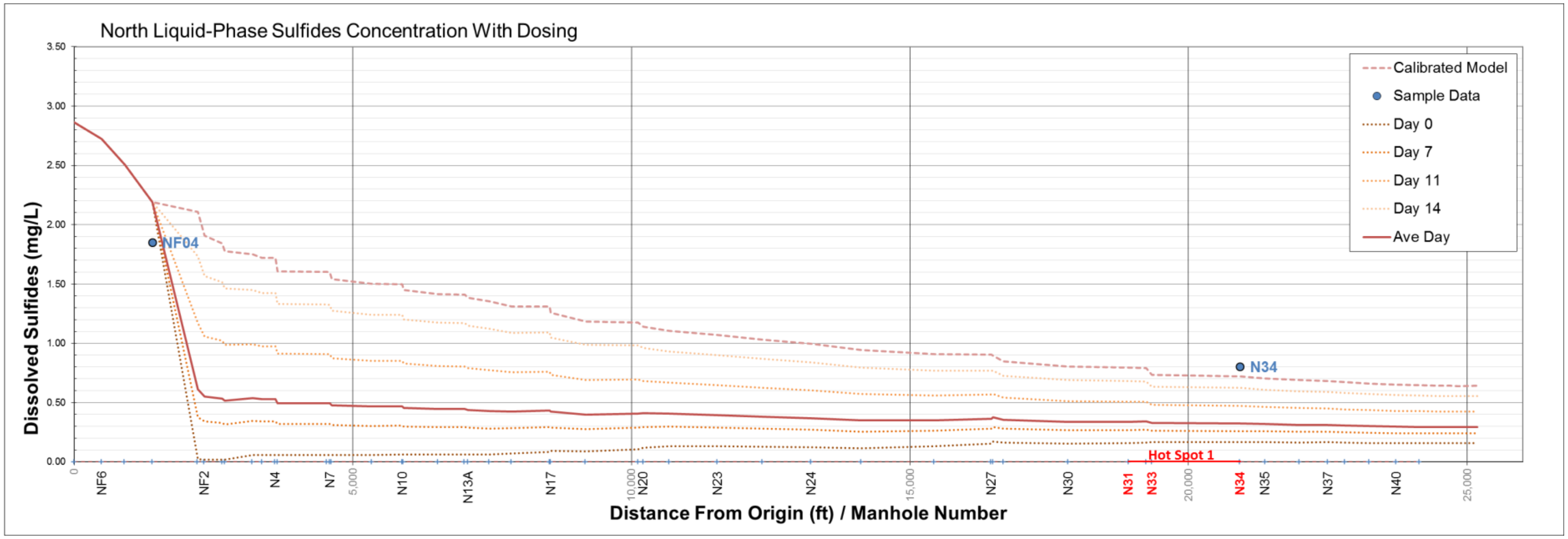

Figure B-9. North Interceptor Liquid-Phase Sulfide Plot with Caustic Slug Dosing at Manhole NF04

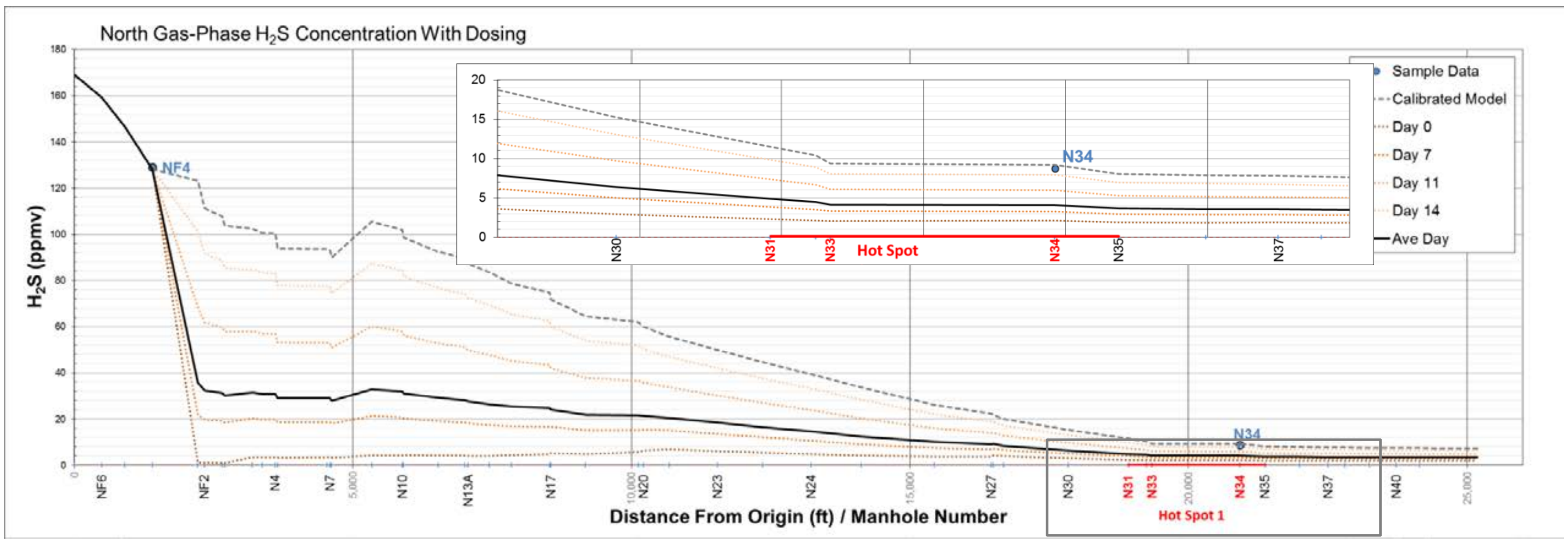

Figure B-10. North Interceptor Gas-Phase H_2S Plot with Caustic Slug Dosing at Manhole NF04

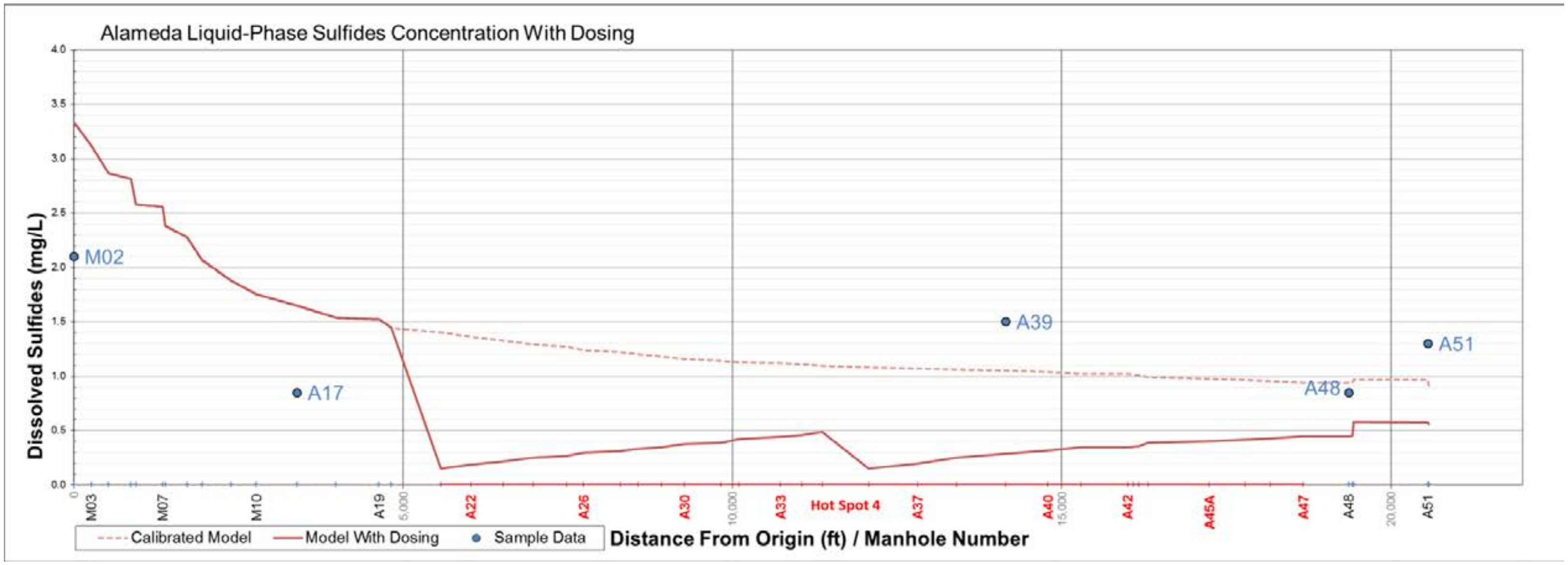

Figure B-11. Alameda Interceptor Liquid-Phase Sulfide Plot with Chemical Addition at Manholes A21 and A36

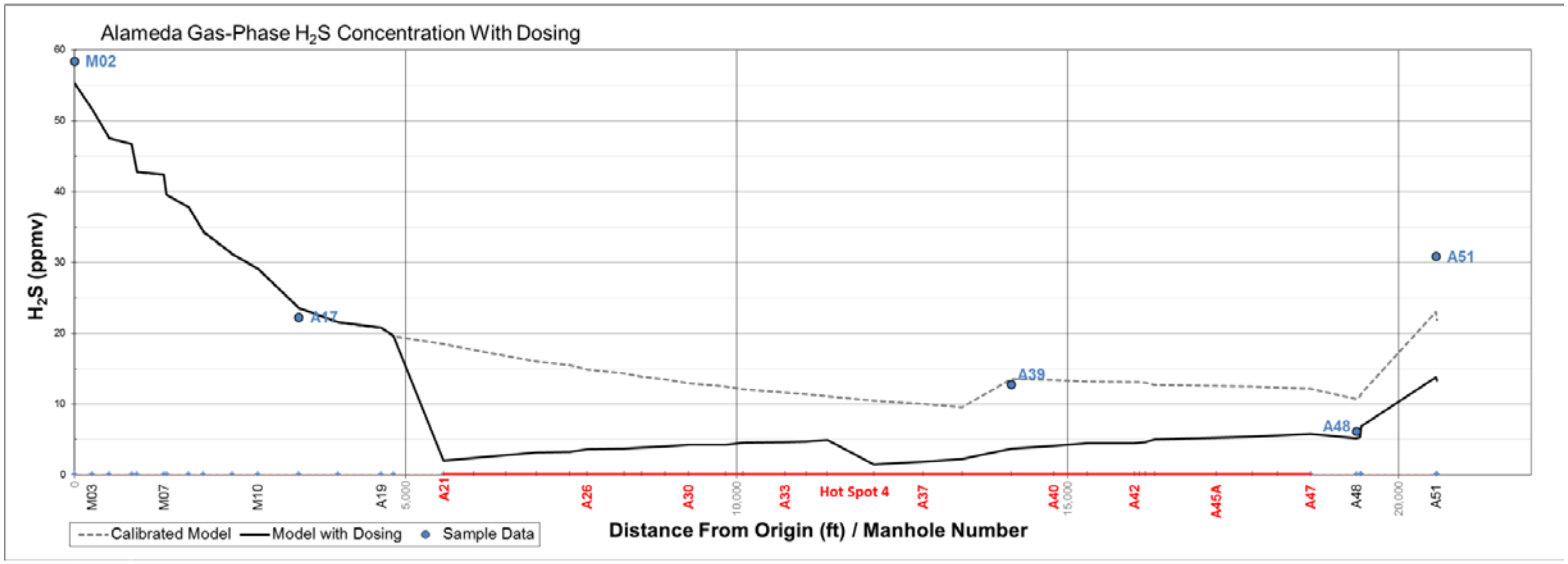

Figure B-12. Alameda Interceptor Gas-Phase H_2S Plot with Chemical Addition at Manholes A21 and A36

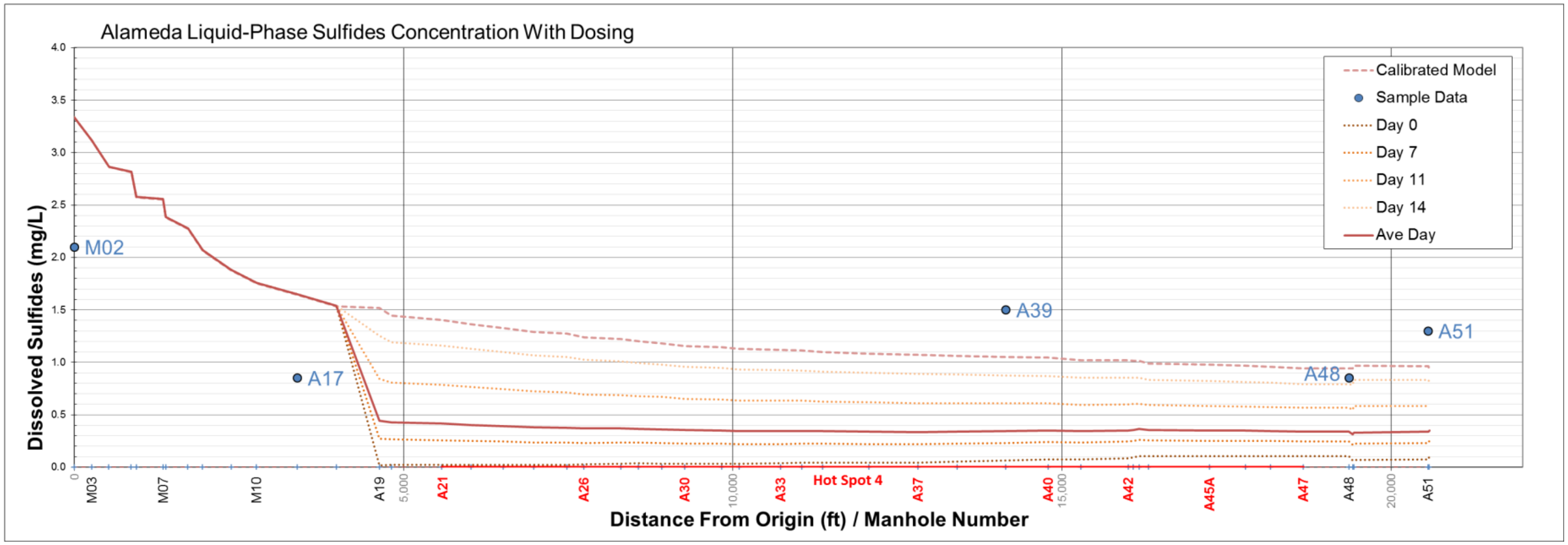

Figure B-13. Alameda Interceptor Liquid-Phase Sulfide Plot with Caustic Slug Dosing at Manhole A18

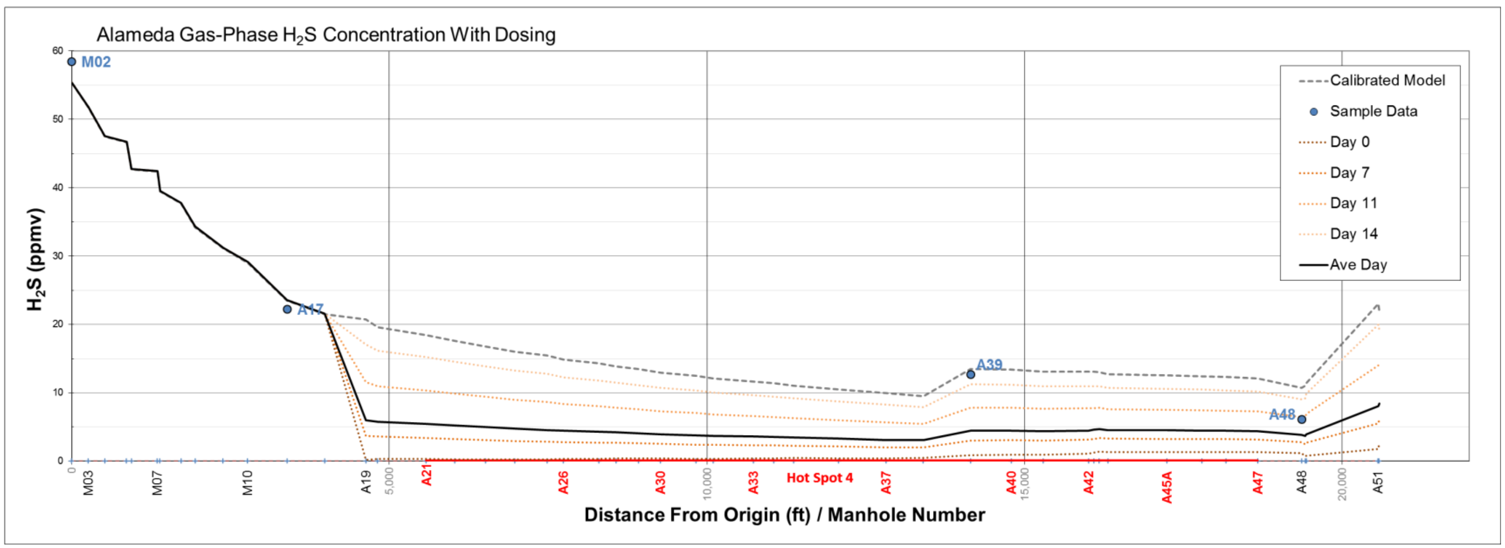

Figure B-14. Alameda Interceptor Gas-Phase H_2S Plot with Caustic Slug Dosing at Manhole A18

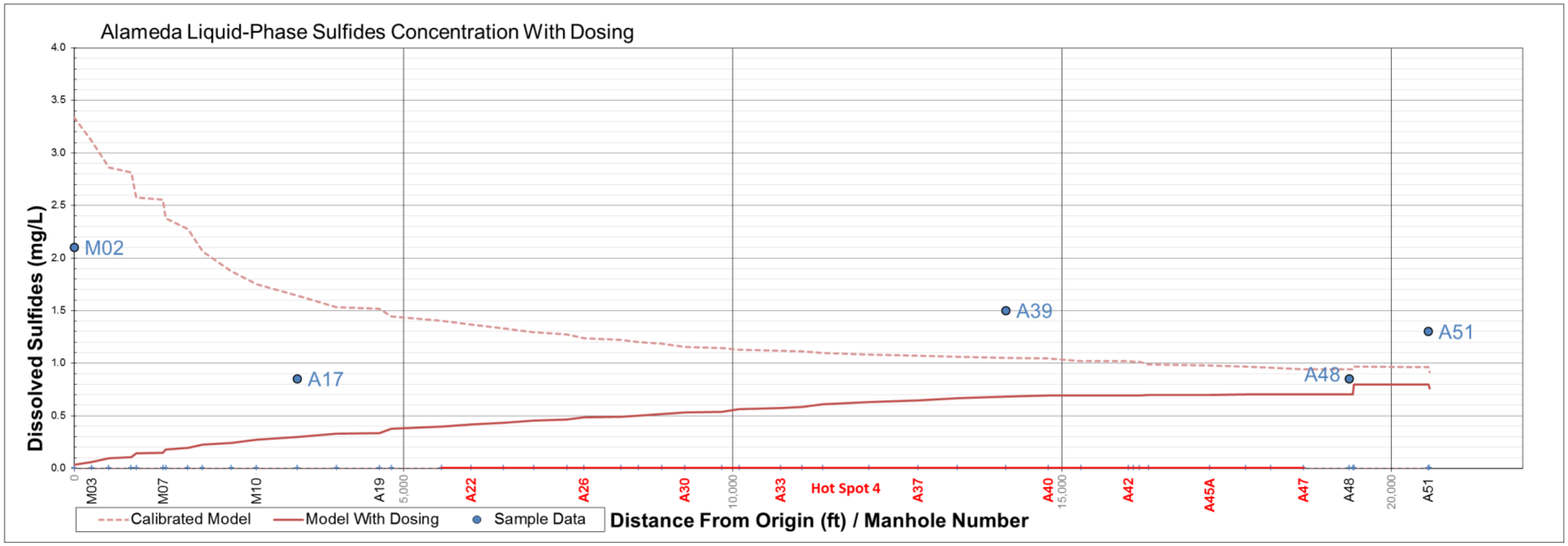

Figure B-15. Alameda Interceptor Liquid-Phase Sulfide Plot with Oxygen Injection at Pump Stations "C"and "M"

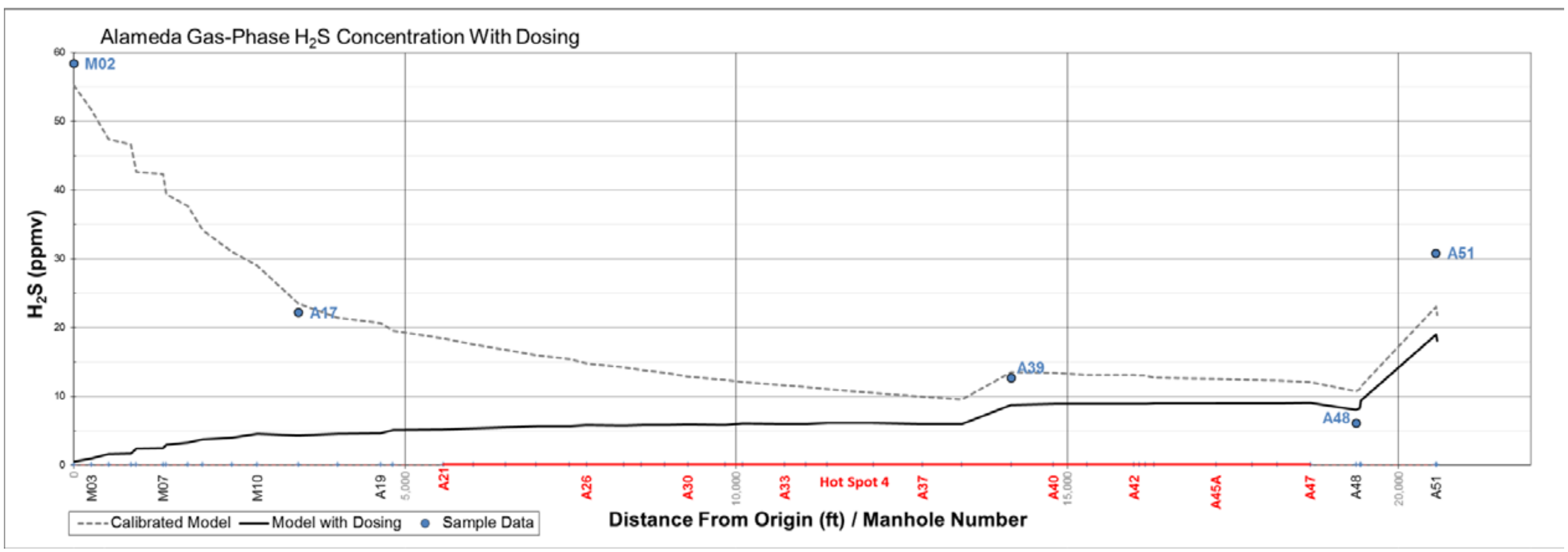

Figure B-16. Alameda Interceptor Gas-Phase H_2S Plot with Oxygen Injection at Pump Stations "C"and "M"

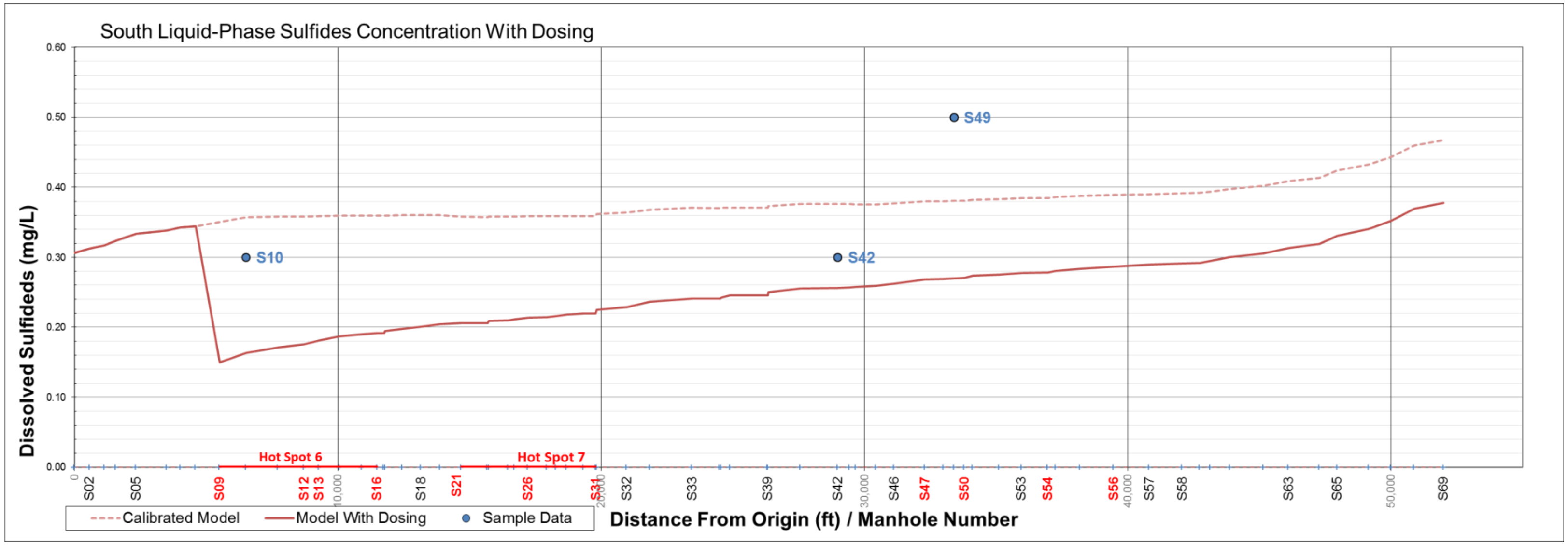

Figure B-17. South Interceptor Liquid-Phase Sulfide Plot with Chemical Addition at Manhole S08

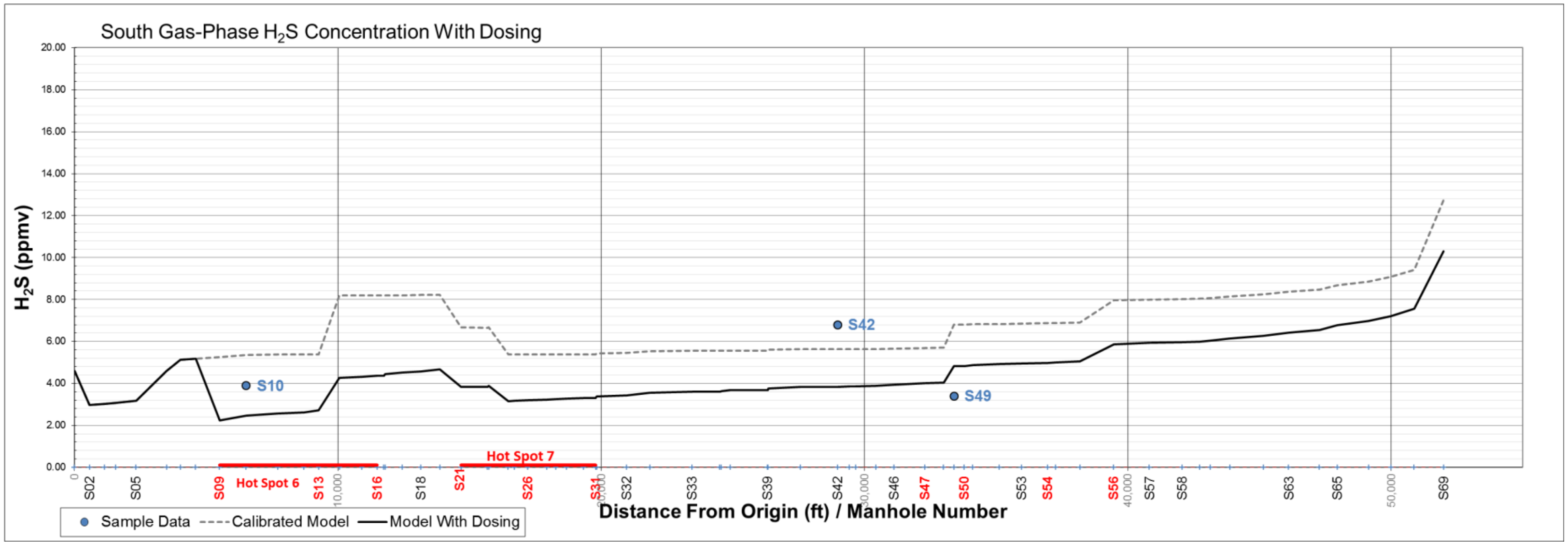

Figure B-18. South Interceptor Gas-Phase H_2S Plot with Chemical Addition at Manhole S08

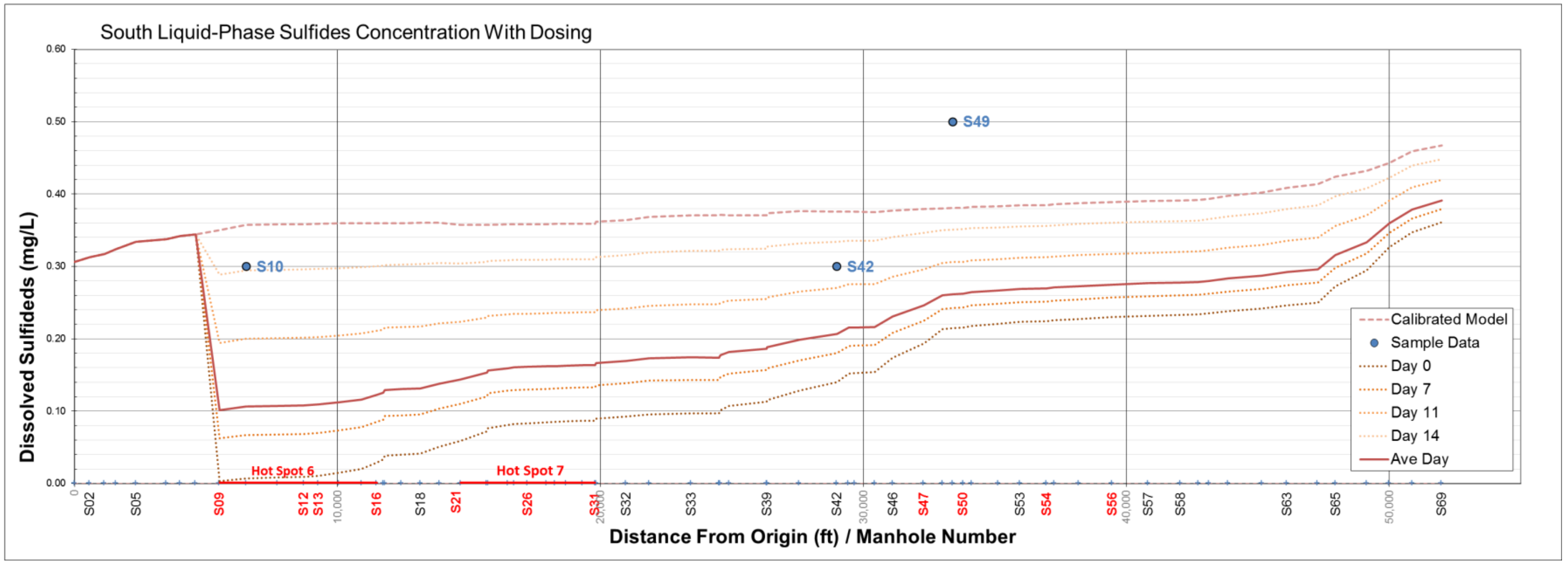

Figure B-19. South Interceptor Liquid-Phase Sulfide Plot with Caustic Slug Dosing at Manhole S08

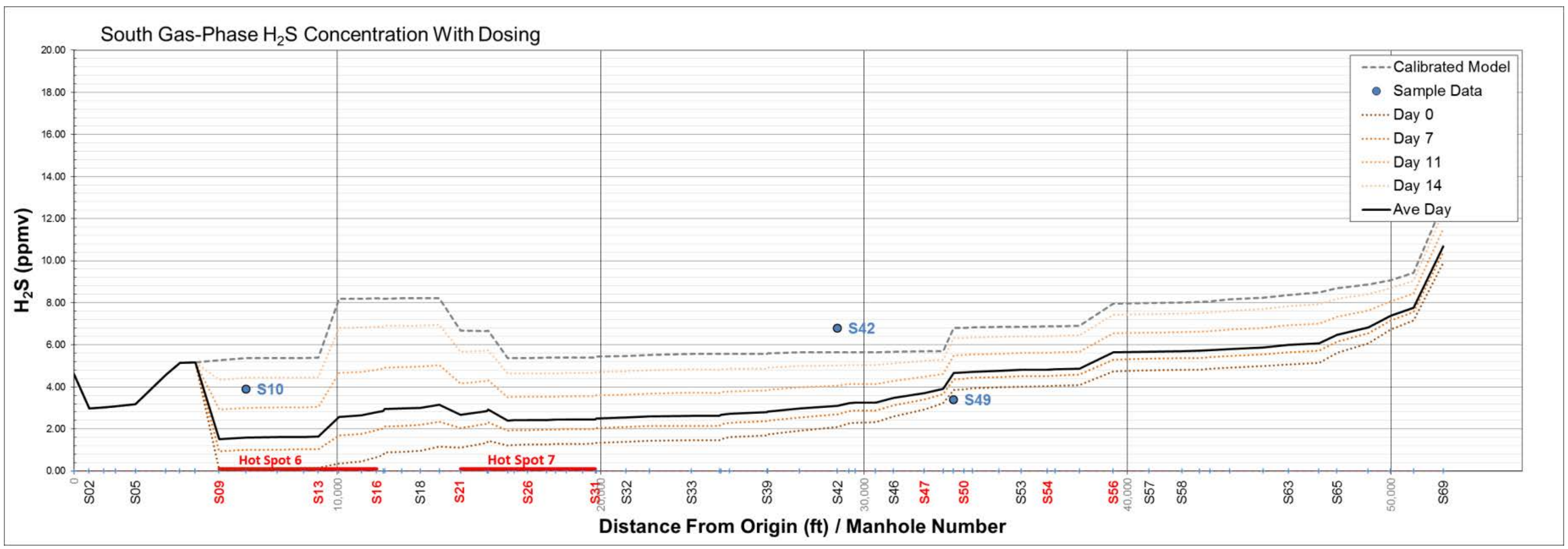

Figure B-20. South Interceptor Gas-Phase H_2S Plot with Caustic Slug Dosing at Manhole S08

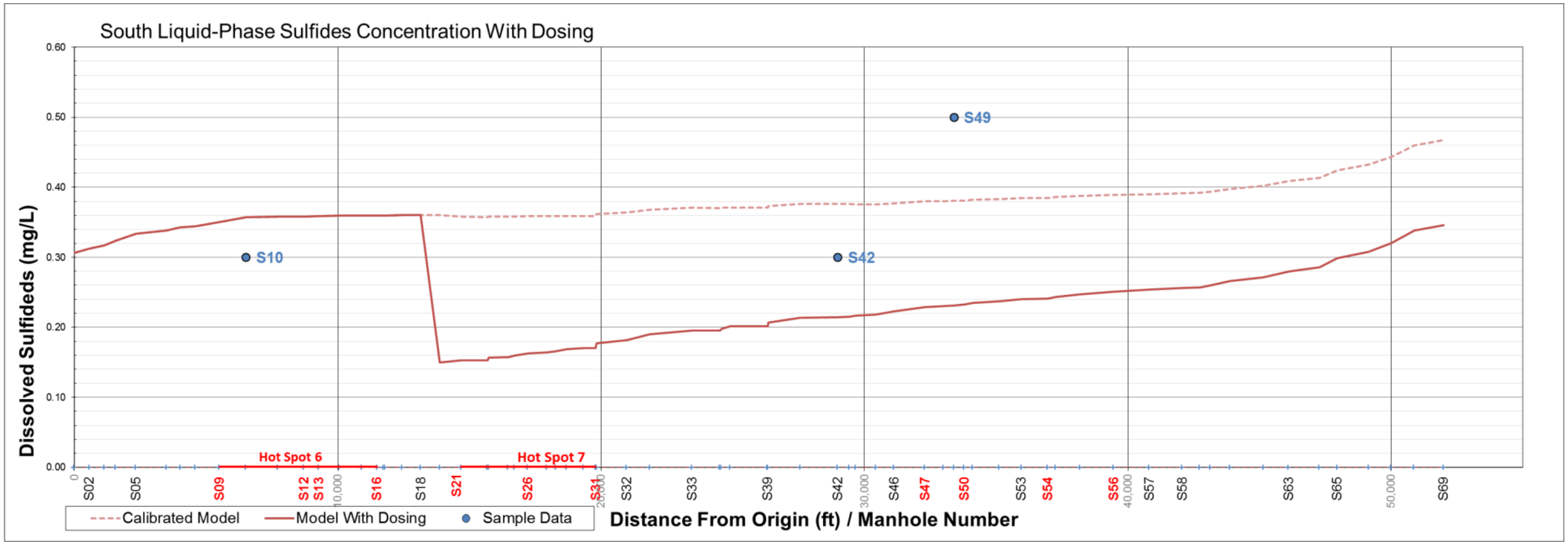

Figure B-21. South Interceptor Liquid-Phase Sulfide Plot with Chemical Addition at Pump Station H

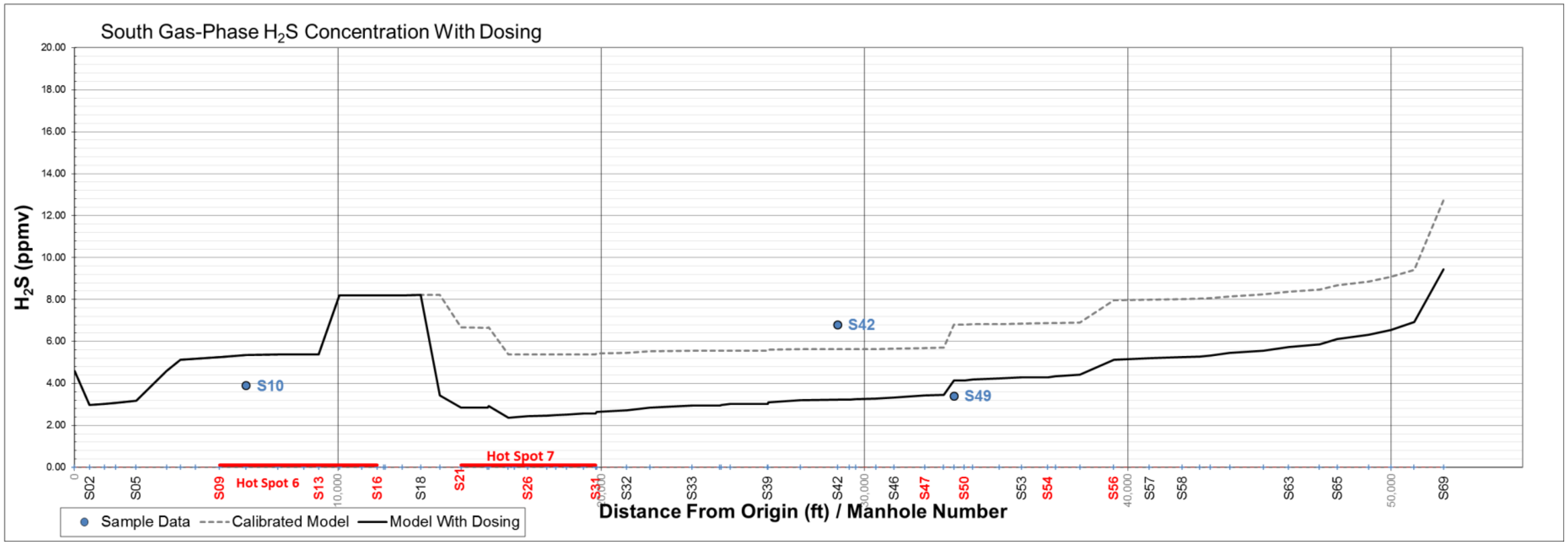

Figure B-22. South Interceptor Gas-Phase H_2S Plot with Chemical Addition at Pump Station H

Brown AND Caldwell

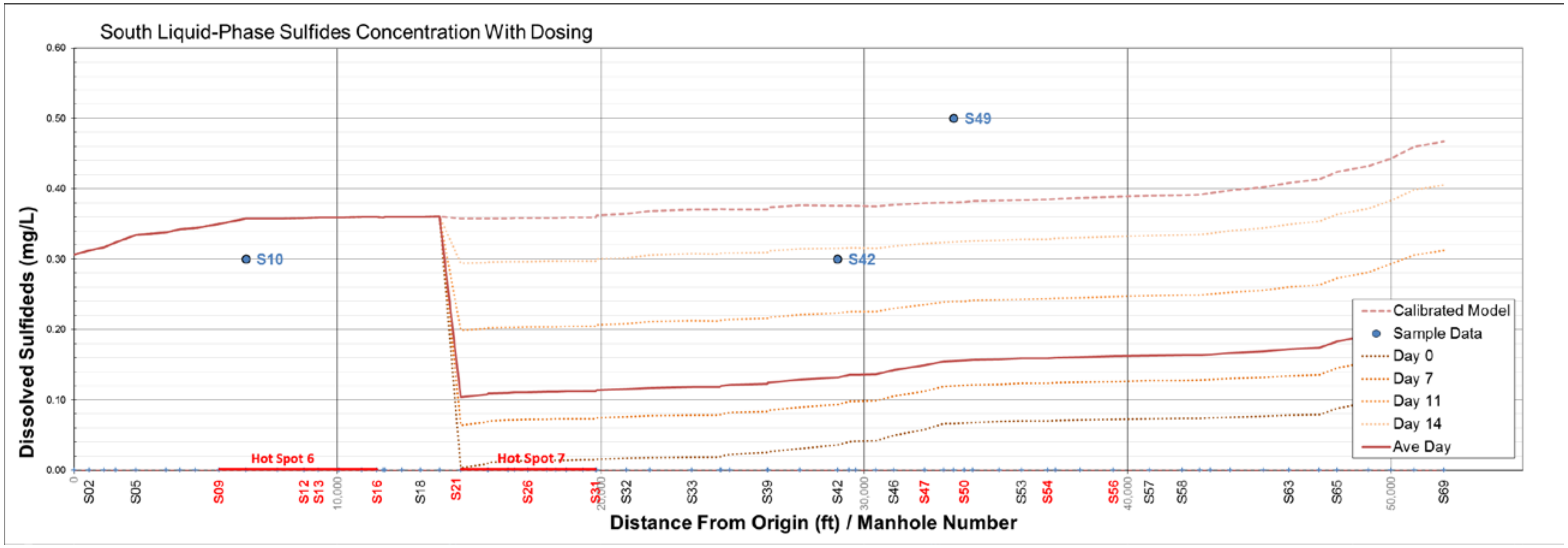

Figure B-23. South Interceptor Liquid-Phase Sulfide Plot with Caustic Slug Dosing at Pump Station H

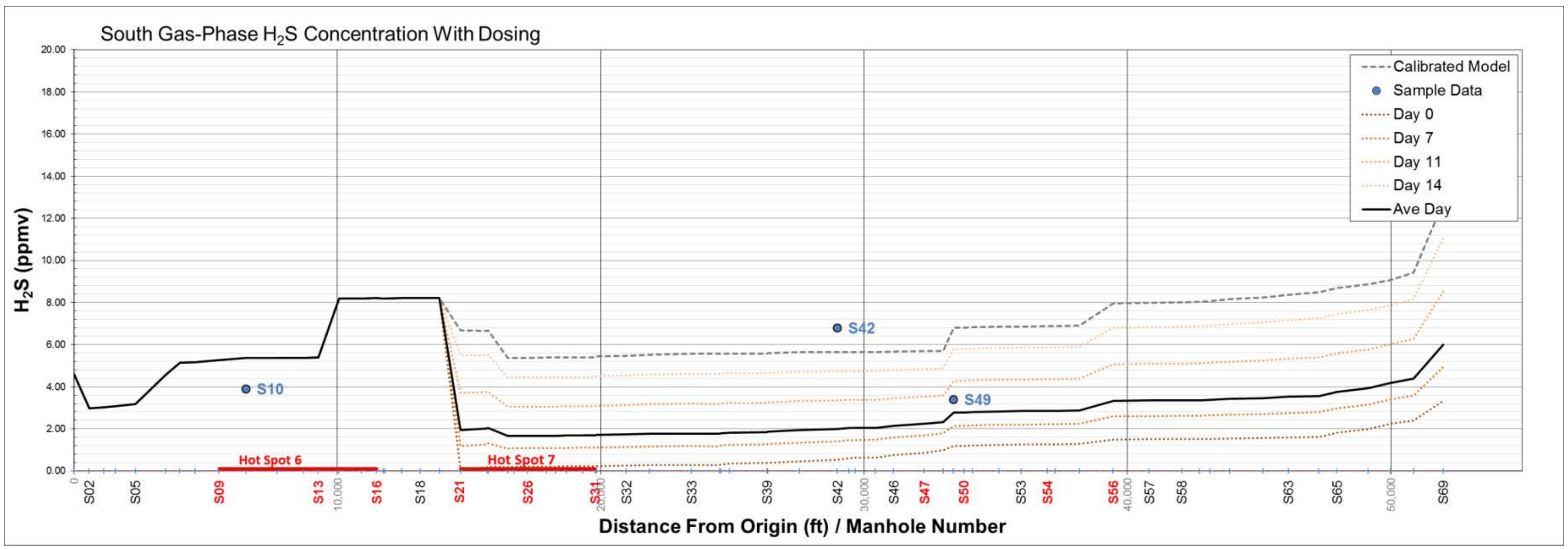

Figure B-24. South Interceptor Gas-Phase H_2S Plot with Caustic Slug Dosing at Pump Station H

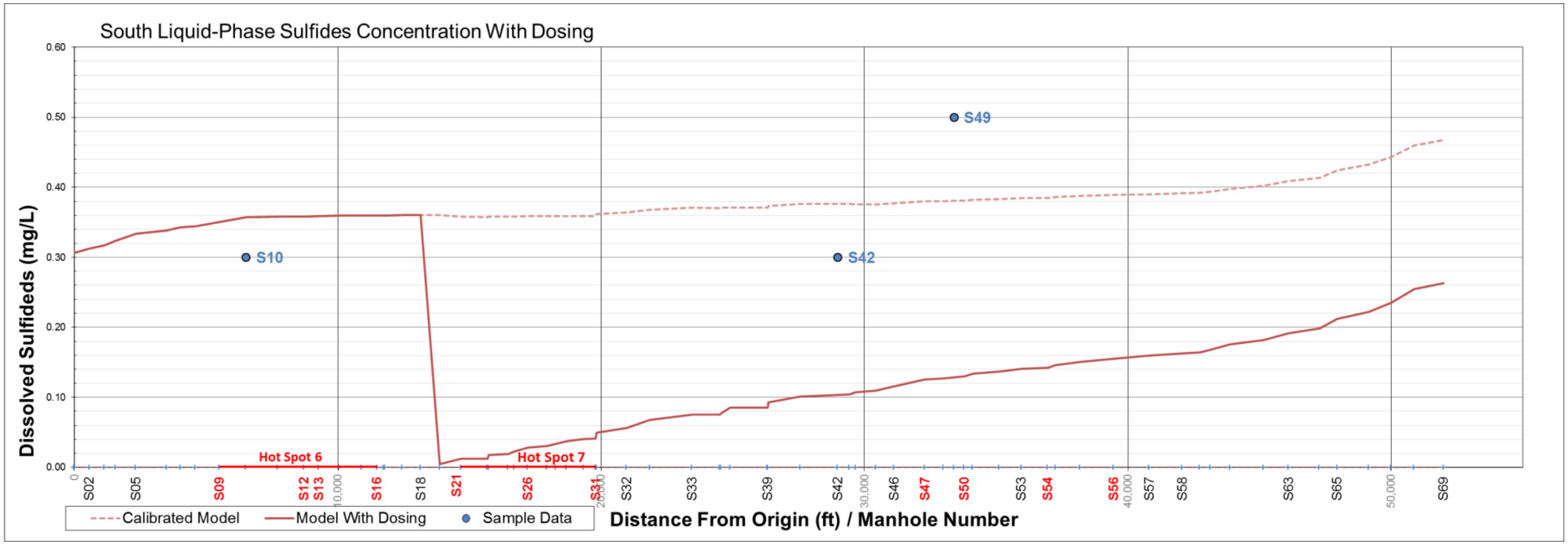

Figure B-25. South Interceptor Liquid-Phase Sulfide Plot with Oxygen Injection at Pump Station H

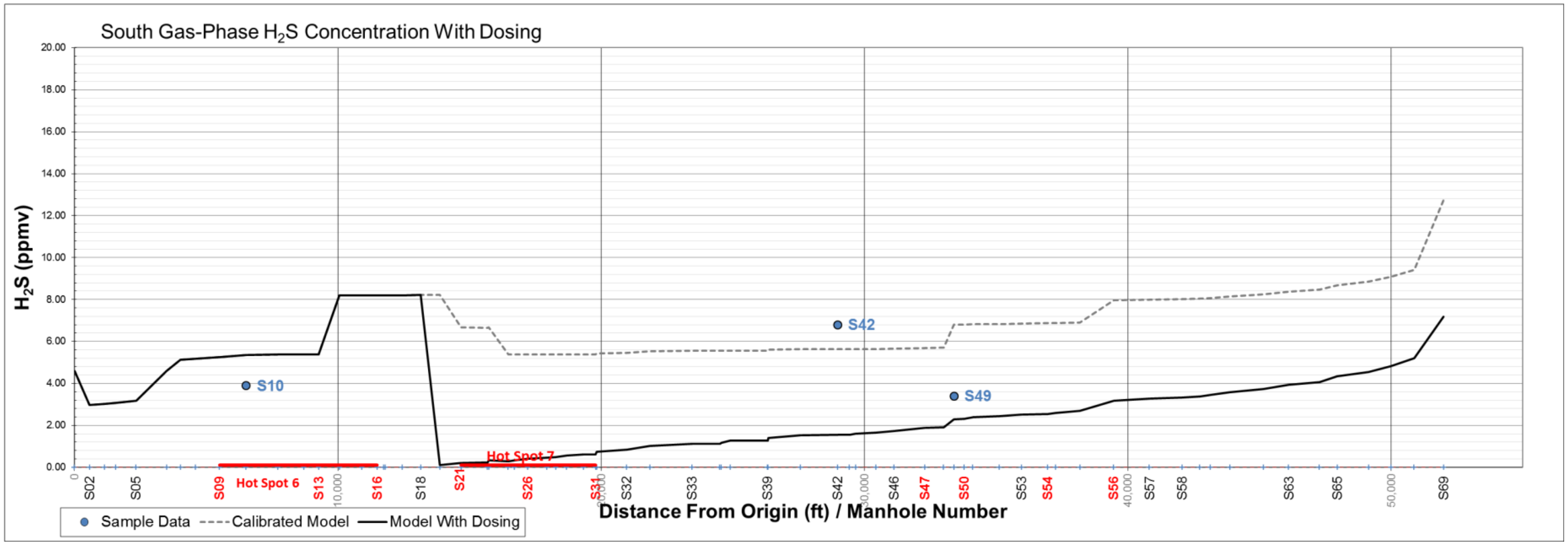

Figure B-26. South Interceptor Gas-Phase H_2S Plot with Oxygen Injection at Pump Station H

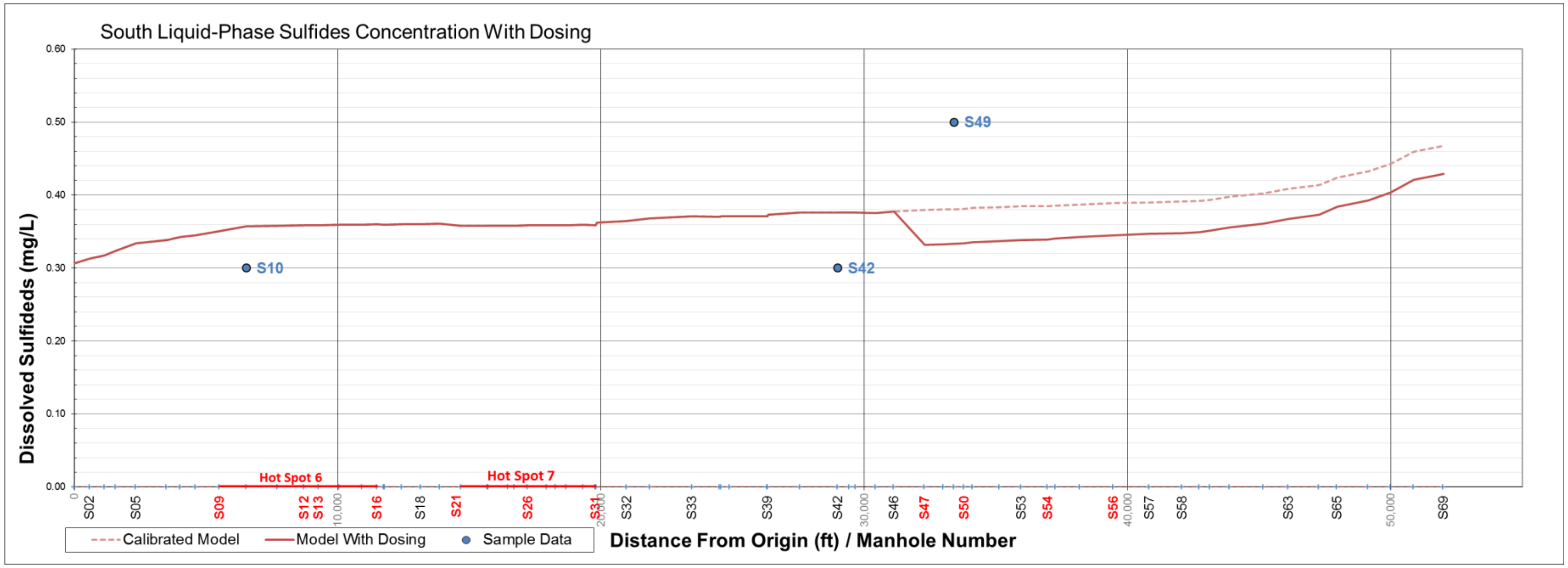

Figure B-27. South Interceptor Liquid-Phase Sulfide Plot with Chemical Addition Upstream in Alameda Interceptor at PS "R"

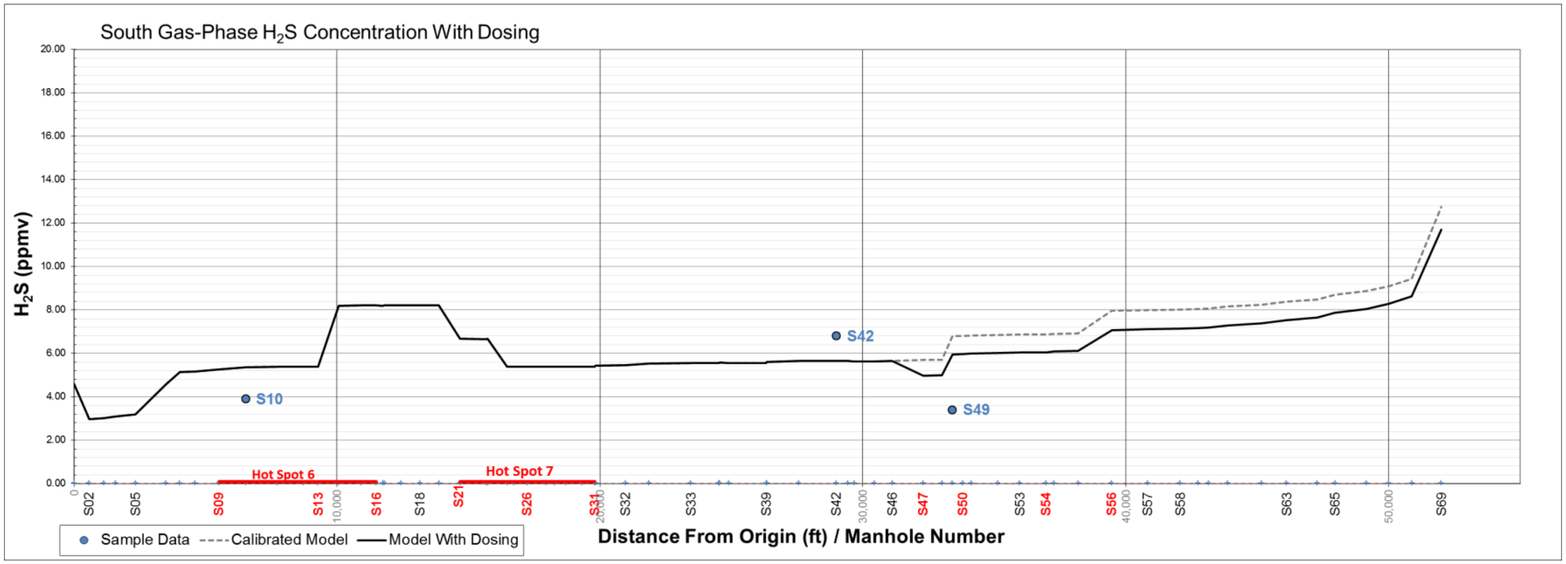

Figure B-28. South Interceptor Gas-Phase H_2S Plot with Chemical Addition Upstream in Alameda Interceptor at PS "R"

Attachment C: Corrosion Calculations

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Attachment C Corrosion Calculations

The following attachment contains corrosion and conceptual cost estimate calculations for each of the hot spots not already associated with a planned rehabilitation activity. In this attachment, Hot Spots 1 and 4 are covered individually in Sections C.1 and C.2, respectively, and Hot Spots 6 and 7 are covered together in Section C.3 (as discussed in the TM, these hot spots are analyzed together because treatment using two corrosion control methods – chemical addition and caustic slug dosing – can be achieved by injection of chemical upstream of Hot Spot 6 only.

For each section, the following text or calculations are provided (these items appear in this order for each Attachment C section):

1. In each section, the first pages(s) provides a conceptual scope description of the location of the hot spot(s), the reasons why the hot spot(s) was identified as a hot spot and the corrosion control options available for the hot spot(s). For each corrosion control option, a summary of the quantified capital and O&M cost items is provided, with detail provided within each section of the costs.
2. In each section a single-page table is provided showing the corrosion control calculations for each reach in the hot spot(s) that was identified as Pipe Severity “C” in the 2010-2012 Condition Assessment. The calculation table ultimately shows for each reach the calculated number of years before the critical amount of cover over the reinforcing steel is reached, given the quantified parameters and dissolved sulfide concentrations (from the September 2013 sampling). Calculations use equations in ASCE MOP No. 69. A “baseline” (no action) set of calculations is provided for each “C” reach and within the hot spot(s), a “critical reach” is identified of those baseline calculations. This critical reach is the reach that has the least amount of time before reaching the critical pipe cover. The table then shows the extended life that can be provided to that critical reach given completion of the various corrosion control options discussed in the section.
3. In each section a single-page table is provided showing calculations of chemical dose requirements for sufficient corrosion control in the hot spot(s). The selected chemical (ferrous chloride, from TM B.2) calculated annual cost is highlighted. Additionally, this table provides estimated construction costs for rehabilitation options, caustic slug dosing, and crown spraying, where applicable. Each of these costs is transferred directly into the cost estimate tables in Item 4.
4. For each hot spot(s) and for each corrosion control option, a conceptual cost estimate table is provided. Capital costs include assumptions for contingencies and also include a line item for planning, engineering, and construction management (CM). Yearly O&M costs for chemicals and various labor activities – monitoring, maintenance, caustic slug dosing, etc. – are provided. Total capital and yearly O&M costs are identified for each option.
5. Life cycle cost calculations for each option are provided in the last portion of each Attachment C section. Costs use escalation rates for capital costs and discount rates for capital and yearly O&M costs. In this final portion of each Attachment C section, detailed corrosion control calculations are provided for Hot Spot 1 only. These calculations are provided to show more detail on how various parameters were used and calculated for the table in Item 1, above.

C.1 Hot Spot 1 Conceptual Scope Description

The downstream section of the North Interceptor that passes through Emeryville (N31-N35) is a hot spot because of a high measured liquid-phase sulfide and gas-phase H_2S concentrations in the September 2013 sampling and the Severity "C" rating given to the N34-N35 reach in the 2010-2012 Condition Assessment. The location of the hot spot is shown in Figure C-1.

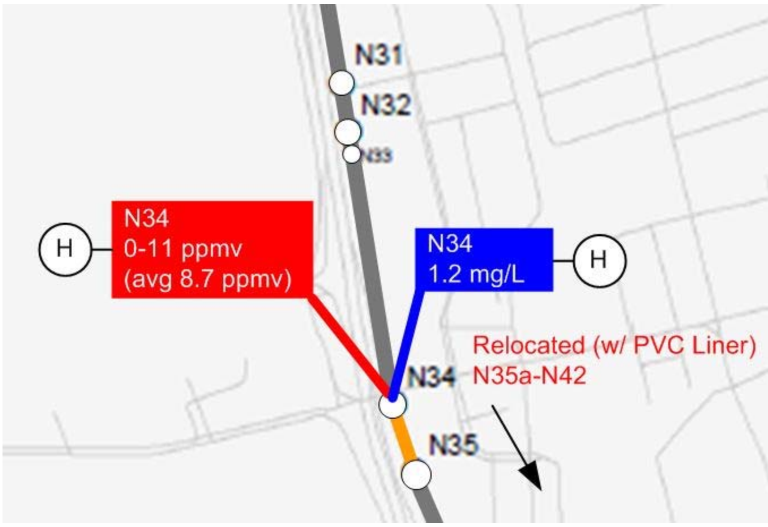

Figure C-1. Hot Spot 1 (North Interceptor): N31-N35

Three alternatives are considered for corrosion control at this hot spot:

- Rehabilitate Reach N34-N35 when corrosion is at Pipe Severity "D" status.
- Install chemical dosing facilities (ferrous chloride) upstream for sulfide reduction in the hot spot.
- Inject caustic slugs every 1-2 weeks to inactivate the slime layer and reduce sulfide accumulation.

Following is a summary of the scope of each option:

Rehabilitation Only: Corrosion rate calculations are provided that estimate the number of years into the future that remain, under current sulfide loads, before Reach N34-N35 becomes Pipe Severity "D" status, at which time rehabilitation (sliplining) would be needed. The number of years is noted for when the pipe has 0.25 inches of cover remaining and 0 inches of cover remaining. Capital costs are estimated for sliplining based upon BC experience. No O&M costs are assumed for this option.

Chemical Dosing: A ferrous chloride injection facility would be constructed at Manhole N31 that would delay the rehabilitation of N34-N35. Approximately 0.02 acres of land would need to be purchased. The facility would include a 10,000-gallon storage tank, chemical metering pumps, piping, and miscellaneous equipment (capital costs). Future capital cost would include sliplining N34-N35. Annual O&M costs would include costs for chemicals, regular maintenance, and H_2S monitoring to confirm effectiveness.

Caustic Slug Dosing: Would include injection of 50 percent caustic solution for 60 minutes weekly (to be confirmed using pilot testing) to delay the rehabilitation of N34-N35. Caustic solution would be injected at Manhole NF07. Future capital costs would include sliplining N34-N35. Annual O&M costs would include costs for caustic deliveries and associated labor, regular maintenance, and H_2S monitoring to confirm effectiveness.

East Bay Municipal Utility District - Corrosion Assessment Project
Corrosion Rate Calculations
January 2014

Hot Spot 1 (North Interceptor)

Pipe Severity "C" Reaches	Condition	Pipe Dia (in)	Reach Slope	Flow (mgd)	Velocity (ft/s) [1]	pH	J [2]	b/p' [3]	Incomplete Acid Reaction Factor (k)	Concrete Alkalinity (mg/L as CaCo3)	Estimated Current Pipe Wall Cover (in)	2013 Dissolved Sulfide (mg/L)	H2S Flux (g/m2 hr) [4]	Avg Corrosion Rate (in/yr)	Max Concrete Cover (in)	Available Cover (in)	Years before Critical Pipe Cover (yr)
N34-N35	Baseline	66	0.001	9.83	2.28	6.7	0.67	0.637	0.7	0.23	0.5	1.1	0.0216	0.0296	0.25	0.25	8.5
N34-N35	Baseline (Alt)	66	0.001	9.83	2.28	6.7	0.67	0.637	0.7	0.23	0.5	1.1	0.0216	0.0296	0	0.50	16.9
N34-N35 (Mod)	FeCl2 Dosing	66	0.001	9.83	2.28	6.7	0.67	0.637	0.7	0.23	0.5	0.3	0.0059	0.0081	0.25	0.25	31.0
N34-N35 (Mod)	Caustic Slug	66	0.001	9.83	2.28	6.7	0.67	0.637	0.7	0.23	0.5	1.1	0.0062	0.0084	0.25	0.25	29.6

IDAP Year	1997
Current Year	2013
Design Year	2063

FeCl2 Dosing Life Extension	22.6 yr
Caustic Slug Dosing Life Extension	21.1 yr

Caustic Slug Dosing Activity 0.286 Fraction of days of normal sulfide activity (10 out of 14 days slime layer is assumed inactive)

Unit Conversions:
1 ft3 = 7.48502 gal
1 day = 86400 sec

Notes:
1 - From updated sulfide accumulation model
2 - From ASCE MOP 69 Table 6-5 (function of pH)
3 - From ASCE MOP 69 Table 6-4
4 - From ASCE MOP 69 Equation 6-8

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North Interceptor Chemical Dose Requirements

Hot Spot 1 (N31-N35)

Chemical	Liquid Sulfide Concentration (mg/L)		Target Sulfide Flow Rate (lb/day)	Dose Ratio		Dose Requirement		Cost ($/gal)	Cost ($/lb)	Annual Chemical Cost	Chemical Properties	
	Initial	Target				lb/day	gal/day				Density (lb/gal)	Strength
Hypochlorite	1.2	0.0	0.0	13	lb / lb H2S	1,290	886	0.75	0.40	$188,000	9.7	0.15
Hydrogen Peroxide	1.2	0.0	0.0	4	lb / lb S	721	144	4.00		$211,000	10	0.5
Ferrous Chloride	1.2	0.15	11.9	10	lb / lb S	1,685	562	0.75	0.33	$200,000	10	0.3
Calcium Nitrate	1.2	0.0	0.0	10	lb / lb S formed	1,804	248	3.00		$272,000	12.1	0.6

Rehab N34-N35 (66-in diameter)

Method	Interceptor Length (LF)	Construction Cost ($/ LF)	Construction Cost
Sliplining	449	$1,013	$455,000
CIPP	449	$1,688	$758,000
Plastic Liner	449	$1,350	$606,000

Ferrous Chloride Chemical Injection

700	gpd (with safety factor)
10,500	gal for 15-day storage

Assume 10,000-gal 12-ft diameter tank

Caustic Slug Dosing

4.19	MGD (assume injection at Manhole NF01)
150	gal 50% NaOH per MGD per week (per ASCE MOP 69)
628.5	gal 50% NaOH per week
12.7	lb/gal density of 50% NaOH at 25 degrees C
7,982	lb 50% NaOH per week
4.0	tons 50% NaOH per week
$500	/ton 50% NaOH
$2,000	per week
$104,000	**per year**

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EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 1: Rehab of N34-N35

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Civil and Structural Costs Total					**$0**
Mechanical Costs					
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
Sliplining Installation for Reach N34-N35	Similar projects, IDAP	1	LS		$455,000
Construction Cost Subtotal					$455,000
Contingencies	35% of Subtotal			35%	**$159,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$614,000**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$276,000**
TOTAL CAPITAL COST ESTIMATE					**$890,000**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost					$0
Caustic Slug Dosing Annual Cost					$0
Crown Spraying Annual Cost					$0
Monitoring Cost					$0
TOTAL YEARLY O&M COST ESTIMATE					**$0**

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 1: Ferrous Chloride Chemical Treatment System

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Site Preparation		1	LS	$30,000	$30,000
Concrete		30	CY	$125	$3,750
Rebar		2.0	TON	$1,250	$2,500
Concrete Coating		1	LS	$10,000	$10,000
Civil and Structural Costs Total					**$46,250**
Mechanical Costs					
Cross-Linked HDPE Double-Wall Tank (10,000 gal)		1	LS	$50,000	$50,000
Chemical Metering Pumps		1	LS	$60,000	$60,000
Piping and Pipe Supports		1	LS	$10,000	$10,000
Miscellaneous Equipment (ladder, eyewash, shower, etc)		1	LS	$10,000	$10,000
Mechanical Cost Total					**$130,000**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$19,500**
Equipment Cost Total					**$195,750**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$117,450**
Land Acquisition Cost					
Parcel adjacent to Manhole N31		0.02	AC	$925,000	$18,500
Construction Cost Subtotal					$331,700
Contingencies	35% of Subtotal			35%	**$116,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$447,700**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$201,000**
TOTAL CAPITAL COST ESTIMATE					**$648,700**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost	Sampling, flow rate				$200,000
O&M Annual Cost		750	HR	$80	$60,000
Caustic Slug Dosing Annual Cost					$0
Crown Spraying Annual Cost					$0
Monitoring Cost					
OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
Operator Labor (for Monitoring)	Similar Projects	48	HR	$80	$3,840
Total Monitoring Cost					**$6,840**
TOTAL YEARLY O&M COST ESTIMATE					**$266,800**

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 1: Caustic Slug Dosing Treatment System

CAPITAL COST ESTIMATE

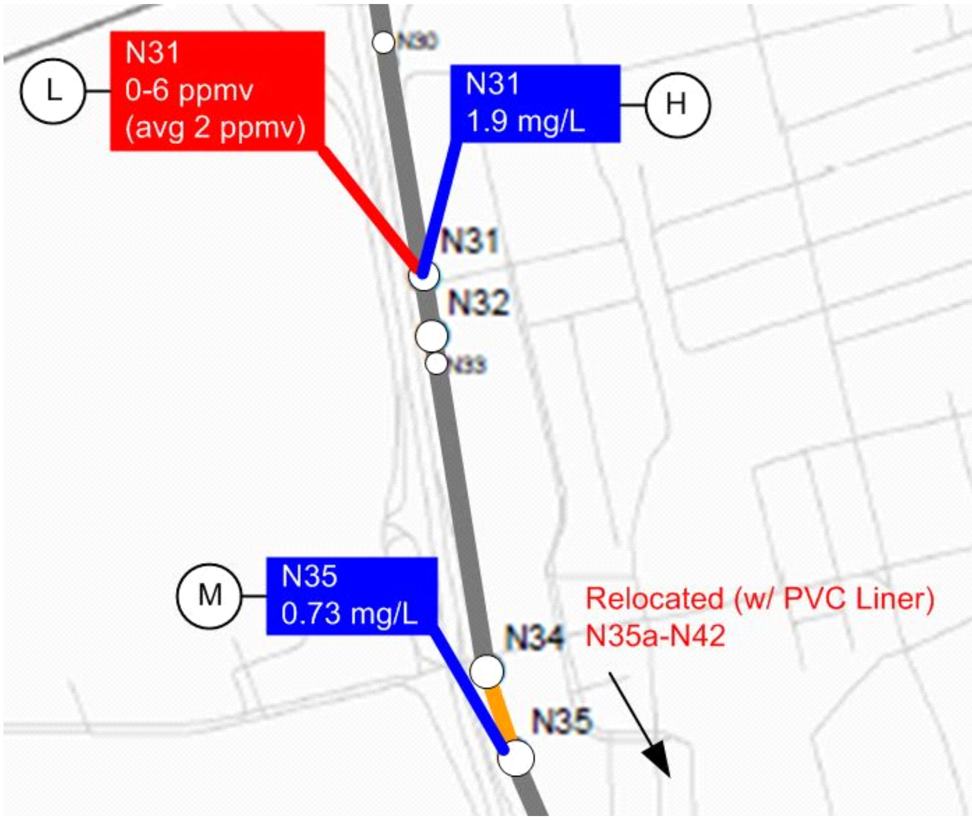
CONSTRUCTION COSTS	**Cost Basis**	**Quantity**	**Units**	**Unit Cost**	**Total Cost**
Civil and Structural Costs					
Site Preparation					$0
Concrete					$0
Rebar					$0
Concrete Coating					$0
Civil and Structural Costs Total					**$0**
Mechanical Costs					
					$0
					$0
					$0
					$0
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
None					
Construction Cost Subtotal					$0
Contingencies	35% of Subtotal			35%	**$0**
TOTAL CONSTRUCTION COST ESTIMATE					**$0**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$0**
TOTAL CAPITAL COST ESTIMATE					**$0**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT					
Chemical Cost					$0
Caustic Slug Dosing Annual Cost	ASCE MOP 69 Guidance				$104,000
Caustic Slug Dosing Annual O&M Cost		200	HR	$80	$16,000
Crown Spraying Annual Cost					$0
Monitoring Cost					
OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
Operator Labor	Similar Projects	260	HR	$80	$20,800
Total Monitoring Cost					**$23,800**
TOTAL YEARLY O&M COST ESTIMATE					**$143,800**

Hot Spot 1 (North Interceptor)

Manhole Range: N31-N35



1. Calculate current pipe wall thickness:

Structural analysis in 1997 IDAP provided the following estimates for imminent structural failure:

For pipe diameter < 57-in, failure occurs when remaining concrete cover (pipe wall) is 0.25 in
For pipe diameter $\geq$ 57-in, failure occurs when remaining concrete cover (pipe wall) is 0 in

Since it is not desirable for the imminent structural failure to be reached, the following guidelines were established in the 1997 IDAP for when rehabilitation must be provided to a pipe reach:

For pipe diameter < 57-in, when remaining concrete cover (pipe wall) is 0.5 in
For pipe diameter $\geq$ 57-in, when remaining concrete cover (pipe wall) is 0.25 in

In Reach N34-N35 (66-in dia), rehabilitation must occur at concrete cover of 0.25 in (equivalent to Pipe Severity "D" rating)

$tcrit_{HS1} := 0.25 \cdot in$ critical pipe wall cover requiring rehab

Given the Pipe Severity "C" rating in the 2010-2012 Condition Assessment, estimate the current pipe wall cover to be 0.25 in more than critical pipe wall cover:

$t2013_{HS1} := tcrit_{HS1} + 0.25 \cdot in = 0.5 \cdot in$

$trem_{HS1} := t2013_{HS1} - tcrit_{HS1} = 0.25 \cdot in$ pipe wall cover remaining before rehab required

2. Calculate current corrosion rate (2013 to 2063):

Assume a 50-year life cycle

$Year_{Present} := 2013 \cdot yr$

$Year_{LC} := Year_{Present} + 50 \cdot yr = 2063 \cdot yr$

a. Calculate peak H_2S flux (ϕsw) to sewer wall for Reach N34-N35 from 2013 to 2063

ϕsw = 0.45 * (sv)^0.375 * J*DS*b/P ASCE MOP 69 Equation 6-8 (peak corrosion rate)
units of ϕsw are g/(m^2 hr)

$s_{HS1} := 0.001$ s = slope of N34-N35 reach

$Q_{HS1} := 9.83 \cdot mgd$ average dry weather flow at N34

$dia_{HS1} := 66 \cdot in$ pipe diameter between N34 and N35

$v_{HS1} := 2.28 \cdot \frac{ft}{s}$ from sulfide accumulation model

From ASCE MOP 69 Table 6-5 Proportions of Dissolved Sulfide Present at H2S (J Factors):

at pH = 6.7 (see Technical Memorandum for Task B.2, Appendix B)

$J_{HS1} := 0.67$ J = adjustment factor of dissolved sulfide for pH

Use the measured dissolved sulfide concentrations in the 9/2013 field sampling and calculated dissolved sulfide concentration using the updated sulfide generation model:

$DS2013_{HS1} := 1.1 \cdot \frac{mg}{L}$ DS = dissolved liquid-phase sulfide concentration in reach

From ASCE MOP 69 Table 6-4 Hydraulic Properties:

$b_P := 0.637$ (b/P) = liquid surface width / perimeter of pipe exposed to headspace

$$\phi2013_{swHS1} := 0.45 \cdot \left(s_{HS1} \cdot 2.28\right)^{(0.375)} \cdot J_{HS1} \cdot 1.1 \cdot b_P \cdot \frac{gm}{m^2 \cdot hr}$$

$$\phi2013_{swHS1} = 0.0216 \cdot \frac{gm}{m^2 \cdot hr}$$ (peak H_2S flux to sewer wall)

b. Calculate average corrosion rate to the sewer wall for Reach N34-N35 from 2013 to 2063

C2013avg = (0.45 * k * ϕ2013sw) / A — ASCE MOP 69 Equation 6-9 (average corrosion rate) units of C2013avg are in/yr

$k := 0.7$ k = incomplete acid reaction factor (0.7 is a typical value)

$A_{HS1} := 0.23 \cdot \frac{mg}{L}$ A = concrete alkalinity (testing done on the concrete as part of the IDAP found the average alkalinity to be 0.23 mg/L as CaCO3)

$$C2013avg_{HS1} := \frac{0.45 \cdot k \cdot \phi2013_{swHS1}}{A_{HS1}} \cdot \frac{in}{yr} \cdot \frac{m^2 \cdot hr}{1000 \cdot L}$$

$C2013avg_{HS1} = 0.0296 \cdot \frac{in}{yr}$ calculated pipe wall loss rate (corrosion rate) for the N34-N35 reach from present (2013) to 2063 (no chemical dosing)

3. Calculate projected number of years to pipe failure due to corrosion in the 50-year life cycle.

In Reach N34-N35 (66-in dia), rehabilitation must occur at concrete cover of 0.25 in

$t2013_{HS1} = 0.5 \cdot in$ calculated current pipe wall cover

$tcrit_{HS1} = 0.25 \cdot in$ critical pipe wall remaining cover requiring rehab

$trem_{HS1} = 0.25 \cdot in$ pipe wall cover remaining before rehab required

$NoYr_{critHS1} := \frac{trem_{HS1}}{C2013avg_{HS1}} = 8.5 \cdot yr$ number of years before critical pipe wall thickness reached

$$Year_{critHS1} := Year_{Present} + NoYr_{critHS1} = 2021 \cdot yr$$

Rehabilitation required in this reach in 2021 at current rate of corrosion

4. Calculate extension of life achieved by short-term methods (liquid-phase treatment or O&M methods).

Liquid-Phase Treatment: Assume construction of a ferrous chloride injection system upstream that will maintain dissolved sulfide concentrations in the reach to 0.3 mg/L (into the target concentration range for "low" corrosion potential in the hot spot)

a. Calculate peak H_2S flux (ϕsw) to sewer wall for Reach N34-N35 from 2013 to 2063

ϕsw = 0.45 * (sv)^0.375 * J*DS*b/P   ASCE MOP 69 Equation 6-8 (peak corrosion rate)
units of ϕsw are g/(m^2 hr)

s, v, J, and b/P are all same as in Step 2

Use a reduced dissolved sulfide concentration following liquid-phase treatment based on model output:

$$DS2013mod_{HS1} := 0.3\cdot\frac{mg}{L}$$ DS = modified dissolved liquid-phase sulfide concentration in reach

$$\phi 2013mod_{swHS1} := 0.45\cdot\left(s_{HS1}\cdot 2.28\right)^{(0.375)}\cdot J_{HS1}\cdot 0.3\cdot b_P\cdot\frac{gm}{m^2\cdot hr}$$

$$\phi 2013mod_{swHS1} = 5.89\times 10^{-3}\cdot\frac{gm}{m^2\cdot hr}$$ (peak H_2S flux to sewer wall)

b. Calculate average corrosion rate to the sewer wall for Reach N34-N35 from 2013 to 2063

C2013avg = (0.45 * k * ϕ2013sw) / A   ASCE MOP 69 Equation 6-9 (average corrosion rate)
units of C2013avg are in/yr

k and A are the same as in Step 2

$$C2013avgmod_{HS1} := \frac{0.45\cdot k\cdot\phi 2013mod_{swHS1}}{A_{HS1}}\cdot\frac{in}{yr}\cdot\frac{m^2\cdot hr}{1000\cdot L}$$

$$C2013avgmod_{HS1} = 8.0604\times 10^{-3}\cdot\frac{in}{yr}$$ calculated pipe wall loss rate (corrosion rate) for the N34-N35 reach from present (2013) to 2063 (rate with chemical dosing)

c. Calculate projected number of years to pipe failure due to corrosion in the 50-year life cycle.

$$NoYrmod_{critHS1} := \frac{trem_{HS1}}{C2013avgmod_{HS1}} = 31\cdot yr$$ number of years before critical pipe wall cover reached

$$Yearmod_{critHS1} := Year_{Present} + NoYrmod_{critHS1} = 2044\cdot yr$$

Assuming ferrous chloride dosing to achieve 0.3 mg/L in the reach, rehabilitation would be required in the reach in 2044 (extended from 2021 without chemical addition)

O&M Method (Caustic Slug Dosing): Assume weekly injection of a slug of caustic (50% solution) that reduces the slime layer such that biological activity is minimized on average 10 out of 14 days

a. Calculate peak H_2S flux (ϕsw) to sewer wall for Reach N34-N35 from 2013 to 2063

ϕsw = 0.45 * (sv)^0.375 * J*DS*b/P ASCE MOP 69 Equation 6-8 (peak corrosion rate)
units of ϕsw are g/(m^2 hr)

DS, s, v, J, and b/P are all same as in Step 2

H2S flux is assumed to be reduce for caustic slug dosing by multiplying by a factor of 4/14 (equivalent to on average inactivating the slime layer for 10 out of 14 days)

$$\phi 2013OMmod_{swHS1} := \left[0.45\cdot\left(s_{HS1}\cdot 2.28\right)^{(0.375)}\cdot J_{HS1}\cdot 1.1\cdot b_P\cdot\frac{gm}{m^2\cdot hr}\right]\cdot\frac{4}{14}$$

$$\phi 2013OMmod_{swHS1} = 6.17\times 10^{-3}\cdot\frac{gm}{m^2\cdot hr}$$ (peak H_2S flux to sewer wall)

b. Calculate average corrosion rate to the sewer wall for Reach N34-N35 from 2013 to 2063

C2013avg = (0.45 * k * ϕ2013sw) / A ASCE MOP 69 Equation 6-9 (average corrosion rate assuming caustic slug dosing)
units of C2013avg are in/yr

k and A are the same as in Step 2

$$C2013avgOMmod_{HS1} := \frac{0.45\cdot k\cdot\phi 2013OMmod_{swHS1}}{A_{HS1}}\cdot\frac{in}{yr}\cdot\frac{m^2\cdot hr}{1000\cdot L}$$

$$C2013avgOMmod_{HS1} = 0.0084\cdot\frac{in}{yr}$$ calculated pipe wall loss rate (corrosion rate) for the N34-N35 reach from present (2013) to 2063

c. Calculate projected number of years to pipe failure due to corrosion in the 50-year life cycle.

$$NoYrOMmod_{critHS1} := \frac{trem_{HS1}}{C2013avgOMmod_{HS1}} = 29.6\cdot yr$$ number of years before critical pipe cover reached

$$YearOMmod_{critHS1} := Year_{Present} + NoYrOMmod_{critHS1} = 2043\cdot yr$$

Assuming caustic slug dosing in the reach, rehabilitation would be required in the reach in 2043 (extended from 2021 without chemical addition)

5. Calculate life cycle costs and determine optimal corrosion prevention solution and timing of improvements.

a. Life cycle cost of Option 1 (no liquid-phase treatment, rehab only)

As calculated in Step 3, rehab required at current corrosion rate in 9 years

Assume rehab of N34-N35 will be completed

Low-cost barrier method in TM B.2 is sliplining

$\text{dollars} := 1$

From Conceptual Cost Estimate Hot Spot 1: Capital cost of rehab is $890,000

Escalate to midpoint of construction (assume 5 years from calculated rehab required year, or +14 years)

$e_{factor} := 0.03$ Use 3% escalation factor

Future worth factor = (1+i)^e

$$FWF_{rehabHS1Op1} := \left(1 + e_{factor}\right)^{14} = 1.513$$

$$CapCost_{HS1Op1} := FWF_{rehabHS1Op1} \cdot 890000 \cdot \text{dollars}$$

$$CapCost_{HS1Op1} = 1.346 \times 10^{6} \cdot \text{dollars}$$

Calculate present worth cost:

$i_{rate} := .05$ Assume 5% interest rate

Present worth factor = (1+i)^n

$$PWF_{HS1Op1} := \left(1 + i_{rate}\right)^{14} = 1.98$$

$$PW_{HS1Op1} := \frac{CapCost_{HS1Op1}}{PWF_{HS1Op1}} = 6.799 \times 10^{5} \cdot \text{dollars}$$

b. Alternate life cycle cost of Option 1 (no liquid-phase treatment, rehab only, concrete cover to <u>zero</u> inches)

Rehab required at current corrosion rate in 17 years

Assume rehab of N34-N35 will be completed

Low-cost barrier method in TM B.2 is sliplining

From Conceptual Cost Estimate Hot Spot 1: Capital cost of rehab is $890,000

Escalate to midpoint of construction (assume 5 years from calculated rehab required year, or +22 years)

Use 3% escalation factor

Future worth factor = (1+i)^e

$$FWF_{rehabHS1Op1a} := \left(1 + e_{factor}\right)^{22} = 1.916$$

$$CapCost_{HS1Op1a} := FWF_{rehabHS1Op1a} \cdot 890000 \cdot dollars$$

$$CapCost_{HS1Op1a} = 1.705 \times 10^{6} \cdot dollars$$

Calculate present worth cost:

Assume 5% interest rate

Present worth factor = (1+i)^n

$$PWF_{HS1Op1a} := \left(1 + i_{rate}\right)^{22} = 2.925$$

$$PW_{HS1Op1a} := \frac{CapCost_{HS1Op1a}}{PWF_{HS1Op1a}} = 5.83 \times 10^{5} \cdot dollars$$

c. Life cycle cost for Option 2 (chemical addition for 31 years)

Capital Cost Estimate

From Conceptual Cost Estimate Hot Spot 1: Capital cost of ferrous chloride treatment is $648,700

PW cost of rehab 36 years after ferrous chloride treatment (+5 years to midpoint of construction)

$$FWF_{rehabHS1Op2C} := \left(1 + e_{factor}\right)^{36} = 2.898$$

$$PWF_{HS1Op2C} := \left(1 + i_{rate}\right)^{36} = 5.792$$

$$PW_{HS1Op2C} := \frac{FWF_{rehabHS1Op2C}}{PWF_{HS1Op2C}} \cdot 890000 \cdot dollars + 648700 = 1.094 \times 10^{6} \cdot dollars$$

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 1: Yearly O&M cost of ferrous chloride treatment is $266,800

$$OMCost_{HS1Op2} := 266800$$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n   i = 0.05, n=31

$$PWF_{HS1Op2OM} := 15.593$$

$$PW_{HS1Op2OM} := OMCost_{HS1Op2} \cdot PWF_{HS1Op2OM} = 4.16 \times 10^{6} \cdot dollars$$

Life Cycle Cost Estimate

$$PW_{HS1Op2} := PW_{HS1Op2C} + PW_{HS1Op2OM} = 5.254 \times 10^{6} \cdot \text{dollars}$$

d. Life cycle cost for Option 3 (caustic slug dosing for 30 years then rehab)

Capital Cost Estimate

PW cost of rehab 35 years after caustic slug dosing treatment (+5 years to midpoint of construction)

$$FWF_{rehabHS1Op3C} := \left(1 + e_{factor}\right)^{35} = 2.814$$

$$PWF_{HS1Op3C} := \left(1 + i_{rate}\right)^{35} = 5.516$$

$$PW_{HS1Op3C} := \frac{FWF_{rehabHS1Op3C}}{PWF_{HS1Op3C}} \cdot 890000 \cdot \text{dollars} = 4.54 \times 10^{5} \cdot \text{dollars}$$

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 1: Yearly O&M cost of caustic slug dosing is $143,800

$$OMCost_{HS1Op3} := 143800$$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n   i = 0.05, n=30

$$PWF_{HS1Op3OM} := 15.372$$

$$PW_{HS1Op3OM} := OMCost_{HS1Op3} \cdot PWF_{HS1Op3OM} = 2.21 \times 10^{6} \cdot \text{dollars}$$

Life Cycle Cost Estimate

$$PW_{HS1Op3} := PW_{HS1Op3C} + PW_{HS1Op3OM} = 2.665 \times 10^{6} \cdot \text{dollars}$$

Recommendation:

At the assumed yearly cost, the present worth cost for rehabilitation of N34-N35 is significantly less than other options, therefore recommend scheduling rehabilitation in 9 years (option for 17 years if concrete cover is allowed to be reduced to zero). Chemical addition is not desirable due to site constraints.

C.2 Hot Spot 4 Conceptual Scope Description

The portion of the Alameda Interceptor between A21 and A46a presents a corrosion concern due to high liquid-phase sulfide and gas-phase H_2S at Manhole A39 as measured in September 2013 and a severity rating of "C" given to several reaches in the 2010-2010 condition assessment, in addition to one severity rating "D" given to Reach A40-A41. (This reach is planned for rehabilitation as part of the Alameda Interceptor Rehabilitation Project.) The location of the hot spot is shown in Figure C-2.

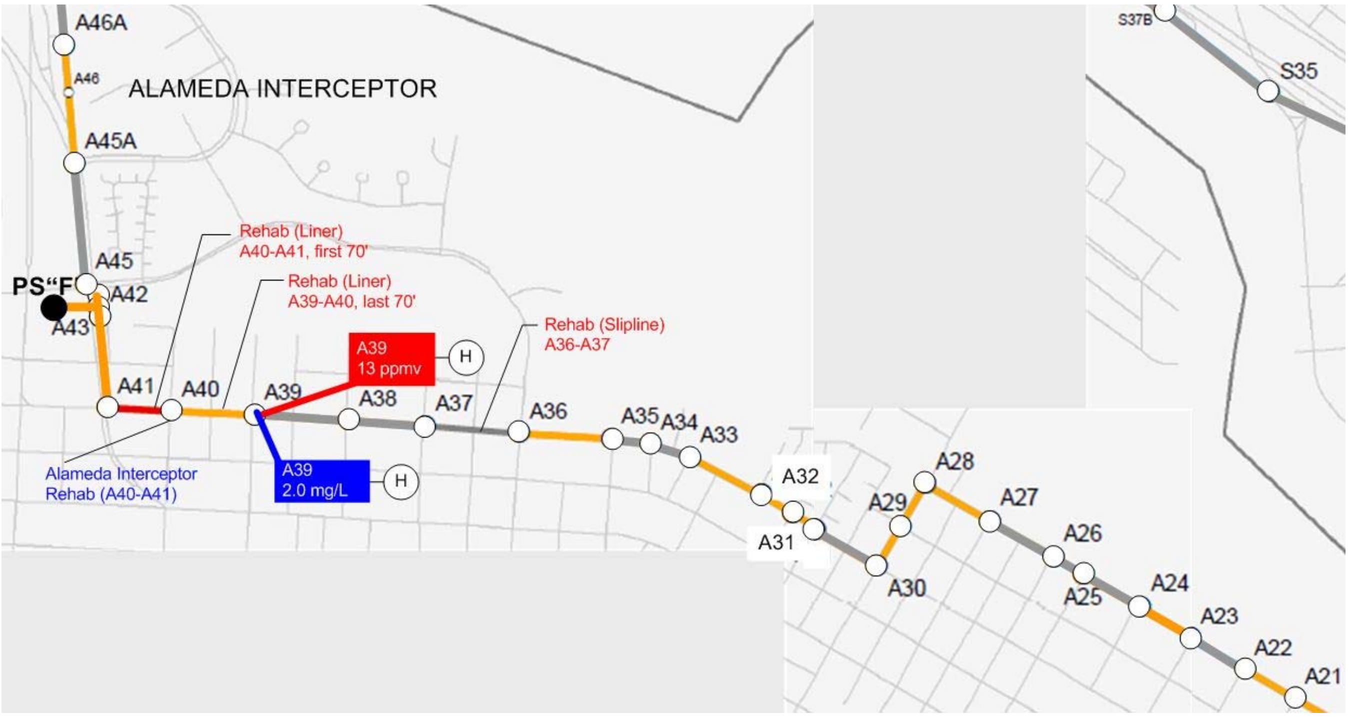


Figure C-2. Hot Spot 4 (Alameda Interceptor): A21-A46a

Four alternatives are considered for corrosion control at this hot spot:

1. Rehabilitate Pipe Severity "C" reaches when corrosion levels are at Pipe Severity "D" status in the reach with the least amount of remaining life (identified as the critical reach) before being classified as Pipe Severity "D" for corrosion.
2. Install chemical dosing facilities (ferrous chloride) upstream for sulfide reduction in the hot spot, which would delay the need for rehabilitation of the "C" reaches.
3. Inject caustic slugs every 1-2 weeks to inactivate the slime layer and reduce sulfide accumulation, which would delay the need for rehabilitation of the "C" reaches.
4. Crown spray the Pipe Severity "C" reaches to limit H_2S accumulation and slow corrosion, which would delay the need for rehabilitation of the "C" reaches.

Following is a summary of the scope of each option:

- **Rehabilitation Only:** Corrosion rate calculations are provided that estimate the number of years into the future that remain, under current sulfide loads, before Critical Reach A41-A42 becomes Pipe Severity "D" status, at which time rehabilitation (sliplining) would be needed. The number of years is noted for when the pipe has 0.25 inches of cover remaining and 0 inches of cover remaining. Capital costs are estimated for sliplining based upon BC experience. No O&M costs are assumed for this option.
- **Chemical Dosing:** Two ferrous chloride injection facilities would be constructed at Manholes A21 and A36 that would delay the rehabilitation of the Pipe Severity "C" reaches in the hot spot. A total of approximately 0.1 acres of land would need to be purchased for the two locations. The facility would include two 10,000-gallon storage tanks, two sets of chemical metering pumps, piping, and miscellaneous equipment (capital costs). Future capital costs would include sliplining of all Pipe Severity "C" reaches. Annual O&M costs would include costs for chemicals, regular maintenance, and H_2S monitoring to confirm effectiveness.
- **Caustic Slug Dosing:** Would include injection of 50 percent caustic solution for 60 minutes weekly (to be confirmed using pilot testing) to delay the rehabilitation of the Pipe Severity "C" reaches. Caustic solution would be injected at Manhole A21. Future capital costs would include sliplining the "C" reaches. Annual O&M costs would include costs for caustic deliveries and associated labor, regular maintenance, and H_2S monitoring to confirm effectiveness.
- **Crown Spraying:** Would include spraying corrosion-resistant material to the crown of all reaches within the hot spot to delay the rehabilitation of the Pipe Severity "C" reaches. Future capital costs would include sliplining the "C" reaches. Annual O&M costs would include associated labor, regular maintenance, and H_2S monitoring to confirm effectiveness.
- **Oxygenation:** Would include installation of superoxygenation facilities at both upstream Pump Stations "C" and "M" to lower liquid-phase sulfide concentrations in the downstream hot spot. This would delay the rehabilitation of the Pipe Severity "C" reaches. Near-term capital costs would include purchase installation of the two systems; an ECO2 oxygenation system is used as a basis for cost estimates. Future capital costs would include sliplining the "C" reaches. Annual O&M costs would include associated power costs, labor, regular maintenance, and H_2S monitoring to confirm effectiveness

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East Bay Municipal Utility District - Corrosion Assessment Project
Corrosion Rate Calculations
January 2014

Hot Spot 4 (Alameda Interceptor)

Pipe Severity "C" Reaches	Condition	Pipe Dia (in)	Reach Slope	Flow (mgd)	Velocity (ft/s) [1]	pH	J [2]	b/p' [3]	Incomplete Acid Reaction Factor (k)	Concrete Alkalinity (mg/L as CaCo3)	Estimated Current Pipe Wall Cover (in)	2013 Dissolved Sulfide (mg/L)	H2S Flux (g/m2 hr) [4]	Avg Corrosion Rate (in/yr)	Max Concrete Cover (in)	Available Cover (in)	Years before Critical Pipe Cover (yr)
A21-A22	Baseline	48	0.000705	2.9	0.82	7.3	0.33	0.637	0.7	0.23	0.75	0.8	0.0046	0.0063	0.5	0.25	39.5
A23-A24	Baseline	48	0.000717	2.9	0.82	7.3	0.33	0.637	0.7	0.23	0.75	0.95	0.0055	0.0076	0.5	0.25	33.1
A27-A28	Baseline	48	0.000702	3.24	0.82	7.3	0.33	0.637	0.7	0.23	0.75	1.1	0.0063	0.0087	0.5	0.25	28.8
A28-A29	Baseline	54	0.000647	3.24	0.82	7.2	0.39	0.637	0.7	0.23	0.75	1.25	0.0083	0.0113	0.5	0.25	22.1
A28-A29 (Mod)	FeCl2 Dosing	54	0.000647	3.24	0.82	7.2	0.39	0.637	0.7	0.23	0.75	0.50	0.0033	0.0045	0.5	0.25	55.2
A28-A29 (Mod)	Caustic/Crown Spray	54	0.000647	3.24	0.82	7.2	0.39	0.637	0.7	0.23	0.75	1.25	0.0024	0.0032	0.5	0.25	77.3
A29-A30	Baseline	54	0.000569	3.24	0.68	7.2	0.39	0.637	0.7	0.23	0.75	1.40	0.0082	0.0113	0.5	0.25	22.2
A31-A32	Baseline	57	0.000559	3.24	0.68	7.2	0.39	0.637	0.7	0.23	0.5	1.55	0.0090	0.0124	0.25	0.25	20.2
A32-A33	Baseline	57	0.000364	3.24	0.68	7.1	0.44	0.637	0.7	0.23	0.5	1.70	0.0095	0.0130	0.25	0.25	19.2
A35-A36	Baseline	60	0.00037	3.52	0.68	7.1	0.44	0.637	0.7	0.23	0.5	1.85	0.0104	0.0143	0.25	0.25	17.5
A35-A36 (Mod)	FeCl2 Dosing	60	0.00037	3.52	0.68	7.1	0.44	0.637	0.7	0.23	0.5	0.50	0.0028	0.0039	0.25	0.25	64.8
A35-A36 (Mod)	Caustic/Crown Spray	60	0.00037	3.52	0.68	7.1	0.44	0.637	0.7	0.23	0.5	1.85	0.0030	0.0041	0.25	0.25	61.3
A39-A40	Baseline	60	0.000391	4.28	1.10	7.0	0.50	0.637	0.7	0.23	0.5	2.00	0.0157	0.0215	0.25	0.25	11.7
A41-A42	Baseline	60	0.000629	4.28	1.10	7.0	0.50	0.637	0.7	0.23	0.5	1.68	0.0157	0.0215	0.25	0.25	11.6
A41-A42	Baseline (Alt)	60	0.000629	4.28	1.10	7.0	0.50	0.637	0.7	0.23	0.5	1.68	0.0157	0.0215	0	0.50	23.3
A42-A44	Baseline	60	0.000629	4.7	1.10	7.0	0.50	0.637	0.7	0.23	0.5	1.35	0.0126	0.0173	0.25	0.25	14.4
A45a-A46	Baseline	60	0.000629	5.12	1.10	7.1	0.44	0.637	0.7	0.23	0.5	1.03	0.0084	0.0116	0.25	0.25	21.6
A46-A46a	Baseline	60	0.000629	5.21	1.10	7.1	0.44	0.637	0.7	0.23	0.5	0.70	0.0058	0.0079	0.25	0.25	31.7
A41-A42 (Mod)	FeCl2 Dosing	60	0.000629	4.28	1.10	7.0	0.50	0.637	0.7	0.23	0.5	0.50	0.0047	0.0064	0.25	0.25	39.0
A41-A42 (Mod)	Caustic/Crown Spray	60	0.000629	4.28	1.10	7.0	0.50	0.637	0.7	0.23	0.5	1.68	0.0045	0.0061	0.25	0.25	40.7
A41-A42 (Mod)	Oxygenation	60	0.000629	4.28	1.10	7.0	0.50	0.637	0.7	0.23	0.5	0.70	0.0066	0.0090	0.25	0.25	27.9

IDAP Year	1997
Current Year	2013
Design Year	2063

FeCl2 Dosing Life Extension	27.4 yr
Caustic Slug Dosing/Crown Spraying Life Extension	29.1 yr
Oxygenation Life Extension	16.2 yr

Caustic Slug Dosing Activity 0.286 Fraction of days of normal sulfide activity (10 out of 14 days slime layer is assumed inactive)

$\boxed{}$ = Critical Reach (used in Cost Estimates)

Unit Conversions:
1 ft3 = 7.48502 gal
1 day = 86400 sec

Notes:
1 - From updated sulfide accumulation model
2 - From ASCE MOP 69 Table 6-5 (function of pH)
3 - From ASCE MOP 69 Table 6-4
4 - From ASCE MOP 69 Equation 6-8

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Alameda Interceptor Chemical Dose Requirements

Hot Spot 4 (A21-A46a)

Chemical	Liquid Sulfide Concentration (mg/L)		Target Sulfide Flow Rate (lb/day)	Dose Ratio		Dose Requirement		Cost ($/gal)	Cost ($/lb)	Number of Dosing Stations	Annual Chemical Cost	Chemical Properties	
	Initial	Target				lb/day	gal/day					Density (lb/gal)	Strength
Hypochlorite	2.0	0.0	0.0	13	lb / lb H2S	741	509	0.75	0.40	2	$216,000	9.7	0.15
Hydrogen Peroxide	2.0	0.0	0.0	4	lb / lb S	507	101	4.00		2	$296,000	10	0.5
Ferrous Chloride	2.0	0.15	5.1	10	lb / lb S	1,215	405	0.75	0.33	2	$288,000	10	0.3
Calcium Nitrate	2.0	0.0	0.0	10	lb / lb S formed	1,266	174	3.00		2	$382,000	12.1	0.6
Magnesium Hydroxide	2.0	N/A	N/A	75	L / ML wastewater	N/A	306	1.50		2	$336,000		

Rehab "C" reaches only:

Method	Interceptor Length (LF)	Construction Cost ($/ LF)	Construction Cost
Sliplining	6,277	$770	$4,833,300
Plastic Liner	6,277	$1,100	$6,904,700

Ferrous Chloride Chemical Injection

500 gpd each tank (with safety factor)
7,500 gal for 15-day storage
Assume 8,700-gal 12-ft diameter tanks at each location

Crown Spraying

$0.33 per in diameter per LF per year
56 in diameter average in HS
$18.75 per LF
6,277 LF of "C" pipe
$117,686 per year

Caustic Slug Dosing

2.9 MGD (assume injection at Manhole A21)
150 gal 50% NaOH per MGD per week (per ASCE MOP 69)
435.0 gal 50% NaOH per week
12.7 lb/gal density of 50% NaOH at 25 degrees C
5,525 lb 50% NaOH per week
2.8 tons 50% NaOH per week
$500 /ton 50% NaOH
$1,000 per week
$52,000 per year

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 4: Rehab of all "C" Reaches

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Civil and Structural Costs Total					**$0**
Mechanical Costs					
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
Sliplining Installation for all "C" Reaches	Similar projects, IDAP	1	LS		$4,833,300
Construction Cost Subtotal					$4,833,300
Contingencies	35% of Subtotal			35%	**$1,692,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$6,525,300**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$2,936,000**
TOTAL CAPITAL COST ESTIMATE					**$9,461,300**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost					$0
Caustic Slug Dosing Annual Cost					$0
Crown Spraying Annual Cost					$0
Monitoring Cost					$0
TOTAL YEARLY O&M COST ESTIMATE					**$0**

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 4: Ferrous Chloride Chemical Treatment System

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Site Preparation		3	LS	$30,000	$90,000
Concrete		90	CY	$125	$11,250
Rebar		6.0	TON	$1,250	$7,500
Concrete Coating		3	LS	$10,000	$30,000
Civil and Structural Costs Total					**$138,750**
Mechanical Costs					
Cross-Linked HDPE Double-Wall Tank (8,700 gal)		2	LS	$45,000	$90,000
Chemical Metering Pumps		2	LS	$60,000	$120,000
Piping and Pipe Supports		2	LS	$10,000	$20,000
Miscellaneous Equipment (ladder, eyewash, shower, etc)		2	LS	$10,000	$20,000
Mechanical Cost Total					**$250,000**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$37,500**
Equipment Cost Total					**$426,250**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$255,750**
Land Acquisition Cost					
Parcels adjacent to Manholes A21 and A36		0.1	AC	$925,000	$92,500
Construction Cost Subtotal					$774,500
Contingencies	35% of Subtotal			35%	**$271,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$1,045,500**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$470,000**
TOTAL CAPITAL COST ESTIMATE					**$1,515,500**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT		Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost		Sampling, flow rate				$288,000
O&M Annual Cost			750	HR	$80	$60,000
Caustic Slug Dosing Annual Cost						$0
Crown Spraying Annual Cost						$0
Monitoring Cost						
	OdaLog Rental	Supplier Contact	36	WK	$250	$9,000
	Operator Labor	Similar Projects	384	HR	$80	$30,720
	Total Monitoring Cost					**$39,720**
TOTAL YEARLY O&M COST ESTIMATE						**$387,700**

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EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 4: Caustic Slug Dosing Treatment System

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Site Preparation					$0
Concrete					$0
Rebar					$0
Concrete Coating					$0
Civil and Structural Costs Total					**$0**
Mechanical Costs					
					$0
					$0
					$0
					$0
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
None					
Construction Cost Subtotal					$0
Contingencies	35% of Subtotal			35%	**$0**
TOTAL CONSTRUCTION COST ESTIMATE					**$0**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$0**
TOTAL CAPITAL COST ESTIMATE					**$0**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost					$0
Caustic Slug Dosing Annual Cost	ASCE MOP 69 Guidance				$52,000
Caustic Slug Dosing Annual O&M Cost		200	HR	$80	$16,000
Crown Spraying Annual Cost					$0
Monitoring Cost					
OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
Operator Labor	Similar Projects	260	HR	$80	$20,800
Total Monitoring Cost					**$23,800**
TOTAL YEARLY O&M COST ESTIMATE					**$91,800**

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EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 4: Crown Spraying Treatment System

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	**Cost Basis**	**Quantity**	**Units**	**Unit Cost**	**Total Cost**
Civil and Structural Costs					
Site Preparation					$0
Concrete					$0
Rebar					$0
Concrete Coating					$0
Civil and Structural Costs Total					**$0**
Mechanical Costs					
					$0
					$0
					$0
					$0
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
None					
Construction Cost Subtotal					$0
Contingencies	35% of Subtotal			35%	**$0**
TOTAL CONSTRUCTION COST ESTIMATE					**$0**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$0**
TOTAL CAPITAL COST ESTIMATE					**$0**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT					
Chemical Cost					$0
Crown Spraying Annual O&M Cost		50	HR	$80	$4,000
Crown Spraying Annual Cost	LACSD Case Study				$117,686
Monitoring Cost					
OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
Operator Labor	Similar Projects	260	HR	$80	$20,800
Total Monitoring Cost					**$23,800**
TOTAL YEARLY O&M COST ESTIMATE					**$145,500**

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EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 4: Oxygen Injection System (Pump Stations "C" and "M")

CAPITAL COST ESTIMATE

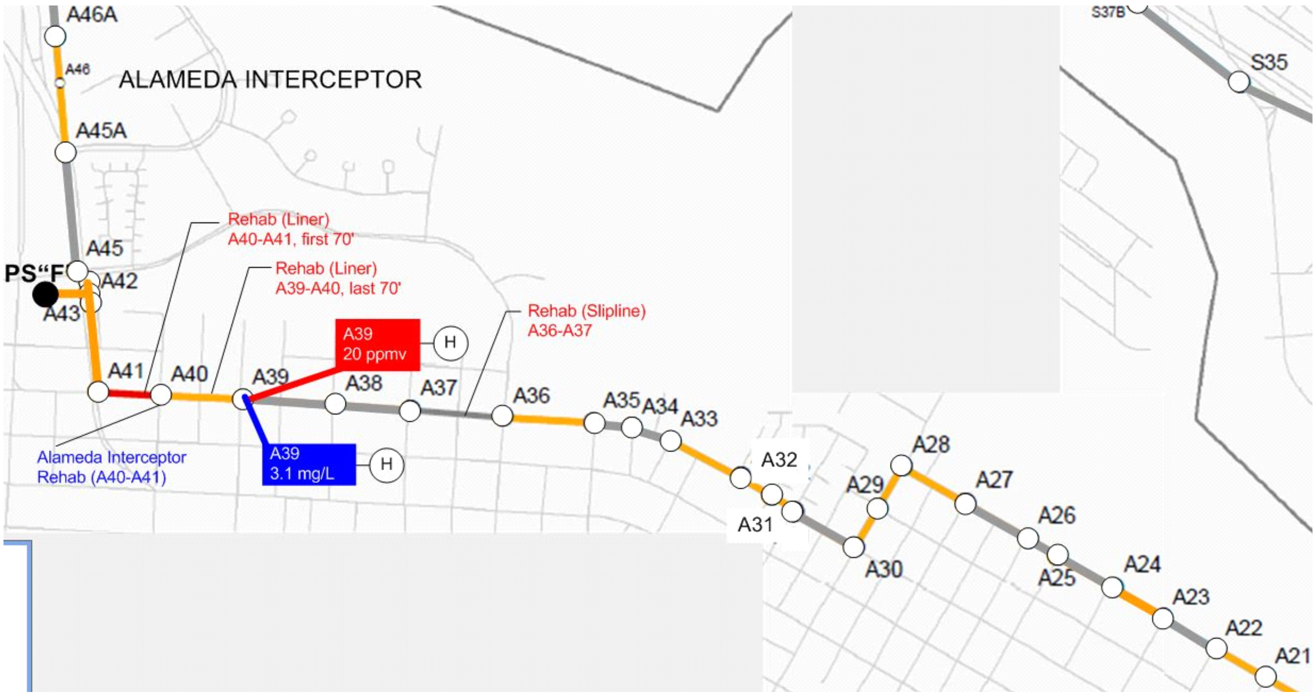
CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Site Preparation		1	LS	$20,000	$20,000
Concrete		10	CY	$125	$1,250
Rebar		1.0	TON	$1,250	$1,250
Concrete Coating		1	LS	$5,000	$5,000
Civil and Structural Costs Total					**$27,500**
Mechanical Costs					
ECO2 System	Quote	1	LS	$800,000	$800,000
Additional oxygen system equipment	estimate	1	LS	$10,000	$10,000
Mechanical Cost Total					**$810,000**
Electrical and Instrumentation	Included in Quote				**$0**
Equipment Cost Total					**$837,500**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$502,500**
Barrier Installation Costs					
None					
Construction Cost Subtotal					$1,340,000
Contingencies	35% of Subtotal			35%	**$469,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$1,809,000**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$814,000**
TOTAL CAPITAL COST ESTIMATE					**$2,623,000**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost					
O&M Annual Cost		100	HR	$80	$8,000
Oxygen System Electrical & Maintenance Costs (Quote)					$89,000
Monitoring Cost					
OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
Operator Labor	Similar Projects	24	HR	$50	$1,200
Total Monitoring Cost					**$4,200**
TOTAL YEARLY O&M COST ESTIMATE					**$101,200**

Hot Spot 4 (Alameda Interceptor)

Manhole Range: A21-A46a



See "Corrosion Rate Calculations" table for calculations of projected corrosion rates and remaining pipe life

Five options for corrosion control:

Option 1: No corrosion prevention treatment, rehab only
Option 2: Ferrous chloride injection in upstream manhole (2 locations), future rehab
Option 3: Caustic slug dosing in manhole upstream of hot spot (1 location), future rehab
Option 4: Crown spraying along hot spot "C" reaches, future rehab
Option 5: Oxygen addition at upstream Pump Stations "C" and "M"

Use Reach A41-A42 for comparison of life cycle costs (lowest calculated remaining life)

Calculate life cycle costs and determine optimal corrosion prevention solution and timing of improvements:

a. Life cycle cost of Option 1 (no liquid-phase treatment, rehab only)

Rehab required at current corrosion rate in 12 years

Assume rehab of all "C" reaches will be completed

Low-cost barrier method in TM B.2 is sliplining

From Conceptual Cost Estimate Hot Spot 4: Capital cost of rehab is $9,461,300

Escalate to midpoint of construction (assume 5 years from calculated rehab required year, or +17 years)

Future worth factor = (1+i)^e

$FWF_{rehabHS4Op1} := \left(1 + e_{factor}\right)^{17} = 1.653$

$CapCost_{HS4Op1} := FWF_{rehabHS4Op1} \cdot 9461300 \cdot dollars$

$CapCost_{HS4Op1} = 1.564 \times 10^{7} \cdot dollars$

Calculate present worth cost:

Present worth factor = (1+i)^n   i =.05, n=17

$PWF_{HS4Op1} := \left(1 + i_{rate}\right)^{17} = 2.292$

$$PW_{HS4Op1} := \frac{CapCost_{HS4Op1}}{PWF_{HS4Op1}} = 6.82 \times 10^{6} \cdot dollars$$

b. Alternate life cycle cost of Option 1 (no liquid-phase treatment, rehab only, concrete cover to zero inches)

Rehab required at current corrosion rate in 23 years

Assume rehab of all "C" reaches will be completed

Low-cost barrier method in TM B.2 is sliplining

From Conceptual Cost Estimate Hot Spot 4: Capital cost of rehab is $9,461,300

Escalate to midpoint of construction (assume 5 years from calculated rehab required year, or +28 years)

Future worth factor = (1+i)^e

$FWF_{rehabHS4Op1a} := \left(1 + e_{factor}\right)^{28} = 2.288$

$CapCost_{HS4Op1a} := FWF_{rehabHS4Op1a} \cdot 9461300 \cdot dollars$

$CapCost_{HS4Op1a} = 2.165 \times 10^{7} \cdot dollars$

Calculate present worth cost:

Present worth factor = (1+i)^n   i =.05, n=17

$PWF_{HS4Op1a} := \left(1 + i_{rate}\right)^{28} = 3.92$

$$PW_{HS4Op1a} := \frac{CapCost_{HS4Op1a}}{PWF_{HS4Op1a}} = 5.52 \times 10^{6} \cdot dollars$$

c. Life cycle cost for Option 2 (liquid-phase treatment for 39 years)

Capital Cost Estimate

From Conceptual Cost Estimate Hot Spot 4: Capital cost of ferrous chloride treatment is $1,515,000

PW cost of rehab 39 years after ferrous chloride treatment (+5 years to midpoint of construction)

$$FWF_{rehabHS4Op2C} := \left(1 + e_{factor}\right)^{44} = 3.671$$

$$PWF_{HS4Op2C} := \left(1 + i_{rate}\right)^{44} = 8.557$$

$$PW_{HS4Op2C} := \frac{FWF_{rehabHS4Op2C}}{PWF_{HS4Op2C}} \cdot 9461300 \cdot dollars + 1515000 = 5.574 \times 10^{6} \cdot dollars$$

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 4: Yearly O&M cost of ferrous chloride treatment is $387,700

$$OMCost_{HS4Op2} := 387700$$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n   i = 0.05, n=39

$$PWF_{HS4Op2OM} := 17.017$$

$$PW_{HS4Op2OM} := OMCost_{HS4Op2} \cdot PWF_{HS4Op2OM} = 6.597 \times 10^{6} \cdot dollars$$

Life Cycle Cost Estimate

$$PW_{HS4Op2} := PW_{HS4Op2C} + PW_{HS4Op2OM} = 1.2172 \times 10^{7} \cdot dollars$$

d. Life cycle cost for Option 3 (caustic slug dosing for 41 years then rehab)

Capital Cost Estimate

PW cost of rehab 41 years after caustic slug dosing treatment (+5 years to midpoint of construction)

$$FWF_{rehabHS4Op3C} := \left(1 + e_{factor}\right)^{46} = 3.895$$

$$PWF_{HS4Op3C} := \left(1 + i_{rate}\right)^{46} = 9.434$$

$$PW_{HS4Op3C} := \frac{FWF_{rehabHS4Op3C}}{PWF_{HS4Op3C}} \cdot 9461300 \cdot dollars = 3.906 \times 10^{6} \cdot dollars$$

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 4: Yearly O&M cost of caustic slug dosing is $91,800

$$OMCost_{HS4Op3} := 91800$$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n   i = 0.05, n=41

$$PWF_{HS4Op3OM} := 17.294$$

$$PW_{HS4Op3OM} := OMCost_{HS4Op3} \cdot PWF_{HS4Op3OM} = 1.588 \times 10^{6} \cdot dollars$$

Life Cycle Cost Estimate

$$PW_{HS4Op3} := PW_{HS4Op3C} + PW_{HS4Op3OM} = 5.494 \times 10^{6} \cdot dollars$$

e. Life cycle cost for Option 4 (crown spraying of "C" reaches for 41 years then rehab)

Capital Cost Estimate

PW cost of rehab 41 years after crown spraying treatment (+5 years to midpoint of construction)

$$FWF_{rehabHS4Op4C} := \left(1 + e_{factor}\right)^{46} = 3.895$$

$$PWF_{HS4Op4C} := \left(1 + i_{rate}\right)^{46} = 9.434$$

$$PW_{HS4Op4C} := \frac{FWF_{rehabHS4Op4C}}{PWF_{HS4Op4C}} \cdot 9461300 \cdot dollars = 3.906 \times 10^{6} \cdot dollars$$

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 4: Yearly O&M cost of crown spraying is $145,500

$$OMCost_{HS4Op4} := 145500$$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n   i = 0.05, n=41

$$PWF_{HS4Op4OM} := 17.294$$

$$PW_{HS4Op4OM} := OMCost_{HS4Op4} \cdot PWF_{HS4Op4OM} = 2.516 \times 10^{6} \cdot dollars$$

Life Cycle Cost Estimate

$PW_{HS4Op4} := PW_{HS4Op4C} + PW_{HS4Op4OM} = 6.422 \times 10^{6} \cdot dollars$

f. Life cycle cost for Option 5 (upstream oxygenation for 28 years then rehab)

Capital Cost Estimate

From Conceptual Cost Estimate Hot Spot 4: Capital cost of oxygen system is $2,623,000

$PW_{HS4Op5C1} := 2623000 \cdot dollars = 2.623 \times 10^{6} \cdot dollars$

PW cost of rehab 33 years after oxygenation treatment (+5 years to midpoint of construction)

$FWF_{rehabHS4Op5C2} := \left(1 + e_{factor}\right)^{33} = 2.652$

$PWF_{HS4Op5C2} := \left(1 + i_{rate}\right)^{33} = 5.003$

$PW_{HS4Op5C2} := \frac{FWF_{rehabHS4Op5C2}}{PWF_{HS4Op5C2}} \cdot 9461300 \cdot dollars = 5.016 \times 10^{6} \cdot dollars$

Include an upgrade cost of the system of 50% of initial capital cost in 25 years

$O2Upgrade_{HS4} := 2623000 \cdot 0.5 = 1.312 \times 10^{6} \cdot dollars$

$PWF_{HS4Op5C3} := (1 + .05)^{25} = 3.386$ i =.05, n=25

$FWF_{HS4Op5C3} := (1 + .03)^{25} = 2.094$ e =.02, n=25

$PW_{HS4Op5C3} := \frac{O2Upgrade_{HS4} \cdot FWF_{HS4Op5C3}}{PWF_{HS4Op5C3}} = 8.109 \times 10^{5} \cdot dollars$

$PW_{HS4Op5C} := PW_{HS4Op5C1} + PW_{HS4Op5C2} + PW_{HS4Op5C3} = 8.45 \times 10^{6} \cdot dollars$

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 4: Yearly O&M cost of oxygenation is $101,200

$OMCost_{HS4Op5} := 101200$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n i = 0.05, n=28

$PWF_{HS4Op5OM} := 14.898$

$$PW_{HS4Op5OM} := OMCost_{HS4Op5} \cdot PWF_{HS4Op5OM} = 1.508 \times 10^{6} \cdot dollars$$

Life Cycle Cost Estimate

$$PW_{HS4Op5} := PW_{HS4Op5C} + PW_{HS4Op5OM} = 9.957 \times 10^{6} \cdot dollars$$

Recommendation:
At the assumed yearly cost, the life cycle cost for caustic slug dosing followed by rehabilitation of the "C" reaches in 41 years is less than rehabilitation of the"C" reaches in 12 years. Therefore, recommend caustic slug dosing pending pilot testing confirmation.

Chemical (ferrous chloride) addition is not desirable due to calculated higher life cycle cost and potential constraints with respect to land acquisition requirements. Crown spraying is also lower life cycle cost than rehabilitation but a higher life cycle cost than caustic slug dosing. If after pilot testing it is projected that caustic slug dosing will be more costly than projected, crown spraying may become the recommended option.

Oxygen addition is higher life cycle cost but the option would additionally provide odor control at Pump Stations "C" and "M", potentially replacing existing chemical injection.

C.3 Hot Spot 6 Conceptual Scope Description

The segment of pipe in the upstream portion of South Interceptor between S09 and S16 is designated as a hot spot due to moderate gas-phase H_2S concentrations measured at Manhole S10 in the September 2013 sampling and the Pipe Severity “C” rating given to Reach S09-S10, S14-S15, and S15-S16 in the 2010-2012 Condition Assessment. The location of the hot spot is shown in Figure C-3.

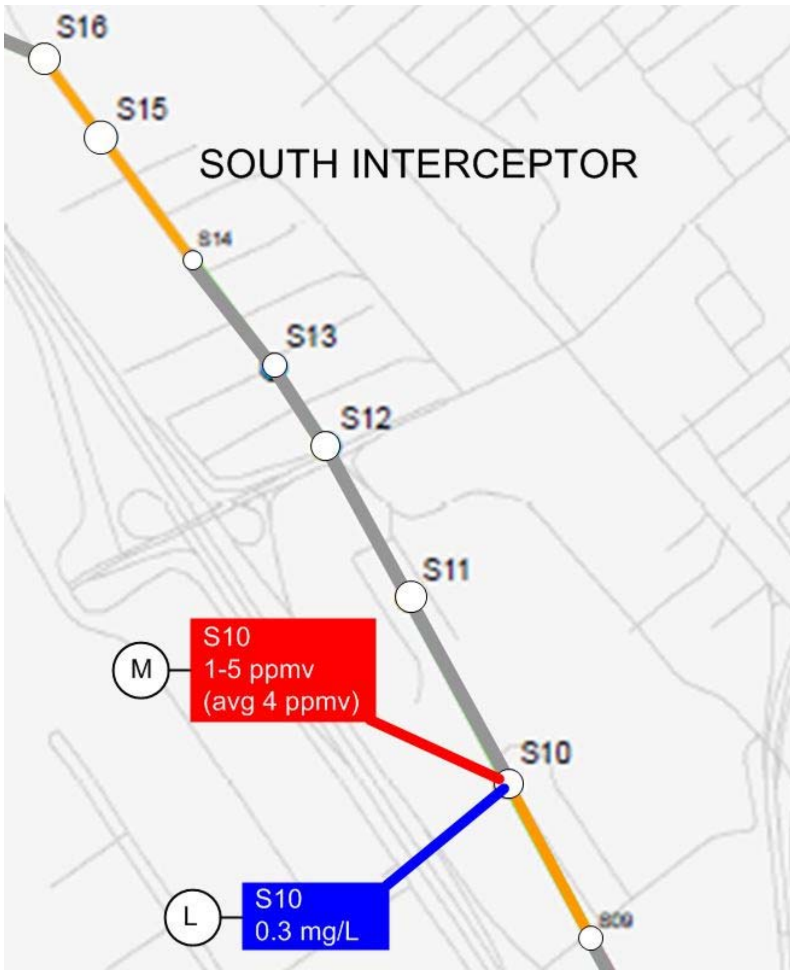


Figure C-3. Hot Spot 6 (South Interceptor): A21-A46a

Three alternatives are considered for corrosion control for this hot spot:

1. Rehabilitate Pipe Severity “C” reaches when corrosion levels are at Pipe Severity “D” status in the reach with the least amount of remaining life (identified as the critical reach) before being classified as Pipe Severity “D” for corrosion.
2. Install chemical dosing facilities (ferrous chloride) upstream of Hot Spot 6 for sulfide reduction, which would delay the need for rehabilitation of the “C” reaches.
3. Inject caustic slugs upstream of Hot Spot 6 every 1-2 weeks to inactivate the slime layer and reduce sulfide accumulation in both hot spots. This would delay the need for rehabilitation of the “C” reaches.

Following is a summary of the scope of each option:

- **Rehabilitation Only:** Corrosion rate calculations are provided that estimate the number of years into the future that remain, under current sulfide loads, before Critical Reach S09-S10 becomes Pipe Severity "D" status, at which time rehabilitation would be needed. Rehabilitation using a plastic liner and cured-in-place pipe (CIPP) are considered as viable options. The number of years before rehabilitation is needed is noted for when the pipe has 0.25 inches of cover remaining and 0 inches of cover remaining. Capital costs are estimated for a plastic liner and CIPP based upon BC experience. No O&M costs are assumed for this option.
- **Chemical Dosing:** One ferrous chloride injection facility would be constructed at Manhole S08 that would delay the rehabilitation of the Pipe Severity "C" reaches. A total of approximately 0.1 acres of land would need to be purchased. The facility would include one 10,000-gallon storage tank, chemical metering pumps, piping, and miscellaneous equipment (capital costs). Future capital costs would include installing a plastic liner or CIPP in all Pipe Severity "C" reaches in both hot spots. Annual O&M costs would include costs for chemicals, regular maintenance, and H_2S monitoring to confirm effectiveness.
- **Caustic Slug Dosing:** Would include injection of 50 percent caustic solution for 60 minutes weekly (to be confirmed using pilot testing) to delay the rehabilitation of the Pipe Severity "C" reaches. Caustic solution would be injected at Manhole S08. Future capital costs would include installing a plastic liner or CIPP in all Pipe Severity "C" reaches. Annual O&M costs would include costs for caustic deliveries and associated labor, regular maintenance, and H_2S monitoring to confirm effectiveness.

East Bay Municipal Utility District - Corrosion Assessment Project
Corrosion Rate Calculations
January 2014

Hot Spot 6 (South Interceptor)

Pipe Severity "C" Reaches	Condition	Pipe Dia (in)	Reach Slope	Flow (mgd)	Velocity (ft/s) [1]	pH	J [2]	b/p' [3]	Incomplete Acid Reaction Factor (k)	Concrete Alkalinity (mg/L as CaCo3)	Estimated Current Pipe Wall Cover (in)	2013 Dissolved Sulfide (mg/L)	H2S Flux (g/m2 hr) [4]	Avg Corrosion Rate (in/yr)	Max Concrete Cover (in)	Available Cover (in)	Years before Critical Pipe Cover (yr)
S09-S10	Baseline	63	0.0005	5.00	0.99	7.0	0.50	0.637	0.7	0.23	0.5	0.60	0.0050	0.0068	0.25	0.25	36.8
S09-S10	Baseline (Alt)	63	0.0005	5.00	0.99	7.0	0.50	0.637	0.7	0.23	0.5	0.60	0.0050	0.0068	0	0.50	73.7
S14-S15	Baseline	63	0.0001	5.40	1.47	6.5	0.76	0.637	0.7	0.23	0.5	0.50	0.0040	0.0055	0.25	0.25	45.9
S15-S16	Baseline	63	0.0001	7.04	1.74	6.5	0.76	0.637	0.7	0.23	0.5	0.50	0.0042	0.0058	0.25	0.25	43.1
S09-S10 (mod)	FeCl2 Dosing	63	0.0005	5.00	0.99	7.0	0.50	0.637	0.7	0.23	0.5	0.20	0.0017	0.0023	0.25	0.25	110.5
S09-S10 (mod)	Caustic Slug	63	0.0005	5.00	0.99	7.0	0.50	0.637	0.7	0.23	0.5	0.60	0.0014	0.0019	0.25	0.25	129.0

IDAP Year	1997
Current Year	2013
Design Year	2063

FeCl2 Dosing Life Extension	64.7	yr
Caustic Slug Dosing Life Extension	83.1	yr

Caustic Slug Dosing Activity 0.286 Fraction of days of normal sulfide activity (10 out of 14 days slime layer is assumed inactive)

= Critical Reach (used in Cost Estimates)

Unit Conversions:

1 ft3 =	7.48502	gal
1 day =	86400	sec

Notes:
1 - From updated sulfide accumulation model
2 - From ASCE MOP 69 Table 6-5 (function of pH)
3 - From ASCE MOP 69 Table 6-4

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South Interceptor Chemical Dose Requirements

Hot Spot 6 (S09-S16)

Chemical	Liquid Sulfide Concentration (mg/L)		Target Sulfide Flow Rate (lb/day)	Dose Ratio		Dose Requirement		Cost ($/gal)	Cost ($/lb)	Annual Chemical Cost	Chemical Properties	
	Initial	Target				lb/day	gal/day				Density (lb/gal)	Strength
Hypochlorite	1.0	0.0	0.0	13	lb / lb H2S	153	105	0.75	0.40	$22,000	9.7	0.15
Hydrogen Peroxide	1.0	0.0	0.0	4	lb / lb S	94	19	4.00		$27,000	10	0.5
Ferrous Chloride	1.0	0.15	4.0	10	lb / lb S	195	65	0.75	0.33	$23,000	10	0.3
Calcium Nitrate	1.0	0.0	0.0	10	lb / lb S formed	235	32	3.00		$35,000	12.1	0.6
Magnesium Hydroxide	1.0	N/A	N/A	75	L / ML wastewater	N/A	238	1.50		$130,000		

Pipe Diameter: 66 in

Rehab "C" reaches only

Method	Interceptor Length (LF)	Construction Cost ($/ LF)	Construction Cost
Sliplining	2,439	$928	$2,264,000
CIPP	2,439	$1,096	$2,672,000
Plastic Liner	2,439	$1,289	$3,144,000

Ferrous Chloride Chemical Injection

90	gpd (with safety factor)
2,700	gal for 30-day storage

Assume 3,050-gal 8-ft diameter tank

Caustic Slug Dosing

3.7	MGD (assume injection at Manhole S08)
150	gal 50% NaOH per MGD per week (per ASCE MOP 69)
555.0	gal 50% NaOH per week
12.7	lb/gal density of 50% NaOH at 25 degrees C
7,049	lb 50% NaOH per week
3.5	tons 50% NaOH per week
$500	/ton 50% NaOH
$2,000	per week
$104,000	**per year**

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EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 6: Rehab of all "C" Reaches

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Civil and Structural Costs Total					**$0**
Mechanical Costs					
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
Plastic Liner Installation for all "C" Reaches	Similar projects, IDAP	1	LS		$3,144,000
Construction Cost Subtotal					$3,144,000
Contingencies	35% of Subtotal			35%	**$1,100,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$4,244,000**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$1,910,000**
TOTAL CAPITAL COST ESTIMATE					**$6,154,000**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost					$0
Caustic Slug Dosing Annual Cost					$0
Crown Spraying Annual Cost					$0
Monitoring Cost					$0
TOTAL YEARLY O&M COST ESTIMATE					**$0**

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 6: Rehab of all "C" Reaches

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Civil and Structural Costs Total					**$0**
Mechanical Costs					
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
Plastic Liner Installation for all "C" Reaches	Similar projects, IDAP	1	LS		$3,144,000
Alternate: CIPP Installation for all "C" Reaches	*Similar projects, IDAP*	*1*	*LS*		*$2,672,000*
Construction Cost Subtotal					$3,144,000
Contingencies	35% of Subtotal			35%	**$1,100,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$3,772,000**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$1,697,000**
TOTAL CAPITAL COST ESTIMATE					**$5,469,000**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost					$0
Caustic Slug Dosing Annual Cost					$0
Crown Spraying Annual Cost					$0
Monitoring Cost					$0
TOTAL YEARLY O&M COST ESTIMATE					**$0**

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 6: Ferrous Chloride Chemical Treatment System

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Site Preparation		1	LS	$30,000	$30,000
Concrete		30	CY	$125	$3,750
Rebar		2.0	TON	$1,250	$2,500
Concrete Coating		1	LS	$10,000	$10,000
Civil and Structural Costs Total					**$46,250**
Mechanical Costs					
Cross-Linked HDPE Double-Wall Tank (3,050 gal)		1	LS	$15,000	$15,000
Chemical Metering Pumps		1	LS	$40,000	$40,000
Piping and Pipe Supports		1	LS	$10,000	$10,000
Miscellaneous Equipment (ladder, eyewash, shower, etc)		1	LS	$10,000	$10,000
Mechanical Cost Total					**$75,000**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$11,250**
Equipment Cost Total					**$132,500**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$79,500**
Land Acquisition Cost					
Parcel adjacent to Manhole S08		0.1	AC	$925,000	$92,500
Construction Cost Subtotal					$304,500
Contingencies	35% of Subtotal			35%	**$107,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$411,500**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$185,000**
TOTAL CAPITAL COST ESTIMATE					**$596,500**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT		Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost		Sampling, flow rate				$23,000
O&M Annual Cost			750	HR	$80	$60,000
Monitoring Cost						
	OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
	Operator Labor	Similar Projects	192	HR	$80	$15,360
	Total Monitoring Cost					**$18,360**
TOTAL YEARLY O&M COST ESTIMATE						**$101,400**

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 6: Caustic Slug Dosing Treatment System

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Site Preparation					$0
Concrete					$0
Rebar					$0
Concrete Coating					$0
Civil and Structural Costs Total					**$0**
Mechanical Costs					
					$0
					$0
					$0
					$0
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
None					
Construction Cost Subtotal					$0
Contingencies	35% of Subtotal			35%	**$0**
TOTAL CONSTRUCTION COST ESTIMATE					**$0**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$0**
TOTAL CAPITAL COST ESTIMATE					**$0**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost					$0
Caustic Slug Dosing Annual Cost	ASCE MOP 69 Guidance				$104,000
Caustic Slug Dosing Annual O&M Cost		200	HR	$80	$16,000
Monitoring Cost					
OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
Operator Labor	Similar Projects	260	HR	$80	$20,800
Total Monitoring Cost					**$23,800**
TOTAL YEARLY O&M COST ESTIMATE					**$143,800**

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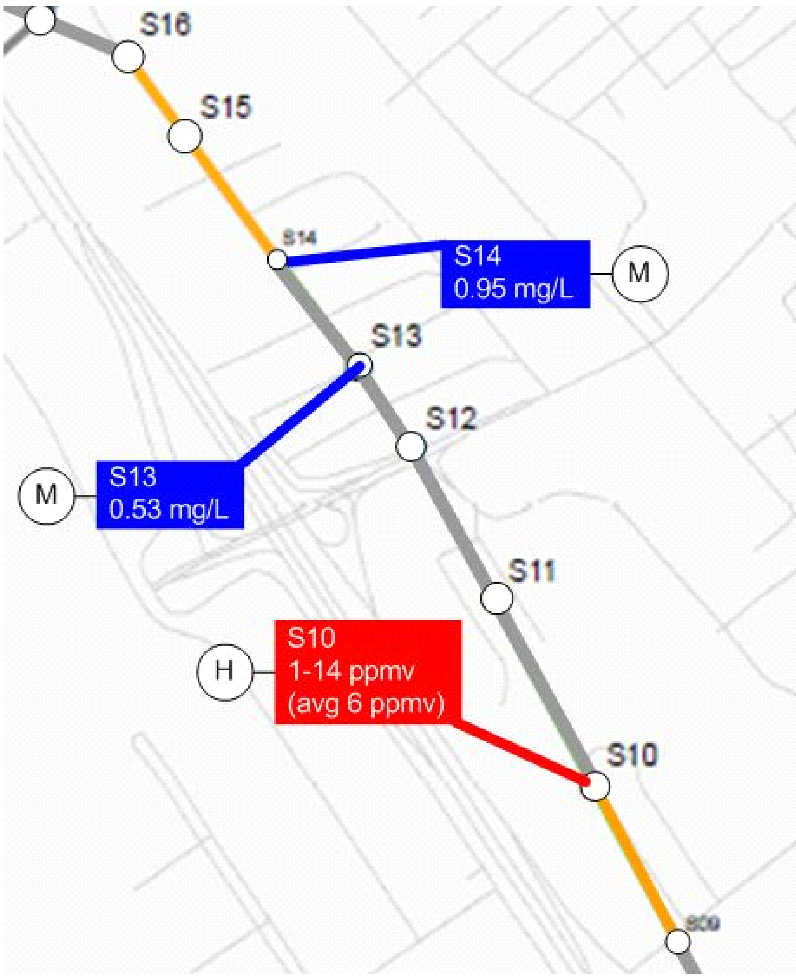
Hot Spot 6 (South Interceptor)

Manhole Range: S09-S16

Use Reach S09-S10 for comparison of life cycle costs (lowest calculated remaining life)



See Corrosion Rate Calculations table for calculations of projected corrosion rates and remaining pipe life

Three options for corrosion control:

Option 1: No corrosion prevention treatment, plastic liner rehab only

Option 2: Ferrous chloride injection in upstream manhole, no rehab in 50-year life cycle
Option 3: Caustic slug dosing in upstream manhole, no rehab in 50-year life cycle

Additional Option 1a: Use CIPP for rehabilitation for Pipe Severity "C" reaches

Additional Option 1b: Assume rehabilitation when concrete cover is 0 in instead of 0.25 in

Use Reach S09-S10 for comparison of life cycle costs (lowest calculated remaining life)

Calculate life cycle costs and determine optimal corrosion prevention solution and timing of improvements:

a. Life cycle cost of Option 1 (rehab only)

Rehab required at current corrosion rate in 37 years

Low cost barrier method in TM B.2 is plastic liner (sliplining not feasible due to hydraulic impacts)

Assume rehab of all "C" reaches will be completed

From Conceptual Cost Estimate Hot Spot 6: Capital cost of rehab is $6,154,000

Escalate to midpoint of construction (assume 5 years from calculated rehab required year, or +42 years)

Future worth factor = (1+i)^e

$$FWF_{rehabHS6Op1} := \left(1 + e_{factor}\right)^{42} = 3.461$$

$$CapCost_{HS6Op1} := FWF_{rehabHS6Op1} \cdot 6154000 \cdot dollars$$

$$CapCost_{HS4Op1} = 1.564 \times 10^{7} \cdot dollars$$

Calculate present worth cost:

Present worth factor = (1+i)^n   i =.05, n=42

$$PWF_{HS6Op1} := \left(1 + i_{rate}\right)^{42} = 7.762$$

$$PW_{HS6Op1} := \frac{CapCost_{HS6Op1}}{PWF_{HS6Op1}} = 2.744 \times 10^{6} \cdot dollars$$

b. Life cycle cost of Option 1a (rehab only, assume CIPP)

Rehab required at current corrosion rate in 37 years

Barrier method is CIPP

Assume rehab of all "C" reaches will be completed

From Conceptual Cost Estimate Hot Spot 6: Capital cost of rehab is $5,469,000

Escalate to midpoint of construction (assume 5 years from calculated rehab required year, or +42 years)

Future worth factor = (1+i)^e

$$FWF_{rehabHS6Op1a} := \left(1 + e_{factor}\right)^{42} = 3.461$$

$$CapCost_{HS6Op1a} := FWF_{rehabHS6Op1a} \cdot 5469000 \cdot dollars$$

$$CapCost_{HS4Op1a} = 2.165 \times 10^{7} \cdot dollars$$

Calculate present worth cost:

Present worth factor = (1+i)^n   i =.05, n=42

$$PWF_{HS6Op1a} := \left(1 + i_{rate}\right)^{42} = 7.762$$

$$PW_{HS6Op1a} := \frac{CapCost_{HS6Op1a}}{PWF_{HS6Op1a}} = 2.438 \times 10^{6} \cdot dollars$$

c. Life cycle cost of Option 1b (rehabilitation when concrete cover is 0 in instead of 0.25 in)

Rehab required at current corrosion rate in more than 50 years

Assuming rehabilitation at 0 in cover, no cost in 50-year life cycle (only regular monitoring)

d. Life cycle cost for Option 2 (liquid-phase treatment for 50 years, no rehab)

Capital Cost Estimate

From Conceptual Cost Estimate Hot Spot 6: Capital cost of ferrous chloride treatment is $596,500

$$PW_{HS6Op2C1} := 596500 = 5.96 \times 10^{5} \cdot dollars$$

Include an cost upgrade of the systemn of 50% of initial capital cost in 25 years

$$FeClUpgrade_{HS6} := .5 \cdot 596500 = 2.982 \times 10^{5}$$

$$PWF_{HS6Op2C2} := (1 + .05)^{25} = 3.386$$ i = .05, n = 25

$$FWF_{HS6Op2C2} := (1 + .03)^{25} = 2.094$$ e = .02, n = 25

$$PW_{HS6Op2C2} := \frac{\left(FeClUpgrade_{HS6} \cdot FWF_{HS6Op2C2}\right)}{PWF_{HS6Op2C2}} = 1.844 \times 10^{5}$$

$$PW_{HS6Op2C} := PW_{HS6Op2C1} + PW_{HS6Op2C2} = 7.809 \times 10^{5}$$

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 6: Yearly O&M cost of ferrous chloride treatment is $101,400

$$OMCost_{HS6Op2} := 101400$$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n   i = 0.05, n=50

$$PWF_{HS6Op2OM} := 18.256$$

$$PW_{HS6Op2OM} := OMCost_{HS6Op2} \cdot PWF_{HS6Op2OM} = 1.851 \times 10^{6} \cdot dollars$$

Life Cycle Cost Estimate

$$PW_{HS6Op2} := PW_{HS6Op2C} + PW_{HS6Op2OM} = 2.632 \times 10^{6} \cdot dollars$$

e. Life cycle cost for Option 3 (caustic slug dosing for 50 years, no rehab)

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 6: Yearly O&M cost of caustic slug dosing is $143,800

$$OMCost_{HS6Op3} := 143800$$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n i = 0.05, n=50

$$PWF_{HS6Op3OM} := 18.256$$

$$PW_{HS6Op3OM} := OMCost_{HS6Op3} \cdot PWF_{HS6Op3OM} = 2.625 \times 10^{6} \cdot dollars$$

Life Cycle Cost Estimate

$$PW_{HS6Op3} := PW_{HS6Op3OM} = 2.625 \times 10^{6} \cdot dollars$$

Recommendation:
The life cycle costs for rehabilitation using CIPP, liquid-phase treatment using ferrous chloride, and caustic slug dosing are effectively identical, within a reasonable margin of error. Therefore, recommend continuing to monitor this hot spot and schedule rehabilitation in approximately 37 years.

C.4 Hot Spot 7 Conceptual Scope Description

The reach of pipe downstream of the discharge line for Pump Station "H" (Manhole S21) through the connection with the Pump Station "J" discharge point (Manhole S31) represent a corrosion hot spot location due to historical (2008) moderate liquid-phase sulfide concentrations and because several reaches in the segment were designated as Pipe Severity "C" in the 2010-2012 Condition Assessment. The location of the hot spot is shown in Figure C-4.

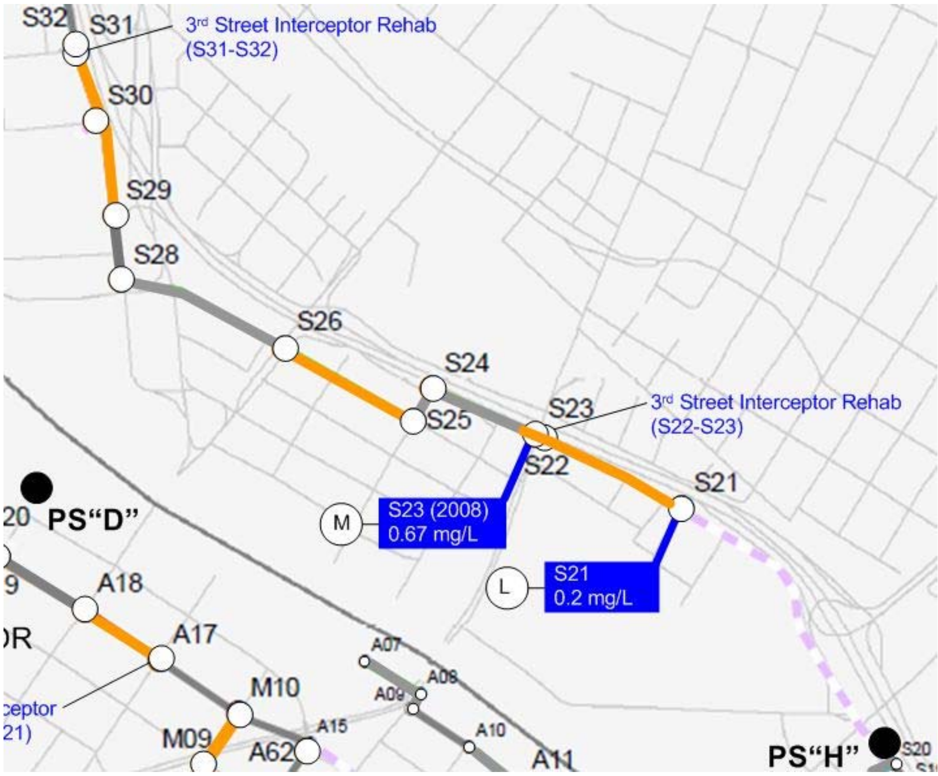


Figure C-4. Hot Spot 7 (South Interceptor): S21-S31

Four alternatives are considered for corrosion control for this hot spot:

1. Rehabilitate Pipe Severity "C" reaches when corrosion levels are at Pipe Severity "D" status in the reach with the least amount of remaining life (identified as the critical reach) before being classified as Pipe Severity "D" for corrosion.
2. Install chemical dosing facilities (ferrous chloride) at Pump Station "H" for sulfide reduction in both hot spots, which would delay the need for rehabilitation of the "C" reaches in the hot spot.
3. Inject caustic slugs into Pump Station "H" every 1-2 weeks to inactivate the slime layer and reduce sulfide accumulation in both hot spots. This would delay the need for rehabilitation of the "C" reaches in the hot spot.

4. Install oxygen injection at Pump Station “H”, which would delay the need for rehabilitation of the Pipe Severity “C” reaches and would also lower the liquid-phase sulfide load to the MWWTP (reducing odor control requirements at the upstream processes in the MWWTP).

Following is a summary of the scope of each option:

- **Rehabilitation Only:** Corrosion rate calculations are provided that estimate the number of years into the future that remain, under current sulfide loads, before Critical Reach S21-S22 becomes Pipe Severity “D” status, at which time rehabilitation would be needed. Rehabilitation using a plastic liner and cured-in-place pipe (CIPP) are considered as viable options. The number of years before rehabilitation is needed is noted for when the pipe has 0.25 inches of cover remaining and 0 inches of cover remaining. Capital costs are estimated for a plastic liner and CIPP based upon BC experience. No O&M costs are assumed for this option.
- **Chemical Dosing:** One ferrous chloride injection facility would be constructed at Pump Station “H” that would delay the rehabilitation of the Pipe Severity “C” reaches in both hot spots. The facility would include one 10,000-gallon storage tank, chemical metering pumps, piping, and miscellaneous equipment (capital costs). Future capital costs would include installing a plastic liner or CIPP in all Pipe Severity “C” reaches in the hot spot. Annual O&M costs would include costs for chemicals, regular maintenance, and H_2S monitoring to confirm effectiveness.
- **Caustic Slug Dosing:** Would include injection of 50 percent caustic solution for 60 minutes weekly (to be confirmed using pilot testing) to delay the rehabilitation of the Pipe Severity “C” reaches. Caustic solution would be injected at Pump Station “H”. Future capital costs would include installing a plastic liner or CIPP in all Pipe Severity “C” reaches in the hot spot. Annual O&M costs would include costs for caustic deliveries and associated labor, regular maintenance, and H_2S monitoring to confirm effectiveness.
- **Oxygen Injection:** Pure oxygen is injected into the Pump Station “H” wet well to elevate dissolved oxygen concentrations and lower the dissolved sulfide concentration to approximately zero and leave dissolved oxygen residual at the pressure pipe discharge. A VSA on-site oxygen generator is assumed for the capital cost estimate. Estimated capital and annual O&M costs for the superoxygenation system are taken from a budgetary cost proposal provided by ECO2 (Eco Oxygen Technologies, LLC), which is included in Attachment D.

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East Bay Municipal Utility District - Corrosion Assessment Project
Corrosion Rate Calculations
January 2014

Hot Spot 7 (South Interceptor)

Pipe Severity "C" Reaches	Condition	Pipe Dia (in)	Reach Slope	Flow (mgd)	Velocity (ft/s) [1]	pH	J [2]	b/p' [3]	Incomplete Acid Reaction Factor (k)	Concrete Alkalinity (mg/L as CaCo3)	Estimated Current Pipe Wall Cover (in)	2013 Dissolved Sulfide (mg/L)	H2S Flux (g/m2 hr) [4]	Avg Corrosion Rate (in/yr)	Max Concrete Cover (in)	Available Cover (in)	Years before Critical Pipe Cover (yr)
S21-S22	Baseline	57	0.001	12.08	1.04	6.8	0.61	0.637	0.7	0.23	0.5	0.50	0.0067	0.0091	0.25	0.25	27.4
S21-S22	Baseline (Alt)	57	0.001	12.08	1.04	6.8	0.61	0.637	0.7	0.23	0.5	0.50	0.0067	0.0091	0	0.50	54.9
S25-S26	Baseline	63	0.001	13.62	0.79	7.0	0.50	0.637	0.7	0.23	0.5	0.50	0.0049	0.0067	0.25	0.25	37.1
S27-S28	Baseline	66	0.001	13.95	0.81	7.0	0.50	0.637	0.7	0.23	0.5	0.50	0.0050	0.0068	0.25	0.25	36.8
S28-S29	Baseline	66	0.001	13.95	0.81	7.0	0.50	0.637	0.7	0.23	0.5	0.50	0.0050	0.0068	0.25	0.25	36.8
S29-S30	Baseline	66	0.001	14.18	0.81	7.0	0.50	0.637	0.7	0.23	0.5	0.50	0.0050	0.0068	0.25	0.25	36.8
S21-S22 (mod)	FeCl2 Dosing	57	0.001	12.08	1.04	6.8	0.61	0.637	0.7	0.23	0.5	0.20	0.0027	0.0036	0.25	0.25	68.6
S21-S22 (mod)	Oxygen	57	0.001	12.08	1.04	6.8	0.61	0.637	0.7	0.23	0.5	0.10	0.0013	0.0018	0.25	0.25	137.2
S21-S22 (mod)	Caustic Slug	57	0.001	12.08	1.04	6.8	0.61	0.637	0.7	0.23	0.5	0.50	0.0019	0.0026	0.25	0.25	96.0

IDAP Year	1997
Current Year	2013
Design Year	2063

FeCl2 Dosing Life Extension	41.2	yr
Oxygen Injection Life Extension	109.7	yr
Caustic Slug Dosing Life Extension	68.6	yr

Caustic Slug Dosing Activity 0.286 Fraction of days of normal sulfide activity (10 out of 14 days slime layer is assumed inactive)

Unit Conversions:

1 ft3 = 7.48502 gal
1 day = 86400 sec

= Critical Reach (used in Cost Estimates)

Notes:
1 - From updated sulfide accumulation model
2 - From ASCE MOP 69 Table 6-5 (function of pH)
3 - From ASCE MOP 69 Table 6-4

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South Interceptor Chemical Dose Requirements

Hot Spot 7 (S21-S31)

Chemical	Liquid Sulfide Concentration (mg/L)		Target Sulfide Flow Rate (lb/day)	Dose Ratio		Dose Requirement		Cost ($/gal)	Cost ($/lb)	Annual Chemical or Power Cost	Chemical Properties	
	Initial	Target				lb/day	gal/day				Density (lb/gal)	Strength
Hypochlorite	1.0	0.0	0.0	13	lb / lb H2S	786	540	0.75	0.40	$115,000	9.7	0.15
Hydrogen Peroxide	1.0	0.0	0.0	4	lb / lb S	484	97	4.00		$141,000	10	0.5
Ferrous Chloride	1.0	0.15	14.5	10	lb / lb S	1,064	355	0.75	0.33	$126,000	10	0.3
Calcium Nitrate	1.0	0.0	0.0	10	lb / lb S formed	1,209	167	3.00		$182,000	12.1	0.6
Magnesium Hydroxide	1.0	N/A	N/A	75	L / ML wastewater	N/A	871	1.50		$477,000		
Oxygen Addition	1.0	N/A	N/A							$17,400		

Pipe Diameter: 57-66 in
Rehab "C" reaches only

Method	Interceptor Length (LF)	Construction Cost ($/ LF)	Construction Cost
Oxygen Addition	2,711		$415,000
Sliplining	2,711	$928	$2,516,000
Plastic Liner	2,711	$1,289	$3,494,000

Ferrous Chloride Chemical Injection

360	gpd (with safety factor)
10,800	gal for 30-day storage

Assume 10,000-gal 12-ft diameter tank

Caustic Slug Dosing

10.8	MGD (assume injection at PS "H")
150	gal 50% NaOH per MGD per week (per ASCE MOP 69)
1,617.0	gal 50% NaOH per week
12.7	lb/gal density of 50% NaOH at 25 degrees C
20,536	lb 50% NaOH per week
10.3	tons 50% NaOH per week
$500	/ton 50% NaOH
$5,000	per week
$260,000	**per year**

Brown AND Caldwell

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 7: Rehab of "C" Reaches

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Civil and Structural Costs Total					**$0**
Mechanical Costs					
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
Sliplining Installation for "C" Reaches	Similar projects, IDAP	1	LS		$2,516,000
Construction Cost Subtotal					$2,516,000
Contingencies	35% of Subtotal			35%	**$881,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$3,397,000**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$1,529,000**
TOTAL CAPITAL COST ESTIMATE					**$4,926,000**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost					$0
Caustic Slug Dosing Annual Cost					$0
Crown Spraying Annual Cost					$0
Monitoring Cost					$0
TOTAL YEARLY O&M COST ESTIMATE					**$0**

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 7: Ferrous Chloride Chemical Treatment System

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Site Preparation		1	LS	$30,000	$30,000
Concrete		30	CY	$125	$3,750
Rebar		2.0	TON	$1,250	$2,500
Concrete Coating		1	LS	$10,000	$10,000
Civil and Structural Costs Total					**$46,250**
Mechanical Costs					
Cross-Linked HDPE Double-Wall Tank (10,000 gal)		1	LS	$50,000	$50,000
Chemical Metering Pumps		1	LS	$60,000	$60,000
Piping and Pipe Supports		1	LS	$10,000	$10,000
Miscellaneous Equipment (ladder, eyewash, shower, etc)		1	LS	$10,000	$10,000
Mechanical Cost Total					**$130,000**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$19,500**
Equipment Cost Total					**$195,750**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$117,450**
Barrier Installation Costs					
None					
Construction Cost Subtotal					$313,200
Contingencies	35% of Subtotal			35%	**$110,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$423,200**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$190,000**
TOTAL CAPITAL COST ESTIMATE					**$613,200**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT		Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost		Sampling, flow rate				$126,000
O&M Annual Cost			750	HR	$80	$60,000
Monitoring Cost						
	OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
	Operator Labor	Similar Projects	192	HR	$80	$15,360
	Total Monitoring Cost					**$18,360**
TOTAL YEARLY O&M COST ESTIMATE						**$204,400**

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 7: Caustic Slug Dosing Treatment System

CAPITAL COST ESTIMATE

CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Site Preparation					$0
Concrete					$0
Rebar					$0
Concrete Coating					$0
Civil and Structural Costs Total					**$0**
Mechanical Costs					
					$0
					$0
					$0
					$0
Mechanical Cost Total					**$0**
Electrical and Instrumentation	15% of Mechanical Cost			15%	**$0**
Equipment Cost Total					**$0**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$0**
Barrier Installation Costs					
None					
Construction Cost Subtotal					$0
Contingencies	35% of Subtotal			35%	**$0**
TOTAL CONSTRUCTION COST ESTIMATE					**$0**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$0**
TOTAL CAPITAL COST ESTIMATE					**$0**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Chemical Cost					$0
Caustic Slug Dosing Annual Cost	ASCE MOP 69 Guidance				$260,000
Caustic Slug Dosing Annual O&M Cost		200	HR	$80	$16,000
Monitoring Cost					
OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
Operator Labor	Similar Projects	260	HR	$80	$20,800
Total Monitoring Cost					**$23,800**
TOTAL YEARLY O&M COST ESTIMATE					**$299,800**

EBMUD Corrosion Control
Conceptual Cost Estimate
Hot Spot 7: Oxygen Injection System

CAPITAL COST ESTIMATE

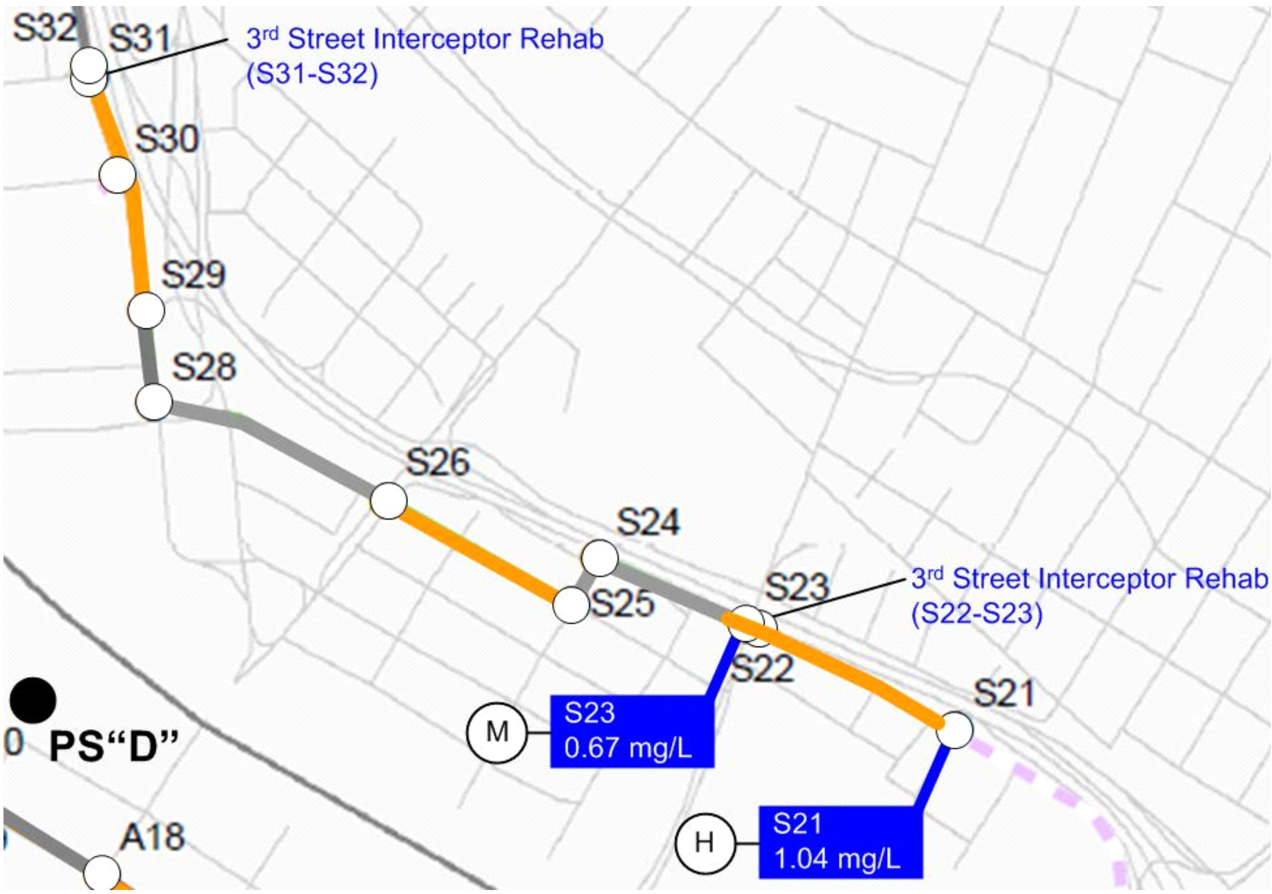
CONSTRUCTION COSTS	Cost Basis	Quantity	Units	Unit Cost	Total Cost
Civil and Structural Costs					
Site Preparation		1	LS	$20,000	$20,000
Concrete		10	CY	$125	$1,250
Rebar		1.0	TON	$1,250	$1,250
Concrete Coating		1	LS	$5,000	$5,000
Civil and Structural Costs Total					**$27,500**
Mechanical Costs					
ECO2 System	Quote	1	LS	$415,000	$415,000
Additional oxygen system equipment	estimate	1	LS	$5,000	$5,000
Mechanical Cost Total					**$420,000**
Electrical and Instrumentation	Included in Quote				**$0**
Equipment Cost Total					**$447,500**
Installation, Start-Up, and Commissioning	60% of Equipment Cost			60%	**$268,500**
Barrier Installation Costs					
None					
Construction Cost Subtotal					$716,000
Contingencies	35% of Subtotal			35%	**$251,000**
TOTAL CONSTRUCTION COST ESTIMATE					**$967,000**
Planning, Engineering, and CM	45% of Construction Cost			45%	**$435,000**
TOTAL CAPITAL COST ESTIMATE					**$1,402,000**

YEARLY OPERATION & MAINTENANCE COST ESTIMATE

COST ELEMENT					
Chemical Cost					$0
O&M Annual Cost		100	HR	$80	$8,000
Oxygen System Electrical & Maintenance Costs (Quote)					$20,900
Monitoring Cost					
OdaLog Rental	Supplier Contact	12	WK	$250	$3,000
Operator Labor	Similar Projects	24	HR	$80	$1,920
Total Monitoring Cost					**$4,920**
TOTAL YEARLY O&M COST ESTIMATE					**$33,800**

Hot Spot 7 (South Interceptor)

Manhole Range: S21-S31



Use Reach S21-S22 for comparison of life cycle costs (lowest calculated remaining life)

Four options for corrosion control:

Option 1: No corrosion prevention treatment, rehab only for Pipe Severity "C" reaches
Option 2: Ferrous chloride injection into Pump Station "H", no rehab in 50-year life cycle
Option 3: Caustic slug dosing into Pump Station "H", no rehab in 50-year life cycle
Option 4: Oxygen injection at Pump Station "H", no rehab in 50-year life cycle

Calculate life cycle costs and determine optimal corrosion prevention solution and timing of improvements:

a. Life cycle cost of Option 1 (rehab only)

Rehab required at current corrosion rate in 27 years

Assume rehab of all "C" reaches will be completed

Low-cost barrier method in TM B.2 is sliplining

From Conceptual Cost Estimate Hot Spot 7: Capital cost of rehab is $4,926,000

Escalate to midpoint of construction (assume 5 years from calculated rehab required year, or +32 years)

Future worth factor = (1+i)^e

$$FWF_{rehabHS7Op1} := \left(1 + e_{factor}\right)^{32} = 2.575$$

$$CapCost_{HS7Op1} := FWF_{rehabHS7Op1} \cdot 4926000 \cdot dollars$$

$$CapCost_{HS7Op1} = 1.268 \times 10^{7} \cdot dollars$$

Calculate present worth cost:

Present worth factor = (1+i)^n   i =.05, n=32

$$PWF_{HS7Op1} := \left(1 + i_{rate}\right)^{32} = 4.765$$

$$PW_{HS7Op1} := \frac{CapCost_{HS7Op1}}{PWF_{HS7Op1}} = 2.662 \times 10^{6} \cdot dollars$$

b. Life cycle cost for Option 2 (chemical addition for 50 years, no rehab)

<u>Capital Cost Estimate</u>

From Conceptual Cost Estimate Hot Spot 7: Capital cost of ferrous chloride treatment is $613,200

$$PW_{HS7Op2C1} := 613200 = 6.13 \times 10^{5} \cdot dollars$$

Include an upgrade cost of the system of 50% of initial capital cost in 25 years

$FeClUpgrade_{HS7} := 613200 \cdot .5 = 3.066 \times 10^{5}$ dollars

$PWF_{HS7Op2C2} := (1 + .05)^{25} = 3.386$ i = 0.05, n = 25

$FWF_{HS7Op2C2} := (1 + .03)^{25} = 2.094$ e = 0.03, n = 25

$PW_{HS7Op2C2} := FeClUpgrade_{HS7} \cdot \frac{FWF_{HS7Op2C2}}{PWF_{HS7Op2C2}} = 1.896 \times 10^{5}$ dollars

$PW_{HS7Op2C} := PW_{HS7Op2C1} + PW_{HS7Op2C2} = 8.028 \times 10^{5}$ dollars

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 7: Yearly O&M cost of ferrous chloride treatment is $204,400

$OMCost_{HS7Op2} := 204400$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n i = 0.05, n=50

$PWF_{HS7Op2OM} := 18.256$

$PW_{HS7Op2OM} := OMCost_{HS7Op2} \cdot PWF_{HS7Op2OM} = 3.732 \times 10^{6} \cdot \text{dollars}$

Life Cycle Cost Estimate

$PW_{HS7Op2} := PW_{HS7Op2C} + PW_{HS7Op2OM} = 4.534 \times 10^{6} \cdot \text{dollars}$

c. Life cycle cost for Option 3 (caustic slug dosing for 50 years, no rehab)

Annual O&M Cost Estimate

From Conceptual Cost Estimate: Yearly O&M cost of caustic slug dosing is $299,800

$OMCost_{HS7Op3} := 299800$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n i = 0.05, n=50

$PWF_{HS7Op3OM} := 18.256$

$PW_{HS7Op3OM} := OMCost_{HS7Op3} \cdot PWF_{HS7Op3OM} = 5.473 \times 10^{6} \cdot \text{dollars}$

Life Cycle Cost Estimate

$PW_{HS7Op3} := PW_{HS7Op3OM} = 5.473 \times 10^{6} \cdot \text{dollars}$

e. Life cycle cost of Option 4 (oxygen injection at PS "H" for 50 years, no rehab)

Capital Cost Estimate

From Conceptual Cost Estimate Hot Spot 7: Capital cost of oxygen system is $1,402,000

$$PW_{HS7Op4C1} := 1402000 \cdot dollars = 1.402 \times 10^{6} \cdot dollars$$

Include an upgrade cost of the system of 50% of initial capital cost in 25 years

$$O2Upgrade_{HS7} := 1402000 \cdot 0.5 = 7.01 \times 10^{5} \cdot dollars$$

$$PWF_{HS7Op4C2} := 1.05^{25} = 3.386$$

$$FWF_{HS7Op4C2} := 1.03^{25} = 2.094$$

$$PW_{HS7Op4C2} := \frac{O2Upgrade_{HS7} \cdot FWF_{HS7Op4C2}}{PWF_{HS7Op4C2}} = 4.334 \times 10^{5} \cdot dollars$$

$$PW_{HS7Op4C} := PW_{HS7Op4C1} + PW_{HS7Op4C2} = 1.835 \times 10^{6} \cdot dollars$$

Annual O&M Cost Estimate

From Conceptual Cost Estimate Hot Spot 7: Yearly O&M cost of oxygen system is $33,800

$$OMCost_{HS7Op4} := 33800$$

Present worth factor = [((1+i)^n)-1]/(i*(1+i)^n   i = 0.05, n=50

$$PWF_{HS7Op4OM} := 18.256$$

$$PW_{HS7Op4OM} := OMCost_{HS7Op4} \cdot PWF_{HS7Op4OM} = 6.17 \times 10^{5} \cdot dollars$$

Life Cycle Cost Estimate

$$PW_{HS7Op4} := PW_{HS7Op4C} + PW_{HS7Op4OM} = 2.452 \times 10^{6} \cdot dollars$$

Recommendation:

The life cycle cost for oxygen addition is the lowest of the four options considered, and installation of an oxygen injection system would result in no rehabilitation in the 50-year life cycle. Therefore, recommend installation of an oxygen injection system at Pump Station "H".

Chemical Dose Requirements

Pump Station "R"

Chemical	Liquid Sulfide Concentration (mg/L)		Target Sulfide Flow Rate (lb/day)	Dose Ratio		Dose Requirement		Cost ($/gal)	Cost ($/lb)	Annual Chemical or Power Cost	Chemical Properties	
	Initial	Target				lb/day	gal/day				Density (lb/gal)	Strength
Hypochlorite	2.52	0.0	0.0	13	lb / lb H2S	34	24	0.75	0.40	$5,000	9.7	0.15
Hydrogen Peroxide	2.52	0.0	0.0	4	lb / lb S	24	5	4.00		$7,000	10	0.5
Ferrous Chloride	2.52	0.2	0.467	10	lb / lb S	54	18	0.75	0.33	$6,000	10	0.3
Calcium Nitrate	2.52	0.0	0.0	10	lb / lb S formed	59	8	3.00		$9,000	12.1	0.6

Method	Interceptor Length (LF)	Construction Cost ($/ LF)	Construction Cost	Planning, Design, CM (45% of Construction Cost)	Capital Cost	Capital Cost (Rounded)
Oxygen Addition			$415,000	$186,750	$601,750	$601,800
Sliplining	3,793	$490	$1,857,000	$835,700	$2,692,700	$2,693,000
Plastic Liner	3,793	$684	$2,594,000	$1,167,300	$3,761,300	$3,761,000

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Attachment D: Pump Station “H” Oxygen Layouts and ECO2 Budgetary Cost Proposal

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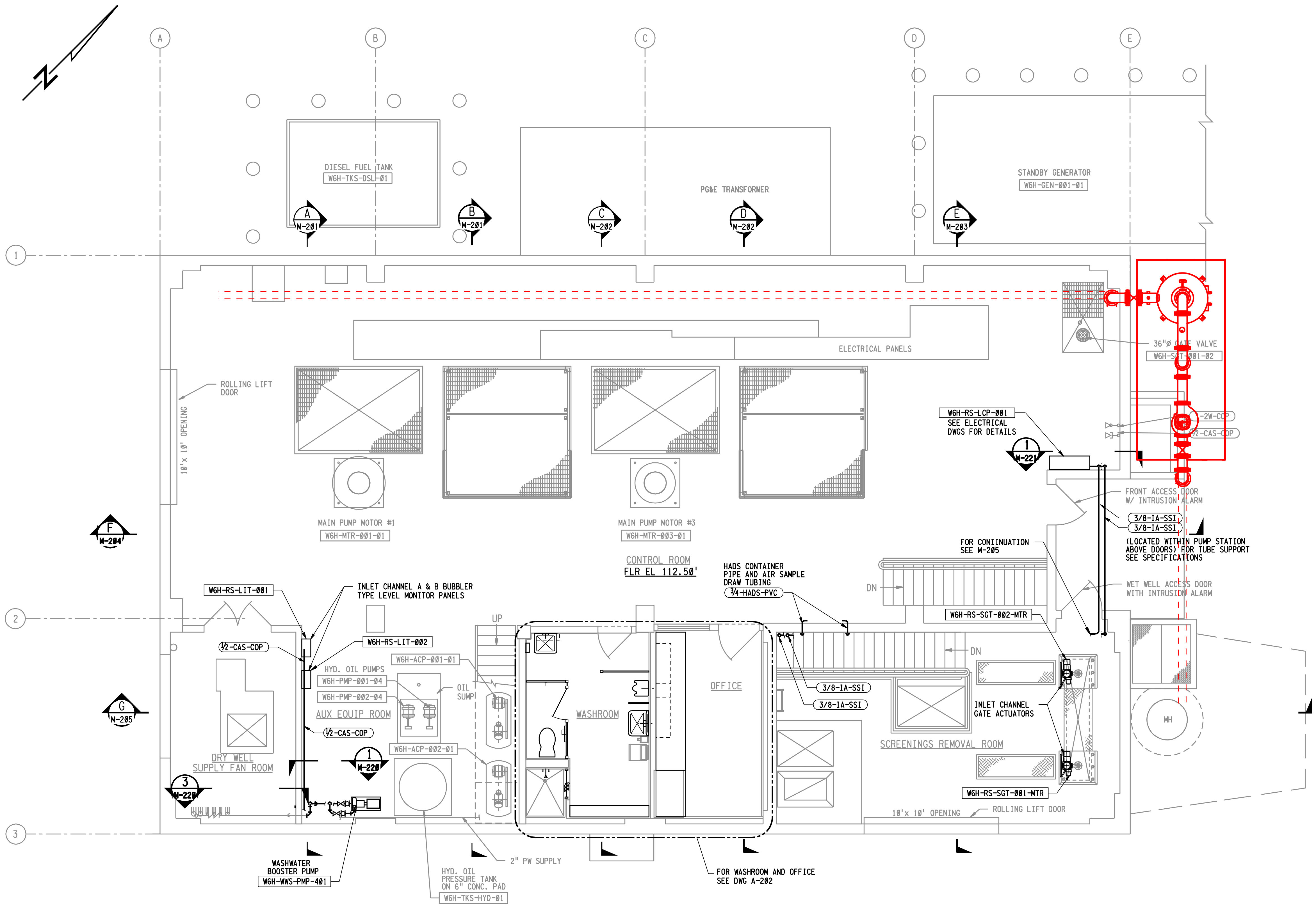

GROUND LEVEL FLOOR PLAN

SCALE: 1/4"=1'-0"

3" ON ORIGINAL DOCUMENT

0 1 2 3

PORTION OF: SP-448-G (SD52)

A COPY OF THE ORIGINAL DRAWING CAN BE FOUND IN THE WASTEWATER DRAFTING UNIT

NO.	DATE	REVISION	BY	REC.	APP.
A	01DEC2010	REVISED AND RENUMBERED DWG PER SD256			GPM

REGISTERED PROFESSIONAL ENGINEER
KARL J. YAKICH
No. C31427
Exp. 06/30/12
CIVIL
STATE OF CALIFORNIA
12/1/2010

SD256 - WASTEWATER PUMP STATION H REHABILITATION - PHASE I

DESIGN	DESIGN BY:	---
	DRAWN BY:	R. MOJICA
REVIEW	DESIGN CHECKED BY: R.P.E. No.	---
	CONSTRUCTABILITY CHECKED BY:	---
	ELECTRICAL CHECKED BY: R.P.E. No.	---
	PROJECT ENGINEER R.P.E. No.	---
	PROJECT MANAGER R.P.E. No.	---
	RECOMMENDED: SR. ENGINEER R.P.E. No.	---

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT NO. 1
OAKLAND, CALIFORNIA

PUMP STATION H

MECHANICAL
GROUND LEVEL FLOOR PLAN

SHEET NO. 51

SCALE AS SHOWN
DATE 03MAY1950

W6H-M-103
DRAWING NUMBER

REV. 0

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REF 7:
REF 8:
REF 9:

PLOT SCALE: 8:1

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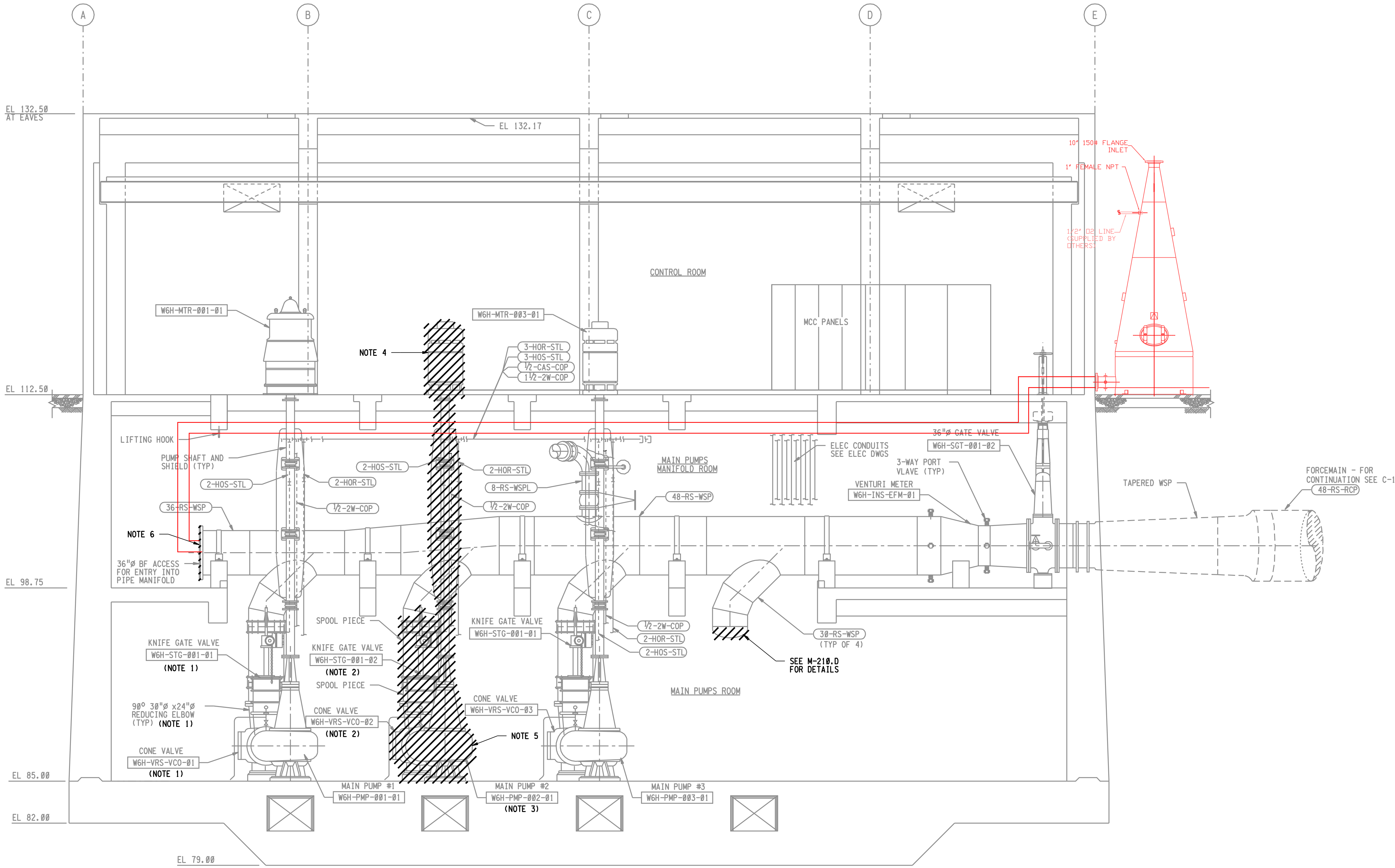

DEMOLITION NOTES

1. MECHANICAL EQUIPMENT NOT FULLY SHOWN (TYP).
2. SEE NOTE 4, M-101.D.
3. SEE NOTE 6, M-101.D.
4. SEE NOTES 2 AND 3, M-103.D.
5. CUT AND CAP ½"Ø CU 2W PIPE AT WALL.
6. SEE NOTE 4, M-102-D.

SECTION F
SCALE: 1/4"=1'-0"
M-101.D, M-102.D, M-103.D

3" ON ORIGINAL DOCUMENT
0 1 2 3

REGISTERED PROFESSIONAL ENGINEER KARL J. YAKICH No. C37427 Exp. 06/30/12 CIVIL STATE OF CALIFORNIA
12/1/2010

NO.	DATE	REVISION	BY	REC.	APP.

SD256 - WASTEWATER PUMP STATION H REHABILITATION - PHASE I

DESIGN BY:	K. YAKICH
DRAWN BY:	R. MOJICA
DESIGN CHECKED BY: R.P.E. No. C65259	GARIN D WARREN
CONSTRUCTABILITY CHECKED BY:	DONALD R SPOTTS
ELECTRICAL CHECKED BY: R.P.E. No.	---
PROJECT ENGINEER R.P.E. No. C37427	KARL J YAKICH
PROJECT MANAGER R.P.E. No. C37427	KARL J YAKICH
RECOMMENDED: SR. ENGINEER R.P.E. No. C65259	GARIN D WARREN

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT NO. 1
OAKLAND, CALIFORNIA

PUMP STATION H

MECHANICAL
DEMOLITION
LONGITUDINAL SECTION F

SHEET NO. 37

SCALE AS SHOWN
DATE 01DEC2010
W6H-M-204.D
DRAWING NUMBER
REV. 0

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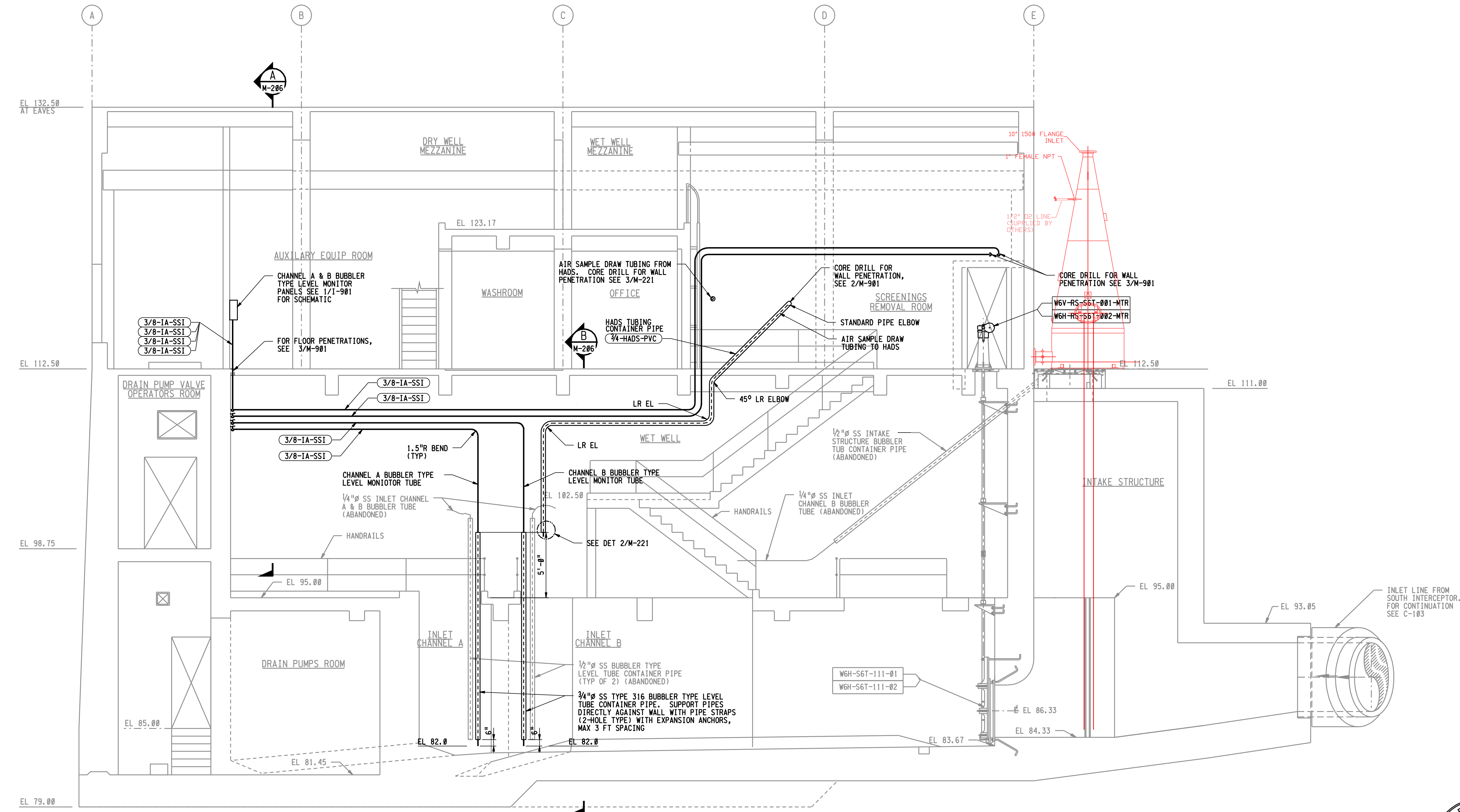

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NOTES

1. FOR PIPE SUPPORTS, SEE TYPE B 6/M-901.
2. FOR TUBE SUPPORTS, SEE SPECFICATIONS.

SECTION G

SCALE: 1/4"=1'-0" M-101, M-102, M-103

3" ON ORIGINAL DOCUMENT

0 1 2 3

REGISTERED PROFESSIONAL ENGINEER
KARL J. YAKIC
No. C31427
Exp. 06/30/12
CIVIL
STATE OF CALIFORNIA
12/1/2010

FORMERLY KNOWN AS: SP-451-G (SD52)

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NO.	DATE	REVISION	BY	REC.	APP.
0	01DEC2010	REVISED AND RENUMBERED DWG PER SD256			

SD256 - WASTEWATER PUMP STATION H REHABILITATION - PHASE I

DESIGN	DESIGN BY:	---
	DRAWN BY:	R. MOJICA
REVIEW	DESIGN CHECKED BY: R.P.E. No.	---
	CONSTRUCTABILITY CHECKED BY:	---
	ELECTRICAL CHECKED BY: R.P.E. No.	---
	PROJECT ENGINEER R.P.E. No.	---
	PROJECT MANAGER R.P.E. No.	---
	RECOMMENDED: SR. ENGINEER R.P.E. No.	---

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT NO. 1
OAKLAND, CALIFORNIA

PUMP STATION H

MECHANICAL
LONGITUDINAL SECTION G

SHEET NO. 56

SCALE AS SHOWN
DATE 09MAY1949

W6H-M-205
DRAWING NUMBER

REV. 0

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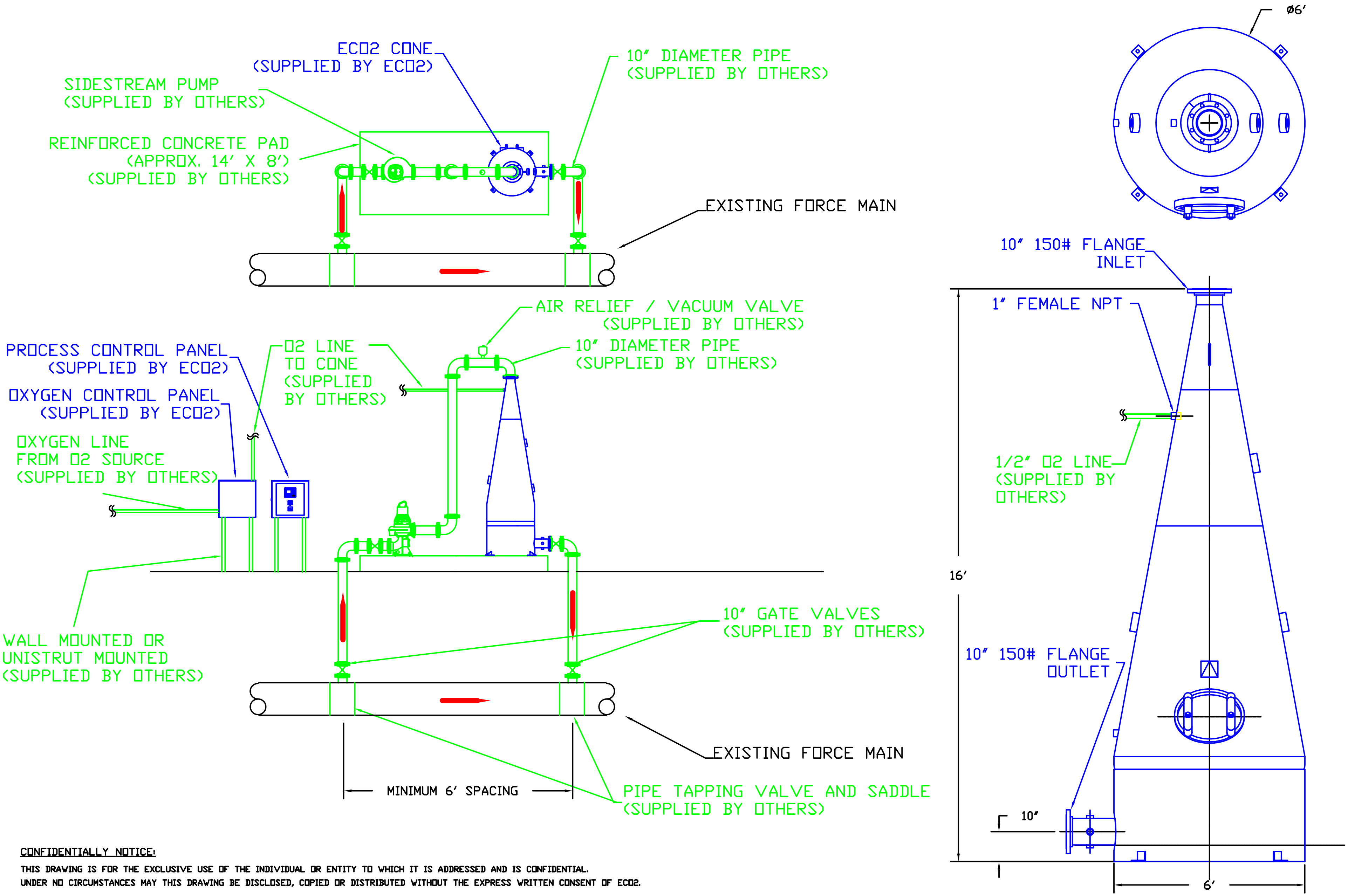

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ECO OXYGEN TECHNOLOGIES
3939 PRIORITY WAY SOUTH DRIVE, SUITE 400
INDIANAPOLIS, INDIANA 46240
(317) 706-6484 FAX (317) 816-0940
www.eco2tech.com

ECO2 SYSTEM
TYPICAL FORCE MAIN INSTALLATION
6 FT CONE

DRAWING:
SHEET: 1 OF 1
DATE:
SCALE:
PROJECT NO:

FORCE MAINS • PRIMARY CLARIFIER • HEAD WORKS • D.O. DISCHARGE / TMDL • LAKE AND RIVER OXYGENATION

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Odor and Corrosion Control
By
SuperOxygenation

EBMUD
Force Mains leading into Interceptors

January 31, 2014

3939 Priority Way South Drive, Suite 400 Indianapolis, IN 46240 317.706.6484 Fax: 317.816.0940 www.eco2tech.com

January 31, 2014

David McEwen, PE
Brown and Caldwell
Walnut Creek, CA
DMcEwen@brwncald.com

Dear Dave:

ECO_2 is pleased to provide you with a design and proposal for three SuperOxygenation Systems that will raise the D.O. level in the force mains to prevent anaerobic conditions and the formation of sulfides. The dissolved oxygen will also oxidize any existing dissolved sulfides in the wastewater and can therefore be used to reduce those before they are discharged into the interceptor that experiences odors and corrosion damage. The result of the SuperOxygenation Systems will be the elimination of H_2S, effectively preventing odor and corrosion at the discharge of the force mains.

ECO_2 is the market leader in SuperOxygenation with over 10 years of experience and more than 30 successfully operating systems in the water and wastewater industry. Our systems distinguish themselves through robust design with few moving parts and wide openings, capable of passing raw wastewater. This makes ECO_2 the number one choice for reliable and effective odor prevention in long force mains, upstream of headworks and primary clarifiers.

We thank you for the opportunity to provide a proposal. Please contact us with any questions you may have. We look forward to working with you on this project.

Best regards,

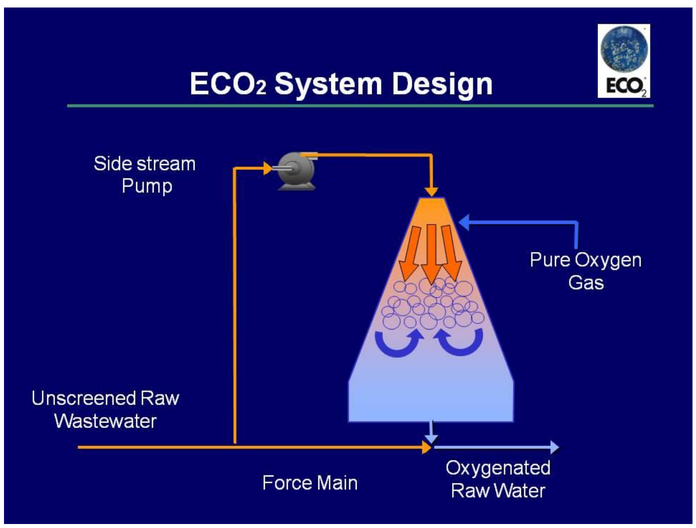
Inken Mello

Inken Mello
Director of Sales & Marketing
Eco Oxygen Technologies, LLC
Phone: 858-272-7102
e-mail: imello@eco2tech.com

I. ECO_2 SYSTEM DESCRIPTION

ECO_2 System Design

ECO_2's technology is based on Henry's Law and works by trapping pure oxygen bubbles inside the ECO_2 cone until they are dissolved. The system operates by pumping a side stream of water through a conical shaped oxygen transfer reactor, also known as the Speece Cone. Gaseous oxygen is fed into the cone and broken up into an intense bubble swarm by the velocity of the wastewater. The cone shape design provides sufficient contact time for the oxygen to fully dissolve in the water. The cone achieves an average oxygen transfer efficiency of 95%.



Odor Control with ECO_2

Sulfides are produced by Sulfate Reducing Bacteria only under anaerobic conditions in a sewer. By adding a sufficient amount of D.O. to the sewer, the ECO_2 System maintains aerobic conditions and with this, PREVENTS the formation of sulfides and H_2S in the sewer. The results are consistently near non-detect levels of H_2S at the discharge of the force main.

Corrosion Control with ECO_2

When gaseous H_2S reaches the surface of the sewer infrastructure, Thiobacillus thiooxidans bacteria oxidize H_2S to sulfuric acid (H_2SO_4), which quickly and tenaciously corrodes concrete and steel. According to the ASCE Manual for manhole rehab, H_2S concentrations of 20ppm corrode concrete at a rate of 1 inch per 5 years.
It is therefore crucially important to not just reduce sulfide concentrations, but to eliminate the formation of sulfides, in order to achieve effective corrosion control.

II. ECO_2 BASIS OF DESIGN

The design is based on data provided by Brown and Caldwell as outlined in the table below. It accounts for 1mg/L of existing sulfides in the wastewater and provides for a slight positive DO at the discharge.

ECO_2 System Construction

The ECO_2 System consists of a hollow, stainless steel cone with no internal mixers, baffles or moving parts. The influent and effluent pipes are a minimum of 4'' diameter, capable of passing dirty wastewater without clogging. The dish-shaped bottom with the discharge pipe at the low point provides for a self-cleaning device with no need for maintenance.

The ECO_2 System has a life expectancy of 20+ years. The oxygen feed is fully automated. The only moving part is the side stream pump that requires standard maintenance.

III. ECO_2 PROPOSAL

Capital Cost

Capital Costs of the required systems are outlined in the table below. Each system is equipped with a PLC controlled oxygen flow control system that fully automates the oxygen feed rate depending on the actual force main flow. A sidestream pump is required to pump a continuous sidestream through the ECO_2 System.
An oxygen source is required and a cost estimate for a VSA On-site Oxygen Generator is included in the proposal. Alternatively, liquid oxygen can be brought to each site by a local gas supplier. This would eliminate the capital cost for the oxygen generator. Prices would have to be confirmed locally.

Anticipated O&M Costs

Each system operates a sidestream pump that requires standard maintenance. The electrical draw for the pump and the oxygen generator are outlined in the table below along with an estimate for maintenance of 20% of the operating costs.
The oxygen generator generates oxygen on demand. It is operated on a VFD and will automatically turn down when the demand is low, resulting in a very energy efficient operation.

Force Main	PS “M”	PS “C” [1)]	PS “H” South	PS “R”
Basis of Design				
Average Daily Flow (gpm)	845	1,500	8,120	153
Pump Flow Rate (gpm)	3,000	1,500		2,153
Pump Operation (Fill/Draw, Continuous)	F/D	Continuous	Continuous	F/D
Force Main Length (ft)	8,042	4,100	2,227	8,000
Force Main Diameter (inches)	24[1)]	24	48	20
Available Pressure, TDH (ft of head)	60[2)]	40	20	40
Available static head (ft of head)	10	10	0	10
Maximum HRT (hrs)	4	2	1	16
Required amount of O_2 (lbs/day)	**525**	**375**	**1,300**	**NOT A**
ECO_2 System Size (ft dia.)	6	3	5	**TECHNICAL FIT**
Flow Rate through ECO_2 (gpm)	2,800	450	2,150	
HP of side stream pump (HP)	14	1	7	
Electricity for VSA O_2 Generation (kWh/day)	250[3)]	125	310	
ECO_2 System				
Capital Cost				
ECO_2 System & O_2 Feed Controls	$290,000	$200,000	$250,000	
Sidestream Pump (Estimate)	$20,000	$3,000	$10,000	
VSA O_2 Generator (Optional)	$115,000	$65,000	$115,000	
Total Capital Cost ECO_2 System	**$425,000**	**$268,000**	**$375,000**	
O&M Cost				
Electrical Draw O_2 Generator *	$11,000	$5,500	$13,600	
Side Stream Pump *	$11,100	$1,100	$5,300	
Maintenance (20%)	$4,400	$1,300	$3,800	
Total O&M Cost (Annually)	**$26,500**	**$7,900**	**$22,700**	

* Cost of power assumed at $0.12/kWhr

3939 Priority Way South Drive, Suite 400 Indianapolis, IN 46240 317.706.6484 Fax: 317.816.0940 www.eco2tech.com

ECO2

Comments:

1) This design is around the worst case scenario assuming 24'' diameter force main for the entire length, which results in a hydraulic retention time of 4hrs.
2) Using 60ft of TDH removes the previous requirement to pressurize the cone, lowering the HP on the pump.
3) Due to the fill/draw cycle of the pumps, the amount of O_2 that has to be fed during the pump time time is larger than the average daily feed rate, requiring a larger VSA Oxygen Generator with higher kWhr demand.

IV. ECO_2 GUARANTEE

Experience

ECO_2 has over 10 years of experience in the design, assembly, start-up and operation of SuperOxygenation Systems. ECO_2 brought the SuperOxygenation Technology to the wastewater market for odor and corrosion control with our first three systems installed in 2003. By now we have over 30 installations across the U.S. that are all running successfully. We're happy to share our installation list with you and have you talk to any of our clients.

The ECO_2 Approach to Successful Installations

We have gained valuable experience in the design of our systems for various applications. Especially force main applications can get very complicated and the SuperOxygenation Technology is not always a technical fit. We recognize the limitations of our systems and share these with our clients before we get into a project. We will not waste your time or money with extended pilot tests or trial and error installations. If you receive a quote from us, we know that our design will work and we will guarantee our design.

ECO_2 Performance Guarantee

ECO_2 will provide performance assessment and adjustment during system commissioning to ensure the system is operating according to the design specifications.

V. OXYGEN SOURCE

Oxygen can either be generated on-site or delivered to the site as liquid oxygen (LOX) by a local gas supplier. ECO_2 is available to help evaluate the various oxygen sources depending on site specifics and client preferences.

A VSA On-Site Oxygen Generation System has been quoted in this proposal, as it typically provides the lowest operating cost. However, a viable alternative for these applications is the purchase of liquid oxygen (LOX) from a local gas supplier. It does not require any additional capital cost, as the equipment is usually leased from the supplier. Costs would have to be confirmed locally.

Liquid Oxygen (LOX)

The LOX tank and equipment are typically maintained by the supplier and don’t require any additional maintenance by the City.

VSA On-Site Oxygen Generation

ECO_2 has been successful working with PCI out of Riverside, CA using their vacuum swing adsorption (VSA) oxygen generators. VSA systems use a reversible blower system to generate oxygen at low pressure and then compress only the 21% of oxygen that have been removed from the air, as opposed to PSA oxygen generators that compress 100% of the air with an air compressor. VSA Systems are therefore much more energy efficient.

Furthermore, a VSA System employs fewer parts, making it a more reliable oxygen source than PSA Systems. A Spec Sheet of the proposed oxygen generator is attached to this proposal.

VI. COMPETITIVE ADVANTAGES

95% Transfer Efficiency

Every ECO_2 System is tested for its transfer efficiency at start-up. The average transfer efficiency that has been documented on our systems is 95%. This is important because:

- Oxygen costs money, any oxygen that is not dissolved is wasted money.
- Systems with a lower transfer efficiency need to make up for it in size or they will not have the same results.

No Bubbles

The ECO_2 System dissolves the oxygen bubbles outside of the force main in the cone. The bubbles are trapped in the cone until they are dissolved. Basically no gaseous oxygen enters the force main. This is important because:

- Gaseous oxygen is not available to the microorganisms as an oxygen source
- Gaseous oxygen will rise to the crown of the pipe and create a potentially hazardous headspace in the sewer
- Gaseous oxygen is either lost through air release valves or may air lock the pipe or pumps.

No small openings

All openings on every ECO_2 System are a minimum of 4’’ in diameter, capable of passing dirty wastewater without clogging. This is important because:

- A system with small openings such as nozzles or venturis is prone to clogging and is therefore not a reliable odor control technology
- Small openings will clog and require constant attention and maintenance, raising the O&M costs and wasting valuable man-power.
- Chopper or grinder pumps may alleviate the problem, but they add another piece of equipment to the maintenance cycle and require additional horse power. They are also designed to pass particles through the pump itself, not necessarily small openings downstream of the pump.

10 Years of Experience

ECO_2 has over 10 years of experience in the design, assembly, start-up and operation of SuperOxygenation Systems. ECO_2 brought the SuperOxygenation Technology to the wastewater market for odor and corrosion control with our first three systems installed in 2003. By now we have over 30 installations across the U.S. that are all running successfully. But don’t take our word for it. Ask for our installation list and have our happy customers validate our claims.

VII. TERMS & CONDITIONS

Prices and Payment

All prices set forth in this proposal are FOB Origin, Indianapolis, IN USA, and unless otherwise stated do not include sales taxes, shipping, insurance, or other similar charges. The prices listed in this proposal are budgetary in nature and are good for 60 days from the date of this proposal.

Warranty

The system described in this proposal includes a limited 12 month warranty commencing from the date the system is placed in operation by the owner.

Attachment E: Pump Station “R” Chemical Dosing Layout

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PLAN

1" = 10'-0"

3" ON ORIGINAL DOCUMENT
0 1 2 3

REGISTERED PROFESSIONAL ENGINEER
JAMES KEN WANG
No. C59914
Exp. 12/31/11
CIVIL
STATE OF CALIFORNIA
03/14/2011

SUPERSEDES: SD247-C-001

A COPY OF THE ORIGINAL DRAWING CAN BE FOUND IN THE WASTEWATER DRAFTING UNIT

NO.	DATE	REVISION	BY	REC.	APP.
4	17AUG2012	IN SERVICE 10NOV2011 RECORD DRAWING INSP. JJ/SJ SD337			
3	14MAR2011	ADDENDUM NO.1 PER SD337	JW	JW	GDW
2	14FEB2010	REVISED AND RENUMBERED DWG PER SD337	JW	JW	GDW
1	04OCT2001	IN SERVICE 7-26-02 RECORD DRAWING INSP.			

SD337 - PUMP STATION R FORCE MAIN IMPROVEMENTS

DESIGN BY:	---
DRAWN BY:	D. KREIDEN-KARAIM
DESIGN CHECKED BY: R.P.E. No.	---
CONSTRUCTABILITY CHECKED BY:	---
ELECTRICAL CHECKED BY: R.P.E. No.	
PROJECT ENGINEER R.P.E. No.	---
PROJECT MANAGER R.P.E. No.	---
RECOMMENDED: SR. ENGINEER R.P.E. No.	---

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT NO. 1
OAKLAND, CALIFORNIA

PUMP STATION R
FORCE MAIN REPLACEMENT
CIVIL
SITE PLAN

SHEET NO. 14

SCALE 1"=10'-0"
DATE 14FEB2011

W7R-C-043
DRAWING NUMBER

REV. 4

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Attachment F: Continuous Sulfide Monitoring System Catalog Sheet for Hot Spot Areas

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micro::station

BOD
COD
BTX
TOC
DOC
UV254
NO_3
NO_2
NH_4
K+
HS
PSU
TSS
FTU/NTU
Color
pH
Redox
Conductivity
Temperature
O_2
O_3
H_2S
AOC
Fingerprints
Alarms

The fully modular micro::station combines s::can instruments to a compact and versatile system. It presents a complete solution, as the user only has to connect water supply and -discharge ("plug & measure") in order to receive at no extra cost a previously unheard variety of immediately available information and parameters.

The s::can micro::station is designed for OnLine monitoring of water quality parameters in waste water. The required components – spectro::lyser, s::can probes and controller - are factory assembled with all required flow cells, mounting fittings and pipes on a compact panel.

micro::station – the s::can solution for water analysis – compact and easy like never before.

1 Terminal

con::cube terminal with moni::tool software for data acquisition, data display and station control

2 Physical probe

One s::can physical probe can be installed

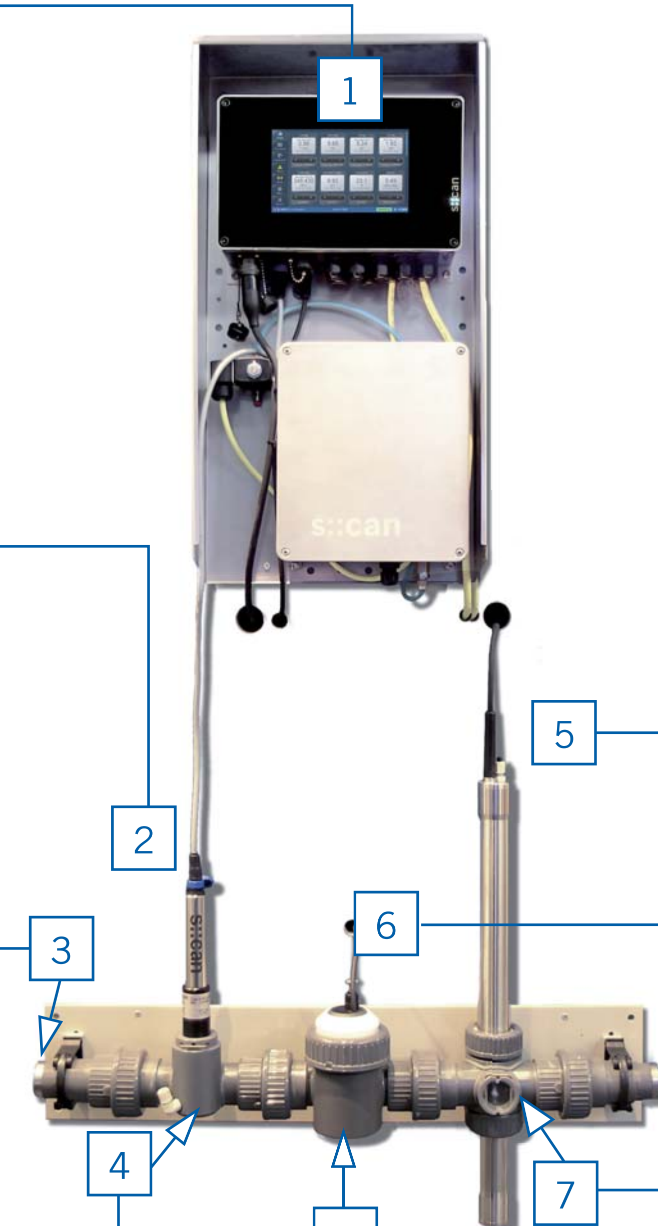
Possible parameters:
pH, Redox, PSU, conductivity and temperature

3 Process connection

Process connection 1", PVC

4 Flow cell for physical probe

s::can physical probe flow-cell (by-pass setup), PVC



5 Spectrometer probe

All s::can spectrometer probes are multi-parameter instruments that can measure a variety of water quality parameters

Possible parameters:
AOC, BOD, BTX, COD, color, DOC, FTU/NTU, H_2S, HS, NO_2-N, NO_3-N, TOC, TSS, UV254, fingerprints and spectral alarms, temperature and pressure

6 Physical probe or ISE probe

oxi::lyser, soli::lyser or one s::can ISE probe (e.g. ammo::lyser) can be installed here

Possible parameters:
K+, NH_4-N, NO_3-N, O_2, pH, TSS, and temperature

7 Flow cell for spectrometer probe

s::can spectrometer flow-cell (by-pass setup), PVC

8 Flow cell for ISE probe or physical probe

Flow cell for soli::lyser, oxi::lyser or s::can ISE probe (e.g. ammo::lyser)

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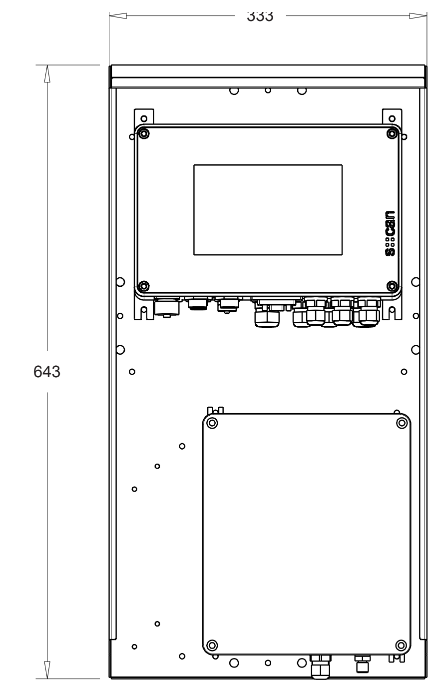
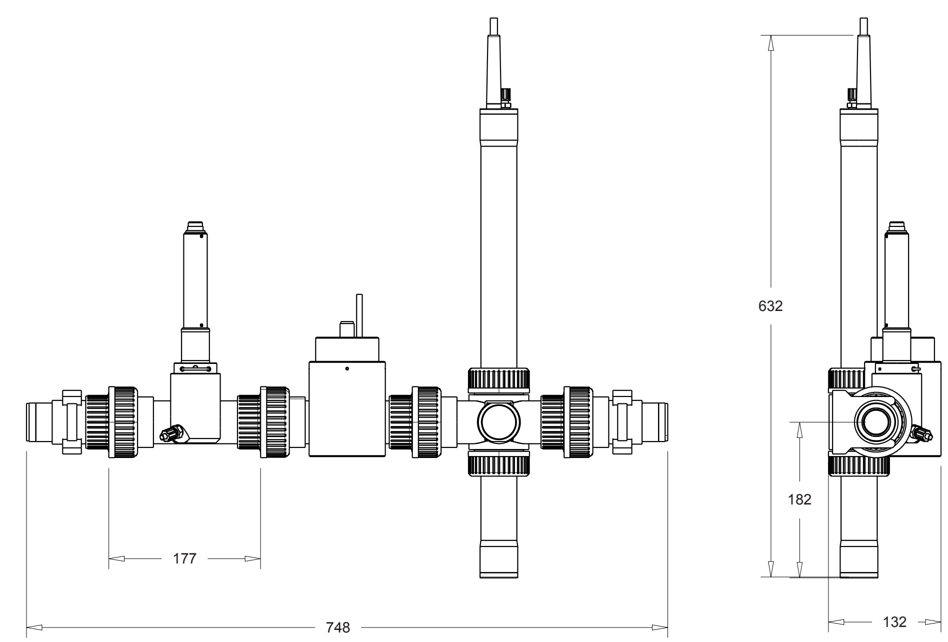
micro::station

Options for s::can micro::station

1 Terminal	con::cube con::lyte 1 eco con::lyte 2 con::lyte 4
2 Physical probe	pH::lyser redo::lyser condu::lyser chlori::lyser
3 Process connection	process connection 1", PVC
4 Flow cell for physical probe	s::can physical probe flow-cell (by-pass setup), PVC
5 Spectrometer probe	spectro::lyser carbo::lyser color::lyser multi::lyser nitro::lyser ozo::lyser uv::lyser
6 Physical probe or ISE probe	ammo::lyser eco ammo::lyser pro fluor::lyser chlorid::lyser oxi::lyser soli::lyser
7 Flow cell for spectrometer probe	s::can spectrometer flow-cell (by-pass setup), PVC
8 Flow cell for ISE probe or physical probe	oxi::lyser or soli::lyser flow-cell (by-pass setup), PVC ammo::lyser flow-cell (by-pass setup), PVC





Spectrometer Probes
i::scan
Ionselective Probes
Physical Probes
Terminals
Software
System Configuration
Monitoring Stations
Spare Parts & Accessories
Services & Solutions

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Prepared by

Walnut Creek

201 North Civic Drive, Suite 115
Walnut Creek, CA 94596
Tel: 925-937-9010

WASTEWATER PUMP STATION
DISCHARGE PIPELINE CONDITION ASSESSMENT

FINAL REPORT

East Bay Municipal Utility District

Prepared for

EBMUD

REGISTERED PROFESSIONAL ENGINEER
JOSE LUIS VILLALOBOS
No. 26659
CIVIL
STATE OF CALIFORNIA

6/12/2014

Prepared by

V&A

June 12, 2014

TABLE OF CONTENTS

ATTACHMENTS

APPENDICES

TABLES

FIGURES

1.0 EXECUTIVE SUMMARY

1.1 Project Overview and Purpose

V&A was retained by the East Bay Municipal Utility District (District) to conduct a condition assessment of the District's pump station discharge pipelines, as well as perform a corrosion prevention study of its interceptor system. Figure 1-1 shows the District interceptor system with general locations of pump stations. This report presents the results of the pump station discharge pipeline condition assessment. The results of this assessment will support the development and prioritization of recommended capital improvements, operation and maintenance (O&M), and future monitoring programs.

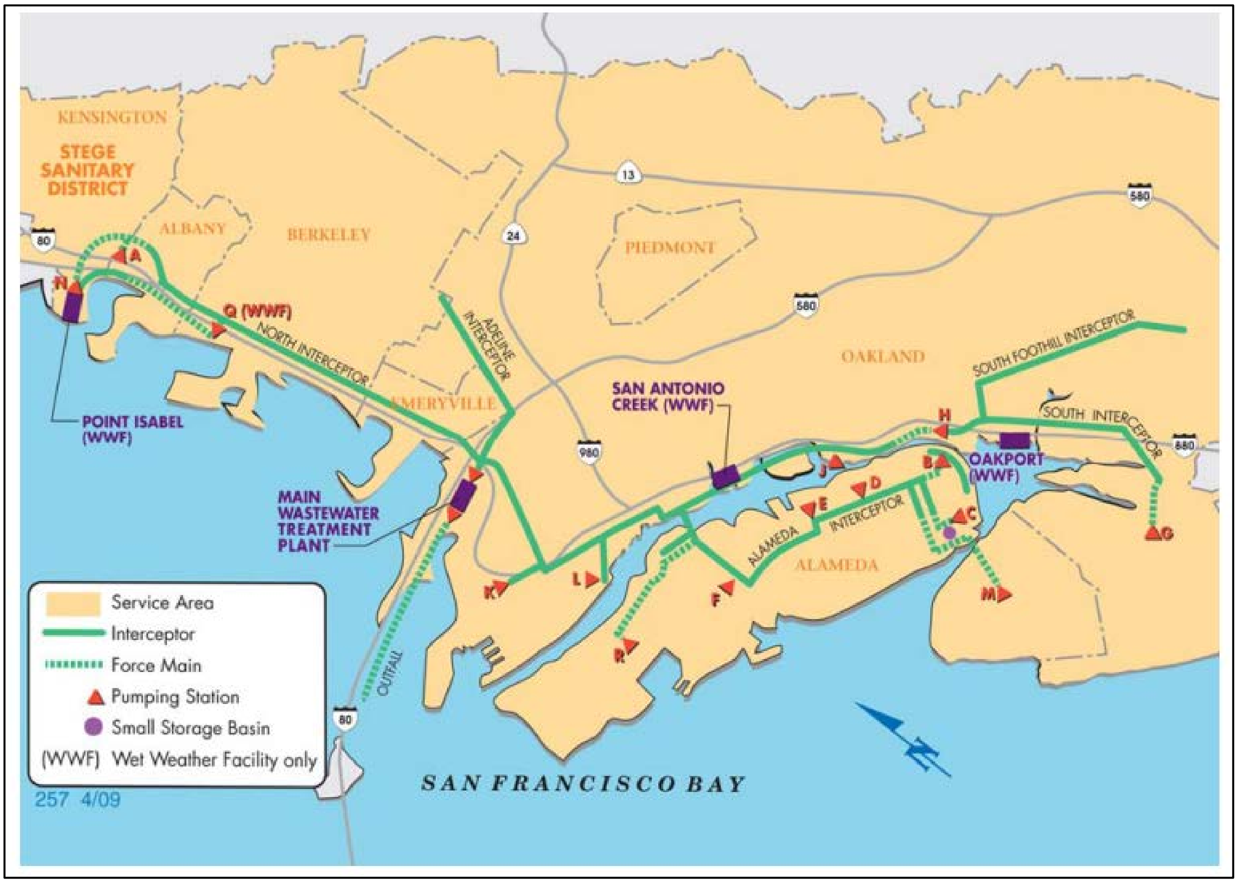

Figure 1-1. Map of Interceptor System with Pump Station Locations

Past inspections and assessments on the interceptor system have focused on the gravity pipelines. This assessment is the first dedicated to the pump station discharge pipelines most of which are pressurized.

1.2 Project Approach

A risk-based approach was relied upon to complete this project. The first step was a preliminary risk analysis based on available data. This analysis identified data gaps and areas of potential high risk. This information was used to develop a field investigation plan. The project then involved gathering field condition data to determine the likelihood of failure under various criteria. The results were subsequently used to update the risk analysis. From this final risk analysis, prioritized recommendations were developed to reduce or alleviate the District's exposure to risk. The process has been depicted graphically in Figure 1-2.

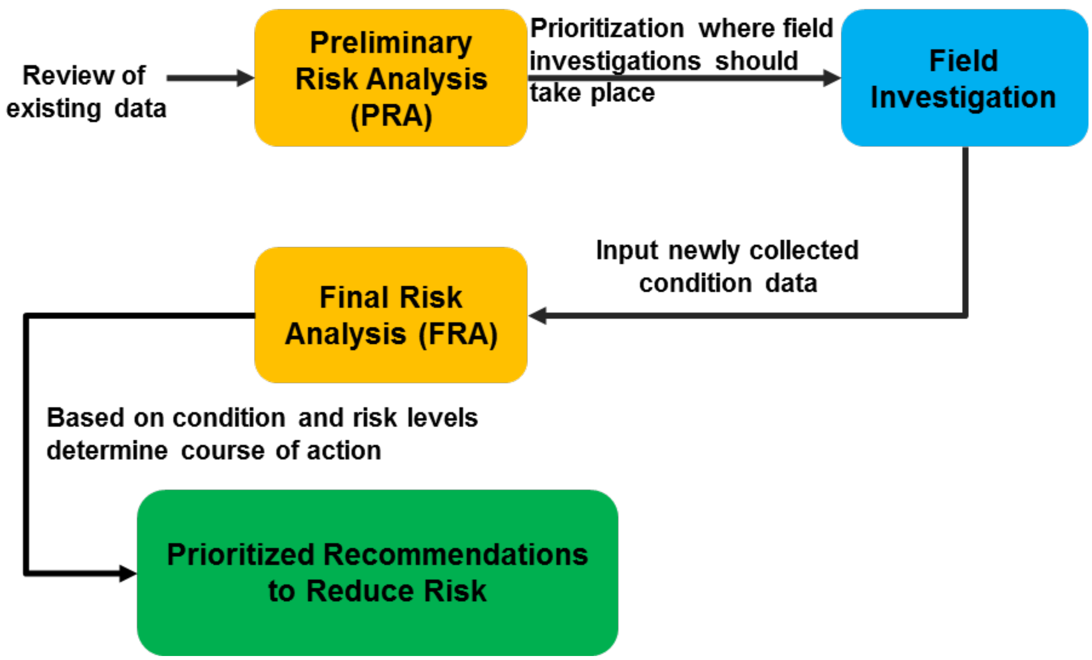

Figure 1-2. Risk-Based Project Approach Flow Chart

1.3 Discharge Pipeline Condition Assessment Findings

Field investigations were targeted to allow the collection of the best representative data that could be extrapolated to other pipelines. Field data was collected through various means. (See Table 3-4 for a summary of the field investigation effort and Field Investigation Finding Report for detailed pipeline conditions).

After the completion of the field investigation, the final risk analysis was performed to generate a relative risk matrix that includes all of the pump station discharge pipelines (Figure 1-3). Overall, the District's discharge pipelines were found to be in good condition. None of the discharge pipelines is at risk of imminent failure based on the risk analysis.

Consequence of Failure	Very Unlikely	Unlikely	Likely
Serious	B H N_N	G N_C	M_{AI} M_{WC} R
Moderate	D E F L M_{BF}	A J Q_N	C_A C_B Q_S
Minor	K		

Likelihood of Failure

Figure 1-3. Final Risk Analysis Matrix of Discharge Pipelines

1.4 Recommendations for Improvements

With the final risk analysis and specific condition findings, remaining useful life estimates were developed. Areas of concern were considered in the development of recommendations. The useful life of pipelines was then estimated based on the recommended improvements (Table 1-1).

Table 1-1. Pump Station Discharge Pipelines Remaining Useful Life Estimates

Discharge Pipeline	Year Installed	Age (Yrs.)	Pipeline Risk (1-9)	Remaining Useful Life (Yrs.)	Activities to Prolong the Service Life	Increased Useful Life (Yrs.)	Remaining Useful Life with Improvements (Yrs.)
A	1987	27	4	30	CP Improvement	20	50
B	2000	14	3	40			40
C_A	1942, 1995	72	6	20	Improve access, Pipe cleaning	10	30
C_B	1968	46	6	20	Improve access, Pipe cleaning	10	30
D	1953	61	2	40	-		40
E	1953	61	2	40	-		40
F	1953	61	2	40	-		40
G	1954	60	6	30	Improve access, Maintenance of appurtenances	10	40
H	1948, 2009	66	3	40	-		40
J	1953	61	4	30	-		30
K	1953	61	1	40	-		40
L	1955	59	2	40	-		40
M_{BF}	1980	34	2	50	-		50
M_{WC}	1949	65	9	20	Build a new line[1]	60	60
M_{AI}	1986	28	9	20	Installation of ARVs, Maintenance of appurtenances	20	40
N_C	1969	45	6	30	Maintenance of appurtenances	10	40
N_N	2000	14	3	50	Minor maintenance of appurtenances.		50
Q_N	1987	27	4	30	CP Improvement[2]	10	40
Q_S	1995	19	6	30	CP Improvement[2]	10	40
R	2001	13	9	30	Maintenance of appurtenances[3]	10	40

[1] After new line is put in service, access, inspection and improvements to the original pipeline can be considered.
[2] Due to test results showing discontinuities on Q_N and Q_S pipelines, CP system improvements may not be fully effective. Increase in service life is estimated lower than other CP system improvements at 10 years.
[3] Discharge Pipeline R is hydraulically oversized. The recommendation also includes a study to improve hydraulics. This study should be initiated after performing CCTV inspection to review the interior condition of the pipeline.

The recommendations for improvement have been categorized into three types of activities: capital improvement projects (CIP), preventive maintenance (PM), and future monitoring/inspection (FMI). The following tables (Table 1-2 through Table 1-4) provide summaries for the improvement activities, timing, and costs in CIP, PM, and FMI by pump station discharge pipeline.

Table 1-2. Summary of CIP Recommendations, Timing, and Costs

Discharge Pipeline	Pipeline Risk (1-9)	Recommendations	Timing	Cost ($)
Installation of pressure manholes so cleaning and inspection can be performed.				
C_A	6	• Construct one access manhole at approx. Station 15+50 • Convert existing ARV manholes to access manholes at Station 24+66 and Station 33+16	Within 5 years	72,000
C_B	6	• Construct two access manholes. One at approx. Station 4+50 and one at approx. Station 15+50 • Convert existing ARV manholes to access manholes at Station 24+66 and Station 33+16	Within 5 years	109,000
G	6	• Construct one pressure manhole at approx. Station 13+30 at Pardee Rd.	Within 5 years	29,000
Provide adequate cathodic protection[4].				
A	4	• Reinstate 4 test stations and replace anodes. • Replace 3 anodes at existing test stations.	Within 5 years	156,000
Q_S	6	• Reinstate 13 test stations and replace associated anodes. • Replace 16 anodes at existing test stations.	Within 5 years	562,000
Q_N	4			
Other capital improvement projects				
M_{WC}	9	• Construct a parallel line to allow for adequate inspection and maintenance.	Within 20 years	1,228,000
M_{AI}	9	• Install ARVs at 6 high point locations (Station numbers: 0+56, 2+82, 6+94, 7+20, 20+00 and 24+98).	Within 10 years	177,000

[4] In addition to the cathodic protection recommendations listed here, see Appendix F for other potential CP improvement and testing recommendations on Discharge Pipelines D, E, J, N, Q, R and the Oakport drainline. Total cost for these additional items are estimated to be between $300,000 and $420,000.

Table 1-3. Summary of PM Recommendations, Timing, and Costs

Discharge Pipeline	Pipeline Risk (1-9)	Recommendations	Timing	Cost ($)
Provide adequate maintenance for the valves and appurtenances to bring poor condition items up to serviceable condition.[5]				
G	6	• Due to corrosive soil conditions to buried metallic components, it is recommended to remove dirt inside Manhole GF01. • Improve area and access to cleanout at GF02. Assess and restore adjacent soil bed as necessary.	Within 5 years	4,800
M_{AI}	9	• Dewater, power tool clean to remove corrosion scale and apply petrolatum tape wrap to metallic surfaces/appurtenances inside Pressure Manholes M11 through M15.	Within 5 years	13,500
N_C	6	• Dewater, power tool clean to remove corrosion scale and apply petrolatum tape wrap to metallic surfaces/appurtenances inside Pressure Manholes NF08, NF09, NF10 and NF11.	Within 5 years	18,900
N_N	3	• Exercise buried plug valves as part of District's routine maintenance program.	Within 5 years	Cost included with N_C
R	9	• Dewater, power tool clean to remove corrosion scale and apply petrolatum tape wrap to metallic surfaces/appurtenances inside pressure manholes and traffic boxes with ARVs at RF01, RF03, RF04, RF06, RF07, RF08, RF09, and RF10.	Within 5 years	33,100
Conduct pipe cleaning.[6]				
C_A	6	• Clean discharge pipeline of heavy grease deposits after installation of access manholes.	After CIP	14,000
C_B	6	• Clean discharge pipeline of sediment after installation of access manholes.	After CIP	14,000

[5] In addition to the specific recommendations for high risk discharge pipelines, V&A recommends that the District establish a program that checks the condition of valves, fittings and appurtenances on a routine basis. Discharge Pipelines C_A, C_B, M_{BF}, Q_S and Q_N had valves, fittings and appurtenances which exhibited slight corrosion. It is recommended that these be visually assessed on at least a 5-year interval to monitor condition.

[6] In addition to the specific cleaning recommendations, there are other discharge pipelines (such as Discharge Pipeline J and Discharge Pipeline K) that would benefit from cleaning activities. Cleaning recommendations are not provided for these pipelines however they should be considered to be included in regular preventative maintenance cleaning activities as best management practices.

Table 1-4. Summary of FMI Recommendations, Timing, and Costs

Discharge Pipeline	Pipeline Risk (1-9)	Recommendations and Timing	Timing	Cost ($)
Conduct CCTV to inspect internal pipe condition.				
A	4	• Conduct CCTV inspection from Pressure Manhole AF02 to check for possible liner failure.	Within 5 years	13,800
C_A	6	• Conduct additional CCTV inspection of more of the pipeline.	After CIP	14,200
C_B	6	• Conduct additional CCTV inspection of more of the pipeline to determine the extent of pipeline that requires rehabilitation after installation of pressure manholes.	After CIP	14,200
F	2	• Conduct CCTV inspection from Discharge Manhole FF01 to determine the extent and need for pipeline rehabilitation. Some cleaning is anticipated.	Within 5 years	5,600
G	6	• Conduct CCTV to evaluate interior condition of the discharge pipeline after installation of a pressure manhole.	After CIP	17,500
J	4	• Conduct CCTV from Discharge Manhole S30 to evaluate interior condition of the discharge pipeline. Some cleaning is anticipated.	Within 5 years	6,000
M_{AI}	9	• Conduct CCTV from Pressure Manhole M15 proceeding downstream towards M01 to determine interior pipe condition.	Within 5 years	39,600
Q_N	4	• Conduct CCTV from Pressure Manhole Q09 proceeding both upstream and downstream to further determine the interior pipe condition and the extent of liner failure.	Within 5 years	12,200
Q_S	4	• Same recommendation as above. The recommendation to perform CCTV inspection from Pressure Manhole Q09 will accommodate the need for condition information for Discharge Pipeline Q_S and Discharge Pipeline Q_N.	Within 5 years	Cost included with CCTV of Q_N
R	9	• Conduct CCTV from the discharge structure. Construct temporary scaffolding to insert the camera into the discharge piping by hand. Alternately, CCTV inspection may require removal of the 90-degree elbow or opening of Pressure Manhole RF09 for access.	Within 5 years	23,000
Conduct future sampling of sulfide.				
B	3	• Conduct a continuous 24-hour sampling using an automated sampler at Discharge Manhole A15. Due to the configuration of the discharge manhole, confined space entry installation of temporary equipment may be required. Perform the sampling during summer months and with sulfide control on and off to compare data results.	Within 10 years	67,000
$C_{A,B}$	6	• Conduct a continuous 24-hour sampling using an automated sampler at the discharge manholes. Perform the sampling during summer months with all flow directed to the discharge pipe being tested. Perform the testing with sulfide control on and off to compare data results.	Within 10 years	94,500

Discharge Pipeline	Pipeline Risk (1-9)	Recommendations and Timing	Timing	Cost ($)
$M_{BF,WC,AI}$	9	• Conduct a continuous 24-hour sampling using an automated sampler at Discharge Manhole M01. Perform the sampling during summer months and with sulfide control on and off to compare data results.	Within 10 years	67,000
$N_{N, C}$	6	• Conduct a continuous 24-hour sampling using an automated sampler at Discharge Manhole NF07. Perform the sampling during summer months and with sulfide control on and off to compare data results.	Within 10 years	67,000
R	9	• Conduct a continuous 24-hour sampling using an automated sampler at the discharge structure. Due to the configuration of the discharge structure, confined space entry installation of temporary equipment or manual data collection may be required. Due to the short run times of Pump Station R, monitoring the on/off pump operation should be conducted simultaneously. Perform the sampling during summer months and with sulfide control on and off to compare data results.	Within 10 years	67,000
Monitor C-Factor over time.				
$N_{N, C}$	6	• Perform C-factor testing to track the change of pipe performance over time.	After 10 years	20,300
R	9	• Perform C-factor testing to track the change of pipe performance over time.	After 10 years	20,300
Other data collection activities.				
B	3	• Perform one excavation to assess the interior and exterior pipe condition.	After 5 years	67,500
J	4	• Perform one excavation to assess the exterior pipe condition near the discharge end of the alignment.	After 5 years	67,500
L	2	• Pothole at one location to collect a soil sample to test for soil corrosivity.	After 5 years	13,500
Q_S	6	• Perform one excavation to assess the exterior pipe condition.	After 5 years	67,500

2.0 INTRODUCTION AND BACKGROUND INFORMATION

2.1 Purpose and Scope of Discharge Pipeline Condition Assessment

The District's interceptor system is comprised of approximately 29 miles of gravity sewers and siphons, 15 pump stations with 16 associated discharge pipelines and other related facilities. V&A was tasked to provide professional engineering services for the condition assessment of the District's pump station discharge pipelines. This report documents the condition assessment results and develops recommendations for capital improvements (CIP), preventive maintenance (PM) activities, and future monitoring or inspection (FMI) efforts for the discharge pipelines within the interceptor system.

2.2 Previous/Related Studies

The District has conducted several previous inspections and assessments of the interceptor system. These previous studies provide background for this Pump Station Discharge Pipeline Condition Assessment project.

- *Interceptor Damage Assessment Project (IDAP) (1997).* This condition assessment documented the physical condition of the pipelines and manholes that comprise the gravity system of the interceptor system. The assessment included the evaluation of the remaining useful life of the pipelines, identified facilities in need of rehabilitation, and developed recommendations for a capital improvement program, preventive maintenance, and future monitoring activities.
- *2008 IDAP Condition Assessment Update (2006).* The purpose of this update was to update the IDAP program documentation based on additional condition information.
- *Interceptor Inspections and Condition Assessment (2010, 2011, 2012 and 2013).* The District began a 5-year program to complete inspection of its interceptor system. The field inspection work is being conducted during the dry weather season to gather data to evaluate conditions.
- *Evaluation of East Bay Municipal Utility District Pump Station Discharge Lines, Phase 1 Evaluation Report (2013).* This document included a detailed review of drawings and previous condition assessment work.

2.3 Description of Pump Station Discharge Pipelines

The discharge pipelines are constructed primarily of cast iron pipe (CIP) or ductile iron pipe (DIP), with the remainder constructed of steel, reinforced concrete pipe (RCP), concrete cylinder pipe (CCP), or high-density polyethylene (HDPE). Table 2-1 summarizes the dates of construction, diameters, lengths and pipe materials of the discharge pipelines for each pump station (PS).

Table 2-1. Pump Station Discharge Pipelines

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
A	1987	20, 24	1,900	DIP	Cement Mortar/Poly-lined	Polyethylene Encasement
B	2000	18	2,700	DIP	Cement Mortar	Polyethylene Encasement
C_A	1942, 1995	16, 20	4,100	CIP, DIP	Cement Mortar	None
C_B	1968	21	4,100	RCP	None	None
D	1953	8	200	CIP	Cement Mortar	None
E	1953	8	100	CIP	Cement Mortar	None
F	1953	16	50	CIP	Unknown	None
G	1954	12	3,000	HDPE, RCP	None	None
H	1948, 2009	48	2,200	RCP	None	None
J	1953	12	100	CIP	Cement Mortar	Unknown
K	1953	12	100	CIP	Cement Mortar	None
L	1955	10	300	CIP	Cement Mortar	Unknown
M_{BF}	1980	24	1,980	DIP	Cement Mortar	Polyethylene Encasement
M_{WC}	1949	16	1,010	CIP	Unknown	None
M_{AI}	1986	24	5,125	DIP	Cement Mortar	Polyethylene Encasement
N_N (PS N to Rydin Rd)	2000	24	2,180	RCP, Steel	HDPE, Cement Mortar	None
N_C (Rydin Rd to MH NF07)	1969	27	4,060	CCP	Epoxy	None
Q_S (PS Q to MH Q11)	1995	36	5,310	Steel	Cement Mortar	Unknown
Q_N (MH Q11 to MH Q16)	1987	24	2,240	DIP	Poly-lined	Polyethylene Encasement
R	2001	20	8,300	DIP	Cement Mortar	Polyethylene Encasement

2.4 Corrosion/Deterioration Mechanisms and Performance Factors

The various discharge pipeline condition assessment activities performed in the field are broadly categorized into three groups: 1) internal evaluation, 2) external evaluation and, 3) hydraulic analysis. For more detail on specific field tests performed, please refer to Section 5.0 in the Field Investigation Plan (Appendix D).

2.4.1 *Internal*

The degree of and the potential for interior corrosion damage of pipes can be determined from the sulfide data and qualitative condition review. Sulfide generation is a major mechanism of corrosion within wastewater sewers. Hydrogen sulfide (H_2S) is a product of sulfate-reducing bacteria in the absence of adequate an electron acceptor (oxygen or nitrate). H_2S can cause odors and corrosion and is very hazardous to humans in high concentrations. Wastewater samples were collected and sulfide levels were recorded at the discharge manholes.

Qualitative evaluation of the internal condition of selected discharge pipelines was conducted though confined space entries at the discharge manholes and through closed-circuit television (CCTV).

2.4.2 *External*

The existing external conditions of seven discharge pipelines were determined by excavating down to the pipe, testing soils for chlorides, sulfates, and acidity, and performing various non-destructive tests, such as ultrasonic testing (UT), broadband electro-magnetic (BEM) scanning, and surface penetrating radar (SPR). In order to determine the effect of the external environment on the discharge pipelines, V&A used various non-destructive techniques. Tests included: soil resistivity testing, phenolphthalein testing, measurement of corrosion pitting, and visual assessment.

2.4.3 *Hydraulic*

The pump stations and associated discharge pipelines underwent hydraulic testing to analyze the capabilities of the system and to identify any potential degradation or resistance to flow. The primary objectives of hydraulic testing were as follows: 1) calculate the Hazen-Williams C-factor of the force mains, 2) calculate the Manning's N-factor of the gravity lines, and 3) evaluate the pump performance. C-factor testing was performed to identify resistance to flow within discharge pipelines flowing full. This resistance can be an indicator of internal corrosion or debris buildup. For the discharge pipelines that were not flowing full, the test procedure was modified to determine the N-factor for gravity flow from Manning's equation. Pump performance tests were carried out to determine pump performance relative to the manufacturer specifications. The purpose of this test was to check for cavitation that would introduce air into the discharge pipeline and induce corrosion.

3.0 PROJECT APPROACH

The approach for the condition assessment effort included review of previous work, development of risk assessments, performance of field investigations, performance of data analysis, and development of recommendations. The following steps were followed:

1. ***Review of Previous Work***: V&A performed a review of the District's Phase 1 Discharge Pipelines Evaluation Report and the available drawings associated with the discharge pipelines to develop a basis for the preliminary risk analysis (PRA).
2. ***Preliminary Risk Analysis***: A PRA was used to prioritize the field investigation activities.
3. ***Field Investigation***: The likelihood ratings for various criteria that were pending evaluation in the PRA were fully evaluated by field investigation activities conducted during the 2013 dry weather season.
4. ***Final Risk Analysis (FRA)***: The likelihood of failure was updated in the risk analysis and used to generate the final risk matrix for the development and prioritization of recommendations.
5. ***Recommendations***: Remaining useful life estimates (RULE) were developed based on condition information. RULE, overall risk, and likelihood criteria ratings were used to develop and prioritize recommendations. The pipelines with the highest overall risk were given higher priority for improvements to lower the overall potential for risk.

3.1 Project Documentation

Project deliverables used to support this Final Discharge Pipeline Condition Assessment Report for different stages of the project are listed in Table 3-1 and, with the exception of the InfoNet Data Integration, are attached in the appendices.

Table 3-1. List of Project Documents

Document	Description	Appendices
Preliminary Risk Analysis TM	A preliminary risk analysis using a desktop approach based on existing data collected; existing condition information and failure records; discharge pipeline configurations; operating conditions; and internal and external corrosion risk.	A
Final Risk Analysis TM	A final risk analysis based on the preliminary desktop risk analysis with new or confirmed findings from the field investigation work. Provides final risk outcome and recommendation for prioritizing improvements.	B
Inspection Technology Review TM	Review and recommend use of applicable technologies based on performance record, ease of use, applicability, cost, and overall effectiveness.	C
Field Investigation Plan	Outline of recommended field work identified to support the condition assessment efforts. Plan provides appropriate details regarding the field work, including locations, investigation methods and testing technologies.	D
Field Investigation Findings Report	A document providing the investigation efforts, records and findings from the condition assessment field work.	E

Document	Description	Appendices
Cathodic Protection Evaluation TM	A document evaluating if conditions warrant the installation of CP systems on discharge pipelines not currently equipped with CP systems, as well as a summary of test methods and results, and recommended scopes of work for existing CP system improvements.	F
InfoNet Data Integration	The condition assessment results are to be integrated into the District's existing InfoNet asset management system.	–

3.2 Results of Preliminary Risk Analysis

Risk analysis has two key components: consequence of failure and likelihood of failure. The PRA focused on consequence of failure and available condition data. Three risk levels (High, Medium, and Low) are used to rate each pipeline under each consequence and likelihood criteria. Weighting factors were also used to weigh criteria based on importance or impact. The detailed method for risk analysis can be found in the Preliminary Risk Analysis TM in Appendix A. Table 3-2 shows the consequence criteria considered in the risk analysis and the preliminary consequence of failure scores for each discharge pipeline.

Table 3-2. Preliminary Consequence of Failure Ratings

Criteria	Consequence Level (CL)	Consequence Rating (CR)																			
		A	B	C-"A" Line	C-"B" Line	D	E	F	G	H	J	K	L	M (Bay Farm)	M (Water Crossing)	M (Alameda Island)	N (Pt Isabel to Rydin Rd)	N (Rydin Rd to MH NF07)	Q (PS-Q to MH Q11)	Q (MH Q11 to MH Q16)	R
Spill Prevention or Mitigation Action	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Emergency Drills	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Property Value	3	3	3	3	3	2	2	3	2	3	2	1	1	3	3	3	3	3	3	3	3
Disruption to Commerce	3	2	3	1	1	2	2	2	3	3	2	1	3	3	3	3	3	3	3	3	3
Population Density	2	1	2	3	3	1	1	1	1	1	1	1	1	3	1	3	1	1	1	1	1
Environmentally Sensitive Areas	3	2	2	1	1	2	2	1	3	1	1	1	1	2	3	2	2	2	2	2	2
Average Dry Weather Flow Rate	2	2	2	2	2	1	1	2	1	3	1	1	1	2	2	2	3	3	1	1	1
Wet Well & System Storage Volume	2	1	3	1	1	1	1	1	1	1	2	1	1	2	2	2	1	1	1	1	2
Feasibility and Distance Required for Bypass	2	1	3	3	3	1	1	1	3	3	1	1	3	3	3	3	3	3	2	3	3
Presence, Nature, and Density of Adjacent Buried Utilities	3	2	2	2	2	2	2	1	3	3	2	2	2	1	1	2	3	3	3	3	3
Redundant Discharge Pipe	1	3	3	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Weighted Sum of CRs (Maximum: 69)		46	59	46	46	41	41	40	54	55	40	32	42	56	55	59	58	58	52	54	56
Consequence of Failure Score		**2**	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**2**	**1**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Table 3-3 shows the resulting preliminary overall risk levels for each discharge pipeline by likelihood of failure criterion. The consequence of failure ratings are factored in this table. This preliminary risk analysis supported the development of the field investigation plan. The risk levels are for planning purposes and establish the priority for collection of field data. High risk does not necessarily indicate imminent danger of failure. It simply indicates where attention should be focused. None of the District's discharge pipelines are at risk of imminent failure based on the FRA.

Table 3-3. Summary of Preliminary Risk Analysis

Discharge Line	Likelihood-of-Failure Criteria *															
	Hydraulics	Structure and Construction	Pump Hydraulic Fit	C Factor	Cathodic Protection	Corrosion	Coatings and Linings	Material of Construction	Remaining Service Life	H_2S Loading	Odor Control	Vertical Location	Horizontal Location	Right of Way Maintenance	Condition of Valves and Appurtenances	Condition of Discharge Manhole
A	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low
B	Low	Low	Medium	Medium	High	Medium	Medium	High	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low
C_A	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
C_B	Low	Low	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
D	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low
E	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
F	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium
G	Low	Low	Medium	Medium	Low	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
H	Low	Low	Medium	Medium	Low	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
J	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
K	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
L	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
M_{BF}	Low	Low	Medium	Medium	Low	Medium	Medium	High	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
M_{WC}	Low	Low	Medium	Medium	High	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Medium	Medium	Medium
M_{AI}	Low	Low	Medium	Medium	High	Medium	Medium	High	High	Medium	Medium	High	Medium	Medium	Medium	Medium
N (Isabel to Rydin)	Low	Low	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium	High	High	Medium	Medium	Low
N (Rydin to MH NF07)	Low	Low	Medium	Medium	High	Medium	Medium	High	High	Medium	Medium	High	Medium	Medium	Medium	Low
Q (PS Q to MH Q11)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Q (MH Q11 to MH Q16)	Low	Low	Medium	Medium	Medium	Medium	Medium	High	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
R	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	High	Medium	Medium	Medium	Medium

* Detailed definitions of Likelihood-of-Failure criteria can be found in Appendix A (Preliminary Risk Analysis TM)

Legend
High
Medium
Low

3.3 Field Investigation Approach

One objective of the PRA was to determine where to focus the field condition assessment activities for the discharge pipelines. The risk levels gave an overall indication of the level of risk associated with each discharge pipeline and were used to determine where the condition assessment activities would yield the most useful information. It is not feasible to collect field data from all pipelines, so representative data was collected for similar pipelines/conditions and then extrapolated to the other pipelines. The rationale for extrapolation is presented in the Final Risk Analysis in Appendix B.

A number of condition assessment technologies appropriate to the discharge pipeline materials were screened and reviewed in the Inspection Technology Review TM (Appendix C). Based on the PRA and the review of the technologies, a variety of field activities were conducted for each discharge pipeline. The summary of field investigation activities for each discharge pipeline is shown in Table 3-4. This table was developed prior to the start of the field work for the Field Investigation Plan (Appendix D). Actual work varied. Items that were not completed are highlighted in gray and rationales are presented as follows.

CCTV:

- Discharge Pipeline M_{AI}: The CCTV crawler was unable to navigate through the bends of the discharge pipeline. Therefore, the survey was terminated within the initial five feet of pipeline.

Interior-access leak detection:

- Discharge Pipeline M_{WC}: The leak detection was cost-prohibitive under the current budget and was not performed.

C-factor Testing:

- Discharge Pipelines C_A and C_B: C-factor testing was attempted at Pump Station C, but it was found that the isolation valves for the parallel discharge pipelines could not fully isolate the flow to a single discharge line. Therefore, C factors could not be estimated for the Pump Station C discharge lines.

Pipe-to-Soil Potential Survey:

- Discharge Pipeline B: There are no CP test stations or other metal appurtenances for electrical connection to the pipeline.
- Discharge Pipelines D, E, F: Based on the soil resistivity data and observations made at other similar discharge pipelines, it was determined that tests were not warranted.
- Discharge Pipeline L: The entire alignment is paved over. No test connection points are available.

Electrical Continuity Testing:

- Discharge Pipelines A, B, M_{AI}, N_N, N_C,: There are missing test stations or no test stations exist for electrical connection to the pipeline.
- Discharge Pipelines D, E, F, J, K, L: These discharge pipelines have no access points for testing. No continuity testing was done on these pipelines.
- Discharge Pipeline M_{BF}: M_{BF} is adequately protected with an impressed current system. A separate continuity test was not needed. The CP system was tested and shows that it is electrically continuous.

Soil Resistivity Testing:

- Discharge Pipeline H: There was not enough undisturbed soil over the alignment to obtain representative data.
- Discharge Pipeline L: Testing was not conducted on this pipeline as pavement covers the entire discharge pipeline. There are no electrical connection points.

Table 3-4. Summary of Condition Assessment Activities

Technology or Field Activity	Pump Station Discharge Pipelines*																			
	A	B	C		D	E	F	G	H	J	K	L	M			N		Q		R
			A	B									BF	WC	AI	N	C	S	N	
Recommended by Preliminary Risk Assessment																				
Potholing and excavations			X	X				X			X		a	X	X		X		X	
Recommended by Investigation Technology Review (External Assessments at Excavations)																				
Visual/hands-on (*qualitative*) evaluation			X	X				X			X		X	X	X		X		X	
Soil chemical analysis			X	X				X			X		X	X	X		X		X	
Ultrasonic thickness (UT) testing			X								X		X	X	X				X	
Pit-depth gauge			X								X		X	X	X				X	
Broadband electromagnetic (BEM)			X								X			X	X				X	
Phenolphthalein indicator				X				X									X			
Surface-penetrating radar (SPR)				X				X									X			
Recommended by Investigation Technology Review (Internal Pipe Assessments)																				
Qualitative evaluation from discharge manhole			X	X			X		X			X			X				X	
Closed-circuit television (CCTV)			X	X					X			X			X		X		X	
Interior-access leak detection														c						
C-factor testing	X	X	X	X		X	X		X				X			X		X		X
N-factor testing					b			b		b	b	X								
Pump performance testing	X	X	X				X	X	X	X	X	X	X			X				X
Recommended by Investigation Technology Review (External Pipe Corrosion Assessments)																				
Pipe-to-soil potential survey	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	X	X
Electrical continuity testing (d)	X	X	X		X	X	X			X	X	X	X		X	X	X	X	X	X
Soil resistivity testing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Other SOW Items																				
GPS coordinates	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sulfide sampling	X	X	X	X	X	X	X	X	X	X	X	X	X			X		X		X
Discharge manhole evaluation			X	X			X								X				X	
Limited functional evaluation of ARVs	X		X	X					X				X				X	X		X
Assessment of valves, fittings, and appurtenances	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

* Refer to Section 4.0 for details pertaining to the following alignment designations: M(BF): Bay Farm Island, M(WC): Water Crossing, M(AI): Alameda Island, N(N):Pt Isabel to Rydin, N(C): Rydin to MH NF07, Q(S): PS Q to MH Q11, Q(N): MH Q11 to MH Q16.

a. An excavation was planned under another project on this segment for installation of an ARV. V&A used this excavation to conduct a condition assessment at this location (M_{ARV}).

b. N-factor tests were extrapolated from the testing conducted at Discharge Pipeline L.

c. Internal-access leak detection was cost-prohibitive under the current budget and was not performed, but remains as a recommendation for future investigation.

d. Continuity testing was not done on piping that did not have access points or test stations.

Items not completed

3.4 Results of Final Risk Analysis

After the completion of the field investigation, the pipeline conditions were evaluated and used to update the likelihood of pipeline failure. Refer to Section 5.1 in the Final Risk Analysis TM (Appendix B) for the incorporation of the field findings into the final risk analysis. The final risk analysis is summarized in Table 3-5.

Table 3-5. Summary of Final Risk Analysis by Criterion (values include RCI)

Criteria	Relative Condition Indicator (RCI)	A	B	C_A (A Line)	C_B (B Line)	D	E	F	G	H	J	K	L	M_{BF} (Bay Farm)	M_{WC} (Water Crossing)	M_{Al} (Alameda)	N_N (Pt. Isabel to Rydin Rd.)	N_C (Rydin Rd. to MH NF07)	Q_S (PS Q to MH Q11)	Q_N (MH Q11 to MH Q16)	R
Hydraulics	1	2	3	2	2	2	2	2	3	3	2	1	2	2	3	3	3	3	2	2	9
Structure / Construction	1	6	3	6	6	2	2	2	9	3	2	1	2	2	9	9	3	3	2	2	9
External Pipe Condition	3	6	9	6	6	6	6	6	9	9	6	3	6	6	9	9	9	9		6	9
Internal Pipe Condition	3	12	9	12	12	6	6	12	9	9	12	6	6			9	9	9		12	9
C-factor/N-factor	2	4	6			4				6	8	4	4	8	12	12	12	12			12
Cathodic Protection	2	12												4			6		12	12	6
Environmental Exposure	2	8	12	4	4	8	8	8	18	18	12	4		4	18	12	12	18	8	8	18
Material of Construction	1	6	9	4	6	4	4	4	9	9	4	2	4	6	6	9	3	9	6	6	9
Sulfide Level	2	8	12	12	12	4	4	4	6	6	4	2	4	12	18	18	12	12			18
Vertical Location	1	4	6	6	6	4	4	4	6	6	4	3	6	4	3	9	9	9	4	4	9
Horizontal Location	1	4	6	6	6	6	6	2	6	6	6	2	6	4	3	6	9	6	4	4	6
Right-of-Way Maintenance	1	2	3	2	2	2	2	2	6	3	2	1	2	2	6	3	3	6	2	2	6
Condition of Valves and Appurtenances	2	4	6	8	8	4	4		12	6	4	2	4	8		12	12	12	8	8	12
Condition of Discharge Manhole	1	2	3	6	6	2	4	4	3	3	6	2	2			6		3		2	8

* Grey shaded cells in the table indicate where the criteria have no relevance or where data could not be extrapolated from other discharge pipelines.

Legend
High
Medium
Low

Based on the FRA, the discharge pipelines are grouped in a matrix, presented in Figure 3-1. Pipelines shown in red boxes have a higher risk level compared to the other pipelines within the District's system, and should therefore receive greater attention. Overall, the District's discharge pipelines are in good condition. None of the discharge pipelines is at risk of imminent failure based on the risk analysis.

Consequence of Failure	Very Unlikely	Unlikely	Likely
Serious	B H N_N (Pt Isabel to Rydin)	G N_C (Rydin to MH NF07)	M_{AI} M_{WC} R
Moderate	D E F L M_{BF}	A J Q_N (MH Q11 to MH Q16)	C_A C_B Q_S (PS Q to MH Q11)
Minor	K		

Likelihood of Failure

Figure 3-1. Final Risk Analysis Matrix of Discharge Pipelines[7]

3.5 Approach to Developing Recommendations

The results of final risk analysis provided likelihood of failure ratings by criterion for each discharge pipeline. The likelihood of failure criteria with the highest overall risk and the deficiencies associated with the overall risk rating are provided in Section 4.0. These areas of concern are grouped by capital improvement (CIP), preventive maintenance (PM), and future monitoring and inspection (FMI) and then summarized in Section 5.0. Also in Section 5.0, remaining useful life estimates (RULE) are developed. The areas of concern, RULE, and overall pipeline risk category, as shown in Figure 3-1, are then considered in developing recommendations. The proposed recommendations in Section 6.0 provide an approach for corrective actions to remedy or mitigate the likelihood of failure.

[7] Note: Pipeline risk has a scale of 1 through 9.

4.0 CONDITION ASSESSMENT FINDINGS

This section provides pipeline system information and a summary of deficiencies that correspond to high overall risk delineated by likelihood of failure criteria. The overall risk rating is defined as below.

Overall Risk Rating (Rated 1 to 27) = Likelihood Rating of Each Criterion (Rated 1 to 3)
x Relative Condition Indicator (Rated 1 to 3)
x Consequence of Failure of a Pipeline (Rated 1 to 3)

Different levels of recommendations are provided based on the overall risk level (Table 4-1) and are organized by capital improvement project (CIP), preventive maintenance (PM), and future monitoring and inspection (FMI).

Table 4-1. Types of Recommendation Provided for Different Overall Risk Level

Overall Risk Level	Overall Risk Rating (1-27)[8]	Recommendation Level
High	12 to 27	All of the high risk criteria are considered for recommendations.
Medium	6 to 9	Generally, no recommendations are provided. However, some of the criteria are provided with the recommendations as the perquisites of providing recommendations to other criteria.
Low	1 to 4	No recommendations are provided.
N/A	0	"N/A (Not Applicable or Not Available)" indicates either the criterion does not apply to the pipeline or no data was collected for the criterion. Recommendations are considered where there is no data.

[8] Although the scale for the overall risk rating scale goes from 1 to 27, for the District's discharge pipelines, the highest risk score of any criteria was 18.

4.1 North Interceptor

The three pump stations with discharge lines that convey flow to the North Interceptor are Pump Station A, Pump Station N and Pump Station Q.

4.1.1 *Discharge Pipeline A*

A summary of Discharge Pipeline A characteristics and an aerial map of its location are shown in the following table and in Figure 4-1 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
A	1987	20	1,740	DIP	Cement Mortar Poly-lined	Asphalt coated with Polyethylene Encasement
	1992	20, 24	160		Poly-lined	

Figure 4-1. Pump Station A and Discharge Pipeline Alignment

Figure 4-2 is a schematic of Discharge Pipeline A. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline.

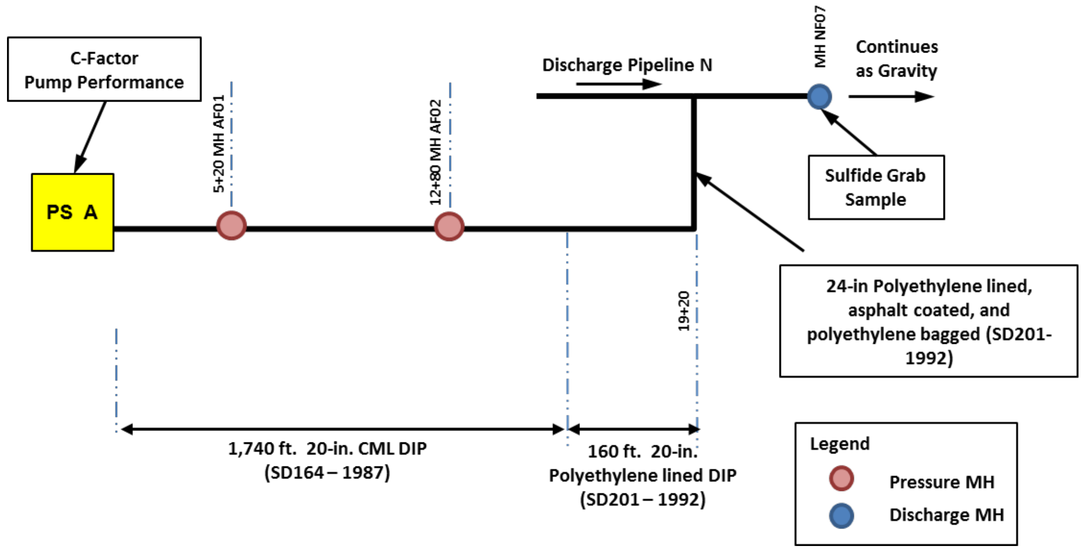

Figure 4-2. Discharge Pipeline A Schematic

Table 4-2 identifies the deficiencies for Discharge Pipeline A.

Table 4-2. Discharge Pipeline A Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies corresponding to higher risk ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	6	3		
Ext. Pipe Condition	6	3		
Interior Pipe Condition	12	6	No direct data. Rating based on extrapolated data from Discharge Pipeline Q_N (Possible liner failure).	Monitor (Conduct CCTV to inspect internal pipe condition.)
C Factor/N Factor	4	2		
Cathodic Protection	12	6	Missing test stations and depleted anodes. CP system not providing adequate protection.	Capital Improvement (Provide adequate CP system)
Environmental Exposure	8	4		
Materials of Construction	6	3		
Sulfide Level	8	4		
Vertical Location	4	2		
Horizontal Location	4	2		
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	4	2		
Condition of Discharge Manhole	2	1		

4.1.2 *Discharge Pipeline N*

A summary of Discharge Pipeline N characteristics and an aerial map of its location are shown in the following table and in Figure 4-3 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
N_N	2000	24	2,180	RCP, Steel	HDPE, Cement Mortar	None
N_C	1969	27	4,060	CCP	Epoxy	None

Figure 4-3. Pump Station N and Discharge Pipeline Alignment

Figure 4-4 is a schematic of Discharge Pipeline N. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline. (Note: The green boxes in Figure 4-4 indicate locations of excavations to expose the exterior surfaces of the pipeline for assessment).

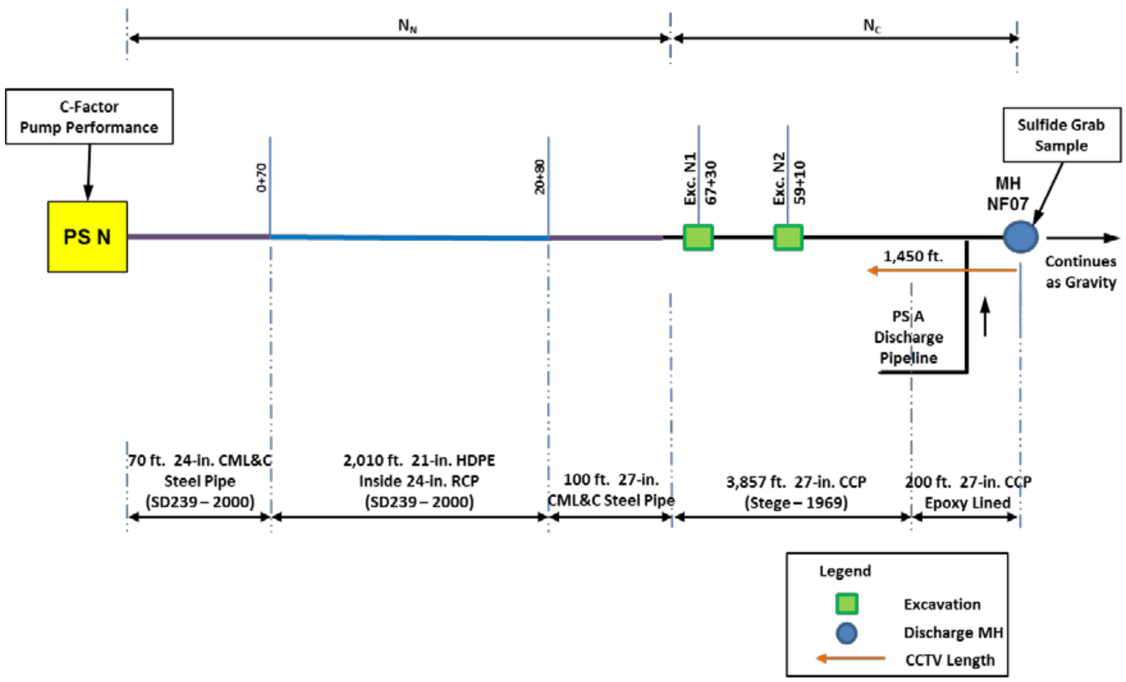

Figure 4-4. Discharge Pipeline N Schematic

Table 4-3 and Table 4-4 identify the deficiencies for Discharge Pipeline N.

Table 4-3. Discharge Pipeline N_N (Pt. Isabel to Rydin Rd.) Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	3	1		
Structural and Construction	3	1		
Ext. Pipe Condition	9	3		
Interior Pipe Condition	9	3		
C-Factor/N- Factor	12	4	Low C-factor value.	Monitor C-Factor over time
Cathodic Protection	6	2		
Environmental Exposure	12	4	Moderate corrosive soil conditions.	No recommendations. (Pipe is cathodically protected and part of the District's routine CP testing program.)
Materials of Construction	3	1		
Sulfide Level	12	4	Moderate sulfide level increases risk of corrosion.	Monitor (Conduct future sampling).
Vertical Location	9	3		
Horizontal Location	9	3		

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Right of Way Maintenance	3	1		
Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Preventative Maintenance.
Condition of Discharge Manhole	0	0	Not applicable.	

Table 4-4. Discharge Pipeline N_C (Rydin Rd. to MH NF07) Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	3	1		
Structural and Construction	3	1		
Ext. Pipe Condition	9	3		
Interior Pipe Condition	9	3		
C-Factor/N- Factor	12	4	Low C-factor value.	Monitor C-Factor over time
Cathodic Protection	0	0	No CP system	No recommendation (Not economically feasible to install CP system.)
Environmental Exposure	18	6	High soil chloride levels present concern for corrosion of reinforcing steel in concrete cylinder pipes.	No recommendation (No feasible way to change conditions. Direct observation indicated good exterior pipe condition since time of installation 1969.)
Materials of Construction	9	3		
Sulfide Level	12	4	Moderate sulfide level increases risk of corrosion.	Monitor (Conduct future sampling).
Vertical Location	9	3		
Horizontal Location	6	2		
Right of Way Maintenance	6	2		
Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Preventative Maintenance.
Condition of Discharge Manhole	3	1		

4.1.3 *Discharge Pipeline Q*

A summary of Discharge Pipeline Q characteristics and an aerial map of its location are shown in the following table and in Figure 4-5 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
Q_S	1995	36	5,310	Steel	Cement Mortar	Unknown
Q_N	1987	24	2,240	DIP	Poly-lined	Polyethylene Encasement

Figure 4-5. Pump Station Q and Discharge Pipeline Alignment

Figure 4-6 is a schematic of Discharge Pipeline Q. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline. (Note: The green boxes in Figure 4-4 indicate locations of excavations to expose the exterior surfaces of the pipeline for assessment).

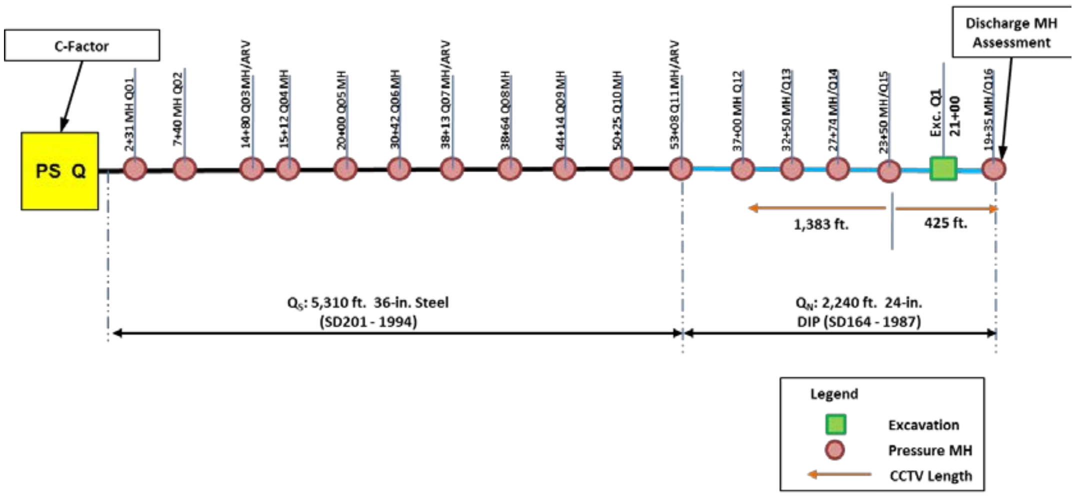

Figure 4-6. Discharge Pipeline Q Schematic

Table 4-5 and Table 4-6 identify the deficiencies for Discharge Pipeline Q.

Table 4-5. Discharge Pipeline Q_S (PS Q to MH Q11) Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	2	1		
Ext. Pipe Condition	0	0	No excavation.	Monitor (Perform condition assessment in the future.)
Interior Pipe Condition	0	0	No CCTV inspection.	Monitor (Perform CCTV in the future.)
C-Factor/N- Factor	0	0	Inconclusive test results.	No recommendation (Discharge pipeline operates intermittently in wet weather only and the ability to test is limited).
Cathodic Protection	12	6	Missing test stations and depleted anodes. CP system not providing adequate protection.	Capital Improvement (Provide adequate CP.)
Environmental Exposure	8	4		
Materials of Construction	6	3		
Sulfide Level	0	0	No access to the discharge manhole to collect data.	No recommendations. (Discharge pipeline operates intermittently in wet weather only, when sulfide generation is very unlikely to occur.)
Vertical Location	4	2		
Horizontal Location	4	2		

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	8	4		
Condition of Discharge Manhole	0	0	No discharge manhole, not applicable.	

Table 4-6. Discharge Pipeline Q_N (MH Q11 to MH Q16) Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	2	1		
Ext. Pipe Condition	6	3		
Interior Pipe Condition	12	6	From partial CCTV inspection, liner detached from the pipe wall	Monitor (Conduct CCTV from MH Q09 both upstream and downstream to further determine the interior pipe condition and the extent of liner failure.)
C-Factor/N- Factor	0	0	Inconclusive test result.	No recommendation (Discharge pipeline operates intermittently in wet weather only and the ability to test is limited).
Cathodic Protection	12	6	Missing test stations and depleted anodes. CP system not providing adequate protection.	Capital Improvement (Provide adequate CP.)
Environmental Exposure	8	4		
Materials of Construction	6	3		
Sulfide Level	0	0	No access to the discharge manhole to collect data.	No recommendations. (Discharge pipeline operates intermittently in wet weather only, when sulfide generation is very unlikely to occur.)
Vertical Location	4	2		
Horizontal Location	4	2		
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	8	4		
Condition of Discharge Manhole	2	1		

4.2 South Interceptor

The South Interceptor has five pump stations that discharge flow to the interceptor. The five pump stations, listed alphabetically, are Pump Station G, Pump Station H, Pump Station J, Pump Station K and Pump Station L.

4.2.1 *Discharge Pipeline G*

A summary of Discharge Pipeline G characteristics and an aerial map of its location are shown in the following table and in Figure 4-7 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
G	1954	12	2,180	RCP	None	None
	1995	14	1,000	HDPE	None	None

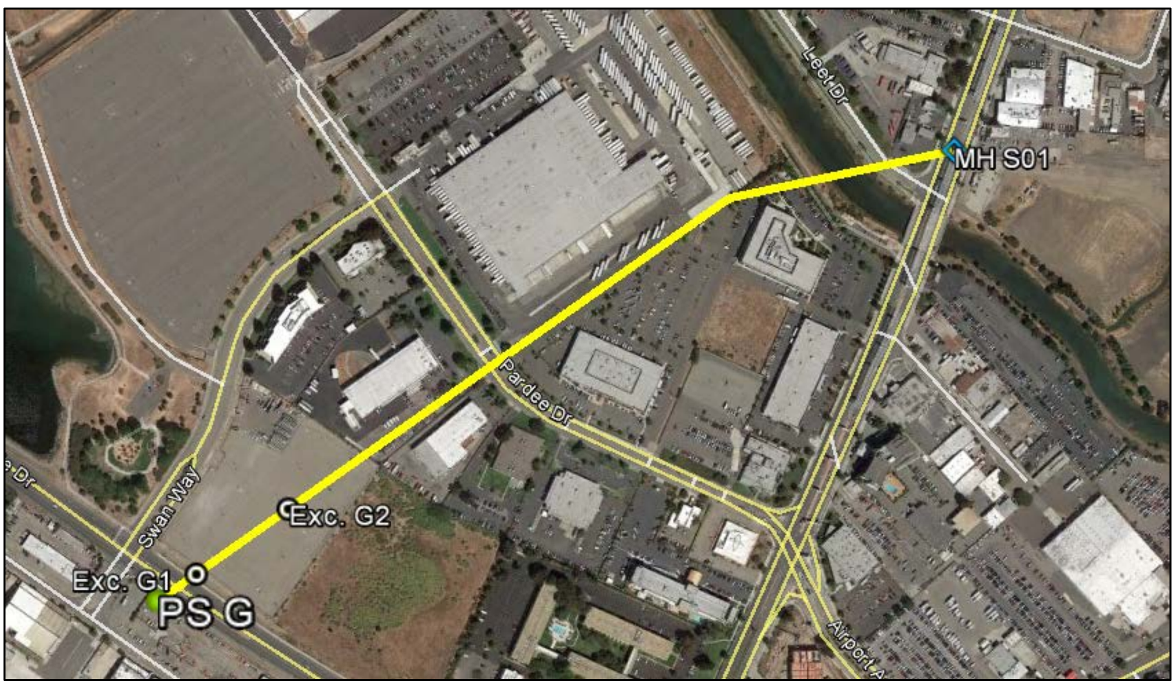

Figure 4-7. Pump Station G and Discharge Pipeline Alignment

Figure 4-8 is a schematic of Discharge Pipeline G. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline. (Note: The green boxes in Figure 4-8 indicate locations of excavations to expose the exterior surfaces of the pipeline for assessment).

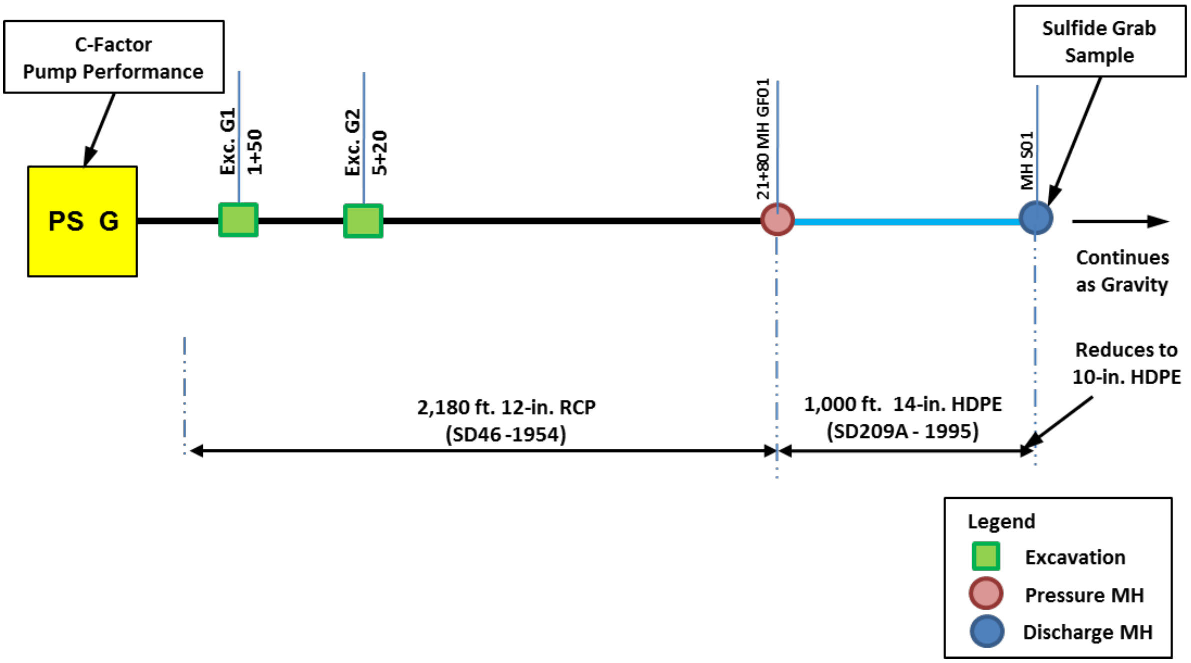

Figure 4-8. Discharge Pipeline G Schematic

Table 4-7 identifies the deficiencies for Discharge Pipeline G.

Table 4-7. Discharge Pipeline G Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	3	1		
Structural and Construction	9	3	No access to the pipe interior to conduct CCTV and cleaning.	Capital Improvement (Install one pressure manhole upstream of MH GF01 to conduct CCTV.
Ext. Pipe Condition	9	3		
Interior Pipe Condition	9	3	Data was extrapolated. No direct data was collected.	Monitor (Conduct CCTV from newly constructed pressure manholes)
C-Factor/N- Factor	0	0	Not tested.	No recommendation. (Pipe profile limits conclusive results. CCTV inspection will provide better data on interior surface condition.)
Cathodic Protection	0	0	Not applicable based on pipe material.	

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Environmental Exposure	18	6	High soil chloride levels present concern for corrosion of reinforcing steel in concrete pipes.	No recommendation (No feasible way to change conditions. Direct observation indicated good exterior pipe condition since time of installation in1954.)
Materials of Construction	9	3		
Sulfide Level	6	2		
Vertical Location	6	2		
Horizontal Location	6	2		
Right of Way Maintenance	6	2		
Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Preventative Maintenance.
Condition of Discharge Manhole	3	1		

4.2.2 *Discharge Pipeline H*

A summary of Discharge Pipeline H characteristics and an aerial map of its location are shown in the following table and in Figure 4-9 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
H	1948	48	1,000	RCP	None	None
	2009		1,150			

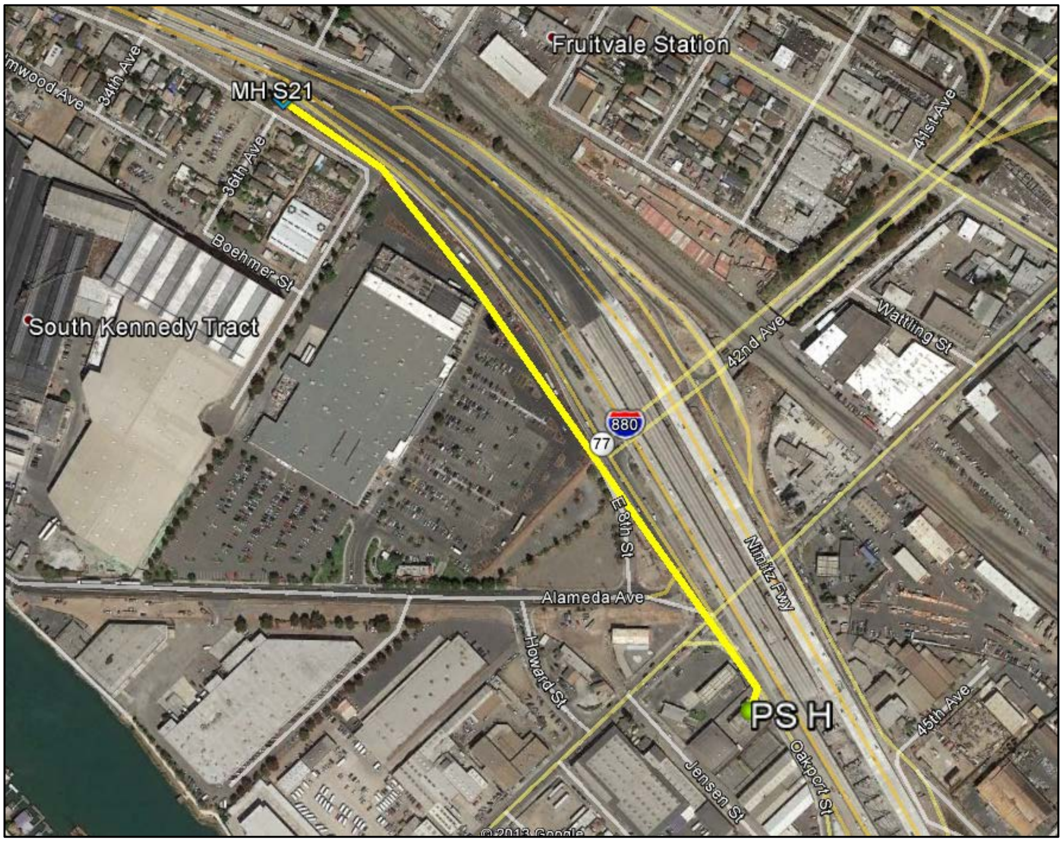

Figure 4-9. Pump Station H and Discharge Pipeline Alignment

Figure 4-10 is a schematic of Discharge Pipeline H. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline.

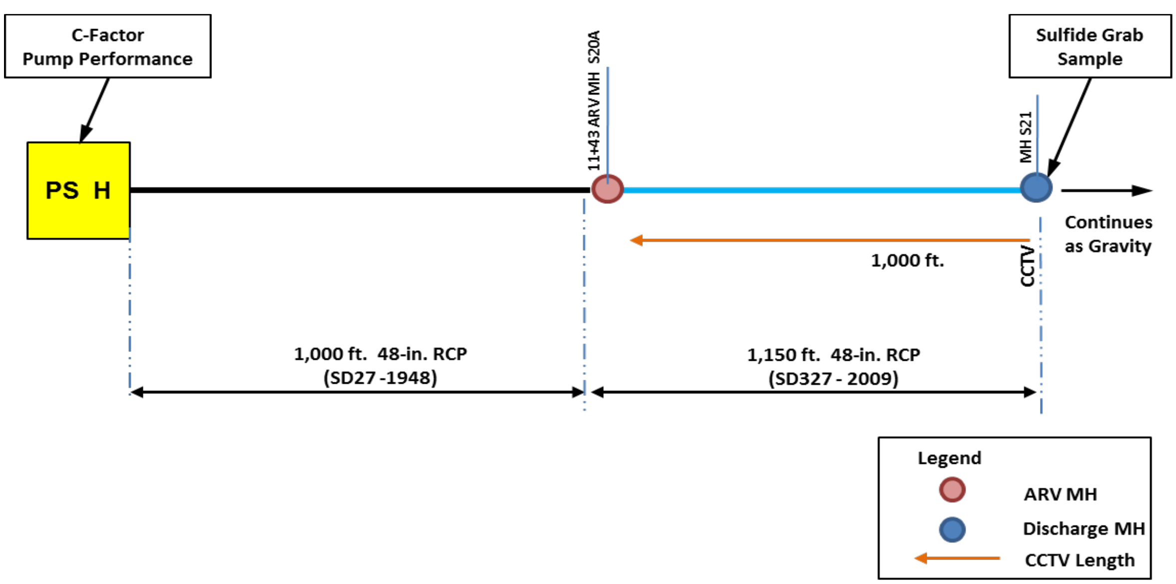

Figure 4-10. Discharge Pipeline H Schematic

Table 4-8 identifies the deficiencies for Discharge Pipeline H.

Table 4-8. Discharge Pipeline H Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	3	1		
Structural and Construction	3	1		
Ext. Pipe Condition	9	3		
Interior Pipe Condition	9	3		
C-Factor/N- Factor	6	2		
Cathodic Protection	0	0	Not applicable based on pipe material.	
Environmental Exposure	18	6	No direct data. Expected high level of chloride as G since both lines are near the shoreline and are relatively close to each other.	No recommendation
Materials of Construction	9	3		
Sulfide Level	6	2		
Vertical Location	6	2		
Horizontal Location	6	2		
Right of Way Maintenance	3	1		
Condition of Valves and Appurtenances	6	2		
Condition of Discharge Manhole	3	1		

4.2.3 *Discharge Pipeline J*

A summary of Discharge Pipeline J characteristics and an aerial map of its location are shown in the following table and in Figure 4-11 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
J	1953	12	160	CIP	Cement Mortar	Unknown

Figure 4-11. Pump Station J and Discharge Pipeline Alignment

Figure 4-12 is a schematic of Discharge Pipeline J. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline.

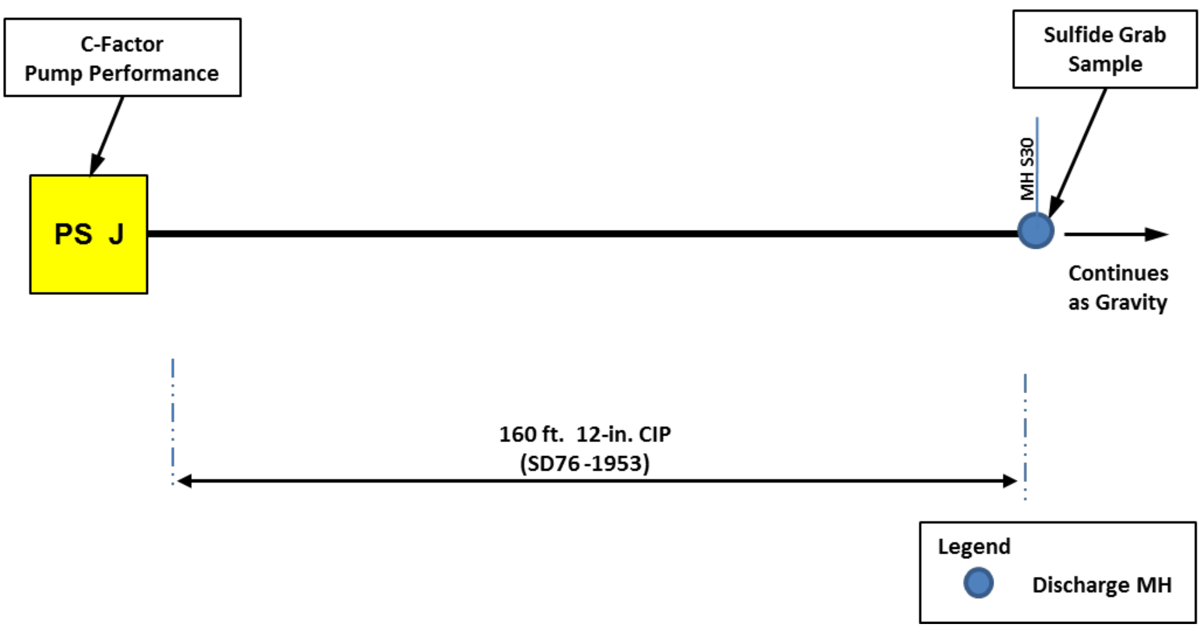

Figure 4-12. Discharge Pipeline J Schematic

Table 4-9 identifies the deficiencies for Discharge Pipeline J.

Table 4-9. Discharge Pipeline J Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	2	1		
Ext. Pipe Condition	6	3		
Interior Pipe Condition	12	6	No direct data. Expected to be similar condition from 2010 evaluation.	Monitor (Perform CCTV to inspect interior pipe condition.)
C-Factor/N- Factor	8	4		
Cathodic Protection	0	0	No existing CP system.	New CP system not recommended.
Environmental Exposure	12	6	High corrosive soil conditions.	Monitor (Excavate to assess the exterior pipe condition.)
Materials of Construction	4	2		
Sulfide Level	4	2		
Vertical Location	4	2		
Horizontal Location	6	3		
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	4	2		
Condition of Discharge Manhole	6	3		

4.2.4 *Discharge Pipeline K*

A summary of Discharge Pipeline K characteristics and an aerial map of its location are shown in the following table and in Figure 4-13 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
K	1953	12	132	CIP	Cement Mortar	None

Figure 4-13. Pump Station K and Discharge Pipeline Alignment

Figure 4-14 is a schematic of Discharge Pipeline K. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline. (Note: The green boxes in Figure 4-14 indicate locations of excavations to expose the exterior surfaces of the pipeline for assessment).

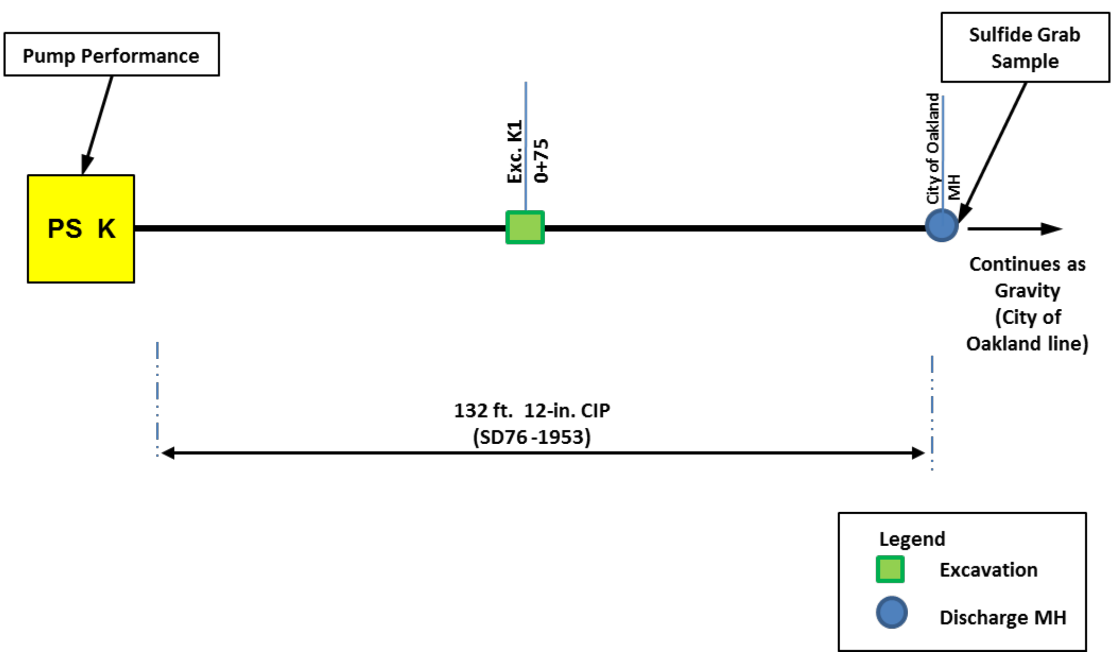

Figure 4-14. Discharge Pipeline K Schematic

Table 4-10 identifies the deficiencies for Discharge Pipeline K.

Table 4-10. Discharge Pipeline K Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	1	1		
Structural and Construction	1	1		
Ext. Pipe Condition	3	3		
Interior Pipe Condition	6	6		
C-Factor/N- Factor	4	4		
Cathodic Protection	0	0	No existing CP system.	New CP system not recommended
Environmental Exposure	4	4		
Materials of Construction	2	2		
Sulfide Level	2	2		
Vertical Location	3	3		
Horizontal Location	2	2		
Right of Way Maintenance	1	1		
Condition of Valves and Appurtenances	2	2		
Condition of Discharge Manhole	2	2		

4.2.5 *Discharge Pipeline L*

A summary of Discharge Pipeline L characteristics and an aerial map of its location are shown in the following table and in Figure 4-15 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
L	1955	10	290	CIP	Cement Mortar	Unknown

Figure 4-15. Pump Station L and Discharge Pipeline Alignment

Figure 4-16 is a schematic of Discharge Pipeline L. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline.

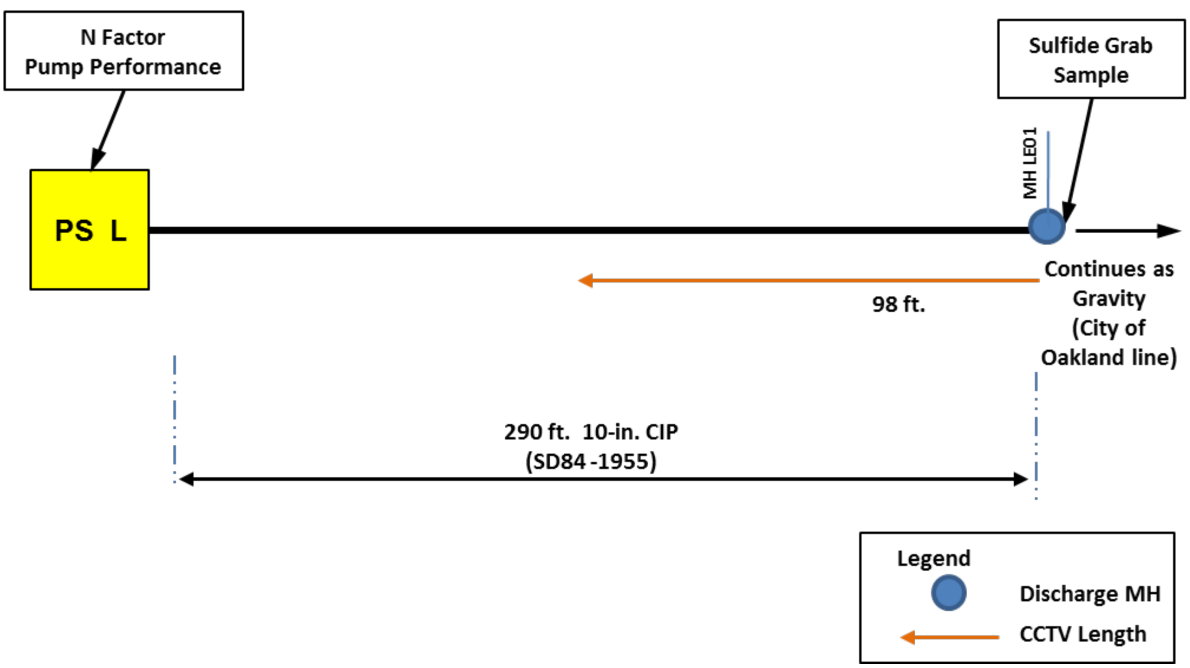

Figure 4-16. Discharge Pipeline L Schematic

Table 4-11 identifies the deficiencies for Discharge Pipeline L.

Table 4-11. Discharge Pipeline L Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	2	1		
Ext. Pipe Condition	6	3		
Interior Pipe Condition	6	3		
C-Factor/N- Factor	4	2		
Cathodic Protection	0	0	No existing CP system.	New CP system not recommended.
Environmental Exposure	0	0	No soil data was collected because the entire alignment is under pavement.	Monitor (Pothole at one location to collect and test a soil sample for corrosivity.)
Materials of Construction	4	2		
Sulfide Level	4	2		
Vertical Location	6	3		
Horizontal Location	6	3		
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	4	2		
Condition of Discharge Manhole	2	1		

4.3 Alameda Interceptor

Given its flat topography, the Alameda Interceptor has more pump stations than the other interceptor sections. A total of seven pump stations contribute flow to the Alameda Interceptor. Listed alphabetically the pump stations are: Pump Stations B, C, D, E, F, M, and R. Of the pump stations listed, Pump Station C has two discharge pipelines.

4.3.1 *Discharge Pipeline B*

A summary of Discharge Pipeline B characteristics and an aerial map of its location are shown in the following table and in Figure 4-17 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
B	1953	15	15	DIP	Unknown	Unknown
	2000	18	2,700	DIP	Cement Mortar	Polyethylene Encasement

Figure 4-17. Pump Station B and Discharge Pipeline Alignment

Figure 4-18 is a schematic of Discharge Pipeline B. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline.

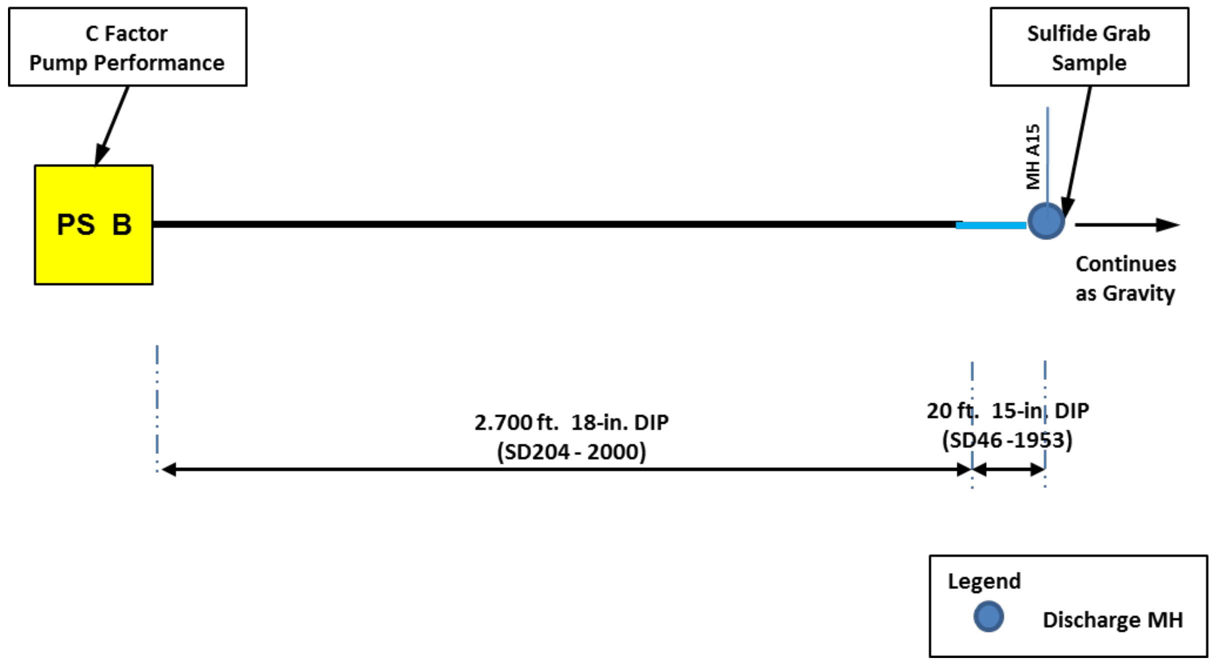

Figure 4-18. Discharge Pipeline B Schematic

Table 4-12 identifies the deficiencies for Discharge Pipeline B.

Table 4-12. Discharge Pipeline B Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	3	1		
Structural and Construction	3	1		
Ext. Pipe Condition	9	3	No direct data. Extrapolated from M_{AI}.	Monitor (Perform excavation to assess the exterior pipe condition).
Interior Pipe Condition	9	3	No direct data. Extrapolated from M_{AI}.	Monitor (Perform excavation to collect data to assess interior pipe condition using non-destructive techniques).
C-Factor/N- Factor	6	2		
Cathodic Protection	0	0	No existing CP system.	New CP system not recommended. (Direct data from excavation recommendation will help determine the need for a CP system, if any).

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Environmental Exposure	12	4	Mild to moderate soil corrosivity level. No exterior pipe condition was available.	No recommendations. (No feasible way to change conditions. The pipe exterior is expected to be in good condition since the pipe was installed in 2000.)
Materials of Construction	9	3		
Sulfide Level	12	4	Moderate sulfide level increases risk of interior corrosion.	Monitor (Conduct future sampling).
Vertical Location	6	2		
Horizontal Location	6	2		
Right of Way Maintenance	3	1		
Condition of Valves and Appurtenances	6	2		
Condition of Discharge Manhole	3	1		

4.3.2 *Discharge Pipeline C*

A summary of Discharge Pipeline C characteristics and an aerial map of its location are shown in the following table and in Figure 4-19 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
C_A	1942	16	3,700	CIP	Cement Mortar	None
	1995	20	450	DIP	Cement lined	Seal coated
C_B	1968	21	4,100	RCP	None	None

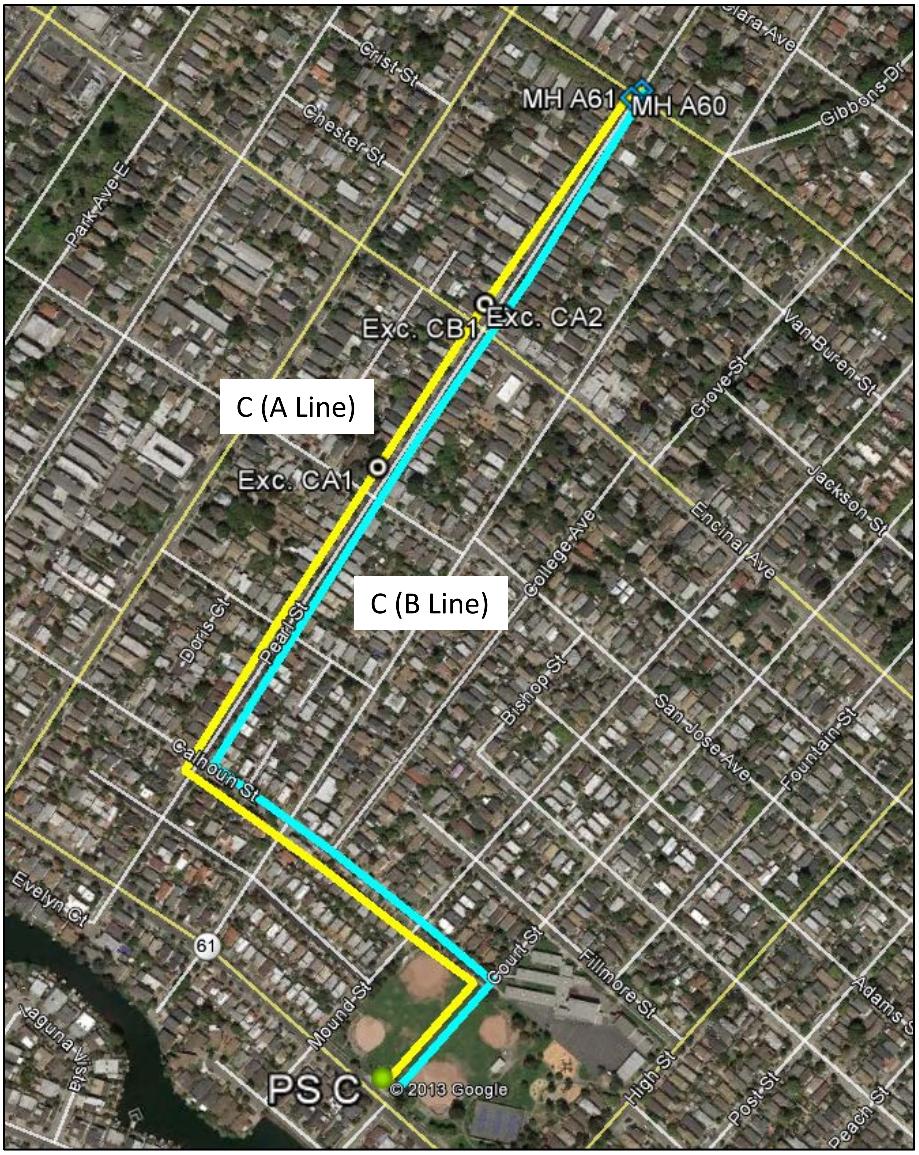

Figure 4-19. Pump Station C and Discharge Pipeline Alignments

Figure 4-20 is a schematic of the Pump Station C discharge pipelines. It indicates the types of testing performed and the approximate locations of the testing along the alignments as referenced from key landmarks or features on the pipelines. (Note: The green boxes in Figure 4-20 indicate locations of excavations to expose the exterior surfaces of the pipeline for assessment).

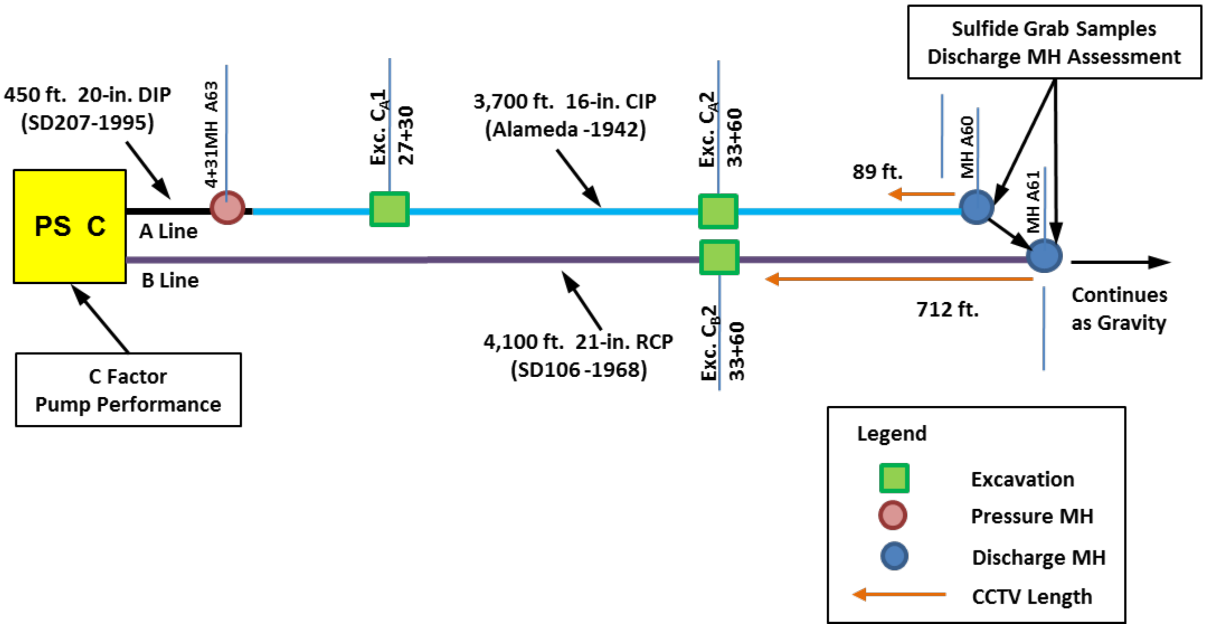

Figure 4-20. Discharge Pipeline C Schematic

Table 4-13 and Table 4-14 identify the deficiencies for the Pump Station C discharge pipelines.

Table 4-13. Discharge Pipeline C_A Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	6	3	Insufficient access through the discharge manhole to conduct CCTV and cleaning for entire length of pipe.	Capital Improvement (Install access manholes as prerequisite to support CCTV and pipe cleaning)
Ext. Pipe Condition	6	3		
Interior Pipe Condition	12	6	Discharge pipeline has grease deposits.	Preventive Maintenance and Monitoring (Conduct pipe cleaning and CCTV to inspect interior pipe condition).
C-Factor/N- Factor	0	0	Inconclusive results.	No recommendation. (Additional CCTV will define interior condition)
Cathodic Protection	0	0	No existing CP system.	New CP system not recommended.
Environmental Exposure	4	2		
Materials of Construction	4	2		

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Sulfide Level	12	6	High sulfide level increases risk of corrosion.	Monitor (Conduct future sampling).
Vertical Location	6	3		
Horizontal Location	6	3		
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	8	4		
Condition of Discharge Manhole	6	3		

Table 4-14. Discharge Pipeline C_B Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	6	3	Insufficient access through the discharge manhole to conduct CCTV and cleaning for entire length of pipe.	Capital Improvement (Install access manholes as prerequisite to support pipe cleaning.)
Ext. Pipe Condition	6	3		
Interior Pipe Condition	12	6	Discharge pipeline has sediment deposits and internal corrosion.	Preventive Maintenance and Monitoring (Conduct pipe cleaning and CCTV to inspect interior pipe condition to determine need and limits for rehabilitation.)
C-Factor/N- Factor	0	0	Inconclusive results.	No recommendation. (Additional CCTV will define interior condition).
Cathodic Protection	0	0	Not applicable based on pipe material.	
Environmental Exposure	4	2		
Materials of Construction	6	3		
Sulfide Level	12	6	Moderate sulfide level increases risk of corrosion.	Monitor (Conduct future sampling).
Vertical Location	6	3		
Horizontal Location	6	3		
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	8	4		
Condition of Discharge Manhole	6	3		

4.3.3 *Discharge Pipeline D*

A summary of Discharge Pipeline D characteristics and an aerial map of its location are shown in the following table and in Figure 4-21 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
D	1953	8	220	CIP	Cement Mortar	None

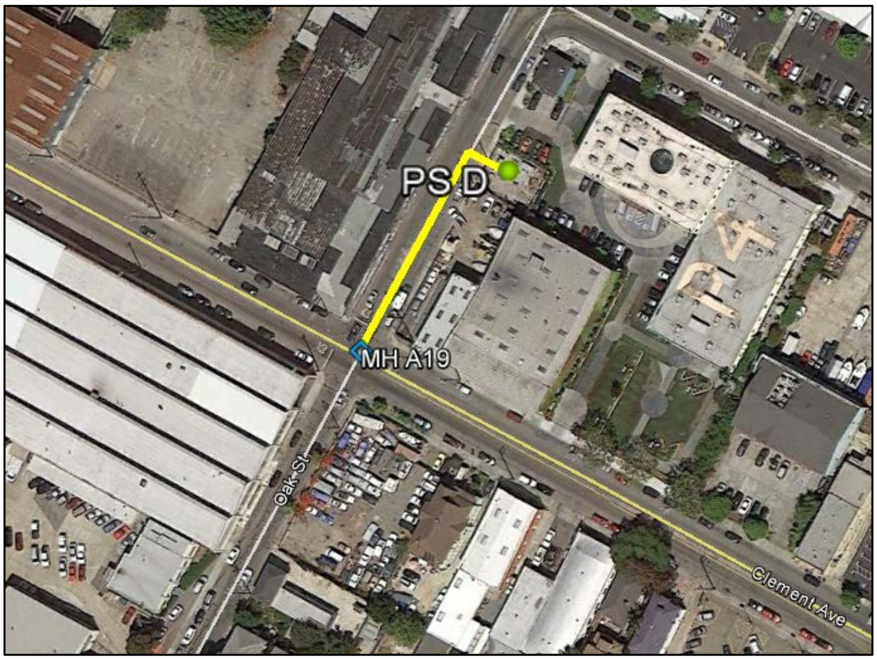

Figure 4-21. Pump Station D and Discharge Pipeline Alignment

Figure 4-22 is a schematic of Discharge Pipeline D. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline.

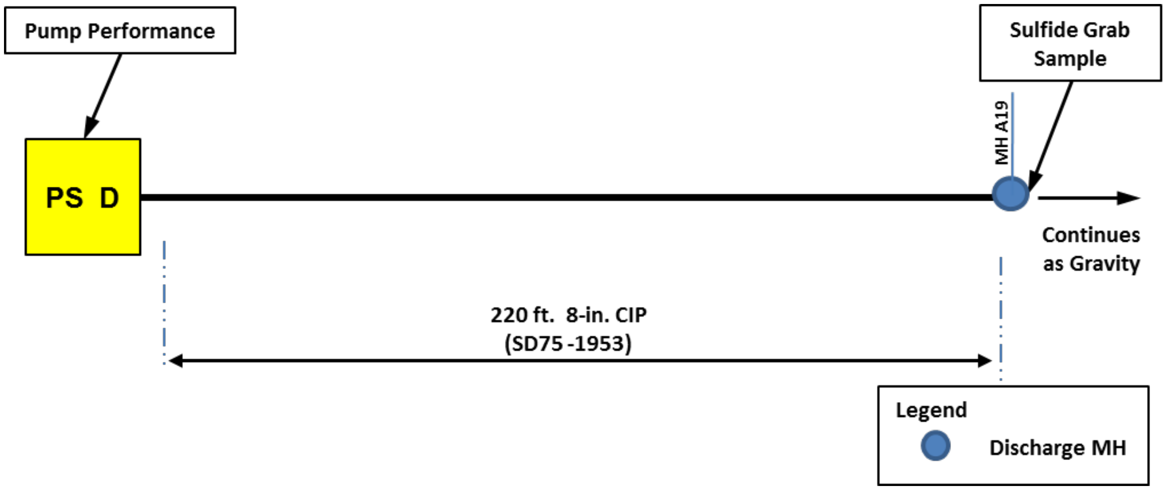

Figure 4-22. Discharge Pipeline D Schematic

Table 4-15 identifies the deficiencies for Pipeline D.

Table 4-15. Discharge Pipeline D Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	2	1		
Ext. Pipe Condition	6	3		
Interior Pipe Condition	6	3		
C-Factor/N- Factor	4	2		
Cathodic Protection	0	0	No existing CP system.	New CP system not recommended.
Environmental Exposure	8	4		
Materials of Construction	4	2		
Sulfide Level	4	2		
Vertical Location	4	2		
Horizontal Location	6	3		
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	4	2		
Condition of Discharge Manhole	2	1		

4.3.4 *Discharge Pipeline E*

A summary of Discharge Pipeline E characteristics and an aerial map of its location are shown in the following table and in Figure 4-23 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
E	1953	8	50	CIP	Cement Mortar	None

Figure 4-23. Pump Station E and Discharge Pipeline Alignment

Figure 4-24 is a schematic of Discharge Pipeline E. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline.

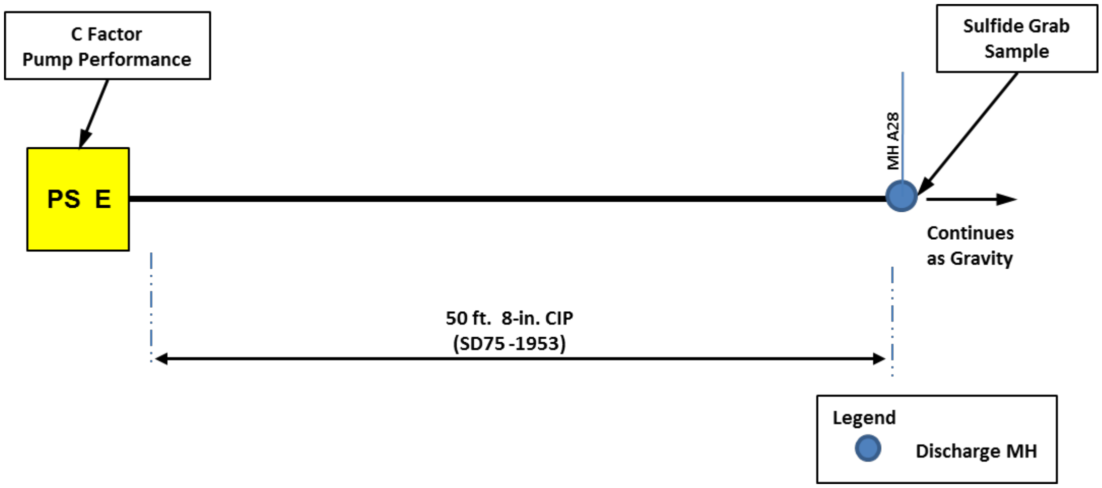

Figure 4-24. Discharge Pipeline E Schematic

Table 4-16 identifies the deficiencies for Discharge Pipeline E.

Table 4-16. Discharge Pipeline E Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	2	1		
Ext. Pipe Condition	6	3		
Interior Pipe Condition	6	3		
C-Factor/N- Factor	0	0	Inconclusive testing results. C-factor testing is sensitive to errors in discharge elevation measurement and estimated minor losses.	No recommendation. (Internal pipe condition can be better determined from available internal pipe inspection results.)
Cathodic Protection	0	0	No existing CP system.	New CP system not recommended.
Environmental Exposure	8	4		
Materials of Construction	4	2		
Sulfide Level	4	2		
Vertical Location	4	2		
Horizontal Location	6	3		
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	4	2		
Condition of Discharge Manhole	4	2		

4.3.5 *Discharge Pipeline F*

A summary of Discharge Pipeline C characteristics and an aerial map of its location are shown in the following table and in Figure 4-25 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
F	1953	16	35	CIP	Unknown	None

Figure 4-25. Pump Station F and Discharge Pipeline Alignment

Figure 4-26 is a schematic of Discharge Pipeline F. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline.

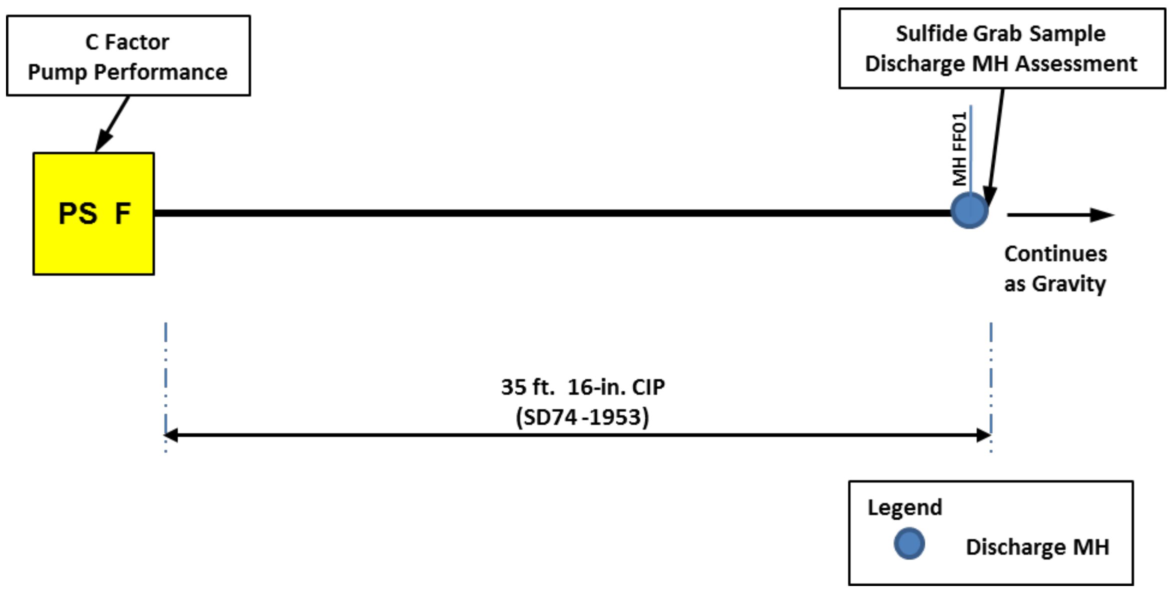

Figure 4-26. Discharge Pipeline F Schematic

Table 4-17 identifies the deficiencies for Discharge Pipeline F.

Table 4-17. Discharge Pipeline F Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	2	1		
Ext. Pipe Condition	6	3		
Interior Pipe Condition	12	6	Corrosion above the waterline and grease deposit below the waterline.	Monitor (Perform CCTV to inspect interior pipe condition to determine need and limits for rehabilitation.)
C-Factor/N- Factor	0	0	Inconclusive testing results. C-factor testing is sensitive to errors in discharge elevation measurement and estimated minor losses.	No recommendation. (Internal pipe condition can be better determined from internal pipe CCTV inspection results.)
Cathodic Protection	0	0	No existing CP system.	New CP system not recommended.
Environmental Exposure	8	4		
Materials of Construction	4	2		
Sulfide Level	4	2		
Vertical Location	4	2		
Horizontal Location	2	1		
Right of Way Maintenance	2	1		

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Condition of Valves and Appurtenances	0	0	No valves or appurtenances.	
Condition of Discharge Manhole	4	2		

4.3.6 *Discharge Pipeline M*

The discharge pipeline serving Pump Station M is divided into three segments, the Bay Farm Island section denoted as M_{BF}, the San Leandro Channel crossing denoted as M_{WC}, and Alameda Island section denoted as M_{AI}. Figure 4-27 shows an overview of the entire alignment of Discharge Pipeline M. The accompanying table presents characteristics of each pipeline segment.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
M_{BF}	1980	24	1,980	DIP	Cement Mortar	Polyethylene Encasement
M_{WC}	1949	16	1,010	CIP	Unknown	None
M_{AI}	1986	24	5,125	DIP	Cement Mortar	Polyethylene Encasement

Figure 4-27. Pump Station M and Discharge Pipeline Alignment

Figure 4-28 is a schematic of Discharge Pipeline M. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline. (Note: The pipeline was exposed at four excavations, denoted as “Exc.” and is indicated by the green boxes in Figure 4-28.)

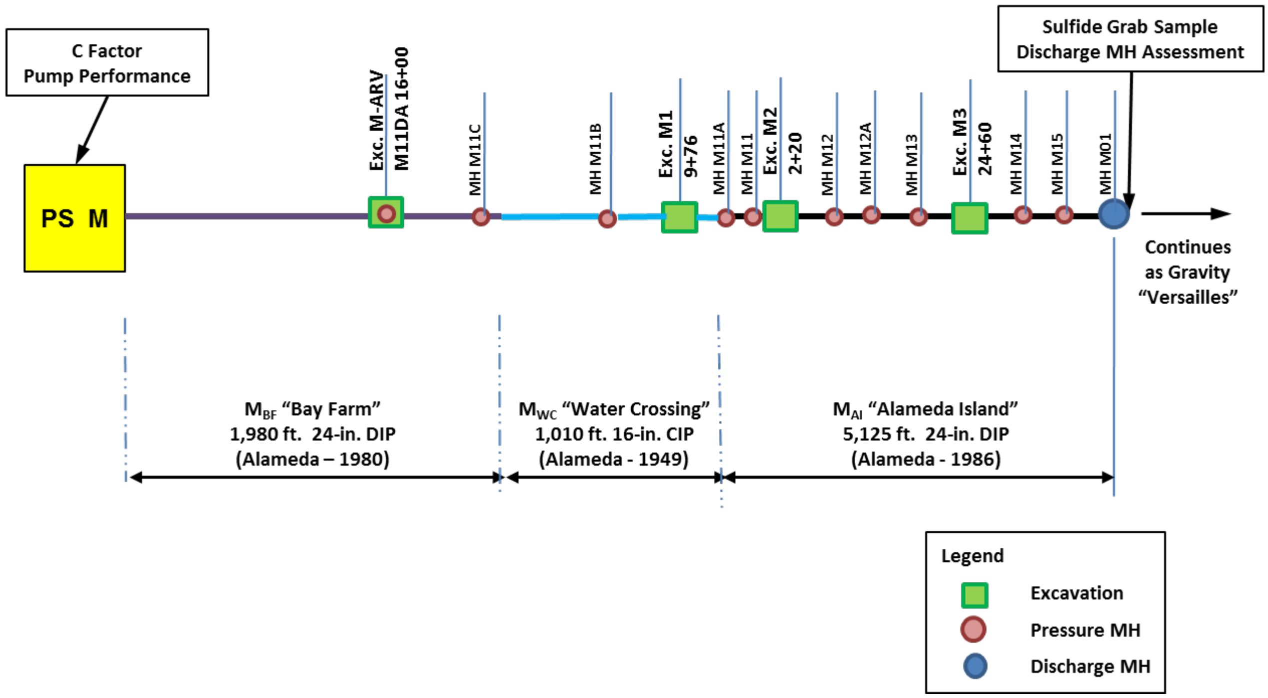

Figure 4-28. Discharge Pipeline M Schematic

Table 4-18, Table 4-19 and Table 4-20 identify the deficiencies for Discharge Pipeline M.

Table 4-18. Discharge Pipeline M_{BF} (Bay Farm Island) Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	2	1		
Structural and Construction	2	1		
Ext. Pipe Condition	6	3		
Interior Pipe Condition	0	0	No CCTV was conducted.	No recommendation. (CCTV inspection is impractical.)
C-Factor/N- Factor	8	4	Low C-factor value.	No recommendation. (Pipe profile limits the ability to collect conclusive results.)
Cathodic Protection	4	2		
Environmental Exposure	4	2		
Materials of Construction	6	3		
Sulfide Level	12	6	High sulfide level increases risk of internal corrosion.	Monitor (Conduct future sampling).
Vertical Location	4	2		
Horizontal Location	4	2		

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Right of Way Maintenance	2	1		
Condition of Valves and Appurtenances	8	4		
Condition of Discharge Manhole	0	0	Not applicable.	

Table 4-19. Discharge Pipeline M_{WC} (Water Crossing) Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	3	1		
Structural and Construction	9	3	No access to adequately inspect or maintain the pipeline. Cannot locate pipeline.	Capital Improvement (Construct a parallel line with adequate access. Leave existing pipeline as it is.)
Ext. Pipe Condition	9	3		
Interior Pipe Condition	0	0	No CCTV was conducted.	No recommendation. (No access to conduct CCTV.)
C-Factor/N- Factor	12	4	Low C-factor.	No recommendation. (New parallel pipeline proposed. Existing pipe profile limits the ability to collect conclusive results.)
Cathodic Protection	0	0	No existing CP system	New CP system not recommended.
Environmental Exposure	18	6	High corrosive soil condition.	No recommendations. (No feasible way to change conditions. Direct observation indicated good exterior pipe condition since time of installation. Only minor pipe wall thickness loss.)
Materials of Construction	6	2		
Sulfide Level	18	6	High sulfide level increases risk of corrosion.	Monitor (Conduct future sampling).
Vertical Location	3	1		
Horizontal Location	3	1		
Right of Way Maintenance	6	2		
Condition of Valves and Appurtenances	0	0	No appurtenances, not applicable.	
Condition of Discharge Manhole	0	0	No discharge manhole, not applicable.	

Table 4-20. Discharge Pipeline M_{AI} (Alameda Island) Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	3	1		
Structural and Construction	9	3	Lack of ARVs at high points.	Capital improvement (Install ARVs)
Ext. Pipe Condition	9	3		
Interior Pipe Condition	9	3	CCTV was not performed.	Monitor (Perform CCTV.)
C-Factor/N- Factor	12	4	Low C-factor	No recommendation. (CCTV inspection will provide better indication of interior condition.)
Cathodic Protection	0	0	No existing CP system	New CP system not recommended.
Environmental Exposure	12	4	Negligible to moderate corrosive soil conditions.	No recommendation. (Exterior pipe is in good condition.)
Materials of Construction	9	3		
Sulfide Level	18	6	Sulfide level increases risk of corrosion.	Monitor (Conduct future sampling).
Vertical Location	9	3		
Horizontal Location	6	2		
Right of Way Maintenance	3	1		
Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Preventative Maintenance
Condition of Discharge Manhole	6	2		

4.3.7 *Discharge Pipeline R*

A summary of Discharge Pipeline R characteristics and an aerial map of its location are shown in the following table and in Figure 4-29 below.

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
R	2001	20	8,360	DIP	Cement Mortar	Polyethylene Encasement

Figure 4-29. Pump Station R and Discharge Pipeline Alignment

Figure 4-30 is a schematic of Discharge Pipeline R. It indicates the types of testing performed and the approximate locations of the testing along the alignment as referenced from key landmarks or features on the pipeline.

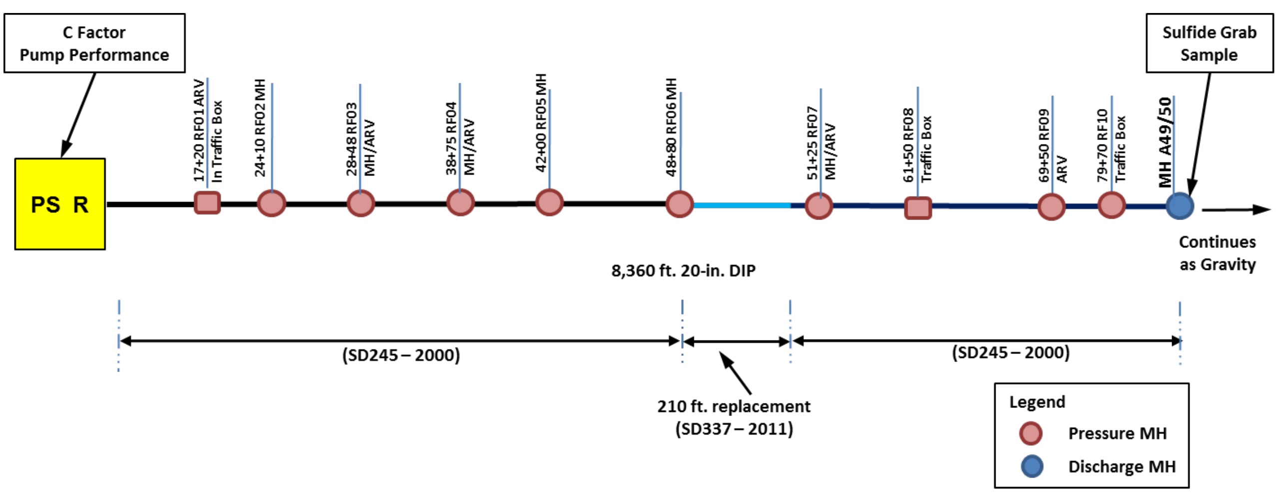

Figure 4-30. Discharge Pipeline R Schematic

Table 4-21 identifies the deficiencies for Discharge Pipeline R.

Table 4-21. Discharge Pipeline R Summary of Deficiencies

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Hydraulics	9	3	Hydraulically oversized.	Monitor (First access the interior of the pipeline to determine condition prior to considering capital improvement to improve hydraulic issues.)
Structural and Construction	9	3		
Ext. Pipe Condition	9	3		
Interior Pipe Condition	9	3	No CCTV was conducted.	Monitor (Perform CCTV.)
C-Factor/N- Factor	12	4	Low C-factor.	Monitor (Monitor C-Factor over time.)
Cathodic Protection	6	2		
Environmental Exposure	18	6	High corrosive soil condition.	No recommendations. (No feasible way to change conditions. The pipe exterior is expected to be in good condition since the pipe was installed in 2001.)
Materials of Construction	9	3		
Sulfide Level	18	6	High sulfide level increases risk of corrosion.	Monitor (Conduct future sampling).
Vertical Location	9	3		
Horizontal Location	6	2		
Right of Way Maintenance	6	2		
Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Preventative Maintenance.
Condition of Discharge Manhole	6	2		

5.0 CONCLUSIONS

5.1 Summary of Condition Assessment

The following tables provide summaries of the areas to be improved in CIP, PM, and FMI per pump station discharge pipeline. These recommendations are based on the results of the condition assessment and final risk assessment.

5.1.1 *Summary of Areas for Capital Improvement*

Table 5-1 provides a summary of areas for capital improvement recommendations per discharge pipeline. These recommendations are based on the condition assessment results.

Table 5-1. Summary of Potential Areas for Capital Improvement by Discharge Pipeline

Discharge Pipeline	Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies	Recommendations
A	Cathodic Protection	12	6	Missing test stations and depleted anodes. CP system not providing adequate protection.	Provide adequate cathodic protection.
C_A	Structural and Construction	6	3	No access through the discharge manhole to adequately inspect and maintain the pipeline.	Install three access manholes as prerequisite to conduct pipe cleaning and CCTV.
C_B	Structural and Construction	6	3	No access through the discharge manhole to adequately inspect and maintain the pipeline.	Install four access manholes as prerequisite to conduct pipe cleaning and CCTV. Additional CCTV is required to determine the limits for pipeline rehabilitation.
G	Structural and Construction	9	3	No access to the pipe interior to conduct CCTV and cleaning.	Install one pressure manhole as prerequisite to conduct CCTV and cleaning if necessary based on CCTV inspection results.
M_{WC}	Structural and Construction	9	3	No access to adequately inspect and maintain the pipeline. Pipeline cannot be located.	Construct a parallel line with access. Leave existing line as it is.
M_{AI}	Structural and Construction	9	3	Lack of ARVs at high points.	Install ARVs.
Q_S	Cathodic Protection	12	6	Missing test stations and depleted anodes. CP system not providing adequate protection.	Provide adequate cathodic protection.
Q_N	Cathodic Protection	12	6	Missing test stations and depleted anodes. CP system not providing adequate protection.	Provide adequate cathodic protection.

5.1.2 *Summary of Areas for Preventive Maintenance*

Table 5-2 provides a summary of areas for preventive maintenance recommendations per discharge pipeline. These recommendations are based on the condition assessment results.

Table 5-2. Summary of Potential Areas for Preventive Maintenance by Discharge Pipeline

Discharge Pipeline	Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies	Recommendations
C_A	Interior Pipe Condition	12	6	Discharge pipeline has grease deposits.	Conduct pipe cleaning and CCTV inspection after access manholes are constructed.
C_B	Interior Pipe Condition	12	6	Discharge pipeline has sediment deposits and internal corrosion.	Conduct pipe cleaning and CCTV inspection after access manholes are constructed.
G	Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Provide adequate maintenance for the assets.
M_{AI}	Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Provide adequate maintenance for the assets.
N_c	Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Provide adequate maintenance for the assets.
N_N	Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Provide adequate maintenance for the assets.
R	Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Provide adequate maintenance for the assets.

5.1.3 *Summary of Areas for Future Monitoring/Inspection*

Table 5-3 provides a summary of recommendations for future monitoring/inspection per discharge pipeline. These recommendations are based on the condition assessment results.

Table 5-3. Summary of Potential Areas for Future Monitoring/Inspection by Discharge Pipeline

Discharge Pipeline	Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies	Recommendations
A	Interior Pipe Condition	12	6	No direct data. Rating based on extrapolated data from Discharge Pipeline Q_N (Possible liner failure).	Conduct CCTV to inspect internal pipe condition.

Discharge Pipeline	Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies	Recommendations
B	Ext. Pipe Condition	9	3	No direct data. Extrapolated condition from M_{AI}	Perform excavation to assess the exterior pipe condition.
B	Interior Pipe Condition	9	3	No direct data. Extrapolated from M_{AI}.	Monitor (Perform excavation to collect data to assess interior pipe condition using non-destructive techniques).
B	Sulfide Level	12	4	Moderate sulfide level increases risk of interior corrosion.	Conduct future sampling.
C_A	Sulfide Level	12	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.
C_A	Interior Pipe Condition	12	6	Discharge pipeline has grease deposits.	Preventative Maintenance and Monitoring (Conduct pipe cleaning and CCTV to inspect interior pipe condition).
C_B	Sulfide Level	12	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.
C_B	Interior Pipe Condition	12	6	Discharge pipeline has sediment deposits and internal corrosion.	Conduct additional CCTV to inspect interior pipe condition to determine need and limits for rehabilitation after access manholes are constructed and cleaning has been performed.
F	Interior Pipe Condition	12	6	Corrosion above the waterline and grease deposit below the waterline.	Perform CCTV to inspect interior pipe condition.
G	Interior Pipe Condition	9	3	Data was extrapolated. No direct data was collected.	Conduct CCTV to inspect interior pipe condition after pressure manhole is constructed.
J	Interior Pipe Condition	12	6	No direct data. Internal corrosion from 2010 evaluation.	Perform CCTV to inspect interior pipe condition.
J	Environmental Exposure	12	6	High corrosive soil conditions.	Excavate to assess the exterior pipe condition.
L	Environmental Exposure	0	0	No soil data were collected because the entire alignment is under pavement.	Pothole at one location to collect a soil sample to test for corrosivity.

Discharge Pipeline	Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies	Recommendations
M_{BF}	Sulfide Level	12	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.
M_{WC}	Sulfide Level	18	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.
M_{AI}	Interior Pipe Condition	9	3	No CCTV was conducted.	Conduct CCTV to inspect internal pipe condition.
M_{AI}	Sulfide Level	12	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.
N_N	C-Factor/N-Factor	12	4	Low C-factor value.	Monitor C-Factor over time.
N_N	Sulfide Level	12	4	Moderate sulfide level increases risk of interior corrosion.	Conduct future sampling.
N_C	C-Factor/N-Factor	12	4	Low C-factor value.	Monitor C-Factor over time.
N_C	Sulfide Level	12	4	Moderate sulfide level increases risk of interior corrosion.	Conduct future sampling.
Q_S	Ext. Pipe Condition	0	0	No excavation.	Perform excavation to assess the exterior pipe condition.
Q_S	Interior Pipe Condition	0	0	No CCTV inspection.	Perform CCTV to inspect internal condition.
Q_N	Interior Pipe Condition	12	6	Liner failure.	Conduct CCTV from MH Q09 both upstream and downstream.
R	Hydraulics	9	3	Hydraulically oversized.	Before considering CIP, conduct CCTV inspection of the pipeline.
R	Interior Pipe Condition	9	3	No CCTV inspection.	Conduct CCTV to inspect internal pipe condition.
R	C-Factor/N-Factor	12	4	Low C-factor value.	Track change in C-Factor value over time.
R	Sulfide Level	18	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.

5.2 Remaining Service Life Estimates

With the available pipeline conditions, it is possible to estimate the remaining service life of the pipelines. It is necessary to provide the following functional definitions of asset life expectancy.

- **Design Life:** The expected length of time an asset is projected to last based on initial considerations of conditions. The design life starts from the beginning of the service cycle of an asset. Typical design life expectancies by material type are provided in Table 5-4 below.
- **Service Life:** The expected length of time an asset is projected to last based on current conditions with the assumption that conditions will stay the same over time.
- **Useful Life:** The expected length of time an asset is projected to last based on current conditions with available improvements and management of conditions to prolong the service life.

Table 5-4. Typical Design Life Expectancy by Pipe Material Type

Pipeline Material	Typical Design Life Expectancy (Years)
Cast Iron	50
Ductile Iron	50
Steel	50
Concrete steel cylinder	50
Reinforced Concrete	40
Asbestos Cement	40
HDPE	60
PVC	60

A large portion of the District's sanitary sewer infrastructure was developed between the 1940s and the 1980s. Facilities built within this period are currently facing different levels of deterioration as they reach or exceed the design life. Many of the District's discharge pipelines are near or have exceeded their design life; this is one of the key drivers that justify the need to evaluate the discharge pipelines as to their current condition and to determine potential improvement needs. Service life estimates are the number of years the discharge pipelines are projected to last from the present year which is directly related to the likelihood of failure ratings. The service life estimates are considered to be "Long" (>40 years for "Very Unlikely"), "Medium" (30 years for "Unlikely"), and "Short" (20 years for "Likely"). Other adjustment factors, such as age and special pipe material, should also be considered. The adjusted service life estimates of the pipelines are summarized in Table 5-5.

Table 5-5. Pump Station Discharge Pipelines Service Life Estimates

Discharge Pipeline	Year Installed	Age (Yrs)	Design Life by Material Type	Likelihood of Failure	Remaining Service Life (Yrs)	Adjustment Factor	Adjusted Remaining Service Life (Yrs)
A	1987	27	50	2	30	-	30
B	2000	14	50	1	40	New pipe, but no direct condition data. No overall adjustment	40
C_A	1942, 1995	72 19	50	3	20	-	20
C_B	1968	46	40	3	20	-	20
D	1953	61	50	1	40	-	40
E	1953	61	50	1	40	-	40
F	1953	61	50	1	40	-	40
G	1954	60	40	2	30	-	30
H	1948, 2009	66 5	40	1	40	-	40
J	1953	61	50	2	30	-	30
K	1953	61	50	1	40	-	40
L	1955	59	50	1	40	-	40
M_{BF}	1980	34	50	1	40	Pipe has functioning CP system	50
M_{WC}	1949	65	50	3	20	-	20
M_{AI}	1986	28	50	3	20	-	20
N_C	1969	45	50	2	30	-	30
N_N	2000	14	60	1	40	New steel pipe cement mortar coated and HDPE Slip Lined inside existing RCP	50
Q_S	1995	19	50	3	20	New steel pipe, Cement mortar-lined	30
Q_N	1987	27	50	2	30	Poly-lined but found to be in poor condition. No overall adjustment.	30
R	2001	13	50	3	20	New pipe	30

6.0 RECOMMENDATIONS FOR IMPROVEMENTS

In Section 5, the areas of concern are identified, deficiencies noted and the remaining service life of the discharge pipelines was calculated. Section 6 develops recommendations for improvements to the discharge pipelines based on these factors. Sets of planning level recommendations are derived based on the concept of reducing discharge pipeline risk associated with the criteria developed in the FRA. The planning level recommendations are categorized into capital improvement projects (CIP), preventive maintenance (PM), and future monitoring/inspection (FMI).

The discussion on recommendations is provided for discharge pipelines in the following order:

- High risk: M_{WC}, M_{AI}, and R.
- Medium risk: A, C_A, C_B, G, J, N_C, Q_N, and Q_S
- Low risk: B, D, E, F, H, K, L, M_{BF}, and N_N,

6.1 Discharge Pipelines with High Risk

6.1.1 *Discharge Pipeline M_{WC}*

Recommendations for improvements to Pipeline M_{WC} are summarized in Table 6-1 below.

Table 6-1. Summary of Recommendations on Discharge Pipeline M_{WC}

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Capital Improvement				
Structural and Construction.	9	3	No access to adequately inspect or maintain the pipeline. Pipeline cannot be located.	Construct a parallel line with adequate access. Leave existing line as it is.
Future Monitoring/Inspection				
Sulfide Level	18	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.

Discharge Pipeline M_{WC} was installed in 1949 across San Leandro Channel. During this study, the pipe exterior was identified to be in good condition from the excavation site on one end of the pipe on Alameda Island. No CCTV inspection for the interior pipe condition assessment was performed because there is no access for CCTV from either side of the pipeline. V&A does not recommend CCTV inspection or undertaking any other inspection methods on the pipeline because: 1) it is cost-prohibitive to construct access points on the active line, 2) locating the pipeline based on record drawings has failed twice, and 3) the age and high risk score of 18 warrants consideration of construction of a parallel pipeline, rather than investing additional funds into condition assessment.

Capital Improvement

Structure and Construction: V&A recommends constructing a parallel pressure pipeline and using this pipeline as the new primary discharge pipeline. The new pipeline should be constructed with adequate access features to support future cleaning and inspection. The existing discharge pipeline can then be taken out of service for construction of access points and inspection. Any improvements can then be made and the pipeline can be placed back in service. The improved parallel pipelines will significantly reduce the risk and provide greater flexibility for operation and maintenance.

The new parallel pipe would consist of approximately1,100 feet of 16-inch diameter heavy wall DIP with restrained joints and can be installed using directional drilling. The new 16-inch DIP pipeline would be connected to the existing Discharge Pipeline M segments on Bay Farm Island (M_{BF}) and Alameda Island (M_{AI}) by installing access vaults at each end. Each connection point will have a tee, and plug valves to isolate each pipe. Each end will also have a pressure manhole. ARV installation will be considered where warranted. Figure 6-1 is a schematic of the proposed parallel pipeline for Discharge Pipeline $M_{WC.}$

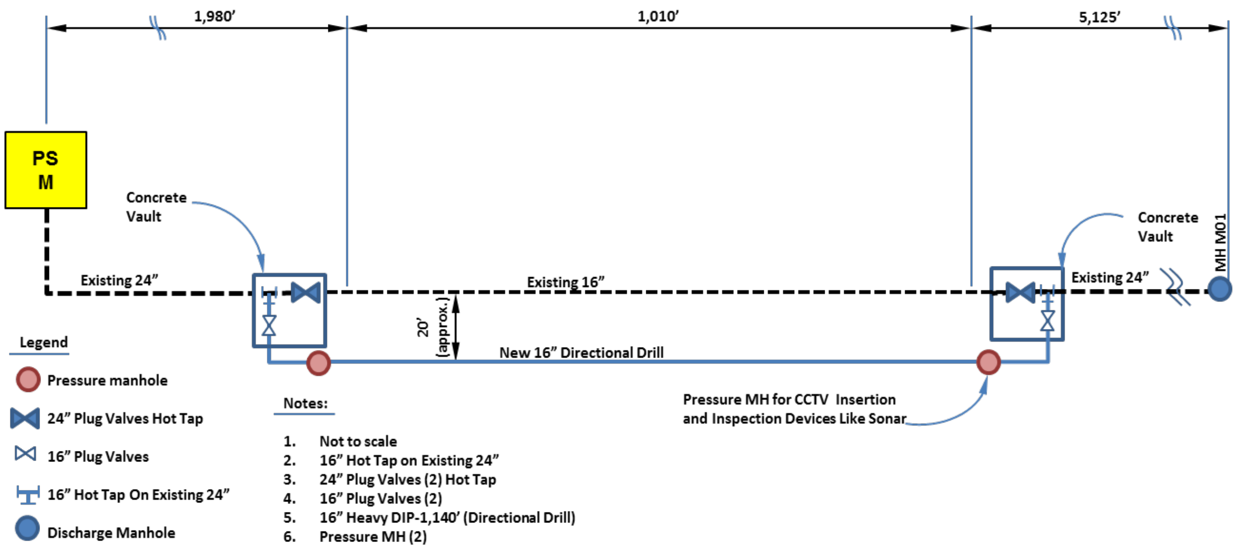

Figure 6-1. Conceptual Parallel Pipeline for Discharge Pipeline M_{WC} Schematic

Future Monitoring/Inspection

The only Future Monitoring/Inspection area of concern is in regards to sulfide levels.

- **Sulfide Level:** Sulfide attack has been identified as a long-term cause for the internal corrosion in gravity wastewater pipes and potentially at high points in force mains. V&A recommends that sulfide is monitored through future sampling. The sampling effort for Discharge Pipeline M_{WC} should be conducted at Discharge Manhole M01. Continuous sampling should be done over a 24-hour period using an automated sampler. The sampling effort should be conducted during the summer months when sulfide levels are expected to be high. Sampling should be conducted both with and without sulfide control to obtain data for comparison. Results of the sulfide study can be used to determine effectiveness of existing sulfide control systems and to evaluate the need for improvements, if any.

6.1.2 *Discharge Pipeline M_{AI}*

Recommendations for improvements to Pipeline M_{AI} are summarized in Table 6-2 below.

Table 6-2. Summary of Recommendations on Discharge Pipeline M_{AI}

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Capital Improvement				
Structural and Construction	9	3	Lack of ARVs at high points.	Install ARVs.
Preventive Maintenance				
Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Maintain the assets.
Future Monitoring/Inspection				
Interior Pipe Condition	9	3	No CCTV was conducted.	Perform CCTV.
Sulfide Level	18	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.

Pipeline M_{AI} lacks ARVs at high points. This becomes a more severe issue especially since the sulfide level for this pipeline is high. The air pockets generated can cause corrosion on the pipe crown.

Capital Improvement

- **Structure and Construction:** Pipeline M_{AI} lacks ARVs at high points. High points can trap pockets of gas which can cause internal corrosion on the pipe crown. V&A recommends installing ARVs at essential high points. Table 6-3 lists the high points along Discharge Pipeline M_{AI} based on review of the drawings. In total, there are six locations where ARVs are recommended to be installed. Design and construction should consider limited depth of cover over the pipeline and the presence of vertical thrust blocks at these locations.

Table 6-3. High Points on Discharge Pipeline M_{AI}

Pipeline Station Number
0+56
2+82
6+94
7+20
20+00
24+98

Preventive Maintenance

- **Condition of Valves and Appurtenances:** The valves and appurtenances were found to be slightly corroded. The valves and appurtenances are considered to be a part of a pipeline that is more susceptible to failure (20-year design life). V&A recommends maintenance to correct defects found. V&A recommends that Pressure Manholes M11 through M15 (5 locations total) be dewatered so that the exposed surfaces can be power-tool cleaned to remove corrosion scale. Once surfaces are cleaned, it is recommended that petrolatum tape wrap be applied to the exposed metal surfaces.

Future Monitoring/Inspection

- **Interior Pipe Condition:** The CCTV was not successfully performed due to the bends immediately upstream of Discharge Manhole M01. V&A recommends conducting CCTV through Pressure Manhole M15 upstream of Discharge Manhole M01. The CCTV camera will be deployed in the downstream direction towards Manhole M01 and proceed for a distance of approximately 1,000 feet, or as long as the cable length of the CCTV camera will allow. CCTV inspection will require temporary shutdown of Pump Station M and approximately 1,000 linear feet (24,000 gal) of wastewater will need to be pumped out from the pipeline at Pressure Manhole M14. Once the wastewater has drained from the pipeline, the blind flange at Pressure Manhole M15 can be removed and the CCTV inspection can be conducted.
- **Sulfide Level:** Sulfide attack has been identified as a long-term cause for the internal corrosion in gravity wastewater pipes and potentially at high points in force mains. V&A recommends that sulfide be monitored through future sampling. The sampling effort for Discharge Pipeline M_{AI} is the same as for M_{WC}. The sampling effort should be conducted at Discharge Manhole M01. Results from the sulfide study can be used to determine effectiveness of existing sulfide control systems and to evaluate the need for improvements, if any, for Discharge Pipeline M_{AI} as well as for M_{WC}.

6.1.3 *Discharge Pipeline R*

Recommendations for improvements to Pipeline R are summarized in Table 6-4 below.

Table 6-4. Summary of Recommendations on Discharge Pipeline R

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Preventive Maintenance				
Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained	Maintain the assets.
Future Monitoring/Inspection				
Hydraulics	9	3	Hydraulically oversized.	Before considering CIP, conduct CCTV inspection of the pipeline.
Interior Pipe Condition	9	3	No CCTV was conducted.	Perform CCTV.
C-Factor/N- Factor	12	4	Low C-factor.	Monitor C-Factor over time.
Sulfide Level	18	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.

Discharge Pipeline R is hydraulically oversized. Even though this criterion does not have high overall risk rating, this condition has an adverse effect on the pipeline.

Preventive Maintenance

- **Condition of Valves and Appurtenances:** The valves and appurtenances were found to be slightly corroded. The valves and appurtenances are considered to be a part of a pipeline that is more susceptible to failure (20-year design life). V&A recommends maintenance to correct defects found. V&A recommends that RF01, RF03, RF04, RF06, RF07, RF08, RF09 and RF10 (pressure manholes and traffic boxes with ARVs) be dewatered so that the exposed surfaces can be power tool cleaned to remove corrosion scale. Once surfaces are cleaned, it is recommended that petrolatum tape wrap be applied to the exposed metal surfaces.

Future Monitoring/Inspection

- **Hydraulics:** The discharge pipeline has a long detention time. With long detention times, the sewage can turn septic and generate hydrogen sulfide that can corrode the pipe interior. Corrosion of the pipe interior needs to be verified by conducting a CCTV inspection. If the interior of the pipeline is in poor condition, V&A recommends a capital improvement program to improve hydraulics. One such option is slip-lining a smaller diameter HDPE pipeline inside of Discharge Pipeline R. This will decrease the hydraulic retention time and consequently reduce potential sulfide impacts. HDPE pipe material is chemically inert which provides high resistance to corrosion. Given the surrounding aboveground conditions, trenchless construction may be cost effective. Another option to consider is to construct a parallel discharge pipeline next to the existing discharge pipeline. The new smaller diameter discharge pipeline would be used as the primary pipeline. The larger existing discharge pipeline can be available for redundancy and flow bypass when maintenance is required for the newer smaller diameter pipeline. If flow increases to Pump Station R, the existing pipeline can return to service. Prior to making a capital improvement, V&A recommends that the District perform CCTV inspection of the interior of the discharge pipeline to assess the condition and review the future build out capacity needs for the pipeline.

- **Interior Pipe Condition:** CCTV was not conducted from the end of the discharge pipeline due to the 90-degree elbow in the discharge structure. V&A recommends conducting CCTV by first attempting to insert the camera through the 90-degree elbow in the discharge structure. This effort would require a confined space entry and the temporary construction of scaffolding to provide a working platform to insert the CCTV crawler into the pipe by hand. Should this method not work, an alternate approach would be to remove the 90-degree elbow in the discharge structure. The removal of the 90-degree elbow would likely also require temporary construction of scaffolding to provide a working platform. If the CCTV inspection approach cannot be performed at the discharge structure, an alternate approach would be to attempt CCTV inspection through Pressure Manhole RF07 upstream of the discharge structure. CCTV inspection will require temporary shutdown of Pump Station R. Pressure Manhole RF07 is an ARV manhole located at a high point in the alignment. The volume of wastewater that may need to be drained from the pipeline at this location to conduct CCTV inspection should be determined. Based on the pipe profile, multiple staging areas may need to be considered. Review of the drawings indicates that Pressure Manhole RF09 may also be a location where CCTV inspection can be considered. Efforts to locate Pressure Manhole RF09 in the field were unsuccessful. The access constraints for Pressure Manhole RF09 should be field verified prior to consideration for CCTV inspection. CCTV inspection should be conducted for approximately 1,000 feet or at least to the limits of the cable length of the equipment, or the extent the pipeline is dewatered. If the CCTV inspection shows that the pipe interior is in good condition, the District may consider postponement of a capital improvement program to improve hydraulics.
- **C-factor:** C-factor value measured for the entire pipeline was low. This indicates possible internal corrosion and sediment issues. V&A recommends performing C-factor testing at 10 year intervals to track the change of pipe performance over time.
- **Sulfide Level:** Sulfide attack has been identified as a long-term cause for internal pipe corrosion in gravity wastewater pipes and potentially at high points in force mains. V&A recommends that sulfide be monitored through future sampling. The sampling effort for Discharge Pipeline R should be conducted at the discharge structure. This effort will require a confined space entry to install sampling equipment to obtain samples from the pipe discharge. Due to the drop inlet pipe discharge, temporary construction of a sampling well may be required. Continuous sampling should be done over a 24-hour period. An automated sampler or manual sample collection may be required due to the discharge drop inlet. Because Pump Station R has short run times, the pump station on/off operation should be recorded simultaneously during the period of sulfide sampling. The sampling effort should be conducted during the summer months when sulfide levels are expected to be high. Sampling should be conducted both with and without sulfide control to obtain data for comparison. Results of the sulfide study can be used to determine effectiveness of existing sulfide control systems and to evaluate the need for improvements.

6.2 Discharge Pipelines with Medium Risk

6.2.1 *Discharge Pipeline A*

Recommendations for improvements to Discharge Pipeline A are summarized in Table 6-5 below.

Table 6-5. Summary of Recommendations on Discharge Pipeline A

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies corresponding to higher risk ratings	Recommended Action
Capital Improvement				
Cathodic Protection	12	6	Missing test stations and depleted anodes. CP system not providing adequate protection.	Provide adequate CP system.
Future Monitoring/Inspection				
Interior. Pipe Condition	12	6	No direct data. Rating based on extrapolated data from Discharge Pipeline Q_N (Possible liner failure).	Conduct CCTV from MH AF02 to inspect internal pipe condition.

CCTV inspection is recommended for Discharge Pipeline A because liner failure was observed in Discharge Pipeline $Q_{N,}$ and Q_N and A were originally part of the same discharge pipeline. Liner failure and corrosion may also be occurring in Discharge Pipeline A.

Capital Improvement

- **Cathodic Protection:** Many test stations were missing, and of the test stations located, testing revealed that anodes were depleted. V&A recommends that four test stations be reinstated and the anodes replaced, and anodes at three existing test stations be replaced.

Future Monitoring/Inspection

- **Interior Pipe Condition:** The CCTV of Discharge Pipeline A was not performed. Based on the CCTV inspection findings for Discharge Pipeline Q_N, V&A recommends conducting CCTV for Discharge Pipeline A from Pressure Manhole AF02 to check for possible liner failure. The CCTV camera will be deployed in the downstream direction towards the tee connection with Discharge Pipeline N and will proceed for a distance of approximately 600 feet or to the extent possible. CCTV inspection will require temporary shutdown of Pump Station A and Pump Station N. Discharge Pipeline N should be drained back to the wet well to an extent that the tee connection with Discharge Pipeline A is dewatered. Additionally, Discharge Pipeline A will need to be drained back to the wet well past Pressure Manhole AF02. Alternately, approximately 600 linear feet (1,400 gal) of wastewater can be pumped out from the Discharge Pipeline A at Pressure Manhole AF01. Once the wastewater has drained from Discharge Pipeline A, the blind flange at Pressure Manhole AF02 can be removed and the CCTV inspection can be conducted.

6.2.2 *Discharge Pipeline C_A*

Recommendations for improvements to Pipeline C_A are summarized in Table 6-6 below.

Table 6-6. Summary of Recommendations on Discharge Pipeline C_A

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Capital Improvement				
Structural and Construction.	6	3	No access through the discharge manhole to conduct CCTV and pipe cleaning.	Install access manholes as prerequisite to support CCTV and pipe cleaning.
Preventive Maintenance				
Interior Pipe Condition	12	6	Discharge pipeline has grease deposits.	Conduct pipe cleaning.
Future Monitoring/Inspection				
Interior Pipe Condition	12	6	Discharge pipeline has grease deposits.	Conduct CCTV to inspect interior pipe condition.
Sulfide Level	12	6	High sulfide level increases risk of corrosion.	Monitor (Conduct future sampling)

There are heavy grease deposits in Pipeline C_A. Also, there are no pressure manholes along the alignment to access the pipe for inspection and cleaning.

Capital Improvement

- **Structure and Construction:** The pipeline lacks access for inspection and maintenance. V&A recommends installing pressure manholes to accommodate maintenance activities. For Discharge Pipeline $C_{A,}$ three additional access points will need to be added. New access points are to be installed at approximately 1,000-foot intervals based on the distance limitations of cleaning equipment. In addition to the recently constructed Pressure Manhole A63 (per SD207 – 1995), Table 6-7 provides the approximate locations of additional pressure manholes to be added to Discharge Pipeline C_A. The recommendation is to construct one additional manhole and to reconfigure two existing manholes with ARVs.

Table 6-7. Approximate Locations for Additional Pressure Manholes on Discharge Pipeline C_A

Pipeline Station Number	Notes
4+30	Existing Pressure Manhole A63 (No additional manhole required. Field verify access capabilities of existing manhole to support maintenance activities)
~ 15+50	Near the second 90-degree bend in the pipeline alignment at the intersection of Calhoun St. and Pearl St.
24+66	Reconstruct existing ARV manhole to add a piping tee with full flanged connection to facilitate access.
33+16	Reconstruct existing ARV manhole to add a piping tee with full flanged connection to facilitate access.

Preventive Maintenance

- **Interior Pipe Condition:** V&A recommends cleaning the pipeline since heavy grease deposits were found. Additional pressure manholes will need to be added prior to cleaning to facilitate access.

Future Monitoring/Inspection

- **Interior Pipe Condition:** Once additional pressure manholes are constructed and the pipeline cleaned, V&A recommends conducting additional CCTV beyond the distance inspected. The recommendation to add pressure manholes will help to facilitate additional CCTV inspection.
- **Sulfide Level:** Sulfide attack has been identified as a long-term cause for internal pipe corrosion in gravity wastewater pipes and potentially at high points in force mains. V&A recommends that the sulfide levels be monitored through future sampling. The sampling effort for Discharge Pipeline C_A should be conducted at Discharge Manhole A60. Continuous sampling should be done over a 24-hour period using an automated sampler. The sampling effort should be conducted during the summer months when sulfide levels are expected to be high. Sampling should be conducted both with and without sulfide control to obtain data for comparison. During the study, all flow from Pump Station C should be flowing through Discharge Pipeline $C_{A.}$ Results of the sulfide study can be used to determine effectiveness of existing sulfide control systems and to evaluate the possible need for improvements.

6.2.3 *Discharge Pipeline C_B*

Recommendations for improvements to Pipeline C_B are summarized in Table 6-8 below.

Table 6-8. Summary of Recommendations on Discharge Pipeline C_B

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Capital Improvement				
Structural and Construction	6	3	No access through the discharge manhole to conduct pipe cleaning and CCTV.	Install access manholes as prerequisite to support pipe cleaning and CCTV.
Preventive Maintenance				
Interior Pipe Condition	12	6	Discharge pipeline has sediment deposits.	Conduct pipe cleaning.
Future Monitoring/Inspection				
Interior Pipe Condition	12	6	Discharge pipeline has internal corrosion.	Conduct additional CCTV to inspect interior pipe condition to determine need and limits for rehabilitation.
Sulfide Level	12	6	High sulfide level increases risk of interior corrosion.	Conduct future sampling.

There is heavy sediment and internal corrosion in Pipeline C_B. Also, there are no pressure manholes along the alignment to support inspection and maintenance of the pipeline. CCTV inspection revealed interior pipe corrosion.

Capital Improvement

- **Structure and Construction:** The pipeline lacks access for inspection and maintenance. V&A recommends installing pressure manholes to accommodate cleaning activities. For Discharge Pipeline $C_{B,}$ four additional access points will need to be added. New access points are to be installed at approximately 1,000-foot intervals based on the distance limitations of cleaning and CCTV inspection equipment. Table 6-7 provides the approximate locations of additional pressure manholes to be added to Discharge Pipeline C_B. The recommendation is to construct two pressure manholes and to reconfigure two existing manholes with ARVs.

Table 6-9. Approximate Locations for Additional Pressure Manholes on Discharge Pipeline C_B

Pipeline Station Number	Notes
~ 4+50	Near the first 90-degree bend in the pipeline alignment near Calhoun St. at Court St. (Krusi Park) adjacent to MH A63
~ 15+50	Near the second 90-degree bend in the pipeline alignment at the intersection of Calhoun St. and Pearl St.
24+66	Reconstruct existing ARV manhole to add a piping tee with full flanged connection to facilitate access.
33+16	Reconstruct existing ARV manhole to add a piping tee with full flanged connection to facilitate access.

Preventive Maintenance

- **Interior Pipe Condition:** V&A recommends cleaning the pipeline since heavy sediment deposits were found. Additional pressure manholes will need to be added prior to cleaning to facilitate access.

Future Monitoring/Inspection

- **Interior Pipe Condition:** Once additional pressure manholes are constructed and the pipeline cleaned, V&A recommends conducting additional CCTV beyond the distance inspected to determine for the extent of pipeline that requires rehabilitation. Approximately 700 feet of the pipeline from the discharge end was CCTV inspected and revealed interior pipe biogenic corrosion from hydrogen sulfide occurring at the crown of the pipe and at localized gas pockets at the joints. The corrosion condition warrants rehabilitation. The recommendation to add pressure manholes will help to facilitate additional CCTV inspection.
- **Sulfide Level:** Sulfide attack has been identified as a long-term cause for internal pipe corrosion in gravity wastewater pipes and potentially at high points in force mains. V&A recommends that sulfide levels be monitored through future sampling. The sampling effort for Discharge Pipeline

C_B is the same as for C_A with the exception that the sampling effort should be conducted at Discharge Manhole A61 and all flow from Pump Station C should be flowing through Discharge Pipeline C_B. Results from the sulfide study can be used to determine the effectiveness of existing sulfide control systems and to evaluate the need for improvements, if any, for Discharge Pipeline C_B as well as for Discharge Pipeline C_A.

6.2.4 *Discharge Pipeline G*

Recommendations for improvements to Pipeline G are summarized in Table 6-10 below.

Table 6-10. Summary of Recommendations on Discharge Pipeline G

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Capital Improvement				
Structural and Construction	9	3	No access to the pipe interior to conduct CCTV and cleaning.	Install pressure manhole upstream of MH GF01 to conduct CCTV.
Preventive Maintenance				
Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Maintain the assets.
Future Monitor/Inspection				
Interior Pipe Condition	9	3	Data was extrapolated. No direct data was collected.	Conduct CCTV.

Pipeline G lacks access to perform CCTV inspection and maintenance if necessary. Also N-factor, an important indicator of interior pipe condition, was not tested. Therefore, the interior pipe condition is unknown.

Capital Improvement

- **Structure and Construction:** The pipeline lacks access for CCTV inspection and maintenance if necessary. V&A recommends installing a pressure manhole upstream of MH GF01 as a prerequisite for CCTV inspection. For Discharge Pipeline G, one additional pressure manhole will need to be added at this time. The proposed location for the pressure manhole is where Discharge Pipeline G crosses Pardee Dr. (approximate Station 13+00 per SD46). This location will be within the public right of way to make the new pressure manhole structure more easily accessible. The suggested manhole location is approximately 1,000 feet upstream from the cleanout at Manhole GF02 and approximately 700 feet upstream from the transition to HDPE pipe at Manhole GF01. The purpose of the new pressure manhole is to facilitate CCTV inspection to evaluate interior pipe condition. Once the pressure manhole is constructed and CCTV inspection has been conducted, it is possible that another pressure manhole would be needed to support cleaning activities based on the CCTV inspection results. A recommendation for a second pressure manhole for pipeline cleaning can be made after review of the CCTV inspection results.

Preventive Maintenance

- **Condition of Valves and Appurtenances:** The valves and appurtenances were found to be slightly corroded. The valves and appurtenances are considered to be a part of a pipeline that is more susceptible to failure (20-year design life). V&A recommends maintenance to correct defects found in Pressure Manhole GF01 and the cleanout at Pressure Manhole GF02. Pressure Manhole GF01 was found to be partially filled in with dirt. It is recommended that the dirt be removed from within Pressure Manhole GF01. The cleanout at Pressure Manhole GF02 was found under vegetation and was partially buried. It is recommended that the area around this access location be cleared and a valve box added so that GF01 does not become buried and inaccessible. Furthermore, the functionality of the associated soil bed for GF02 needs to be assessed. The soil bed is also covered with vegetation. The vegetation should be removed and the soil bed mulch and drain rock should be evaluated and replaced as necessary.

Future Monitoring/Inspection

- **Interior Pipe Condition:** CCTV was not performed as there was no access to the pipe interior. V&A recommends having CCTV inspection after the installation of the pressure manhole proposed in the capital improvement project.

6.2.5 *Discharge Pipeline J*

Recommendations for improvements to Pipeline J are summarized in Table 6-11 below.

Table 6-11. Summary of Recommendations on Discharge Pipeline J

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Future Monitoring/Inspection				
Interior. Pipe Condition	12	6	No direct data. Expected to be similar condition from 2010 evaluation.	Perform CCTV to inspect interior pipe condition.
Environmental Exposure	12	6	High corrosive soil conditions.	Excavate to assess the exterior pipe condition.

Discharge Pipeline J is a short pipeline that did not receive a thorough condition assessment. The interior and exterior conditions are based on previous inspection and extrapolation, respectively. The pipeline is buried under high-corrosivity soil which may cause exterior pipe deterioration.

Future Monitoring/Inspection

- **Interior Pipe Condition:** The interior pipe condition is expected to be in similar condition to a manhole inspection conducted in 2010. The discharge end of the pipeline was found to be corroded above the waterline. V&A recommends conducting CCTV to inspect the internal condition of the pipeline from Discharge Manhole S30. It is likely that cleaning will be needed prior to CCTV inspection. Cleaning has been included in the cost estimate.

- **Environmental Exposure:** High corrosive soil conditions were found around the pipe. Given that the pipe has been in service for more than 60 years, V&A recommends performing one excavation on Fredrick Street near the discharge end of the alignment to evaluate the exterior pipe condition.

6.2.6 *Discharge Pipeline N_C*

Recommendations for improvements to Pipeline N_C are summarized in Table 6-12 below.

Table 6-12. Summary of Recommendations on Discharge Pipeline N_C

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Preventive Maintenance				
Condition of Valves and Appurtenances	12	4	Valves, fittings, and appurtenances are not adequately maintained.	Maintain the assets.
Future Monitor/Inspection				
C-Factor/N- Factor	12	4	Low C-factor value.	Track change in C-Factor value over time.
Sulfide Level	12	4	Moderate sulfide level increases risk of internal corrosion.	Conduct future sampling.

There are no issues related to exterior pipe condition except for the minor corrosion of the valves and appurtenances. Although CCTV inspection shows no notable issues for interior pipe condition, C-factor shows the increase of internal pipe roughness due to corrosion or sediment/grease.

Preventive Maintenance

- **Condition of Valves and Appurtenances:** The valves and appurtenances were found to be slightly corroded. The valves and appurtenances are considered to be a part of the pipeline that is more susceptible to failure (20-year design life). V&A recommends establishing a program that checks the condition of valves and appurtenances on a routine basis. V&A recommends that metal surfaces of the blind flanges within Pressure Manholes NF11, NF10, NF09, NF08 (4 locations total) be power tool cleaned to remove corrosion scale. Once surfaces are cleaned, it is recommended that petrolatum tape wrap be applied to the exposed metal surfaces. It should be noted that some of these manholes will require dewatering in order to conduct the required maintenance.

Future Monitoring/Inspection

- **C-factor:** C-factor value measured for the entire pipeline was low. This indicates possible internal corrosion and sediment issues. V&A recommends performing C-factor testing at 10 year intervals to track the change of pipe performance over time.

- **Sulfide Level:** Sulfide attack has been identified as a long-term cause for internal corrosion in gravity wastewater pipes and potentially at high points in force mains. V&A recommends sulfide levels be monitored through future sampling. The sampling effort for Discharge Pipeline N_C should be conducted at Discharge Manhole NF07. Continuous sampling should be done over a 24-hour period using an automated sampler. The sampling effort should be conducted during the summer months when sulfide levels are expected to be high. Sampling should be conducted both with and without sulfide control to obtain data for comparison. Results of the sulfide study can be used to determine effectiveness of existing sulfide control systems and to evaluate the need for improvements, if any.

6.2.7 *Discharge Pipeline Q_N*

Recommendations for improvements to Pipeline Q_N are summarized in Table 6-13 below.

Table 6-13. Summary of Recommendations on Discharge Pipeline Q_N

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Capital Improvement				
Cathodic Protection	12	6	Missing test stations and depleted anodes. CP system not providing adequate protection.	Provide adequate CP.
Future Monitoring/Inspection				
Interior Pipe Condition	12	6	Liner detached from the pipe wall	Conduct CCTV from MH Q09 both upstream and downstream to further determine the interior pipe condition and the extent of liner failure.

Discharge Pipeline Q_N is not adequately protected by the cathodic protection system. CCTV revealed liner failures along the downstream 1,000 feet of the total 1,800-foot section of pipeline CCTV inspected.

Capital Improvement

- **Cathodic Protection:** Many test stations were missing, and of the test stations located, testing revealed that anodes were depleted. V&A recommends providing adequate CP protection, including constructing additional test stations and replacing depleted anodes. The CP system for Discharge Pipeline Q (Q_N and Q_S) requires that 13 test stations be reinstated and the anodes replaced. In addition, anodes at 16 existing test stations require replacement.

Future Monitoring/Inspection

- **Interior Pipe Condition:** CCTV of 1,800 feet of Discharge Pipeline Q_N revealed liner failures in the last 1,000 feet downstream end of the discharge pipeline. V&A recommends conducting CCTV through the entire pipeline (Discharge Pipeline Q_N) to verify the extent of liner failure before conducting rehabilitation. In order to maximize the effectiveness of CCTV inspection, the recommendation is to perform CCTV inspection from Pressure Manhole Q09 which is on Discharge Pipeline Q_S. CCTV inspection will proceed both downstream to inspect the remainder of Discharge Pipeline Q_N, as well as proceed upstream to assess the condition of Discharge Pipeline Q_S. Based on the pipe profile, multiple staging areas may need to be considered and this factor has been included in the cost estimate.

6.2.8 *Discharge Pipeline Q_S*

Recommendations for improvements to Pipeline Q_S are summarized in Table 6-14 below.

Table 6-14. Summary of Recommendations on Discharge Pipeline Q_S

Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Deficiencies Corresponding to Higher Risk Ratings	Recommended Action
Capital Improvement				
Cathodic Protection	12	6	Missing test stations and depleted anodes. CP system not providing adequate protection.	Provide adequate CP.
Future Monitor/Inspection				
Exterior Pipe Condition	0	0	No excavation.	Perform excavation to assess the exterior pipe condition.
Interior Pipe Condition	0	0	No CCTV inspection.	Perform CCTV inspection through MH Q09 to inspect internal condition.

Discharge Pipeline Q_S is a steel pipe. Discharge Pipeline Q_S is not adequately protected by the cathodic protection system; therefore, condition assessment results from other discharge pipelines are difficult to extrapolate in order to judge the exterior and interior pipe conditions. Additional condition assessment of Discharge Pipeline Q_S is recommended.

Capital Improvement

- **Cathodic Protection:** Many test stations were missing, and of the test stations located, testing revealed that anodes were depleted. V&A recommends providing adequate CP protection, including constructing additional test stations and replacing depleted anodes. The CP system for Discharge Pipeline Q (Q_N and Q_S) requires that 13 test stations be reinstated and the anodes replaced. In addition, anodes at 16 existing test stations require replacement.

Future Monitoring/Inspection

- **Exterior Pipe Condition:** The exterior pipe condition is unknown since no excavation was conducted, and no extrapolation can be made from condition assessment results from other discharge pipelines. V&A recommends performing an excavation to assess the exterior pipe condition.

- **Interior Pipe Condition:** The interior pipe condition was not available in the absence of CCTV inspection. V&A recommends conducting CCTV inspection through Pressure Manhole Q09. In order to maximize the effectiveness of CCTV inspection, the recommendation to perform CCTV inspection from Pressure Manhole Q09 will accommodate the need for condition information for Discharge Pipeline Q_S and Discharge Pipeline Q_N. Based on the pipe profile, multiple staging areas may need to be considered and this factor has been included in the cost estimate.

6.3 Discharge Pipelines with Low Risk

The following discharge pipelines are considered to be of low risk: B, D, E, F, H, K, L, M_{BF}, and N_N. Of the low risk pipelines, only B, F, L, M_{BF} and N_N have recommendations. Recommendations for improvements to these pipelines are summarized in Table 6-15 below.

Table 6-15. Summary of Recommendations for Low Risk Discharge Pipelines

Discharge Pipeline	Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Recommendations
Preventative Maintenance				
N_N	Condition of Valves and Appurtenances	12	4	Exercise buried plug valves as part of District's routine maintenance program.
Future Monitoring and Inspection				
B	Ext. Pipe Condition	9	3	Perform one excavation to assess the exterior pipe condition.
	Interior Pipe Condition	9	3	Perform excavation to collect data to assess interior pipe condition using UT and BEM non-destructive testing techniques.
	Sulfide Level	12	4	Conduct continuous 24-hour sampling using an automated sampler at Discharge Manhole A15. Due to the configuration of the discharge manhole confined space entry installation of temporary equipment may be required. Perform the sampling during summer months and with sulfide control on and off to compare data results.
F	Interior Pipe Condition	12	6	Conduct CCTV inspection from Discharge Manhole FF01 to determine the extent and need for pipeline rehabilitation. Cleaning required prior to CCTV is likely.
L	Environmental Exposure	0	0	Pothole at one location to collect a soil sample to test for soil corrosivity.
M_{BF}	Sulfide Level	12	6	The recommendation for M_{WC} and M_{AI} addresses this condition. Conduct continuous 24-hour sampling using an automated sampler for Discharge Pipeline M_{BF} at Discharge Manhole M01. Perform the sampling during summer months and with sulfide control on and off to compare data results.

Discharge Pipeline	Likelihood of Failure Criteria	Risk Score (1-27)	Likelihood Rating (1-9)	Recommendations
N_N	C-Factor/N- Factor	12	4	Conduct C-Factor testing to track the change of pipe performance over time.
	Sulfide Level	12	4	Conduct continuous 24-hour sampling using an automated sampler at Discharge Manhole NF07. Perform the sampling during summer months and with sulfide control on and off to compare data results

6.4 Summary of Recommendations

The following tables (Table 6-16 through Table 6-18) provide per pump station discharge pipeline summaries for the improvement activities, timing, and costs in CIP, PM, and FMI.

Table 6-16. Summary of CIP Recommendations, Timing, and Costs

Discharge Pipeline	Pipeline Risk (1-9)	Recommendations	Timing	Cost ($)
Installation of pressure manholes so cleaning and inspection can be performed.				
C_A	6	• Construct one access manhole at approx. Station 15+50 • Convert existing ARV manholes to access manholes at Station 24+66 and Station 33+16	Within 5 years	72,000
C_B	6	• Construct two access manholes. One at approx. Station 4+50 and one at approx. Station 15+50 • Convert existing ARV manholes to access manholes at Station 24+66 and Station 33+16	Within 5 years	109,000
G	6	• Construct one pressure manhole at approx. Station 13+30 at Pardee Rd.	Within 5 years	29,000
Provide adequate cathodic protection.[9]				
A	4	• Reinstate 4 test stations and replace anodes. • Replace 3 anodes at existing test stations.	Within 5 years	156,000
Q_S	6	• Reinstate 13 test stations and replace associated anodes. • Replace 16 anodes at existing test stations.	Within 5 years	562,000
Q_N	4			
Other capital improvement projects				
M_{WC}	9	• Construct a parallel line to allow for adequate inspection and maintenance.	Within 20 years	1,228,000
M_{AI}	9	• Install ARVs at 6 high point locations (Station numbers: 0+56, 2+82, 6+94, 7+20, 20+00 and 24+98).	Within 10 years	177,000

[9] In addition to the cathodic protection recommendations listed here, see Appendix F for other potential CP improvement and testing recommendations on Discharge Pipelines D, E, J, N, Q, R and the Oakport drainline. Total cost for these additional items are estimated to be between $300,000 and $420,000.

Table 6-17. Summary of PM Recommendations, Timing, and Costs

Discharge Pipeline	Pipeline Risk (1-9)	Recommendations	Timing	Cost ($)
Provide adequate maintenance for the valves and appurtenances to bring poor condition items up to serviceable condition.[10]				
G	6	• Due to corrosive soil conditions to buried metallic components, it is recommended to remove dirt inside Manhole GF01. • Improve area and access to cleanout at GF02. Assess and restore adjacent soil bed as necessary.	Within 5 years	4,800
M_{AI}	9	• Dewater, power tool clean to remove corrosion scale and apply petrolatum tape wrap to metallic surfaces/appurtenances inside Pressure Manholes M11 through M15.	Within 5 years	13,500
N_C	6	• Dewater, power tool clean to remove corrosion scale and apply petrolatum tape wrap to metallic surfaces/appurtenances inside Pressure Manholes NF08, NF09, NF10 and NF11.	Within 5 years	18,900
N_N	3	• Exercise buried plug valves as part of District's routine maintenance program.	Within 5 years	Cost included with N_C
R	9	• Dewater, power tool clean to remove corrosion scale and apply petrolatum tape wrap to metallic surfaces/appurtenances inside pressure manholes and traffic boxes with ARVs at RF01, RF03, RF04, RF06, RF07, RF08, RF09, and RF10.	Within 5 years	33,100
Conduct pipe cleaning.[11]				
C_A	6	• Clean discharge pipeline of heavy grease deposits after installation of access manholes.	After CIP	14,000
C_B	6	• Clean discharge pipeline of sediment after installation of access manholes.	After CIP	14,000

Table 6-18. Summary of FMI Recommendations, Timing, and Costs

Discharge Pipeline	Pipeline Risk (1-9)	Recommendations and Timing	Timing	Cost ($)
Conduct CCTV to inspect internal pipe condition.				
A	4	• Conduct CCTV inspection from Pressure Manhole AF02 to check for possible liner failure.	Within 5 years	13,800

[10] In addition to the specific recommendations for high risk discharge pipelines, V&A recommends that the District establish a program that checks the condition of valves, fittings and appurtenances on a routine basis. Discharge Pipelines C_A, C_B, M_{BF}, Q_S and Q_N had valves, fittings and appurtenances which exhibited slight corrosion. It is recommended that these be visually assessed on at least a 5-year interval to monitor condition.

[11] In addition to the specific cleaning recommendations, there are other discharge pipelines (such as Discharge Pipeline J and Discharge Pipeline K) that would benefit from cleaning activities. Cleaning recommendations are not provided for these pipelines however they should be considered to be included in regular preventative maintenance cleaning activities as best management practices.

Discharge Pipeline	Pipeline Risk (1-9)	Recommendations and Timing	Timing	Cost ($)
C_A	6	• Conduct additional CCTV inspection of more of the pipeline.	After CIP	14,200
C_B	6	• Conduct additional CCTV inspection of more of the pipeline to determine the extent of pipeline that requires rehabilitation after installation of pressure manholes.	After CIP	14,200
F	2	• Conduct CCTV inspection from Discharge Manhole FF01 to determine the extent and need for pipeline rehabilitation. Some cleaning is anticipated.	Within 5 years	5,600
G	6	• Conduct CCTV to evaluate interior condition of the discharge pipeline after installation of a pressure manhole.	After CIP	17,500
J	4	• Conduct CCTV from Discharge Manhole S30 to evaluate interior condition of the discharge pipeline. Some cleaning is anticipated.	Within 5 years	6,000
M_{AI}	9	• Conduct CCTV from Pressure Manhole M15 proceeding downstream towards M01 to determine interior pipe condition.	Within 5 years	39,600
Q_N	4	• Conduct CCTV from Pressure Manhole Q09 proceeding both upstream and downstream to further determine the interior pipe condition and the extent of liner failure.	Within 5 years	12,200
Q_S	4	• Same recommendation as above. The recommendation to perform CCTV inspection from Pressure Manhole Q09 will accommodate the need for condition information for Discharge Pipeline Q_S and Discharge Pipeline Q_N.	Within 5 years	Cost included with CCTV of Q_N
R	9	• Conduct CCTV from the discharge structure. Construct temporary scaffolding to insert the camera into the discharge piping by hand. Alternately, CCTV inspection may require removal of the 90-degree elbow or opening of Pressure Manhole RF09 for access.	Within 5 years	23,000
Conduct future sampling of sulfide.				
B	3	• Conduct a continuous 24-hour sampling using an automated sampler at Discharge Manhole A15. Due to the configuration of the discharge manhole, confined space entry installation of temporary equipment may be required. Perform the sampling during summer months and with sulfide control on and off to compare data results.	Within 10 years	67,500
$C_{A,B}$	6	• Conduct a continuous 24-hour sampling using an automated sampler at the discharge manholes. Perform the sampling during summer months with all flow directed to the discharge pipe being tested. Perform the testing with sulfide control on and off to compare data results.	Within 10 years	94,500

Discharge Pipeline	Pipeline Risk (1-9)	Recommendations and Timing	Timing	Cost ($)
$M_{BF,WC,AI}$	9	• Conduct a continuous 24-hour sampling using an automated sampler at Discharge Manhole M01. Perform the sampling during summer months and with sulfide control on and off to compare data results.	Within 10 years	67,500
$N_{N,C}$	6	• Conduct a continuous 24-hour sampling using an automated sampler at Discharge Manhole NF07. Perform the sampling during summer months and with sulfide control on and off to compare data results.	Within 10 years	67,500
R	9	• Conduct a continuous 24-hour sampling using an automated sampler at the discharge structure. Due to the configuration of the discharge structure, confined space entry installation of temporary equipment or manual data collection may be required. Due to the short run times of Pump Station R, monitoring the on/off pump operation should be conducted simultaneously. Perform the sampling during summer months and with sulfide control on and off to compare data results.	Within 10 years	67,500
Monitor C-Factor over time.				
$N_{N,C}$	6	• Perform C-factor testing to track the change of pipe performance over time.	After 10 years	20,300
R	9	• Perform C-factor testing to track the change of pipe performance over time.	After 10 years	20,300
Other data collection activities.				
B	3	• Perform one excavation to assess the interior and exterior pipe condition.	After 5 years	67,500
J	4	• Perform one excavation to assess the exterior pipe condition near the discharge end of the alignment.	After 5 years	67,500
L	2	• Pothole at one location to collect a soil sample to test for soil corrosivity.	After 5 years	13,500
Q_S	6	• Perform one excavation to assess the exterior pipe condition.	After 5 years	67,500

6.5 Remaining Useful Life Estimates

The useful life of a pipeline is estimated from the current pipeline conditions (remaining service life) plus the management to control known conditions to prolong the service life. The increases of service life can be estimated as follows[12].

- CP Improvement: In the presence of adequate cathodic protection system, the pipe exterior should be kept in good condition. The estimated increase of service life is 20 years. The typical design life of a CP system is 20 years. While the CP system is working, corrosion of the pipeline being protected is brought to near zero mils per year.
- Sulfide Control: Sulfide can cause long term internal corrosion issue. With effective sulfide control, the estimated increase of service life is 10 years.
- Pipe Cleaning: Debris build-up in the pipe can reduce the pipe cross-sectional area, and consequently, the pipe capacity. By cleaning the pipe, the increase in pipe service life can be 10 years.
- Installation of ARVs: This improvement has a similar effect to sulfide control in the reduction of the risk of internal pipe corrosion. The estimated increase of service life is 10 years.
- Maintenance of Valves and Appurtenances: Valves and appurtenances are considered to be a part of the pipeline that is more susceptible to failure. The maintenance of valves can increase the service life by 10 years.
- Building a New Line: Depending on design considerations, the service life of a new line with adequate CP and a proper lining/coating system can be in excess of 60 years.

The activities that can prolong the service life and the estimated useful life are listed in Table 6-19. Note that multiple preventative maintenance activities can extend the service life for up to 20 years. To extend the service life beyond 20 years, an investment in capital improvements is generally required. Useful life can be expected to be up to 60 years based on the current pipe conditions and the proposed improvement.

Table 6-19. Discharge Pipelines Useful Life Estimates

Discharge Pipeline	Pipeline Risk (1-9)	Year Installed	Age (Yrs)	Adjusted Remaining Service Life (Yrs)	Activities to Prolong the Service Life	Increased Service Life (Yrs)	Useful Life (Yrs)
A	4	1987	27	30	CP Improvement	20	50
B	3	2000	14	40	-		40
C_A	6	1942 1995	72 19	20	Improve access. Perform pipe cleaning.	Up to 10 yrs.	30

[12] This information is a compilation from: manufacturers, industrial associations, GASB, colleagues, consulting engineers, research (professional associations, universities) and the international community. Modification factors for service life tables can be applied for various condition variables: design standards, construction quality, material quality, operational history, operating environment and external stresses. Modification factors can increase or decrease service life tables with impact rating factors of ±10% of the asset's remaining service life.

Discharge Pipeline	Pipeline Risk (1-9)	Year Installed	Age (Yrs)	Adjusted Remaining Service Life (Yrs)	Activities to Prolong the Service Life	Increased Service Life (Yrs)	Useful Life (Yrs)
C_B	6	1968	46	20	Improve access. Perform pipe cleaning.	Up to 10 yrs.	30
D	2	1953	61	40	-		40
E	2	1953	61	40	-		40
F	2	1953	61	40	-		40
G	6	1954	60	30	Improve access. Perform maintenance of appurtenances.	10	40
H	3	1948 2009	66 5	40	-		40
J	4	1953	61	30	-		30
K	1	1953	61	40	-		40
L	2	1955	59	40	-		40
M_{BF}	2	1980	34	50	-		50
M_{WC}	9	1949	65	20	Build a new line.	60	60
M_{AI}	9	1986	28	20	Install ARVs, Maintain appurtenances.	20	40
N_C	6	1969	45	30	Maintain appurtenances.	10	40
N_N	3	2000	14	50	Minor maintenance of appurtenances.		50
Q_N	4	1987	27	30	CP Improvement[13]	10	40
Q_S	6	1995	19	30	CP Improvement[13]	10	40
R	9	2001	13	30	Maintain appurtenances.	10	40

[13] Due to test results showing discontinuities on QN and QS pipelines, CP system improvements may not be fully effective. Increase in service life is estimated lower than other CP system improvements at 10 years.

ATTACHMENT A: OPINION OF PROBABLE COSTS

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATES

Discharge Pipeline A

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	CAPITAL IMPROVEMENT COST ESTIMATE								
1	Test Station Installation/Reinstallation and Anode Replacemen	4	ea.	$800	$15,000		$3,200	$60,000	$63,200
2	Anode Replacement	3	ea.	$800	$4,200		$2,400	$12,600	$15,000
	Contingencies	35	%						$27,370
	Planning, Engineering and CM	45	%						$47,507
	Onsite Inspection and Activation	1	LS	$0	$2,500		$0	$2,500	$2,500
	Total CIP Cost Estimate (rounded up to nearest $1,000):								**$156,000**
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	CCTV from Pressure Manhole AF02 @ $2.50/ft. + 1xmob of $2,000 + Blind Flange removal $2,000 and dewatering cost approx. $3,000	1280	LF	incl.	$2.5		$7,000	$3,200	$10,200
	Contingencies	35	%						$3,570
	Total FMI Cost Estimate (rounded up to nearest $100):								**$13,800**

Notes:

1. Labor rates:

Unskilled Labor	$50/hr.
Skilled Labor	$65/hr.
Foreman	$80/hr.
Engineer	$130/hr.

2 Engineering (15%), Construction Management (15%), Administration (15%)
Project Contingencies (35%)

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East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATES

Discharge Pipeline B

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	Sulfide Level - Conduct continuous 24-hour sampling using an automated sampler at Discharge Manhole A15. Evaluate and report results to investigate potential sulfide reduction strategies by CIP and PM activities	1	ea.	$0	$50,000		$0	$50,000	$50,000
	Contingencies (Item #1 - Sulfide Level)	35	%						$17,500
2	Env. Exp. - Perform one excavation of the pipe to assess the effect of soil on exterior pipe condition. Collect UT and BEM data to assess the interior condition of the pipe at this time as	1	ea.	$0	$50,000		$0	$50,000	$50,000
	Contingencies (Item #2 - Excavation)	35	%						$17,500
	Total FMI Cost Estimate (rounded up to nearest $100):								**$135,000**

Notes:

1.	Labor rates:	Unskilled Labor	$50/hr.
		Skilled Labor	$65/hr.
		Foreman	$80/hr.
		Engineer	$130/hr.
2	Engineering (15%), Construction Management (15%), Administration (15%)		
	Project Contingencies (35%)		

V&A

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATE
Pump Station C - Discharge Line A

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	CAPITAL IMPROVEMENT COST ESTIMATE								
	Install 1 Pressure Manhole								
1	Install Manhole (4' Deep max., base bid)	1	ea.	$5,000	$4,000		$5,000	$4,000	$9,000
2	Install Manhole (1' deep increment)	4			$250			$1,000	$1,000
3	Install 16" DIP Tee w/ fittings	1	ea.	$2,000	$4,000		$2,000	$4,000	$6,000
4	TRENCH PAVING (saw cut, disposal, baserock, AC)	200	SF	$38	incl.		$7,600		$7,600
	Reconstruct 2 ARV Manholes with Pipe Tee Fittings								
5	Remove Manhole Top	1	ea.	$1,000	$4,000		$1,000	$4,000	$5,000
6	Install 16" DIP Tee w/ fittings	2	ea.	$2,000			$4,000	$4,000	$8,000
	Construction Cost Subtotal:								$36,600
	Construction Contingency	35	%						$12,810
	Planning Engineering, CM	45	%	of construction cost					$22,235
	Total CIP Cost Estimate (rounded up to nearest $1,000):								**$72,000**
	PREVENTATIVE MAINTENANCE COST ESTIMATE								
1	Cleaning Costs @ $2.50/ft. if >500 ft. + 1xmob of $2,000	4100	LF	incl.	$3		$2,000	$10,250	$10,300
	Contingencies	35	%						$3,605
	Total PM Cost Estimate:								**$14,000**
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	CCTV from both newly constructed access manholes @ $2.50/ft. + 1xmob of $2,000	3400	LF	incl.	$2.5		$2,000	$8,500	$10,500
	Contingencies (Item #1 - CCTV)	35	%						$3,675
2	Sulfide Level - Conduct continuous 24-hour sampling using an automated sampler at discharge manholes. Evaluate and report results to investigate potential sulfide reduction strategies by CIP and PM activities. Cost considers performing test on both C_A and C_B concurrently.	1	ea.	$0	$70,000		$0	$70,000	$70,000
	Contingencies (Item #2 - Sulfide Level)	35	%						$24,500
	Total FMI Cost Estimate:								**$94,500**

Notes:
1. Labor rates:
   - Unskilled Labor $50/hr.
   - Skilled Labor $65/hr.
   - Foreman $80/hr.
   - Engineer $130/hr.
2. Engineering (15%), Construction Management (15%), Administration (15%)
   Project Contingencies (35%)

V&A

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATE
Pump Station C - Discharge Line B

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor (1)	**** Total **** Matl	Labor	Total
	CAPITAL IMPROVEMENT COST ESTIMATE							
	Install 2 Pressure Manholes							
1	Install Manole (4' Deep max., base bid)	2	ea.	$5,000	$4,000	$10,000	$8,000	$18,000
2	Install Manhole (1' deep increment)	4			$250		$1,000	$1,000
3	Install 16" DIP Tee w/ fittings	2	ea.	$2,000	$4,000	$4,000	$8,000	$12,000
4	Demo/Restoration (saw cut, disposal, baserock, AC)	200	SF	$38	incl.	$7,600		$7,600
	Reconstruct 2 ARV Manholes with Pipe Tee Fitings							
5	Remove Manhole Top	1	ea.	$1,000	$4,000	$1,000	$4,000	$5,000
6	Install 16" DIP Tee w/ fittings	2	ea.	$2,000	$4,000	$4,000	$8,000	$12,000
	Construction Cost Subtotal:							$55,600
	Construction Contingency	35	%					$19,460
	Planning Engineering, CM	45	%	of construction cost				$33,777
	Total Cost Estimate							**$108,840**
	Total CIP Cost Estimate (rounded up to nearest $1,000):							**$109,000**
	PREVENTATIVE MAINTENANCE COST ESTIMATE							
1	Cleaning Costs @ $2.50/ft. if >500 ft. + 1xmob of $2,000	4100	LF	incl.	$3	$2,000	$10,250	$10,300
	Contingencies	35	%					$3,605
	Total PM Cost Estimate:							**$14,000**
	FUTURE MONITORING/INSPECTION COST ESTIMATE							
1	CCTV from both newly constructed access manholes @ $2.50/ft. + 1xmob of $2,000	3400	LF	incl.	$2.5	$2,000	$8,500	$10,500
	Contingencies (Item #1 - CCTV)	35	%					$3,675
2	Sulfide Level - Conduct continuous 24-hour sampling using an automated sampler at discharge manholes. Evaluate and report results to investigate potential sulfide reduction strategies by CIP and PM activities. Cost is already included in Discharge Pipeline C_A							
	Contingencies (Item #2 - Sulfide Level is incl. in C_A)	35	%					
	Total FMI Cost Estimate (rounded up to nearest $100):							**$14,200**

Notes:

1. Labor rates:
   - Unskilled Labor $50/hr.
   - Skilled Labor $65/hr.
   - Foreman $80/hr.
   - Engineer $130/hr.
2. Engineering (15%), Construction Management (15%), Administration (15%)
   Project Contingencies (35%)

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East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATE
Pump Station F

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	CCTV and cleaning from discharge manhole @ $2.50/ft. + 1xmob of $4,000	35	LF	incl.	$2.5		$4,000	$88	$4,100
	Contingencies	35	%						$1,435
	Total FMI Cost Estimate (rounded up to nearest $100):								**$5,600**

Notes:

1. Labor rates:
   - Unskilled Labor $50/hr.
   - Skilled Labor $65/hr.
   - Foreman $80/hr.
   - Engineer $130/hr.
2. Engineering (15%), Construction Management (15%), Administration (15%)
   Project Contingencies (35%)

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATES

Discharge Pipeline G

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	Install 1 Pressure Manhole								
1	Install Manhole (4' Deep max., base bid)	1	ea.	$2,500	$2,000		$2,500	$2,000	$4,500
2	Install Manhole (1' deep increment)	10			$625			$625	$625
3	Install 16" DIP Tee w/ fittings	1	ea.	$1,000	$1,000		$1,000	$1,000	$2,000
4	Demo/Restoration (saw cut, disposal, baserock, AC)	100	SF	$38			$3,800	$3,800	$7,600
	Construction Cost Subtotal:								$14,725
	Construction Contingency	35	%						$5,154
	Planning Engineering, CM	45	%	of construction cost					$8,945
	Total Cost Estimate								**$28,830**
	Total CIP Cost Estimate (rounded up to nearest $1,000):								**$29,000**
	PREVENTATIVE MAINTENANCE COST ESTIMATE								
1	Clear pressure manhole GF01 of dirt. Maintain cleanout GF02 and soil bed.	1	ea.	$0	$3,500		$0	$3,500	$3,500
	Contingencies	35	%						$1,225
	Total PM Cost Estimate (rounded up to nearest $100):								**$4,800**
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	CCTV and cleaning from newly constructed pressure manhole @ $5/ft. + 1xmob of $2,000	2180	LF	incl.	$5.0		$2,000	$10,900	$12,900
	Contingencies	35	%						$4,515
	Total FMI Cost Estimate (rounded up to nearest $100):								**$17,500**

Notes:
1. Labor rates:
   - Unskilled Labor $50/hr.
   - Skilled Labor $65/hr.
   - Foreman $80/hr.
   - Engineer $130/hr.
2. Engineering (15%), Construction Management (15%), Administration (15%)
   Project Contingencies (35%)

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATES

Discharge Pipeline J

Prepared By: **Derek Wurst**
Date: **5/27/2014**
File Name: **V&A Cost Estimates.xls**

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	CCTV and cleaning from Discharge Manhole S30 @ $2.50/ft. + 1xmob of $4,000	160	LF	incl.	$2.5		$4,000	$400	$4,400
	Contingencies	35	%						$1,540
2	Env. Exp. - Perform one excavation to assess the exterior pipe condition near the discharge end of the alignment	1	ea.	$0	$50,000		$0	$50,000	$50,000
	Contingencies	35	%						$17,500
	Total FMI Cost Estimate (rounded up to nearest $100):								**$73,500**

Notes:

1. Labor rates:
   - Unskilled Labor $50/hr.
   - Skilled Labor $65/hr.
   - Foreman $80/hr.
   - Engineer $130/hr.
2. Engineering (15%), Construction Management (15%), Administration (15%) Project Contingencies (35%)

V&A

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATES

Discharge Pipeline L

Prepared By: **Derek Wurst**
Date: **5/27/2014**
File Name: **V&A Cost Estimates.xls**

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
2	Env. Exp. - Pothole to collect soil samples to assess the effect of soil on exterior pipe condition	1	ea.	$0	$10,000		$0	$10,000	$10,000
	Contingencies	35	%						$3,500
	Total FMI Cost Estimate (rounded up to nearest $100):								**$13,500**

Notes:

1.	Labor rates:	Unskilled Labor	$50/hr.
		Skilled Labor	$65/hr.
		Foreman	$80/hr.
		Engineer	$130/hr.
2	Engineering (15%), Construction Management (15%), Administration (15%)		
	Project Contingencies (35%)		

V&A

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATE
Discharge Pipeline M - Water Crossing

Prepared By: Derek Wurst
Date: 4/21/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	CAPITAL IMPROVEMENT COST ESTIMATE								
1	Site Prep	1	LS		$30,000			$30,000	$30,000
2	Piping Connections	1	LS		$10,000			$10,000	$10,000
3	Install 16" DIP Tee w/ fittings	2	ea.	$2,000			$4,000	$4,000	$8,000
4	Demo/Restoration (saw cut, disposal, baserock, AC)	400	SF	$38			$15,200	$4,000	$19,200
5	HDD 16-in. DIP Pipe	1000	LF	$560			$560,000		$560,000
	Construction Cost Subtotal:						$579,200	$48,000	$627,200
	Construction Contingency	35	%						$219,520
	Planning Engineering, CM	45	%	of construction cost					$381,024
	Total CIP Cost Estimate (rounded up to nearest $1,000):								**$1,228,000**

Notes:
1. Labor rates:
   - Unskilled Labor $50/hr.
   - Skilled Labor $65/hr.
   - Foreman $80/hr.
   - Engineer $130/hr.
2. Engineering (15%), Construction Management (15%), Administration (15%)
   Project Contingencies (35%)

V&A

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATE
Discharge Pipeline M - Alameda Island

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	CAPITAL IMPROVEMENT COST ESTIMATE								
	Installation of ARV at high points								
1	Install Manhole (4' Deep max., base bid)	6	ea.	$5,000	$4,000		$30,000	$24,000	$54,000
2	Install Manhole (1' deep increment)	6			$250			$1,500	$1,500
3	Install ARV w/ fittings	6	ea.	$2,000	incl.		$12,000		$12,000
4	TRENCH PAVING (saw cut, disposal, baserock, AC)	600	SF	$38	incl.		$22,800		$22,800
	Construction Cost Subtotal:								$90,300
	Construction Contingency	35	%						$31,605
	Planning Engineering, CM	45	%	of construction cost					$54,857
	Total Estimated Cost								**$177,000**
	Total CIP Cost Estimate (rounded up to nearest $1,000):								**$177,000**
	PREVENTATIVE MAINTENANCE COST ESTIMATE								
1	Clear Pressure Manholes M11 through M15 of water, power tool clean to remove corrosion scale and apply petrolatum tape wrap of exposed metal surfaces.	5	ea.	$0	$2,000		$0	$10,000	$10,000
	Contingencies	35	%						$3,500
	Total PM Cost Estimate (rounded up to nearest $100):								**$13,500**
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	Sulfide Level - Conduct continuous 24-hour sampling using an automated sampler at Discharge Manhole M01. Evaluate and report results to investigate potential sulfide reduction strategies by CIP and PM activities. (Note this cost covers recommendations for Discharge Pipelines M_{WC} and M_{BF} also).	1	ea.	$0	$50,000		$0	$50,000	$50,000
	Contingencies (Item #1 - Sulfide Level)	35	%						$17,500
2	CCTV and cleaning from Pressure Manhole M15 @ $5/ft. + 1xmob of $2,000 + Blind Flange removal $2,000 and dewatering cost of approx. $15,000	2045	LF	incl.	$5.0		$19,000	$10,225	$29,300
	Contingencies (Item #2 - CCTV)	35	%						$10,255
	Total FMI Cost Estimate (rounded up to nearest $100):								**$107,100**

Notes:

1. Labor rates:
   - Unskilled Labor $50/hr.
   - Skilled Labor $65/hr.
   - Foreman $80/hr.
   - Engineer $130/hr.
2. Engineering (15%), Construction Management (15%), Administration (15%)
   Project Contingencies (35%)

East Bay Municipal District
Wastewater Pump Station Condition Assessment
COST ESTIMATES
Discharge Pipeline N

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	PREVENTATIVE MAINTENANCE COST ESTIMATE								
1	Clear pressure manholes NF08 to NF11 of water, power tool clean to remove corrosion scale and apply petrolatum tape wrap of exposed metal surfaces. Exercise plug valves on N_N. (Annual recurring costs include just periodic cleaning and visual check of manholes at $150/MH = $600)	4	ea.	$0	$3,500		$0	$14,000	$14,000
	Contingencies	35	%						$4,900
	Total PM Cost Estimate (rounded up to nearest $100):								**$18,900**
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	Sulfide Level - Conduct continuous 24-hour sampling using an automated sampler at Discharge Manhole NF07. Evaluate and report results to investigate potential sulfide reduction strategies by CIP and PM activities. (Note this cost covers recommendations for Discharge Pipelines N_C and N_N both).	1	ea.	$0	$50,000		$0	$50,000	$50,000
	Contingencies (Item #1 - Sulfide Level)	35	%						$17,500
2	C-Factor Test (at 10 yrs.)	1	LS		$15,000			$15,000	$15,000
	Contingencies (Item #2 - C-Factor)	35	%						$5,250
	Total FMI Cost Estimate:								**$87,750**

Notes:

1. Labor rates:
   - Unskilled Labor $50/hr.
   - Skilled Labor $65/hr.
   - Foreman $80/hr.
   - Engineer $130/hr.
2. Engineering (15%), Construction Management (15%), Administration (15%)
   Project Contingencies (35%)

V&A

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATES

Discharge Pipeline Q

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	CAPITAL IMPROVEMENT COST ESTIMATE								
1	Test Station Installation/Reinstallation and Anode Replacemen	13	ea.	$800	$15,000		$10,400	$195,000	$205,400
2	Anode Replacement	16	ea.	$800	$4,200		$12,800	$67,200	$80,000
	Contingencies	35	%						$99,890
	Planning, Engineering and CM	45	%						$173,381
	Onsite Inspection and Activation	1	LS	$0	$2,500		$0	$2,500	$2,500
	Total CIP Cost Estimate (rounded up to nearest $1,000):								**$562,000**
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	Env. Exp. - Perform one excavation of Discharge Pipe Q_S to assess the effect of soil on exterior pipe condition	1	ea.	$0	$50,000		$0	$50,000	$50,000
	Contingencies	35	%						$17,500
2	CCTV from Pressure Manhole Q09 @ $2.50/ft. + Blind Flange	2000	LF	incl.	$2.5		$4,000	$5,000	$9,000
	Contingencies	35	%						$3,150
	Total FMI Cost Estimate (rounded up to nearest $100):								**$79,700**

Notes:

1. Labor rates:

Unskilled Labor	$50/hr.
Skilled Labor	$65/hr.
Foreman	$80/hr.
Engineer	$130/hr.

2 Engineering (15%), Construction Management (15%), Administration (15%)
Project Contingencies (35%)

V&A

East Bay Municipal District
Wastewater Pump Station Condition Assessment

COST ESTIMATES

Discharge Pipeline R

Prepared By: Derek Wurst
Date: 5/27/2014
File Name: V&A Cost Estimates.xls

Item	Description	Qty	Unit	*** Unit Price *** Matl	Labor	(1)	**** Total **** Matl	Labor	Total
	PREVENTATIVE MAINTENANCE COST ESTIMATE								
1	Clear pressure manholes and traffic boxes with ARVs at RF03, RF06, RF11, RF12, RF13, RF16 and RF17 of water, power tool clean to remove corrosion scale and apply petrolatum tape wrap of exposed metal surfaces.	7	ea.	$0	$3,500		$0	$24,500	$24,500
	Contingencies	35	%						$8,575
	Total PM Cost Estimate (rounded up to nearest $100):								**$33,100**
	FUTURE MONITORING/INSPECTION COST ESTIMATE								
1	C-Factor Test (at 10 yrs.)	1	LS		$15,000			$15,000	$15,000
	Contingencies (Item # - C-Factor)	35	%						$5,250
2	Sulfide Level - Conduct continuous 24-hour sampling using an automated sampler at the discharge manhole structure. Evaluate and report results to investigate potential sulfide reduction strategies by CIP and PM activities.	1	ea.	$0	$50,000		$0	$50,000	$50,000
	Contingencies (Item #2 - Sulfide Level)	35	%						$17,500
3	CCTV and cleaning from discharge structure @ $2.50/ft. + 1xmob of $2,000 + Confined space entry and scaffolding set up $12,000.	1000	LF	incl.	$5.0		$12,000	$5,000	$17,000
	Contingencies (Item #3 - CCTV)	35	%						$5,950
	Total FMI Cost Estimate (rounded up to nearest $100):								**$110,700**

Notes:

1.	Labor rates:	Unskilled Labor	$50/hr.
		Skilled Labor	$65/hr.
		Foreman	$80/hr.
		Engineer	$130/hr.
2	Engineering (15%), Construction Management (15%), Administration (15%)		
	Project Contingencies (35%)		

APPENDIX A: PRELIMINARY RISK ANALYSIS TM

APPENDIX B: FINAL RISK ANALYSIS

APPENDIX C: INSPECTION TECHNOLOGY REVIEW TM

APPENDIX D: FIELD INSPECTION PLAN

APPENDIX E: FIELD INVESTIGATION FINDINGS REPORT

APPENDIX F: CATHODIC PROTECTION SYSTEM ASSESSMENTS AND EVALUATIONS TM

EBMUD

Pump Station Master Plan Update

Final 12/18/15

P S M P U P D A T E

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Pump Station
Master Plan Update

Final 12/18/15

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Acknowledgements

I would like to acknowledge the significant contributions from Jenny Tran - WED Design, Jennifer Ku - WED Planning, and Mike Purcell, Dillon Cowan, and Maura Bonnarens - WTD. Jenny Tran was the key contributor who participated in, and provided the continuity through, inspections, assessments, and recommendations. I would also like to acknowledge V&A Consulting Engineers for providing field testing services.

Diana Lee, P.E.

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List of Reference Documents

Item	File Location
AM Inspection Memos	Planning Library and O:\DCowan\2013_PS_Inspections
Inspection Checklists	W:\NAB\Planning\MASTER PLANS\PS Master Plan\2013 PSMP Update\Inspection Checklist
Inspection Findings List	W:\NAB\Planning\MASTER PLANS\PS Master Plan\2013 PSMP Update\Inspection Checklist\Copy of 2013 Inspection - Noted Deficiencies.xlsx
Potential Improvement Matrix	W:\NAB\Planning\MASTER PLANS\PS Master Plan\2013 PSMP Update\Submittals\Table of Potential Improvements 2014-10-02.docx
Pump Test Data	W:\NAB\Planning\MASTER PLANS\PS Master Plan\2013 PSMP Update \Submittals\Pump Test Data
Equipment Risk Assessment	W:\NAB\Planning\MASTER PLANS\PS Master Plan\2013 PSMP Update \Risk Assessment\AM Equipment Risk Assessment

Executive Summary

Pump Station Master Plan Update Project Report

This project report covers an update to the 1998 Wastewater Pump Stations Master Plan (PSMP). This update is based on pump station inspections that were performed in 2013 by the District as required by the 2009 Stipulated Order for Preliminary Relief. This update is not a comprehensive master plan but rather a limited update incorporating system changes and inspection findings. This report also provides collected data and summaries on the pump station facilities such as:

- Installation and Upgrade Information
- Key System Information
- Discharge Pipeline Data
- Capacity and Flow Data
- Pump Performance Data
- Estimate Times to Overflow
- Ventilation and Odor Control System Information
- Climate and Sea Level Rise Issues
- Facility and Equipment Risk Data

Updating Conditions and Determining Risks

The conditions based on pump station inspection were used in conjunction with developed consequence factors, to perform a risk assessment of the pump stations. The risk assessment was used to prioritize rehabilitation work and incorporate projects into the Capital Improvement Program (CIP). Table E-1 shows the results of the risk assessment based on likelihood of failure (condition) and consequence of failure. Red indicates the highest risk, yellow medium risk, and blue low risk.

Table E-1 Overall Risk Matrix

Consequence	13-14	H	G	C
	11-12		B, F, N, R	A, L, M
	6-10	D, E, Q		J, K
		<40	40-50	>50
		Likelihood		

Incorporation of Projects into the CIP

Rehabilitation projects for Pump Stations A, C, L, and M have been incorporated into the CIP for FY16-FY20. See Table E-2 below. All of these projects are in the first five years of the current

10 year CIP. Next pump stations for CIP consideration will include Pump Stations G, then B, F, N, and R.

Table E-2 CIP Projects

CIP Projects (FY16-FY20)		**Total Cost $1000**
Pump Station A Improvements	Design	$349
	Construction	$1,580
	Total	**$1,929**
Pump Station C Improvements	Design	$350
	Construction	$1,514
	Total	**$1,864**
Pump Station L Improvements	Design	$304
	Construction	$1,231
	Total	**$1,535**
Pump Stations M Improvements	Design	$553
	Construction	$2,489
	Total	**$3,042**

1 Introduction

1.1 Purpose and Objectives

Purpose: The purpose of this project is to update the 1998 Wastewater Pump Stations Master Plan (PSMP) which was developed by Kennedy/Jenks Consultants under the direction of Karl Yakich who served as the District's project manager. This update is based on recent pump station inspections that were performed in 2013 by the District as required by the 2009 Stipulated Order for Preliminary Relief. This update is not a comprehensive master plan but rather a limited update incorporating system changes and inspection findings since the 1998 plan was completed.

Objectives: The overarching objectives for updating the 1998 PSMP include:

- Service Reliability: Providing a plan for maintaining and rehabilitating the pump stations in order to provide reliable service.
- Regulatory Requirements: Supporting fulfillment of *Sewer System Management Plan* regulatory requirements regarding inspections and condition assessment.
- Environmental: Providing a plan for maintaining and rehabilitating the pump stations in order to prevent failures that could lead to sanitary sewer overflows (SSOs).

1.2 Updating Conditions and Determining Risks

Updating conditions includes review of pump station inspection findings and other service records. By using these updated conditions and developing consequence factors, a relative risk assessment among the pump stations can be performed. The risk assessment supports the recommendations for improvement and incorporation of projects into the CIP.

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2 Pump Station and System Info

2.1 Collection System General Information

Figure 2-1 shows the locations of the pump stations throughout the collection system, along with interceptors and wet weather facilities (WWFs). The collection system includes approximately 29 miles of gravity interceptors, 330 manholes, 8 miles of force mains, 15 pump stations, and 3 WWFs. Not shown, but also found throughout the collection system, are level monitoring stations, overflow structures, and diversion structures.

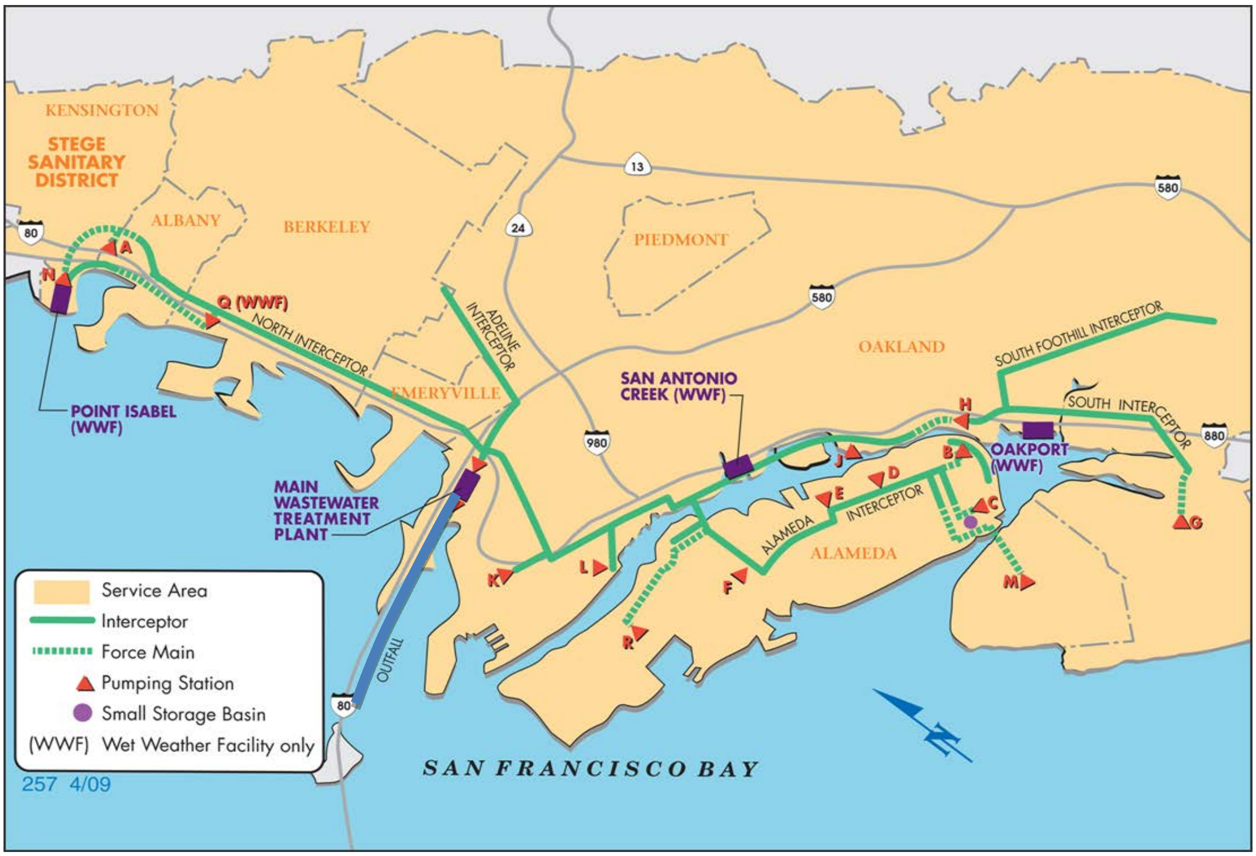

Figure 2-1 EBMUD Wastewater Collection System

The District has completed a number of recent investigative and assessment efforts on the collection system. They include the following:

- Gravity Interceptor System Inspections, 2010-2013
- Gravity Interceptor System Risk Assessment, 2014
- Interceptor Corrosion Prevention Study, 2014
- Pump Station Discharge Pipeline Condition Assessment, 2014

2.2 Pump Station Information

The wastewater collection system has 15 pump stations. Pump Station Q is a designated wet weather pump station and is used to divert flows from the north interceptor towards the Pt Isabel WWF. Pump Station H is the largest pump station and is an in-line lift station on the south interceptor. All other pump stations lift flows from surrounding satellite collection systems into the interceptor system.

Below is a series of tables that provide information on pump station location, history, and key facility features. Reference drawings for each pump station are provided in Appendix A, and additional pump station information can be found in Section 6 of this report.

Pump Station location information is provided in Table 2-1. Pump station Global Positioning System (GPS) coordinate information can be found in the Pump Station Discharge Pipeline Condition Assessment Project Final Report under Field Investigation Findings. GPS data was collected to be compatible with the North America Datum 1983 Geographic Coordinate System.

Table 2-1 Pump Station Location

Station ID	Interceptor Location	Address	Phone Number (510)
A	North	500 Cleveland Ave, Albany	525-8165
B	Alameda	3133 Marina Dr, Alameda	986-7657
C	Alameda	2901 Otis Dr, Alameda	986-7598
D	Alameda	2018 Oak St, Alameda	521-2310
E	Alameda	2003 Grand St, Alameda	522-6127
F	Alameda	2000 Constitution Ave, Alameda	522-8606
G	South	9301 Doolittle Dr, Oakland	287-1921
H	South	4399 Oakport St, Oakland	533-3127
J	South	2201 Frederick St, Oakland	261-3699
K	South	2101 7th St, Oakland	834-7698
L	South	1420 Middle Harbor Rd, Oakland	465-2077
M	Alameda	1 Packet Landing Rd, Alameda	865-2632
N	North	2755 Isabel St, Richmond (at Pt Isabel WWF)	287-1768 (PI WWF)
Q	North	1452 2nd St, Berkeley	287-1927
R	Alameda	1001 W. Red Line Ave, Alameda	986-7810

The oldest pump stations were built in the early 1950's, and all, except Pump Station L, have been refurbished over the years. The remainder of the pump stations were acquired or built in the 1980's and 1990's. A summary of the pump station installation and upgrade histories is provided in Table 2-2. Related construction and upgrade work on level monitoring stations and discharge pipelines are not included in this table.

A good resource for additional information on upgrades can be found in the WW Design Library or on the WW Dox server.

Table 2-2 Pump Station Installation and Upgrade Information

Pump Station	Year Built/ Acquired (Spec.)	Year of last Rehab (Rank)	Upgrades*		
			Date	Spec.	Description
A	1952 (SD71)	1987 (2)	1987	SD 164	Pump, drives, MCC, force main relocation
			2009	Maintenance	Overhaul of Pump #1 and Pump #3
			2011	SD 313	Flow meter on force main
B	1952 (SD72)	1998 (8)	1976	SD 132	Chemical dosing system
			1989	SD 172	Emergency generator
			1998	SD 204	All major equipment and force main replacement
			2009	SD 326	Bypass connection on FM
C	1964 (City)	1998 (8)	1965	SD 105, 106	FM connection and improvements
			1972	SD 127	Chemical dosing
			1980	SD136	Electrical and civil improvements
			1988	SD 162a	Electrical
			1989	SD 172	Emergency generator
			1998	SD 207	All new equipment, storage basin, FM replacement
			2009	SD 326	Bypass connection on FM
D	1953 (SD75)	2013 (14)	2000	SD 239	Ventilation improvements
			2009	SD 326	Connection for portable generator
			2013	SD 263	All equipment
E	1953 (SD75)	2013 (14)	2000	SD 239	Ventilation improvements
			2009	SD 326	Connection for portable generator
			2013	SD 263	All equipment
F	1953 (SD74)	2000 (10)	1998	SD 231	Chemical dosing and odor control
			2000	SD 242	All equipment
G	1953 (SD73, SD74)	1995 (7)	1989	SD 172	Emergency generator
			1994	SD187a	Quality monitoring station
			1995	SD 209	All major equipment
H	1951 (SD37, SD52)	2011 (13)	1988	SD 162a	Electrical, lighting, VFDs installed pumps #2 & #3
			1991	SD170	Electrical, controls
			1992	SD 198	Electrical, controls, emergency generator installed
			1994	SD187a	Quality monitoring station
			2000	SD 239	Ventilation improvements
			2011	SD 256	2 pumps replaced , some major equipment
J	1953 (SD76)	1989 (4)	1988	SD 172	Emergency generator
			1989	SD 177	Expand building and replace major equipment
			2009	SD 326	Flex and bypass connections on FM
K	1953 (SD78)	1989 (4)	1989	SD 177	Expand building and replace major equipment
			1994	SD187a	Quality monitoring station
			2009	SD 326	Flex and bypass connections on FM
L	1956 (SD84)	1956 (1)	2009	SD 326	Bypass connection on FM
M	1990 (City)	1988 (3)	1988	City	PS Expansion (8200-31)
			1998	SD 231	Chemical dosing
			1999	SD 239	Odor control and ventilation
			2009	SD 326	Bypass connection on FM
N	2000 (SD239)	2000 (10)	2000	SD 239	Pt. Isabel/PS N consolidation (PS N Relocated)
			2013	Maintenance	Pump work
Q	1994 (SD201)	1994 (6)	2011	SD 313	Electrical, controls, diversion struct. modifications
			2013	SD344	Diversion gate rehab
R	2000 (Navy)	2001 (12)	2001	SD 247	PS Rehabilitation

* The smaller upgrades performed by District maintenance staff are not included here.

Key system features for each pump station are provided in Table 2-3. Additional discussions on pump station capacities and pump performances can be found in Section 4 of this report.

Table 2-3 Pump Station Key System Information

Pump Station[1]	Location of Pumps[2]	Type of Pumps[3,4]	No. of Pumps @flow rating/ horsepower	Motor Speed	Pump Sta. Design[5] Capacity (MGD)	Remote DCS Ability[6]
A	Dry well	Vertical	4 @ 1,700 gpm/ 10hp	Constant	7.3	Control
B	Dry well	Closed Couple	2 @ 1,300-600 gpm/ 30/15 hp 2 @ 2,600-1700 gpm/ 75/56 hp	Dual	7.5	Monitor
C	Wet well	Closed Couple	3 @ 600 gpm/15 hp (dry weather) 2 @ 3000 gpm/77 hp (wet weather) 2 @ 600 gpm/15 hp (dewatering)	Constant VFD Constant	8.2	Control
D	Dry well	Closed Couple	2 @ 355 gpm/ 3.7 hp	Constant	0.7	Monitor
E	Dry well	Closed Couple	2 @ 355 gpm/ 3.7 hp	Constant	0.7	Monitor
F	Dry well	Closed Couple	4 @ 1,500 gpm/ 15 hp	Constant	6.5	Monitor
G	Dry well	Vertical	3 @ 700 gpm/ 15 hp	Constant	2.0	Monitor
H	Dry well	Vertical Vertical Closed Couple	1@19,000 gpm / 162 hp 1@19,000 gpm / 162 hp 2@ 20,200 gpm/ 200 hp	VFD VFD VFD	66	Control
J	Dry well	Vertical	3 @ 980 gpm/ 8 hp	Constant	2.3	None
K	Dry well	Vertical	3 @ 700 gpm/ 6.7 hp	Constant	2.0	None
L	Dry well	Vertical	2 @ 450 gpm/ 3 hp	Constant	0.6	None
M	Dry well	Vertical	4 @ 1,575 gpm/ 60 hp	Constant	6.8	None
N	Wet well	Closed Couple	4 @ 3,470 gpm/ 148 hp	VFD	15	Control
Q	Dry well	Vertical	4 @ 5,555-3935 gpm/ 200/100 hp	Dual	24	Control
R	Dry well	Closed Couple	3 @ 3,600-2,350 gpm/ 75/56 hp	Dual	7.5	Monitor

1. All pump stations are lift stations except for Pump Station Q which is a diversion station.
2. Dry well = Pump is installed in the dry well, is not in direct contact with sewage and receives sewage through suction piping in wet well. Wet well installation = pumps are submerged in the wet well, is in direct contact with sewage.
3. All pumps are centrifugal, non-clog pumps.
4. Closed couple pumps = motor location on the pump, typically submersible. Vertical pumps = motor is located some distance above the pump and operates through a shaft
5. See Section 4 for additional information on pump station capacities.
6. DCS ability: Control = Pump control. Monitor = Pump monitoring, but no control.

Additional pump station information can be found in the following sources:

- Wastewater Treatment Division's Online Remote O&M Page: http://ebmudnet/wastewater-treatment/ommanual.htm
- Remote Operations Training Manual, 2011
- Wet Weather Facilities Operations Workshop Presentation, 2010

Additional information on the pump station discharge pipelines can be found in Table 2-4 below and the Pump Station Discharge Pipeline Condition Assessment Project Final Report.

Table 2-4 Pump Station Discharge Pipeline Data

Discharge Pipeline	Year Installed	Diameter (inches)	Approx. Length (feet)	From Reference Information		
				Pipe Materials	Interior Lining	Exterior Coating
A	1987	20, 24	1,900	DIP	Cement Mortar/Poly-lined	Polyethylene Encasement
B	2000	18	2,700	DIP	Cement Mortar	Polyethylene Encasement
C_A	1942, 1995	16, 20	4,100	CIP, DIP	Cement Mortar	None
C_B	1968	21	4,100	RCP	None	None
D	1953	8	200	CIP	Cement Mortar	None
E	1953	8	100	CIP	Cement Mortar	None
F	1953	16	50	CIP	Unknown	None
G	1954, 1995	12	3,000	HDPE, RCP	None	None
H	1948, 2009	48	2,200	RCP	None	None
J	1953	12	100	CIP	Cement Mortar	Unknown
K	1953	12	100	CIP	Cement Mortar	None
L	1955	10	300	CIP	Cement Mortar	Unknown
M_{BF}	1980	24	1,980	DIP	Cement Mortar	Polyethylene Encasement
M_{WC}	1949	16	1,010	CIP	Unknown	None
M_{AI}	1986	24	5,125	DIP	Cement Mortar	Polyethylene Encasement
N_N (PS N to Rydin Rd)	2000	24	2,180	RCP, Steel	HDPE, Cement Mortar	None
N_C (Rydin Rd to MH NF07)	1969	27	4,060	CCP	Epoxy	None
Q_S (PS Q to MH Q11)	1995	36	5,310	Steel	Cement Mortar	Unknown
Q_N (MH Q11 to MH Q16)	1987	24	2,240	DIP	Poly-lined	Polyethylene Encasement
R	2001	20	8,300	DIP	Cement Mortar	Polyethylene Encasement

C_A = PS C parallel FM on west side; C_B = PS C parallel FM on west side
M_{BF} = PS M FM on Bay Farm Island side; M_{WC} = PS M FM at water crossing; M_{AI} = PS M FM on Alameda Island side

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3 Pump Station Investigations

3.1 Pump Station Inspections

Pump station inspections were performed in 2013 by Wastewater Engineering Division (WED) Planning, Wastewater Treatment Division (WTD) Asset Management (AM), and other WTD staff. The key objective of the inspections is to identify deficiencies that should be addressed by future capital improvement projects. Twelve of the 15 pump stations were inspected; they included Pump Stations A, B, C, F, G, J, K, L, M, N, Q, and R. Pump Stations D, E, and H were not inspected because they had recently been inspected and upgraded.

Inspection Preparation: In preparation for the inspections, staff reviewed past recommendations in the 1998 PSMP Report and other related past reports listed in Table 3-1, and determined if recommendations had been completed. All recommendations not completed and still valid were included in follow up reviews.

Table 3-1 Related Past Reports

Related Past Reports
1998 Pump Station Master Plan
1991-94 Seismic Evaluation by EQE
1998 Odor Control Master Plan
2011 Regulatory Compliance Office (RCO) Annual Facility Audit of WW Remote Facilities

An inspection checklist was developed for use during the inspections to help identify deficiencies/issues. A sample checklist with descriptions of how to navigate the checklist is located in Appendix B. The checklist was based mainly on the draft Pump Station Design Criteria developed by WED Design staff in the 1990s as well as feedback from recent pump station design projects and WTD staff.

Pump Station Inspections: Inspections were completed between March and November 2013. Each pump station inspection lasted approximately two hours. Attendees at each inspection are listed in the AM memos noted below Generally, WTD staff familiar with the facility and from each discipline attended the inspections. Planning staff focused mainly on potential areas for capital improvements, while AM focused on issues that can be addressed or managed by in-house WTD staff.

During the inspection, both Planning and AM staff had specific focus items to review. They discussed issues with the WTD staff, conducted visual inspections of the facility, and took photos of deficiencies to respond to the “Basic User” level criteria of the inspection checklist. Limited functional testing of equipment was conducted by AM and WTD staff. Equipment commonly tested during these inspections included sump pumps and manual influent isolation gates. Main pump tests were not conducted during these inspections because they were being performed under the Force Main Condition Assessment Project; see Section 4.2.

This PSMP Update documents the investigations. AM also produced inspection memos which are more focused on equipment deficiencies, MAXIMO records and past performance, and potential WTD remedies. These memos can be found in the Planning Library. For electronic files, see List of Reference Documents. Reviews and developments were coordinated between WED Planning and AM.

Other Inspections:

- In February 2015, cracks were observed in the Pump Station R chemical/generator building. The cracks are located in the west wall and southwest corner of the building. After review of the crack pattern, it appeared that the southwest corner of the building may be settling. Periodic settlement monitoring was recommended on a 6 to 12 month interval. This monitoring will be included with the findings and recommendations.

- In April 2015, the District’s Workplace Health and Safety (WHS) documented safety concerns at Pump Stations F, G, J, K and R where roof fans are located too close to the roof edge and present fall hazards during servicing. These safety concerns have been included with the other inspection findings resulting from the pump station investigations.

3.2 Inspection Findings and Potential Improvements

A 2013 Inspection Findings List was developed for each pump station based on the results of the inspections, and was formatted based on the checklist format. Checklist deficiencies are typically those with an inspection response of F, ~, U, and NA (False, Partially True, Unknown, and Not Applicable). These deficiencies were then evaluated to determine whether potential improvements were warranted. If warranted, the deficiency was included on a Potential Improvement Matrix for further review. Refer to Appendix B for more information on the inspection check list development, an example of a 2013 Inspection Finding List, and the Potential Improvement Matrix.

The Potential Improvement Matrix was developed to sort deficiencies by disciplines and general severity categories. Table 3-2 provides the disciplines used and descriptions of typical items categorized under each discipline.

Table 3-2 Description of Disciplines

Discipline	General Description	Types of Deficiency/Improvement Items
General	Includes work related to general station perception, aesthetics, site work, work encompassing major pump station design criteria	• Civil/site, architectural work. • Pump station design capacity • Odor complaints • Rag and grease
Mechanical	Includes items related to pump stations' mechanical equipment and piping	• Sewage pumps and piping • Vent fans and ducts • Chemical equipment • Compressed air • Sump pumps
Structural	Includes items related to pump stations' structural integrity, structural support of equipment and personnel.	• Concrete structure • Platforms, stairs, ladders, hand/guard rails • Access hatches • Equipment support
Electrical	Includes items related to lighting and power	• Electrical service • MCC • Lights and outlets
Instrumentation	Includes items related to control and communication	• PLC • DCS • DAQ • Instrumentation and control panels

General severity categories were developed to group the deficiency/potential improvement in the context of how severe the deficiency is considered. Deficiencies that are safety issues under category "1 – Safety/Regulatory" are generally considered the most severe. Severity level generally reduces with each level down to the lowest level, aesthetic issues, "5 – Convenience/Aesthetics." Table 3-3 contains description of these general severity categories.

Table 3-3 Description of General Severity Categories

General Severity Category	Description
1. Safety/Regulatory	Deficiencies that: • can frequently cause harm to people and environment • is related to site security
2. Functionality/Reliability	Deficiencies that: • may reduce pump station sewage pumping capacity • severely reduce the functionality and/or reliability of core equipment. Core equipment includes the following items: o Main Sewage Pump & Piping o Sump Pump & Piping o Chemical Pumps & Piping o Washdown Pumps & Piping o Air compressor & Piping o Level Sensor o Level Switches o HVAC fans o Isolation gate o Chemical Tank o Wet well structure o DAQ (phone alarm) o PLC (controls, remote communication)
3. O&M Staff Efficiency	Deficiencies that: • affect efficiency of Staff's regular operation or maintenance of a process or equipment • affect Staff's troubleshooting of a process or equipment
4. Good Neighbor	Deficiencies that: • may cause negative impact on public or lead to negative feedback from public.
5. Convenience/Aesthetics	Deficiencies that: • currently function, but can be improved • do <u>not</u> function ideally, can be improved, but does not affect the primary "functions" of the pump station

3.3 Summary of Findings

The investigation findings were used to estimate likelihood-of-failure risk levels. See Section 5 for details of the risk assessments. Also final findings and recommendations for each pump station were developed for consideration of inclusion in the District's capital improvement program. See Section 6 for the resulting findings and recommendations for each pump station.

4 Reviews

4.1 Pump Station Capacities

Data on the pump station capacities and flows were collected from multiple sources, and are summarized here. In addition, this section provides a summary of pump stations with identified capacity or hydraulic issues or limitations. There is additional pump station capacity information, from recent pump performance test, that can be found in Section 4.2 of this report.

4.1.1 Capacity and Flow Data

Pump station capacity and flow data are summarized in Table 4-1.

<u>Operation Log Data:</u> Average daily flows were calculated from monthly total flow records for each pump station.

<u>Modeled Flows based on 2010-2011 Flow Monitoring:</u> The model was calibrated based on flow monitoring performed throughout the service area and on the District interceptor system. Modeled flow results include pump station average and peak dry weather flows (Avg. DWF and Peak DWF) which include minimum groundwater infiltration, and peak wet weather flows (Peak WWF). Pump Stations A, N and H do not convey Peak WWFs because they are controlled during wet weather to divert flow to a wet weather facility. No flows are provided for Pump Station Q since it is only used for wet weather flow and controlled to divert flow to a wet weather facility.

The dry weather flows for Pump Stations D and E are from the City of Alameda model. The flows for Pump Stations D and E are rough estimates since the flows were not verified by flow monitoring and are based on generalized land use unit flow factors (not water use data) and diurnal curves, plus a gross estimate of GWI that came from previous EBMUD analyses using data from very large areas (i.e., based on meters placed on Alameda Interceptor).

No flows provided for Pump Stations J, K, or L. These pump stations were upstream of any flow meters and only pump a portion of the flow from the basin so there was no basis for estimating flows from these pump stations.

<u>Modeled Flows for Design Storm Event:</u> Maximum pumped-flow modeling results from the 2011 calibrated model are included for the pump stations that are included in the model. For those not included in the model, some pump station flow data can be estimated from interceptor tributary area flow data.

<u>Design Capacity:</u> Recorded design capacities. Most have not changed from the 1998 PSMP. Updates include the capacities for Pump Stations D, E and H to reflect the recent upgrades and the inclusion of Pump Station R capacity. These capacities are generally based on one standby pump.

Table 4-1 Pump Station Capacity and Flow Data

Pump Station	Avg. Daily Flow[1]	Flow Model Data 2010-2011 Flows[2]			Design Capacity[4]	Notes
		Avg. DWF	Peak DWF	Peak[3] WWF		
	All flows are in MGD					
A	1.0	1.0	1.5	5.4*	7.3	Controlled to divert flow to WWF. Model reflects 1998 noted limited capacity of 6.0 MGD
B	0.32	0.32	0.57	4.3	7.5	
C	1.9	1.2	1.7	5.7	8.2	WWF capacity based on both WW pumps in service. PS can be controlled to store flow during WW events.
D	.06	0.25	0.36	NA	0.7**	PS not in model
E	.02	0.12	0.14	NA	0.7**	PS not in model
F	0.87	0.90	1.3	4.5	6.5	
G	0.38	0.33	0.46	1.8	2.0	Design capacity adjusted per 1996 Upgrade, 10% Design Report
H	10.4	11.2	14.8	66*	66**	Controlled to divert flow to WWF
J	0.20	NA	NA	NA	2.3	No monitoring data. PS not in model.
K	0.16	NA	NA	NA	2.0	No monitoring data. PS not in model.
L	0.30	NA	NA	NA	0.6	No monitoring data. PS not in model.
M	1.1	1.1	1.6	3.7	6.8	
N	2.8	2.7	4.0	15*	15	Controlled to divert flow to WWF
Q	NA	NA	NA	23*	24	Only operates during major wet weather events
R	0.22	0.27	0.33	1.8	7.5	

(1) Data from 2013 EBMUD Remote Operations logs. Abnormal flow records not included in calculation.
(2) Data based on monitored flows in 2010-2011. NA indicates data not available or not conclusive.
(3) Peak WWF from simulated design storm in model.
* PSs A, H, N, and Q are controlled during a storm events based on level set points at critical downstream manholes. Flows listed under design storm are PS capacities set in the model.
(4) Design capacities after improvements. For PSs without improvements, the 1998 PSMP indicates that design capacities define the pump station capacity with the largest pump out of service. An exception would be Pump Station N which is based on a small pumping unit out of service.
** Improvements as of 2013.

4.1.2 Capacity Limitations and Reviews

Pump Station C Capacity Limitation

The current dry weather pumps at Pump Station C are not always capable of handling Peak DWF without use of all three pumps, i.e., no standby pump. One or two pumps are normally used during low flow periods (overnight) and two or three pumps are used during the day. Ideal operation would have at least one dry weather pump on standby instead of all three pumps running during peak flow conditions.

According to the 10% design report, dated April 1994, for the 1998 upgrade project, the operating concept includes three pumps, one of which is a standby unit. Pump Station C was originally expected to receive the following dry weather flows:

Maximum Daily = 1.5 MGD
Average Daily = 1.0 MGD
Minimum Daily = 0.4 MGD

The report does not state when the flow monitoring was performed but California was in a drought from 1987-1993 so water usage, thus sewer flow, was likely lower than normal due to conservation efforts. Also during the planning and design effort of the Inflow/Infiltration Program in the late 1980s, there were inaccuracies with the flow monitoring and modeling especially in Alameda per the consultant. The combination of these conditions may have led to the underestimation of expected flow. Based off 2013 operation log data records, Pump Station C has an average daily flow of 1.9 million gallons per day (MGD) which is roughly double the value estimated in 1994.

To reach the design capacity of 8.2 MGD, both wet weather pumps must be in service. Currently there is a limitation which only allows use of one wet weather pump at a time. Recent pump tests indicate that one wet weather pump is currently capable of handling the modeled peak wet weather flow value of 5.7 MGD, and there have been no reports of insufficient wet weather capacity.

The improvements should be considered to increase the dry weather pumping capacity to allow for a dedicated standby unit.

Pumps Station G Capacity Limitation

According to the 10% design report, dated March 1994, for the 1995 upgrade project, the operating concept includes three pumps, one of which is a standby unit. The design capacity of the pump station was limited to the estimated capacity of the force main at 2.0 MGD. A 4-inch diameter surge relief vent (hairpin) is connected to the force main just outside the pump station. This vent protects the 12-inch force main from excessive pressures and discharges back to the wet well. Once a siphon is established in the hairpin, the siphon will continue until broken which requires shutting down the pumps and stopping flow to the force main.

The 1998 PSMP states that the Port of Oakland is expecting to increase their flows to 5 MGD in the future due to the expansion of the Oakland Airport. The pump station is not currently equipped to handle that amount of flow but it is unknown if the Port of Oakland is still expecting to increase flows to 5 MGD. One airport terminal expansion has been completed and another is currently underway. Communication from Operations as of November 2014 notes that the current pump station capacity is adequate and there are not recirculation issues through the surge vent.

Pumps Station K Capacity Review

A 1952 Pump Station K site plan shows that a “Navy 27” line and lines from the Oakland Army Base to the north connect into City of Oakland manholes just downstream of the discharge manhole for the Pump Station K force main. Thus these flows do not go through Pump Station K. There appears to be only one 18-inch incoming line to Pump Station K.

Pump Station K, like Pump Station L, has a short force main that discharges into a City of Oakland manhole. The flows then continue for some length in city sewer lines before discharging into the interceptor system.

Pump Station R Capacity Review

When the pump station was rehabilitated in 2001, the capacity was not increased. Per the Alameda Naval Air Station Pump Station Rehabilitation, Discharge Pipeline Relocation, & Third Alameda Siphon Project Predesign Report dated October 1999, even though the ultimate future flow projections for planned development in the area showed a need for additional capacity in the future, it was recommended against upsizing the station at that time. This was due to the fact that upsizing would require an environmental impact statement/environmental impact report (EIS/EIR) which would delay the project and was consider not feasible. It was recommended to defer expansion to increase pump station capacity to a later date in the future when future growth occurs. However, the new force main from the pump station was sized to accommodate the future ultimate flows. The force main was sized to handle a peak capacity of 18.8 cfs (12 MGD) whereas the pump station was rehabilitated at its existing capacity of 11.7 cubic feet per second (cfs) (7.5 MGD). The oversized force main has since been identified as an area of concern during recent condition assessment work due to extended travel time and pump cycles which together can exacerbate interior pipe corrosion potential.

Currently there are no issues with the capacity or operations of the pump station. Overall, the system is oversized for the current flow levels. Since 1999, development in the area has not occurred as rapidly as was expected.

4.1.3 Estimated Time to Overflow for Pump Station Shutdowns

Table 4-2 presents estimated times to first overflow in the event of a dry weather pump station shutdown. Most are rough estimates based on past documentation (1991) which doesn’t indicate data sources, assumptions, nor basis of development. Exceptions include the Alameda pump stations B, C, D, E, F, and M for which an analysis on location and time to overflow was performed using a hydraulic model and examination of hydraulic grade line impacts on the Alameda collection system. The technical memorandum, produced by RMC, covering this analysis can be found in Appendix C. Flow rates were used to proportion some estimates. The flow rate values can be found in Table 4-1.

Table 4-2 Estimated Times to Overflow

Pump Station	Flow Conditions during PS Shutdown			Notes
	Average Dry Weather Flow	Peak Dry Weather Flow	Peak Wet Weather Flow	
A	45 min	1.5 hrs	10 mins	When shutdown, flow passively diverts to PS N. Estimated times are to start of diversion.
B	6 hrs	3.5 hrs	25 mins	DWF times from hydraulic model analysis.
C	5 hrs	3 hrs	50 mins	DWF times from hydraulic model analysis which assumes storage basin is not used. If storage basin is included time to overflow is estimated to range from 9.5 to 16 hours during DWFs.
D	None			Hydraulic model analysis performed. System has bypass (PS F) or loops and flow backs up and discharge via another connection to the interceptor (PSs D and E).
E				
F				
G	3 hrs	2 hrs	30 mins	
H	2 hrs	1.5 hrs	20 mins	When shutdown, flow passively diverts to Oakport. Estimated times are to start of diversion.
J	5 hrs	2 hrs	30 mins	No flow monitoring data.
K	6 hrs	4 hrs	1 hr	No flow monitoring data.
L	6 hrs	4 hrs	3 hrs	No flow monitoring data.
M	5.75 hrs	2.75 hrs	1 hr	DWF times from hydraulic model analysis.
N	4 hrs	2.5 hrs	45 mins	When shutdown, flow passively diverts to Point Isabelle. Estimated times are to start of diversion
Q	NA	NA	Unknown	PS Q is only used in severe wet weather. Unknown when overflow would occur is not put into service.
R	6 hrs	3 hrs	30 mins	

4.2 Pump Performance

Generally the pumps at the pump stations perform well, are reliable, and are suitable for their application. Table 4-3 provides a list of the notable reported pump performance issues. For capacity related issues see Section 4.1.

Table 4-3 Notable Pump Performance Issues

Pump Station	Item(s) Noted	Possible Cause
A	Poor performance test for Pump #1 (Subsequently maintenance was performed)	Past maintenance issue with Ragging. Bar screen removed.
N	Below curve performance on a number of pumps. Impellers damage. Cavitation issues noted.	Wet well hydraulics not suitable for pumps. (Also see response to WER 89-Pump Station N)

A review of pump station preventative maintenance and corrective maintenance history of pump station assets for each pump station can be found in an AM Inspection Memo for each pump station. Copies can be found in the Planning Library. For electronic files, see List of Reference Documents. There is a significant amount of information on the main pumps at each station.

4.2.1 Pump Performance Tests

Pump performance tests and tests to determine C-factor values were performed during the Pump Station Discharge Pipeline Condition Assessment Project by V&A Consulting Engineers. The pumps were tested to determine their performance relative to manufacturer specification such as catalog curves or test curves. The methodology and findings for these tests can be found in Appendix D which is an excerpt from that project's Field Findings Report.

4.2.2 Pump Station System Curves

Pump station system curves were not developed under the condition assessment project. Design Section staff subsequently collected additional testing data from that project and developed some of the system curves. They are presented in Figures 4-1 to 4-4. This data has been collected for all the pump stations, and the remaining system curves can be developed in the future as needed. The developed system curves and test data can be found in W:\Planning\MASTER PLANS\PS Master Plan\2013 PSMP\Submittals\Pump Test Data.

The general approach in developing the system curves includes the following:

- Data was taken from:
    - V&A test data points
        - System curves were mainly developed from C-Factor test data points
        - Other test data points from individual pump performance tests show performance relationship to manufacture's pump curves
    - Manufacturer's pump curves
- Estimated system curves were drawn to match test data points. There can be some variability due to wet well levels.
- Manufacturer's pump curves were plotted. Note that some impeller or other pump modification may not be reflected.
- Pump station design capacity is noted.

Development of system curves is useful for graphic representation of pump station flow data at maximum and intermediate pump usage, and can be helpful for the design of future pump upgrade improvements.

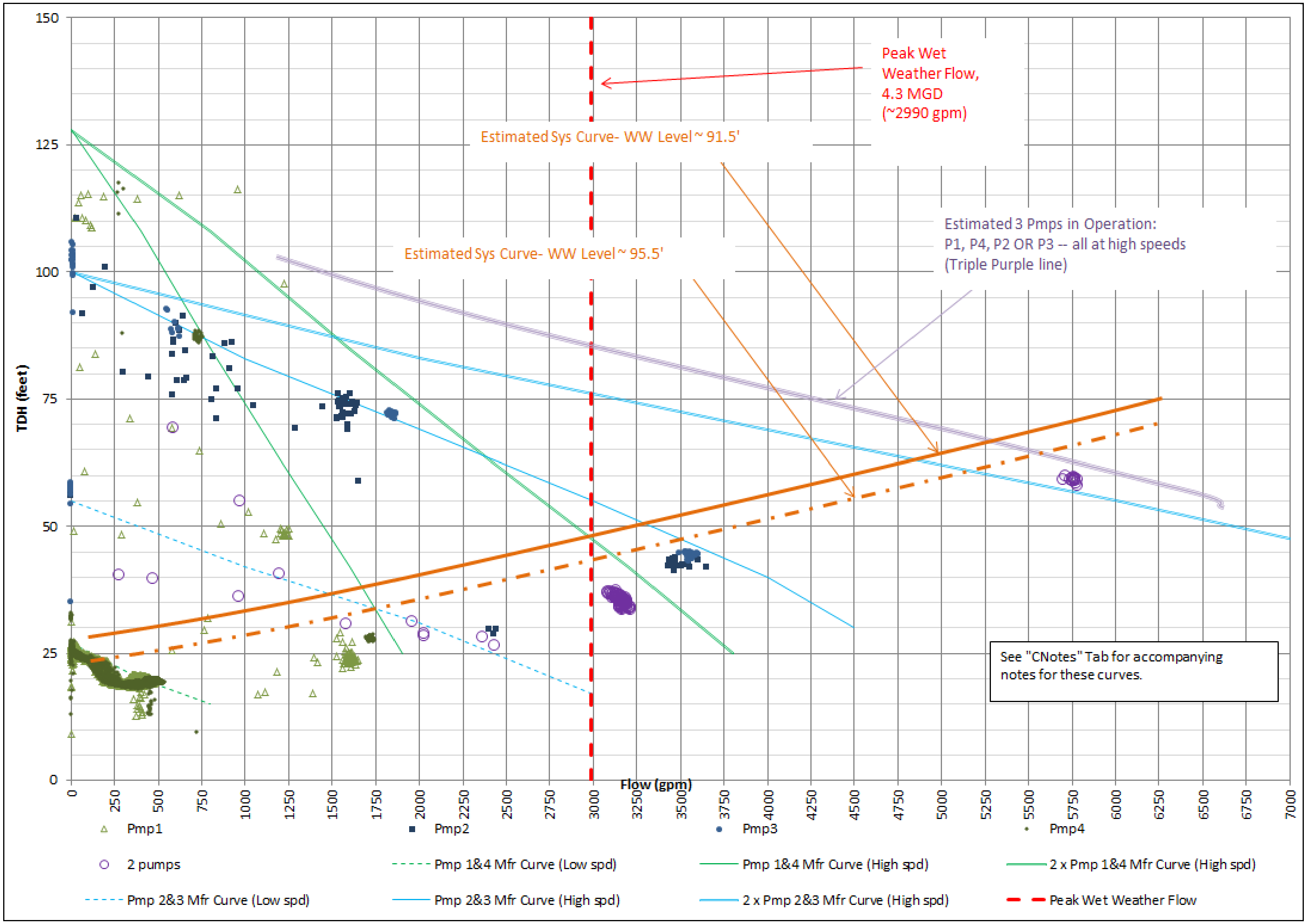

Figure 4-1 Pump Station B – Pump System Curve

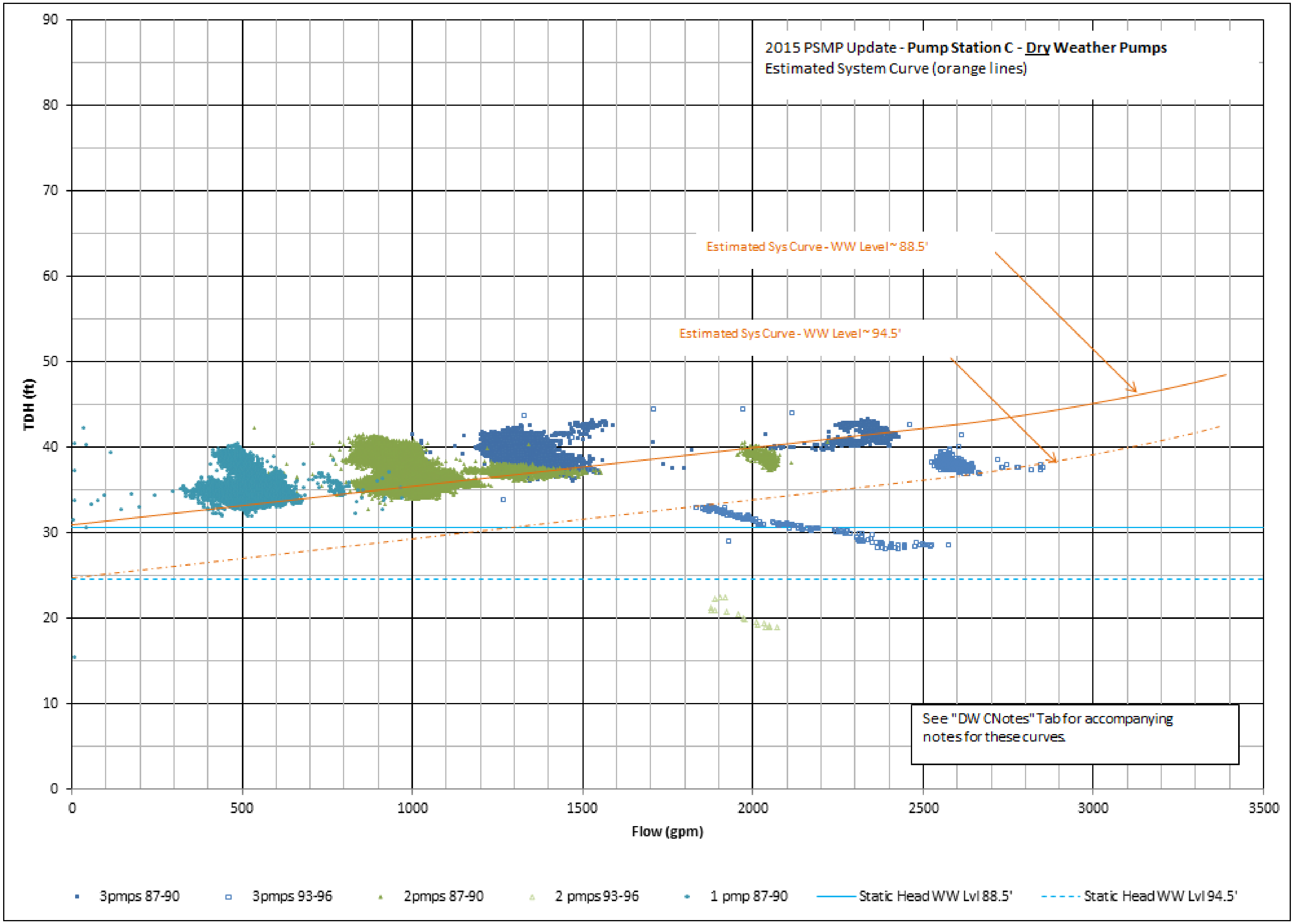

Figure 4-2 Pump Station C - Dry Weather Pump System Curve

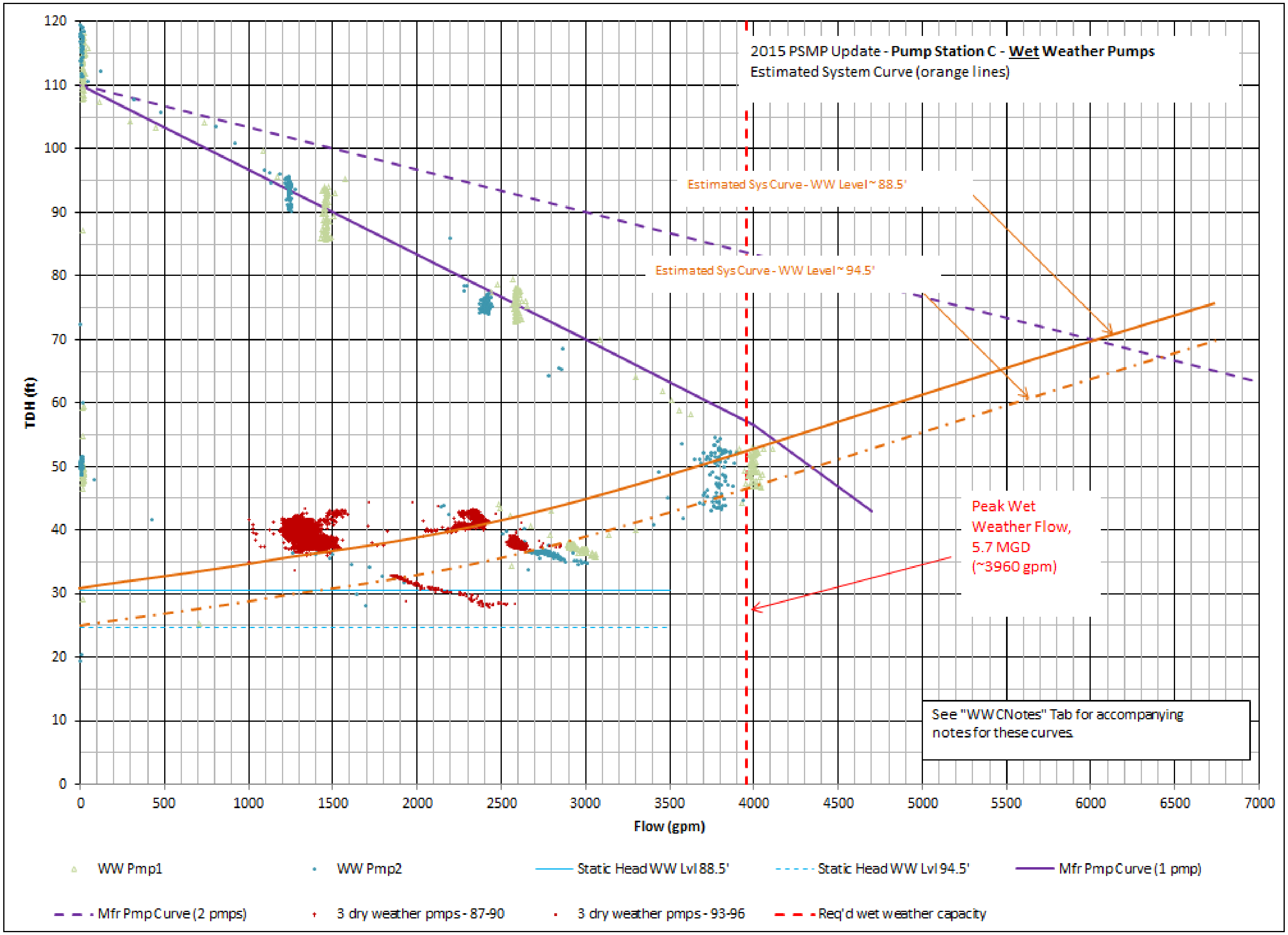

Figure 4-3 Pump Station C - Wet Weather Pump System Curve

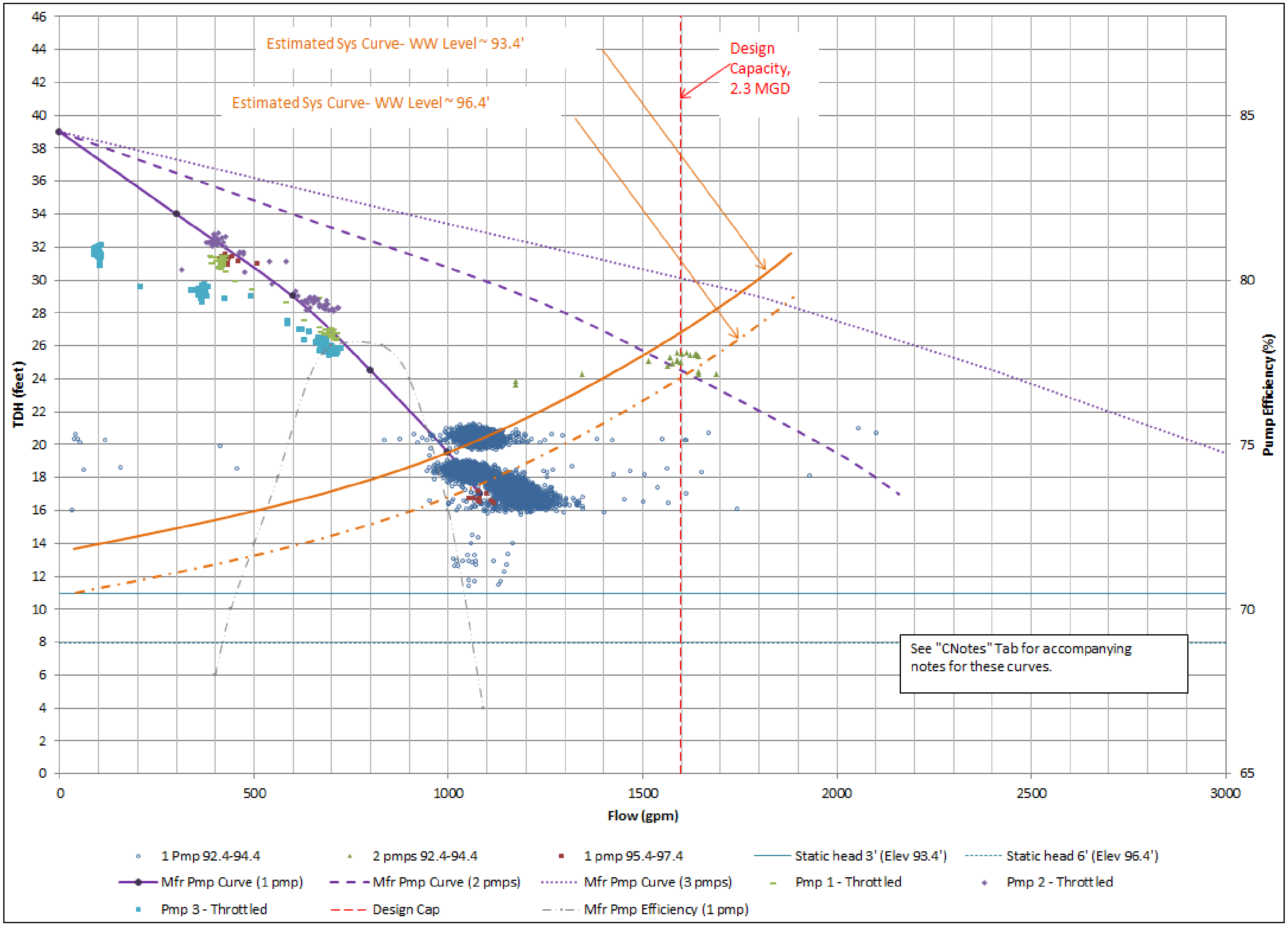

Figure 4-4 Pump Station J - Pump System Curve

4.3 Ventilation and Odor Control Reviews

Data on the pump station ventilation systems was collected from multiple sources, and are summarized here along with some of the key ventilation findings from the recent inspections. In addition, this section covers some ventilation and odor control issues that should be considered when pump station improvements are undertaken.

4.3.1 Existing Ventilation and Odor Control Systems

Below in Table 4-4 is a summary of the existing ventilation and odor control systems at each pump station along with some related comments and recent inspection notes.

Although standards may have changed or deficiencies developed over the years, all pump station wet and dry wells had been furnished with ventilation systems intended for human occupancy (not confined spaces). These systems include continuous ventilation by means of supply fan, exhaust fan, or both. Ventilation deficiencies noted in the 1998 PSMP, but not yet resolved, have been added to the comment column of Table 4-4.

Based on available information and inspection findings, some ventilation improvements have been included in Section 6.

Table 4-4 Pump Station Ventilation and Odor Control Systems Information

Pump Station	Dry Well[1]		Wet Well[1]		Odor Control[2] System(s)	Comments and Inspection Notes
	Supply Fan	Exhaust Fan	Supply Fan	Exhaust Fan		
A	√	√	√	√		• 1998 PSMP items (fans, ductwork, and failure sensors) not implemented • No bar screen in wet well (removed)
B	√	√	√	√		• Dry well supply fan pulls in emergency generator exhaust • Bar screen in wet well
C	--	--		√	• Hypo dosing • Dry soil bed filter	• No dry well. Control room has an exhaust fan • No bar screen in wet well
D	√	√		√	• Exhaust stack (10 FT)	
E	√	√		√	• Exhaust stack (10 FT)	• Record of odor complaints – lowering influent isolation gate to reduce air flow and operating wet well exhaust fan intermittently (at night) has improved odor issues
F	√	√	√	√	• Hypo dosing • Phoenix Scrubber • Light pole exhaust stack (35 FT)	• Safety issue with roof fan location • Wet well exhaust fan can pull water at high water conditions • Hypo tank has exhaust fan • No bar screen in wet well

Pump Station	Dry Well[1]		Wet Well[1]		Odor Control[2] System(s)	Comments and Inspection Notes
	Supply Fan	Exhaust Fan	Supply Fan	Exhaust Fan		
G	√	√	√	√		• Safety issue with roof fan location • Bar screen in wet well
H	√	√	√	√		• No bar screen in wet well
J		√		√		• Safety issue with roof fan location • 1998 PSMP items (fans, ductwork, and failure sensors) not implemented • Bar screen in wet well
K		√		√		• Safety issue with roof fan location • 1998 PSMP items (fans, ductwork, and failure sensors) not implemented • No bar screen in wet well (removed)
L		√	--	--	• Exhaust stack (10 FT)	• No wet well – pumps from City MH • 1998 MP recommendations (fans, failure sensors) not implemented
M	√	√	√	√[3]	• Hypo dosing • Phoenix Scrubber	• Wet well exhaust fan removed • No effective wet well ventilation • 1998 PSMP items (fans, ductwork) not implemented • Poor maintenance access to dry well ventilation equipment. • No bar screen in wet will
N	--	--	√			• No dry well • No bar screens in wet well
Q	√	√	--	--		• No wet well. Direct flow from Page St. diversion structure • 1998 PSMP items (fans, failure sensors) not implemented • No bar screens
R	√	√	√	√	• Hypo dosing • Phoenix Scrubber with exhaust stack above roof level	• Safety issue with roof fan location • Scrubber fan used as wet well exhaust fan • Chemical room has exhaust fan • Bar screen in wet well

1. All ventilation systems are designed to run continuously.
2. Hypo dosing is used during the dry weather season. Phoenix scrubbers are not currently used. Most stations have the wet well exhaust located at the roof level, unless noted otherwise.
3. Wet well exhaust fan at Pump Station M has been removed.

In general the Alameda Interceptor poses higher odor potential due to its relatively flat terrain and long detention time. In addition, there are a number of long force mains which are major sources of sulfide generation. For these reasons, more odor control infrastructure has been built into the Alameda pump stations. The cost effectiveness of the active (dosing and scrubbers) odor control system has not been proven thus dosing is done minimally during the dry weather season, and the scrubbers are not used at all. Although there are reports of odorous conditions at some pump stations, currently odor complaints have not warranted reinstating full utilization of the scrubbers. However, if improvements are made to station ventilation systems whereby higher exhaust levels are achieved, odor issues may become more of a problem. The recent ventilation upgrade at Pump Station E serves as an example of such changes. The improvements to the wet well ventilation system included an exhaust fan, 10 feet exhaust stack and gas detection and alarm system. The pump station is located adjacent to an office building parking lot. After the upgrade was in place, odor complaints from the building occupants started. Odalog measurements were taken and showed spikes of H_2S > 10 parts per million (ppm), however the point source of the odors was not conclusive. Efforts to adjust the exhaust fan run time reduced complaints but did not resolve them completely. Only after also partially lowering the influent isolation gate to reduce the incoming sewer air flow did the complaints stop.

There is not a log of odor complaints for the collection system. Reportedly, all complaints are along the Alameda interceptor. Key complaint locations include the Barnhill Marina which is just upstream of the Alameda siphon crossings, and along Lincoln Avenue between Pearl and Versailles which is just downstream of the Pump Stations M and C force main discharge manholes. Other complaints have been due to construction/improvements on the Wood Street Interceptor Project and the Pump Station E Upgrade Project. There have been few odor complaints at the pump stations.

4.3.2 Pump Station Ventilation Considerations

Ventilation with adequate air-changes per hours (AC/H) and failure sensors is needed for human occupancy. Continuous or intermittent ventilation can provide adequate ventilation however intermittent ventilation requires higher AC/H equipment and the space is considered a confined space until the atmosphere is cleared. Since 1) most pump station systems are currently equipped with continuous ventilation, 2) Operations staff is accustomed to working under such conditions, and 3) odor complaints are not an issue, continuous ventilation should be maintained unless it is determined that odor issues exist or may increase with upgrade. In which case, intermittent ventilation could be considered to mitigate odor issues. Future upgrades to the Pump Station M wet well ventilation system which is currently inactive could be a candidate for an intermittent ventilation system due to the close proximity of residents and a school.

The following are some design criteria/standard information from various sources as a general guideline in considering suitable ventilation.

- There are numerous codes and guidelines: *NFPA 820* establishes minimum requirements for protection against fire and explosion hazards in wastewater treatment plants and associated collection systems, including the hazard classification of specific areas and processes. Also there is the *Ten-State Standards, Recommended Standards for Sewage Works* that may be useful.
- An odor evaluation should be performed to determine the odor levels and need for mitigation.
- For intermittent ventilation, the ventilation system should be interconnected with the lighting system.
- Ventilation levels:

  - Under continuous ventilation, 6 to 15 AC/H with 100% fresh air has been noted as adequate for human occupancy.
  - Under intermittent ventilation: 30 AC/H with 100% fresh air has been noted as required to purge the atmosphere of hazardous gases. A two speed system with 30 AC/H and lower speed could be used to conserve energy.
- Dry Well ventilation considerations:
  - Air supply louvers should only be used if the dry well is located above grade.
- Wet Well ventilation considerations:
  - If there is equipment that requires maintenance or inspection in the wet well, permanently installed ventilation should be required. Table 4-4 notes which pump stations have existing bar screens.
  - Force air is recommended rather than solely exhausting air.
  - Multiple inlet and outlets are recommended.
- Chlorination or chlorine storage room ventilation considerations:
  - Exhaust fan capacity requires 60 AC/H.
  - Ventilation should have supply at ceiling level and exhaust at floor level.

4.4 Climate Change and Sea Level Rise Issues

Data was collected on site-specific climate change and sea level rise impacts anticipated at the pump station locations. The following two sources of information were reviewed:

- The Adapting to Rising Tides (ART) Project led by the San Francisco Bay Conservation and Development Commission (BCDC) for impacts in the Oakland, Emeryville, and Alameda areas.
- BCDC data via their consultant for tidal data in the Richmond, El Cerrito, Albany and Berkeley areas.

Future pump station rehabilitation and improvement design efforts should consider and further evaluate potential impacts of climate change and sea level rise, and consider mitigation efforts as warranted.

<u>Bay Area Data</u>

The ART Project report looked at four different sea level rise scenarios as shown in the header of Table 4-5. The study calculated the average depth of water at the facilities for each scenario. These depths are also shown in Table 4-5. Facilities only exposed to wind waves during storm events could experience shallow flooding for short durations but the exact depth is unclear.

Data obtained from the BCDC consultant includes only tides and elevations for two locations. Staff used this data to calculate corresponding depths for Pump Stations A, Q, and N for each ART Project scenario. While the analysis performed by District staff did not have the in-depth modeling used in the ART Project study, it does provide comparable levels.

Table 4-5 Depth of Inundation at Each Pump Station

Pump Station	Year 2050 – 16-inch Sea Level Rise		Year 2100 – 55-inch Sea Level Rise	
	Daily high tide Average depth	100-year Storm Average depth	Daily High tide Average depth	100-year Storm Average depth
All Depths are in Feet				
A*		1	1	4
B		Wind waves only		Wind waves only
C		1	1	1
D		Wind waves only		Wind waves only
E		Wind waves only		Wind waves only
F		Wind waves only	1	1
G	4	6	7	7
H				Wind waves only
J				Wind waves only
K		Wind waves only		Wind waves only
L		Wind waves only	1	1
M		1	2	2
N*				2
Q*				2
R		Wind waves only	1	1

* These pump stations were not part of the official ART study by BCDC. District staff calculated depths from tide data provided from BCDC's consultant.

Considerations for Addressing Climate Change and Sea Level Rise Impacts

The ART Project report suggests that pump stations be reengineered to improve their capacity to accommodate or adjust to storm events and tidal inundation. Any electrical equipment or instrumentation that is susceptible to flooding could impact the ability of the pump station to operate. Inflow of floodwaters could overload the pumping capacity. Possible solutions include a backup power supply or portable generator and portable pumps to assist with the temporary increase in flow. Other options include making electrical components flood proofed, raising the structure or sensitive equipment to be above the floodwaters.

It would be unrealistic to raise Pump Station G to avoid the six and seven feet of flooding. It also may not be practical to raise the electrical components above the floodwaters since it would place everything at a height where it would be difficult to access and maintain. The most typical solution would be to provide for a backup generator and portable pumps to help handle the storm surge. However, if the surrounding area is flooded as estimated, it would seem unlikely that staff would be able to get the equipment to the site, and there will likely be full disruption in sewer service with the city's sewers surcharged with floodwaters.

Pump Station G is also within the Oakland Airport area. The Oakland Airport is expected to see considerable flooding with sea level rise. It is possible that any improvements made at the airport to address sea level rise will benefit Pump Station G. However, with the magnitude of flooding expected at the various areas of the airport and the number of other capital projects needed at the airport, it is unknown how much will be spent to reduce exposure to sea level rise. Any adaptation to sea level rise at the pump station should be developed in conjunction with the airport. It is unlikely that the District could provide adequate flood protection for Pump Station G without the Oakland Airport doing some protection effort in the surrounding area.

Pump Stations A, C, M F, L and R could be potentially raised, or sensitive equipment raised, to protect from flooding since inundation depths are not very high at these locations. Another solution would be to provide for a backup generator and portable pumps to help handle the storm surge. However, if the surrounding area is substantially flooded, staff might not be able to get the equipment to the site or turn on the equipment if it is already located there. Locating equipment at the site with automation would be a solution to access issues. Flooding is not expected to occur until 2100 so there is adequate time to formulate additional solutions. For pump stations that would only be subject to wind waves, sandbags during large storm events would be recommended.

4.5 Required Modification if Pump Station A is Decommissioned

Under normal operations, Pump Station A can be shut down and the incoming flows will back up in the influent line and passively divert into the 36-inch Q gravity line at the Cleveland Avenue. diversion structure. The flow will then be conveyed to Pump Station N. Under severe wet weather conditions, when Pump Stations A and N are shutdown or when Pump Station N cannot handle the flows, the flows will then overflow to the Pt Isabelle Wet Weather Facility. See Figure 4-5 for a layout of the pipelines in the Pump Station A Vicinity.

If Pump Station A is decommissioned, there are a number of modifications that will be required in addition to the removal of the pump station improvements. If decommissioning Pump Station A is considered, these modifications should be taken into account in a life-cycle cost analysis comparing continued operations with the option to decommission.

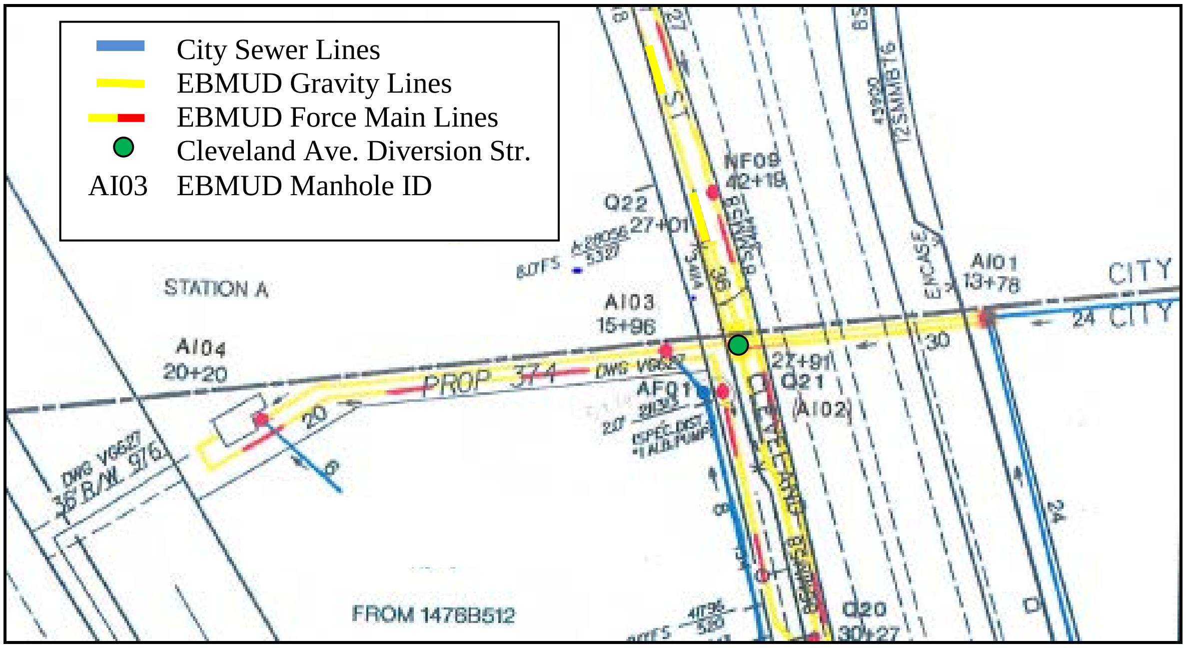

Figure 4-5 Pump Station A Map

Modifications that will be required if Pump Station A is decommissioned include the following:

- Removal of pump station improvements.
- Abandon in place or remove downstream portion of influent line and force main to the confluence with the Pump Station N discharge line.
- Reroute incoming pipelines which currently discharge into the Pump Station A influent line. Figure 4-5 shows two pipelines: 6-inch line at the pump station and an 8-inch line closer to Cleveland Avenue.
- Modify Cleveland Avenue diversion structure to cut off flows toward Pump Station A
- Upsize Pump Station N capacity to handle eliminated Pump Station A capacity. This is more important under small and medium size wet weather conditions where the loss of Pump Station A capacity to divert flows away from the Pt Isabelle WWF could potentially cause more use and discharges from the WWF.

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5 Risk Assessments

Two separate risk assessments were used to support the PSMP Update. They include the Pump Station Overall Risk Assessment and the Pump Station Equipment Risk Assessment. Both use the same general risk assessment approach involving the likelihood of failure and the consequence of failure. The 1998 PSMP did not include a risk assessment.

The Pump Station Overall Risk Assessment covers the risks as compared between the pump station facilities. This assessment takes into account the overall conditions at pump stations to determine likelihood of failure. The consequence of failure for each pump station is based on the complete failure of the pump station to convey flows. Information from pump station inspections and meetings with Operations and Maintenance (O&M) was used to assign rating values. The Pump Station Overall Risk Assessment was used to determine which pump stations pose the greater risk and to prioritize improvements.

The Pump Station Equipment Risk Assessment develops the risks for equipment within each pump station facility. This risk assessment is based on the condition of equipment and the remaining useful life estimates. The source of data includes Maximo records, inspection findings, and other collected data. The consequence of failure for each piece of equipment is based on its impact on the overall function of the pump station. The Pump Station Equipment Risk Assessment was used to identify equipment that poses the greatest risk and identify capital or O&M tasks to mitigate the risk. This information was considered in the development of the scope of work for the CIP projects recommended herein.

5.1 Pump Station Overall Risk Assessment

Risk assessment was performed to determine which facilities pose the greatest risk for the District. By prioritizing improvements based on the risk assessment, the District is better able to reduce its overall risk and also allocate resources where they are most needed.

Risk assessment combines the likelihood of failure which is based on the condition of the facility with the consequence of failure which is based on impacts if a failure occurs. The overall risk value can be simplified with the equation below:

$$\text{Overall Risk Score} = \text{Likelihood of Failure Score} \times \text{Consequence of Failure Score}$$

5.1.1 Likelihood of Failure

The determination of a likelihood of failure score for each pump station was based on inspection findings and the collection of system data. Likelihood of failure scores were not developed for

Pump Stations D, E, and H since they were recently rehabilitated and were not inspected as part of this effort.

Criteria were developed to cover all disciplines and functions of a pump station. The criteria are weighted using Relative Condition Indicators (RCI) which accounts for the degree of importance each criterion has on the overall likelihood of failure. An RCI value of 1 has low impact while an RCI value of 3 has a high impact. Table 5-1 shows the likelihood criteria, RCI, and threshold limits used to determine the likelihood of failure scores.

Based on the inspection findings, collected system data, and meetings with O&M supervisors, each criterion was rated for each pump station. Note that the ratings provide a relative comparison. The resulting weighted likelihood scores are shown in Table 5-2 and are based on the following formula.

$$\text{Likelihood Score} = \sum (\text{Criterion Rating} \quad \text{x} \quad \text{RCI})$$

The Criterion Rating and RCI range from 1 and 3.

Table 5-1 Likelihood of Failure Criteria

Criteria	RCI	Likelihood Rating		
		Very Unlikely (1)	**Unlikely (2)**	**Likely (3)**
General Site Conditions	1	Conditions Good. Access suitable for O&M	Improvements could avoid further deterioration of conditions.	Conditions and/or access is directly impacting O&M.
General O&M Efficiency	1	Improvements likely not to improve efficiencies.	Improvements could greatly improve operation and maintenance efficiencies.	Improvements could help avoid operator error.
Civil/Structural Safety & Regulatory	3	No safety or regulatory concerns.	Precautionary concerns exist.	Unsafe conditions or regulatory violations likely to occur unless changes are made.
Civil/Structural Capacity/ Function/ Reliability	2	Structures adequate in size, configuration, and condition for facility.	Changes in size, configuration, or condition could be made to improve facility	Structure inadequate in size, configuration, or condition for facility
Mechanical Safety & Regulatory	3	No safety or regulatory concerns.	Precautionary concerns exist.	Unsafe conditions or regulatory violations likely to occur unless changes are made.
Mechanical Capacity	2	Can handle peak hydraulic loads and other demands under normal operations.	Can handle peak hydraulic loads and other demands for short durations and/or under only special operations.	Cannot handle peak hydraulic loads and other demands.

Criteria	RCI	Likelihood Rating		
		Very Unlikely (1)	**Unlikely (2)**	**Likely (3)**
Mechanical Function & Reliability	2	Mechanical systems adequate for operation of the facility. Number of corrective work orders is low.	Changes could be made to improve mechanical systems. Number of corrective work orders is median.	Mechanical systems inadequate for operation of the facility. Number of corrective work orders is high.
Mechanical Maintenance	2	Maximo PM Completion Rate above 80%.	Maximo PM Completion Rate between 50% and 80%.	Maximo PM Completion Rate below 50%
Electrical Safety & Regulatory	3	No safety or regulatory concerns.	Precautionary concerns exist.	Unsafe conditions or regulatory violations likely to occur unless changes are made.
Electrical Function & Reliability	2	Electrical systems adequate for operation of the facility. Number of corrective work orders is low.	Changes could be made to improve electrical systems. Number of corrective work orders is median.	Electrical systems inadequate for operation of the facility. Number of corrective work orders is high.
Electrical Maintenance	2	Maximo PM Completion Rate above 80%.	Maximo PM Completion Rate between 50% and 80%	Maximo PM Completion Rate below 50%.
Instrumentation Safety & Regulatory	3	No safety or regulatory concerns.	Precautionary concerns exist.	Unsafe conditions or regulatory violations likely to occur unless changes are made.
Instrumentation Function & Reliability	2	Instrumentation adequate for monitoring and controlling operations of the facility. Number of corrective work orders is low.	Changes could be made to improve monitoring and controls. Number of corrective work orders is median.	Instrumentation inadequate for monitoring and controlling operations of the facility. Number of corrective work orders is high.
Instrumentation Maintenance	2	Maximo PM Completion Rate above 80%.	Maximo PM Completion Rate between 50% and 80%	Maximo PM Completion Rate below 50%.

Table 5-2 Likelihood of Failure Scores

		Likelihood Rating											
Criteria	**RCI**	**A**	**B**	**C**	**F**	**G**	**J**	**K**	**L**	**M**	**N**	**Q**	**R**
General Site Conditions	1	2	1	1	2	2	1.5	2	3	1	1	2	1.5
General O&M Efficiency	1	2	1	3	2	1.5	1.5	1.5	3	3	2	1	1
Civil/Structural Safety & Regulatory	3	2	2	3	2.5	2	2.5	2.5	1	3	1	1	2
Civil/Structural Capacity/Function/Reliability	2	2.5	1.5	1.5	1.5	1	2	1.5	1.5	2	1.5	1.5	2
Mechanical Safety & Regulatory	3	2	1	1.5	1	2	2	2	2	3	1	1	1.5
Mechanical Capacity	2	2	1	3	1.5	1	1.5	1.5	1.5	1	1	1	1
Mechanical Function & Reliability	2	3	1	2.5	2.5	1	1	1.5	1.5	3	2.5	1	2
Mechanical Maintenance	2	1	1	2	2	1	1	1	2	1	2	1	2
Electrical Safety & Regulatory	3	1	1	1	1	2	2	2	2	1	1	1	1
Electrical Function & Reliability	2	3	1.5	2	2	2	2.5	2.5	3	3	2	1.5	1.5
Electrical Maintenance	2	3	3	3	3	3	3	3	3	3	3	3	3
Instrumentation Safety & Regulatory	3	2	2	1	1	2	2	2	2	2	1.5	1	2
Instrumentation Function & Reliability	2	1.5	1	1	1	1	1	1	3	3	1	1	1
Instrumentation Maintenance	2	1	1	1	1	1	1	1	1	1	1	1	1
	Total Score:	**57**	**40**	**53.5**	**47.5**	**47.5**	**52.5**	**53**	**58**	**63**	**42.5**	**35**	**47**
	Likelihood Rank:	3	11	4	7	7	6	5	2	1	10	12	9

Table 5-3 provides a summary, by criteria, of the contributing factors for all each pump station that received a high risk rating of (3). More information on the conditions can be found in Section 6 of this report.

Table 5-3 Summary of “Likely (3)” Scores

Criteria		Items with rating of “Likely (3)”	
		Pump Station	**Description**
General	Site Conditions	L	PS is below grade.
	O&M Efficiency	C	Chronic grit issue. Access limitations for bypass operations.
		L	Substandard access and parking.
		M	Access limitation for maintenance and bypass operations.
Civil/ Structural	Safety & Regulatory	C	Inadequate fall protection at hatches. Limited access to roof mounted fan.
		M	Condition of ladder supports and treads. Chemical containment deficiencies.
	Capacity/Function/Reliability	None	
Mechanical	Safety & Regulatory	M	Condition of ventilation system.
	Capacity	C	Dry weather pumps capacity limited.
	Function & Reliability	A	Chronic pump ragging. Condition of main pumps and piping.
		M	Wastewater and hypo piping deficiencies. Adequacy of main pump size.
	Maintenance	None	
Electrical	Safety & Regulatory	None	
	Function & Reliability	A	Corroded equipment and fixtures.
		L	Equipment below grade and past normal service life.
		M	Corroded equipment and fixtures. Age of generator.
	Maintenance	All	Maximo PM completion rate low.
Instrumen-tation	Safety & Regulatory	None	
	Function & Reliability	L	Equipment is past normal service life. Condition of level sensors.
		M	Level monitoring inadequate.
	Maintenance	None	

5.1.2 Consequence of Failure

The consequence of failure score is based on the ease of flow management in the event of a failure and impacts to the environment, and the community. Importance factors (IF) are used to weight each criterion based on its overall impact on the consequence of failure. Table 5-4 includes the consequence criteria, thresholds, and importance factors used in this assessment. Table 5-5 shows pertinent site-specific information, determined ratings and the resulting roll up of the scores which are based on the following formula:

$$\text{Consequence Score} \quad = \quad \sum \ (\text{Criterion Rating} \ \ \text{x} \ \ \text{IF})$$

Table 5-4 Consequence of Failure Criteria

Criteria	IF	Consequence Rating		
		Very Unlikely (1)	**Unlikely (2)**	**Likely (3)**
Flow to be Managed	2	Average monthly pump station flows:		
		Less than 20MGD	Between 20 and 40 MGD	Greater than 40 MGD
Bypassing Requirements	2	Considers: Available bypass connection, passive overflow containment, and estimated available shutdown time.		
		Available passive overflow containment	Available bypass connection and greater than 5 hours of shutdown time	Either no bypass connection or less than 5 hours of shutdown time
Environmental Impacts	1	Containment and partial treatment available	Not near sensitive receptor such as waterway	Near sensitive receptor such as waterway
Community Impacts	1	Near residential area	Near lt. industrial or mixed-use area	Near major facility or commercial area

Table 5-5 Consequence of Failure Scores

	Flow		Bypassing Requirements				Environmental Impacts		Commercial Impacts		
Pump Station	Average Monthly Total flow (MGD)	Rating based on Flow	Bypass connec-tion exists	Est. Avail. Shutdown time (hrs)[1]	Passive Overflow to containment	Rating based on Bypassing	- Impact or + Avail. Treatment	Rating based on Environ.	Development in the Vicinity	Rating based on Upstr Impacts	Weighted Consequence Rating
A	31.2	2	Yes	NA	Yes	1	- Waterway	3	Lt Industrial	2	11
B	9.8	1	Yes	3		3	- Waterway	3	Residential	1	12
C	63.7	3	Yes	5	Yes to Sm. WW Stor.	2	- Lagoon	3	Residential	1	14
D	1.0	1	Yes	NA	Yes	1		2	Commercial	3	9
E	0.3	1	Yes	NA	Yes	1		2	Commercial	3	9
F	26.4	2	No	NA	Yes	1		2	Commercial	3	11
G	10.8	1	Yes	3		3	- Waterway	3	Lt industrial	2	13
H	317	3	No	NA	Yes to Oakport	2	+ Tmt at Oakport	1	Mixed	2	13
J	6.2	1	Yes	5		2		2	Lt Industrial	2	10
K	4.7	1	Yes	6		2		2	Lt Industrial	2	10
L	0.9	1	Yes	6		2		2	Lt Ind./Port	3	11
M	33.1	2	Yes	6		2	- Lagoon	3	Residential	1	12
N	86.0	3	Yes	NA	Yes to Pt I.	1	+ Tmt at PI	1	Commercial	3	12
Q	NA	1	Need only in severe Wet Weather			1		2	Lt industrial	2	8
R	6.8	1	Yes	6		2	Near waterway	3	Mixed	2	11
Importance Factor	2		2				1		1		

1. Information from FM CA Report July 2014, App A, page 9. RMC modeling report Dec 2010 showed longer times for B, and F.

5.1.3 Results of Overall Pump Station Risk Assessment

The overall risk of failure scores and ranking, based on the likelihood and consequence of failure scores and in accordance with the equation below, are summarized in Table 5-6.

$$\text{Overall Risk Score} = \text{Likelihood of Failure Score} \times \text{Consequence of Failure Score}$$

Table 5-6 Overall Risk of Failure Scores and Ranking

	Overall Risk Calcuation			
Pump Station	Weighted Consequence Score	Weighted Likelihood Score	Overall Risk Score	Overall Risk Ranking
A	11	57	627	**4**
B	12	40	480	11
C	14	53.5	749	**2**
D	9			
E	9			
F	11	47.5	522.5	8
G	13	47.5	617.5	**5**
H	13			
J	10	52.5	525	7
K	10	53	530	6
L	11	58	638	**3**
M	12	63	756	**1**
N	12	42.5	510	10
Q	8	35	280	12
R	11	47	517	9

The results of the risk assessment shows that the greatest risk to the District exists at Pump Stations M, C, and L followed by A and G. Table 5-7, illustrates the risk levels among the pump stations. Red indicates the highest risk. Blue indicates the lowest risk.

Table 5-7 Overall Risk Matrix

Consequence	13-14	H	G (5)	C (2)
	11-12		B, F, N, R	A, L, M (4) (3) (1)
	6-10	D, E, Q		J, K
		<40	40-50	>50
		Likelihood		

( ) indicate calculated risk ranking

In 2015, the District's WHS documented safety concerns at Pump Stations F, G, J, K and R where roof fans are located too close to the roof edge and present fall hazards. For all of these stations, the Civil/Structural Safety & Regulatory likelihood criterion was scored at a 2 or 2.5 which indicates that "Precautionary concerns exist."

5.2 Pump Station Equipment Risk Assessment

The Pump Station Equipment Risk Assessment develops the risks for equipment within each pump station facility and is used to identify equipment that poses the greatest risk and that are candidates for improvements. The key source this assessment method is based on US EPA Fundamentals of Asset Management course Support Material. Below is a summary of the key elements of this assessment.

The full Equipment Risk Assessment Report can be found in the Asset Management and Planning libraries and at planning\MASTER PLANS\2013 PSMP Update\Risk Assessment\AM Equipment Risk Assessment. Appendix A to that report summaries the risk scores for all equipment. It is can be found in this report in Appendix E.

5.2.1 Likelihood of Failure

The determination of likelihood of failure score for each piece of equipment was based on its estimated remaining useful life which was estimated by considering preventive maintenance history, condition, performance, and reliability, and its estimated effective life which is based on the type of asset. Table 5-8 provides a list of typical effective life values that were considered.

Table 5-8 Equipment General Effective Life Values

Class	Asset Type	Effective Life Values Years
1	Civil	75
2	Pressure pipework	60
3	Sewers	100
4	Pumps	40
5	Valves	30
6	Motors	35
7	Electrical	35
8	Controls	25
9	Building assets	60
10	Land	300

Likelihood of failure score was calculated using the following formula:

$$L_f = Max\left[10\left(1 - \frac{U}{E}\right), 1\right]$$

where L_f = likelihood of failure score, U = remaining useful life (years), and E = estimated effective life (years).

Likelihood of failure scores ranges between 1 and 10, and basically is a measure of the extent to which the life of the asset has been consumed.

5.2.2 Consequence of Failure

The consequence of failure score is based on evaluation criteria related to operation impacts. The Criteria and thresholds are provided in Table 5-9.

Table 5-9 Equipment Consequence of Failure Criteria

Criteria		Consequence Rating				
	Very Unlikely (1)	**(3)**	**(5)**	**(7)**	**(9)**	**Likely (10)**
Service	Length of time that equipment can be out of service					
	Indefinitely	One month	One week	One day	8 hours	Less than 1 hour
Safety	No Impact	Minor Inconven-ience	Minor Injury	Moderate Injury and some sickness	Major Injury, sickness, some death	Substantial death, wide-spread injury and sickness
Economic	Low cost, low hassle	Low cost, high hassle	High cost, low hassle	High cost, high hassle and diverts money	Painful change of priorities	Likely trigger rate increase; staff changes
Environ-mental	Short duration, small quantity on-site, no complaints	Backups, small number of complaints	Aggressive complaints and liability	Substantial liability, many impacted	Has hot happened on this scale before	Sustained, large quantity, off-site, many complaints

5.2.3 Results of Equipment Risk Assessment

A risk score is the product of the likelihood of failure rating and the consequence of failure rating. No weighting factors were used in this assessment. Final risk scores can be found in Appendix E. Resulting equipment risk scores range from 1 to 100 and fall into the following defined levels:

Risk Levels	Score Range	Color
High Risk	Score >80	
Medium - High Risk	60< Score ≤ 80	
Medium Risk	40< Score ≤ 60	
Medium - Low Risk	20< Score ≤ 40	
Low Risk	Score ≤ 20	

From this evaluation, it was found that none of the pump station assets received a High or Medium-High risk score. Among all of the pump stations, medium risk equipment accounted for 0 to 27% of the equipment. The remaining area of concern is the equipment that has the highest likelihood of failure rating of 10. See Table 5-10 for a list of high likelihood of failure equipment which may be considered higher priority equipment in recommendations for improvements.

Table 5-10 Equipment with High Likelihood Scores

Asset ID	Asset Description	Year Installed	Likelihood of failure	Consequence of failure	Risk	Contributing Factors	Comments and Noted Recommendations
Pump Station A							
W-1A-ACP-001-01	#1 Air Compressor	1987	10	1	5	Age (27 yrs, typ. life is 25 yrs); Unit has redundency	Implement PM program and monitor
W-1A-FAN-002-01	Pump Room Exhaust Fan	1987	10	3	30	Age (27 yrs, typ. life is 25 yrs)	Implement PM program and monitor
W-1A-INS-INT-01	Intrusion Detection System	1987	10	5	50	Age (27 yrs, typ. life is 25 yrs)	Monitor/maintain
W-1A-INS-PLC-01	Programmable Level Controls	1987	10	1	10	Age (27 yrs, typ. life is 25 yrs)	Monitor/maintain
W-1A-PMP-001-01	#1 Main Pump	1987	10	2	10	Significant number of CM work orders in CMMS	Implement PM program and monitor
W-1A-PMP-002-01	#2 Main Pump	1987	10	2	10	Significant number of CM work orders in CMMS	Implement PM program and monitor
W-1A-PMP-003-01	#3 Main Pump	1987	10	2	10	Significant number of CM work orders in CMMS	Implement PM program and monitor
W-1A-PMP-004-01	#4 Main Pump	1987	10	2	10	Significant number of CM work orders in CMMS	Implement PM program and monitor
W-1A-SGT-A01-01	Wet Well Inlet Gate	1987	10	1	10	Gate is inoperable	Address with next station rehab project
Pump Station C							
W-7C-EE-VFD-001	VFD #1 Wet Weather Pump	1997	10	3	15	End of useful life; previously no PM history; moderate reliability.	Replace.
W-7C-EE-VFD-002	VFD #2 Wet Weather Pump	1997	10	3	15	End of useful life; previously no PM history moderate reliability.	Replace.

Table 5-10 Equipment with High Likelihood Scores (Cont.)

Asset ID	Asset Description	Year Installed	Likelihood of failure	Consequence of failure	Risk	Contributing Factors	Comments and Noted Recommendations
Pump Station K							
W-6K-FAN-001-01	Wet Well Exhaust Fan	1988	10	4	40	Age (26 years old, typ. life is 25 years); 50% PM completion rate; fair condition. No supply fan at station.	Implement PM program and monitor.
W-6K-FAN-002-01	Pump Room Exhaust Fan	1988	10	4	40	Age (26 years old, typ. life is 25 years); 40% PM completion rate; moderate condition. No supply fan at station.	Implement PM program and monitor.
W-6K-GEN-001-01	Emergency Diesel Generator	1988	10	6	60	PM completion rate 15%; moderate condition rating.	Implement PM program and monitor.
W-6K-INS-BLB-01	Bubbler System	1988	10	2	20	Age (26 years old, typ. life is 25 years); moderate condition.	Monitor and replace when fails.
W-6K-INS-DAQ-01	DAQ Telemetry System	1988	10	2	20	Age (26 years old, typ. life is 25 years); moderate condition.	Monitor and replace when fails.
W-6K-INS-EFM-01	Raw Sewage Flow Meter	1988	10	1	10	Age (26 years old, typ. life is 25 years); moderate condition.	Monitor and replace when fails.
W-6K-INS-INT-01	Intrusion Detection System	1988	10	5	50	Age (26 years old, typ. life is 25 yrs.); no PMs in place; moderate condition rating	Monitor and replace when fails.
W-6K-SEE-ATS-001	Automatic Transfer Switch	1988	10	5	50	Age (26 years old, typ. life is 20 years).	Implement PM program and monitor. Plan for replacement within 5 years. If ATS fails, a manual transfer can be done by an operator.

Table 5-10 Equipment with High Likelihood Scores (Cont.)

Asset ID	Asset Description	Year Installed	Likelihood of failure	Consequence of failure	Risk	Contributing Factors	Comments and Noted Recommendations
Pump Station L							
W-6L-PMP-001-01	#1 Main Pump	1956	10	4	20	Age (58 yrs, typ. useful life 40 yrs); PM compl. is 60%; very poor condition; poor reliability	Implement PM program. Replace with next station upgrade
W-6L-PMP-002-01	#2 Main Pump	1956	10	4	20	Age (58 yrs, typ. useful life 40 yrs); PM compl. rate is 60%; very poor condition; poor reliability	Implement PM program. Replace with next station upgrade
W-6L-FAN-001-02	Pump Room Exhaust Fan	1956	10	4	40	Age (58 yrs., typ. useful life is 25 yrs); PM compl. rate is 60%; very poor condition; employee safety considerations	Implement PM program. Replace with next station upgrade
W-6L-INS-INT-01	Intrusion Detection System	1990	10	5	50	Age (24 yrs, typ. useful life is 25 yrs); safety issues	Monitor and replace when fails
W-6L-INS-DAQ-01	DAQ Telemetry System	1990	10	2	20	Age (24 yrs, typ. useful life is 25 yrs)	Implement PM program. Replace with next station upgrade
W-6L-ACP-001-01	Air Compressor	1956	10	2	20	Age (58 yrs, typ. useful life is 25 yrs); PM compl. rate is 60%; very poor condition; average performance and reliability.	Implement PM program. Replace with next station upgrade
W-6L-INS-BLB-01	Bubbler System	1956	10	2	20	Age (58 yrs, typ. useful life is 25 yrs); PM compl. rate is 60%; very poor condition; avg. performance.	Monitor. Replace with next station upgrade
W-6L-INS-MIP-01	Main Instrument Panel	1956	10	5	50	Age (58 yrs, typ. useful life is 40 yrs); spare parts not available; condition is poor.	Monitor. Replace with next station upgrade
W-6L-MCC-001-01	Motor Control Center	1956	10	6	60	Age (58 yrs, typ. useful life is 40 yrs); spare parts not available; condition is poor.	Implement PM program. Replace with next station upgrade.

Table 5-10 Equipment with High Likelihood Scores (Cont.)

Asset ID	Asset Description	Year Installed	Likelihood of failure	Consequence of failure	Risk	Contributing Factors	Comments and Noted Recommendations
Pump Station M							
W-7M-ACP-001-01	#1 Air Compressor	1989	10	2	20	Age (25 yrs, typ. life is 25 yrs); no elect. PMs prior to inspection, 50% compl. rate for mech. PMs; moderate condition. No back up	Implement PM program and monitor. Replace as part of next station rehab
W-7M-FAN-EF1-01	Odor Control Exhaust Fan	1989	10	2	20	Age (25 yrs, typ. life is 25 yrs); no PMs in place; very poor condition	As part of next station rehab, consider alternatives for odor control
W-7M-FAN-EF2-01	Generator Exhaust Fan	1989	10	1	10	Age (25 yrs, typ. life is 25 yrs); no PMs in place prior to inspection; good conditio	Implement PM program and monitor. Consider replacing as part of next station rehab
W-7M-FAN-SF1-01	Dry Well Supply Fan #1	1989	10	3	15	Age (25 yrs, typ. life is 25 yrs); no elect. PMs prior to inspection, 50% compl. rate for mech. PMs; moderate condition	Implement PM program and monitor. Consider replacing as part of next station rehab
W-7M-FAN-SF2-01	Dry Well Supply Fan #2	1989	10	3	15	Age (25 yrs, typ. life is 25 yrs); no elect. PMs prior to inspection, 50% compl. rate for mech. PMs; moderate condition; poor reliability	Implement PM program and monitor. Consider replacing as part of next station rehab
W-7M-FAN-SF3-01	Wet Well Supply Fan	1989	10	2	20	Age (25 yrs, typ. life is 25 yrs); no PMs prior to inspection	Replace as part of next station rehab
W-7M-HVS-EF-003	Dry Well Exhaust Fan	2000	10	3	30	No PMs prior to inspection; poor condition and realiability; moderate performance	Implement PM program and monitor. Replace as part of next station rehab
W-7M-INS-LCP-01	Level Control Panel Bubbler	1989	10	2	20	Age (25 yrs, typ. life is 25 yrs); moderate condition	Consider replacing as part of next station rehab
W-7M-INS-SAP-01	Station Alarm Panel	1989	10	5	50	Age (25 yrs, typ. life is 25 yrs); moderate condition	Implement PM program and monitor.
W-7M-INS-VSD-03	Wet Well Supply Fan Speed Control	1989	10	1	10	Age (25 yrs, typ. life is 25 yrs); no PMs prior to inspection	Replace as part of next station rehab

Table 5-10 Equipment with High Likelihood Scores (Cont.)

Asset ID	Asset Description	Year Installed	Likelihood of failure	Consequence of failure	Risk	Contributing Factors	Comments and Noted Recommendations
Pump Station M (Cont.)							
W-7M-MSL-002-02	Odor Control Exhaust Fan Control	1989	10	1	10	Age (25 yrs, typ. life is 25 yrs); no PMs prior to inspection	Replace as part of next station rehab
W-7M-MSL-003-03	Wet Well Supply Fan Disconnect	1989	10	1	10	Age (25 yrs, typ. life is 25 yrs); no PMs prior to inspection.	Replace as part of next station rehab.
W-7M-MSL-ATS-01	Automatic Transfer Switch	1989	10	5	50	Age (25 yrs, typ. life is 20 yrs); moderate condition; fair reliability.	Replace within one year. If ATS fails, it will require an electrician to transfer to the generator; wet well has limited capacity.
W-7M-MSL-DWF-01	Dry Well Supply Fan Control Panel	1989	10	3	30	Age (25 yrs, typ. life is 25 yrs); 0% PM compl. rate.	Implement PM program and monitor.
W-7M-MSL-EF2-01	Generator Exhaust Fan Control	1989	10	1	10	Age (25 yrs, typ. life is 25 yrs); 0% PM compl. rate.	Implement PM program and monitor. Consider replacing as part of next station rehab
W-7M-MSL-SCR-02	Odor Scrubber	1989	10	1	10	Age (25 yrs, typ. life is 25 yrs; no PMs in CMMS; very poor condition.	Replace as part of next station rehab
W-7M-RS-HV-001	Force Main Isolation Valve	1989	10	5	50	Age (25 yrs, typ. life is 30 yrs); no PMs in CMMS prior to inspection; fair to poor condition; pin at the bottom of the valve is a weak point.	Implement PM program and monitor. Replace as part of next station rehab
W-7M-SAF-EYE-01	Eyewash Station	1989	10	5	50	Age (25 yrs, typ. life is 25 yrs); moderate condition	Implement PM program and monitor. Replace as part of next station rehab
W-7M-SAF-EYE-02	Eyewash Station (Truck Unloading Area)	1989	10	5	50	Age (25 yrs, typ. life is 25 yrs); moderate condition	Implement PM program and monitor. Replace as part of next station rehab
W-7M-SGT-M01-01	Wet Well Inlet Gate	1989	10	2	20	Failed in place.	Replace as part of next station rehab

Table 5-10 Equipment with High Likelihood Scores (Cont.)

Asset ID	Asset Description	Year Installed	Likelihood of failure	Consequence of failure	Risk	Contributing Factors	Comments and Noted Recommendations
Pump Station N							
W-1N-EE-VFD-001	VFD #1 Influent Pump	2009	10	4	20	No PMs prior to inspection; moderate performance; very poor reliability	Implement PM program and monitor
W-1N-EE-VFD-003	VFD #3 Influent Pump	2000	10	4	20	No PMs prior to inspection; moderate condition and performance; poor reliability; no available vendor support	Replace
W-1N-EE-VFD-004	VFD #4 Influent Pump	2000	10	4	20	No PMs prior to inspection; moderate condition and reliability; no available vendor support	Replace
W-1N-PMP-INF-01	#1 Influent Pump	2000	10	4	20	60% PM compl. rate; moderate condition and performance; poor reliability	Implement PM program and monitor
W-1N-PMP-INF-04	#4 Influent Pump	2000	10	4	20	60% PM compl. rate; moderate condition and performance; poor reliability	Implement PM program and monitor
Pump Station Q							
W-1Q-SEE-001-01	Main Electrical Switch Gear	1993	10	5	50	Age (21 yrs, typ. life is 20 yrs); 0% PM compl. rate	Implement PM program and monitor

Table 5.11 lists the final equipment risk assessment recommendations. For additional findings and notes refer to the full report.

Table 5-11 Equipment Risk Assessment Report Recommendations

Capital Recommendations		
Asset Description	**Pump Station**	**Recommendation**
Full Pump Station Rehabilitation	L	Rehabilitate under the Pump Station L Improvement CIP Project
Automatic Transfer Switch	K, M	Replace ATS under the Routine Capital Equipment Replacement (RCER) CIP Project
VFDs (Qty-2ea)	C, N	Replace VFDs under the Large VFD Replacement CIP Project

O&M Recommendations	
Task	**Description**
Maximize effective useful life of assets	Ensure implementation and documentation of PM programs to maximize the effective useful life of the assets.
Track conditions in CMMS	Establish a program condition rating system in the CMMS database to track asset condition trends.
Review CMMS database for future assessments and PM adjustments	Perform a routine review of CMMS database activities for use in updating the risk assessment and adjusting PM coordination and frequency.
Paints and Coatings maintenance program	Set up a system-wide assessment of paints and coatings with the goal of developing recommendations for a coatings maintenance program.

6 Pump Station Descriptions, Findings, Evaluations, and Recommendations

This section includes general overview descriptions, summaries of findings, and site specific notes.

Higher risk pump stations as evaluated in Section 5 have been prioritized in the District's CIP. These include Pump Stations A, C, L, and M. The scope and cost estimate for Pump Station A have been developed in more detail. Notable potential improvements have been listed for Pump Stations C, L, and M and additional information can be found in the Potential Improvement Matrix in Appendix B.

Information provided in this section includes the following:

Descriptions

Overview information is provided. Additional general system and pump information can be found in Sections 2 and 4. For more detailed information on the pump stations refer to Appendix A – Reference Drawings.

Findings and Recommendations Table

A Findings and Recommendations Table was only developed for Pump Station A. The information was largely taken from the Potential Improvement Matrix in Appendix B. Similar information for the other pump stations can also be found there.

Source codes are used to indicate where the findings originated. See Table 6-1.

Table 6-1 Source of Findings

	Source Code	Source of Information
Past Reports	1998	1998 Pump Station Master Plan
	Seismic	1991-94 Seismic Evaluation by EQE
	1998	1998 Odor Control Master Plan
	2011	2011 Regulatory Compliance Office (RCO) Annual Facility Audit of WW Remote Facilities
	Misc	Miscellaneous documents such as emails, meeting notes, etc.
Recent Invest.	2013	2013 Pump Station Inspections and Review of Pump Data
	Max	2013 Maximo Review (Limited to PS A, L, and M)
	AM	2014 Asset Management Reports

After taking into consideration the findings and reviews, means of addressing each identified deficiency was determined. The legend used to show the means of addressing findings is provided in Table 6-2.

Table 6-2 Legend for Means of Addressing Deficiencies

Means of Addressing	Description
Project	To be addressed in CIP project
Design	To be investigated further during design of CIP project
AM/Maint	To be addressed by Asset Management/ WW Maintenance Programs
Remove	Removed from consideration or addressed by other means

Pump Station Notes:

For each pump station, key notes have been included to cover site-specific issues. Additional pump station information can be found in Sections 2 and 4 and in the investigation reference documents noted in Section 3.

Cost Estimate:

A cost estimate was only developed for Pump Station A. It is based on the Findings and Recommendation Table.

The scope should be considered planning level. Determination of inclusion of minor equipment/improvements and review of alternatives are anticipated to be completed during the design phase. The cost estimate encompasses the CIP project cost including the design review costs. The estimated project costs are based on the following project percentages:

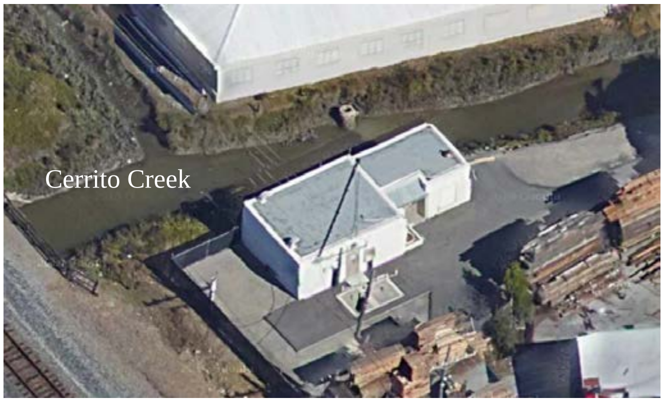
Contractor's Overhead and Profit	25%
Construction Change Order	10%
Engineering (Planning and Design)	29% of Construction Cost (includes change orders)
CM and Administration	20% of Construction Cost (includes change orders)
Planning Level Contingency	30% of sum of Construction, Engineering, and CM & Admin

6.1 Pump Station Summaries

Below are overview summaries for each pump station. Pump Station A recommendations, scope and cost estimate have been developed in more detail. This report and appendices provide additional information for the other pump stations for future development work.

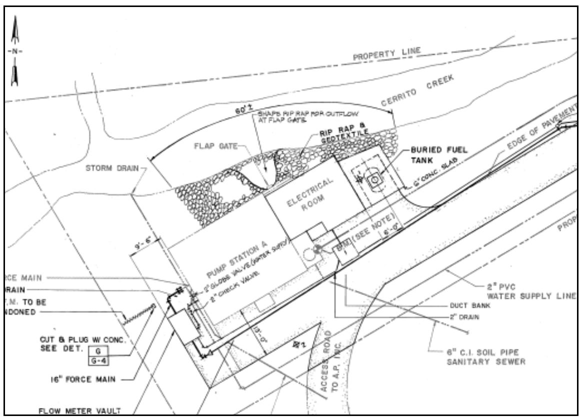
Pump Station A

Pump Station A is located on the North Interceptor and is situated adjacent to Cerrito Creek and a railroad corridor.

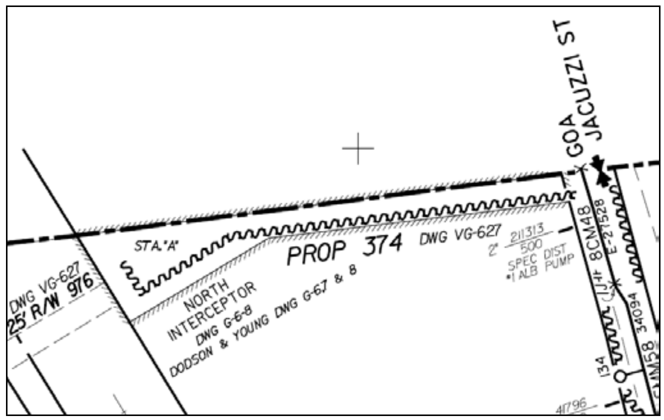


Pump Station A Site Photo

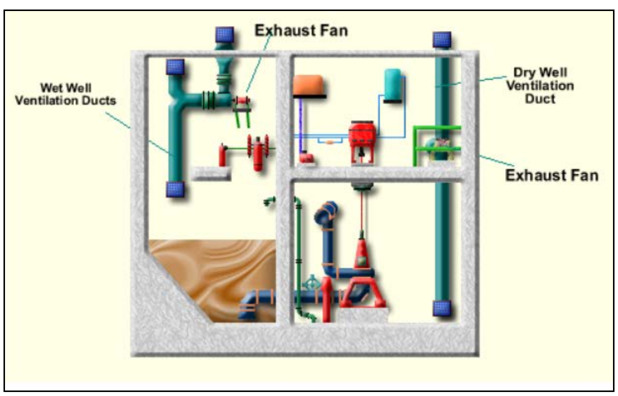
Pump Station A Bldg Photo



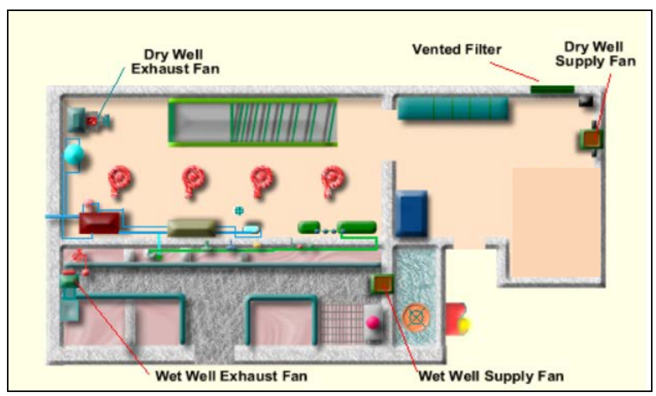
Pump Station A Layout



Pump Station A – B-Map Info



Pump Station A General Section



Pump Station A General Plan

The Pump Station A - Findings and Recommendations Table below is based on potential improvements noted in Appendix B.

Table 6-3 Pump Station A – Findings and Recommendations

	Deficiency Category	Deficiency Description	Source of Findings	Means of Addressing
General/ Civil	Safety/Regulatory	• Insufficient parking barriers adjacent to creek	• 2013	• Project
	Function/ Reliability	• Grease accumulation is an issue	• 2013	• Design
	O&M Staff Efficiency	• Minimal site parking and turnaround space • Wet well door not corrosive resistant	• 1998, 2013 • 2013	• Design • Project
	Convenience/ Aesthetics	• Exterior paint is peeling • Perimeter fence could use repairs • No restroom facilities (only sink)	• 2013 • 2013 • 1998	• AM/Maint* • AM/Maint • Removed
Mechanical	Safety/Regulatory	• Wet well ventilation inadequate, ductwork corroded	• 1998, 2013	• Project
	Function/ Reliability	• Washdown pump is over 20 years old • Air compressor is over 20 years old • Dry well fan problems reported • Check valve failure reported (pre 2009) • Discharge piping layout not optimal, causes blockage • Hole reported in header line • Debris causing sump pump blockage • 1W line rubber expansion joint damaged • Air release valve in wet well appears inoperable • Pump capacity reported less than design capacity • Influent gate in wet well is inoperable	• 1998 • 1998 • Max • Max • 1998, 2013 • Max • Max • 2013 • 2013 • 1998 • 2013	• Project • Project • Project • Design • Design • Design • Design • Project • Project • Removed • Project
	O&M Staff Efficiency	• No bar screens and rags clog pump • Pump shaft and joint failures recorded	• 1998, 2013 • Max	• Design • Design
	Convenience/ Aesthetics	• New in-line water heater could replace old heater • Abandoned piping in the wet well should be removed • EcoBionics unit is not hardwired	• 2013 • 2013 • 2013	• Project • Project • AM/Maint
Structural	Safety/Regulatory	• Bolts for safety chain at wet well corroded • Corroded supports for sump pump piping • Step slippery	• 2013 • 2013 • 2013	• Project • Project • Design
	Function/ Reliability	• Moisture damage in dry well, possible roof leaks • Coating in wet well in poor condition, possible corrosion	• 2013 • 2013	• Design* • Project
	O&M Staff Efficiency	• Steep "ship ladders" exist at station	• 1998, 2013	• Design*
	Convenience/ Aesthetics	• No monorail/hoist system at station • Grade at WW door not suitable for equipment removal	• 2013 • 2013	• Project • Design
Electrical	Function/ Reliability	• Outlets, lights, and conduit in wet well corroded	• 2013 & Max	• Project
	O&M Staff Efficiency	• Electrical panels not labeled well	• 2013	• Design
	Convenience/ Aesthetics	• Lighting could be upgraded to more efficient models • Auto transfer switch in MCC for generator is no longer needed. Generator was removed.	• 2013, Max • 2013	• Design • Project
Instrumen-tation	Safety/Regulatory	• Inadequate HVAC failure alarms/warning lights	• 1998, 2013	• Project
	Function/ Reliability	• Loss of communication noted • HADS system suitability and function needs review	• Max • 2013	• Design • Design
	O&M Staff Efficiency	• Redundant indicators around PS not consistent • Centralized instrument air panel does not exists	• 2013 • 2013	• Project • Project

* Items included in Project due to significant cost impact if included or not covered by maintenance.

Pump Station A Notes:

Relative Risk: Pump Station A is considered a medium risk among the pump station facilities. Because of its higher likelihood of failure rating, it has been included in the CIP. Refer to Section 5 for more information.

Capacity: It was reported in the 1998 PSMP that the operating capacity of Pump Station A is approximately 6.0 MGD, which is less than the original design capacity of 7.3 MGD. Although the realized capacity may be less than the original design capacity, this may not be considered a deficiency since handling of flows have changed since the original design. In 1999, wet weather improvements were made such that Pump Station A can be shut down during severe wet weather conditions and all flows are diverted to Pump Station N and then the Pt Isabel WWF.

Safety: Ventilation and corrosion in the wet well, HVAC alarms/warning lights, and other miscellaneous corrosion pose safety concerns. Insufficient parking barriers adjacent to the creek and slippery interior steps also are safety concerns.

Structure /Foundation: Peeling paint on the walls and ceiling may be an indication of a leak. The roof may have exceeded its service life.

Standby Power: Back up power is not needed at Pump Station A. If pump shutdown, flow will back up in the influent line and passively be diverted to the Pump Station Q discharge line to Pump Station N and then to the Pt Isabel WWF.

Estimated Remaining Useful Life of Main Pumps: Pumps #1 and #3 (Overhauled in 2009) – 10 years. Pumps #2 and #4 (Installed in 1987) – Has exceeded their typical service lives. There have been past ragging issues on the pumps. They may have been aggravated with the removal of the bar screen.

Below Grade Access Improvements: During pre-design, alternatives should be reviewed to determine cost effective measures to provide safe access to below grade facilities. Replacing the ship-ladder with stairs and improving tread tractions should be considered.

Alternative Analysis if Pump Station A is Decommissioned: A life-cycle cost analysis may be warranted to address maintaining verses decommissioning Pump Station A. See Section 4.5 for additional information.

Odor Control Facilities: No odor monitoring has been completed at Pump Station A. Conditions warrant improvements to the station ventilation systems. Odor monitoring and impacts due to improved ventilation should be considered to avoid new odor problems.

Pump Station A Conceptual Cost Estimate based on the findings table is provided below.

Table 6-4 Pump Station A − Conceptual Cost Estimate

Discipline	Scope Item	FY15 Dollars
Site Improvements	• Upgrade parking barriers at creek/site grading	$30,000
	• Interior/Exterior Painting (Added: Potential high cost item.)	$20,000
	• Improve below grade access (Added: Potential high cost item.)	$95,000
Wet Well Improvements	• Influent sluice gate improvements	$32,000
	• Remove electrical fixtures, ducts, bolts, abandoned piping, fans	$23,000
	• Clean, repair, and coat interior	$40,000
	• Install new electrical fixtures, bolts, and ventilation system (incl. fans)	$35,000
	• Repair air release valve	$1,400
	• Replace wet well door	$500
Equipment Replacement/ Overhaul	• Washdown pump	$4,500
	• Air compressor	$5,000
	• Water heater	$3,000
	• Dry well fans	$12,000
	• New Monorail	$25,000
	• Pumps (Replace 4)	$135,000
Repairs – misc.	• Joint repair on 1-Water line	$500
	• Bar screen (Added: Potential high cost item)	$18,000
	• Sump pump upgrade	$5,000
Electrical Upgrades	• Remove auto transfer switch in MCC	$3,000
	• Misc Upgrades	$10,000
Instrumentation Upgrades	• HVAC failure alarms/warning lights	$8,500
	• Fix redundant indicator panels	$10,000
	• Centralize instrument air panel	$11,100
	Subtotal	$527,500
	25% Contractor’s Overhead and Profit	$131,875
	Subtotal	$659,375
	10% Change Orders	$65,938
	Subtotal	$725,313
	49% Engineering (P 4%,D 25%, CM&A 20%,)	$355,403
	Subtotal	$1,080,716
	30% Contingency	$324,215
	Total Project Cost	$1,404,930
	Say:	**$1,405,000**

Escalated at 3%/year ($1,000)

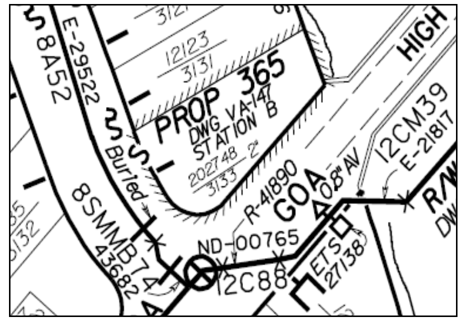
FY17$	FY19$	FY21$
$1,491	$1,581	$1,678

Pump Station B

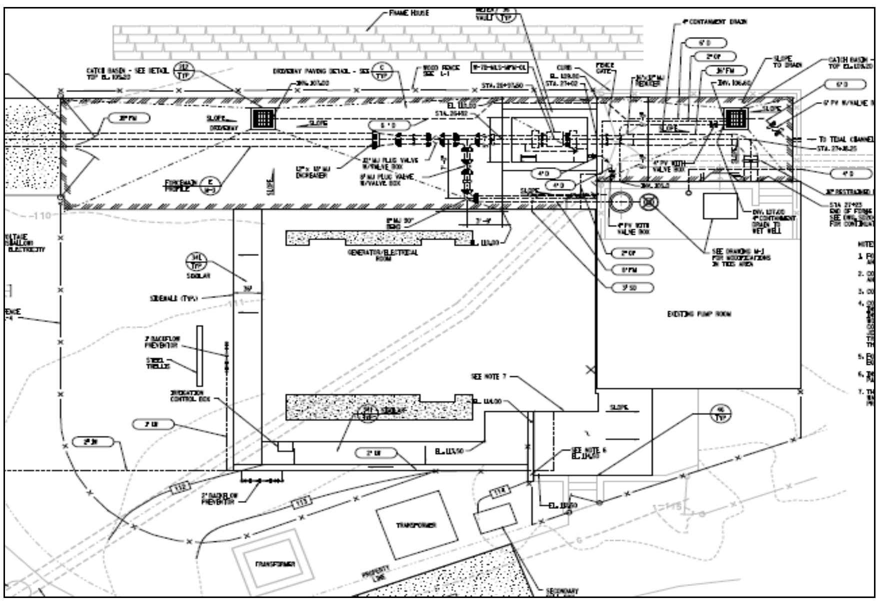
Pump Station B is located on the Alameda Interceptor in a residential area, and is situated adjacent to Oakland Estuary and High Street corridor and bridge.

Pump Station B Site Photo


Pump Station B Bldg Photo



Pump Station B – B Map Info


Pump Station B Layout

Pump Station B Notes:

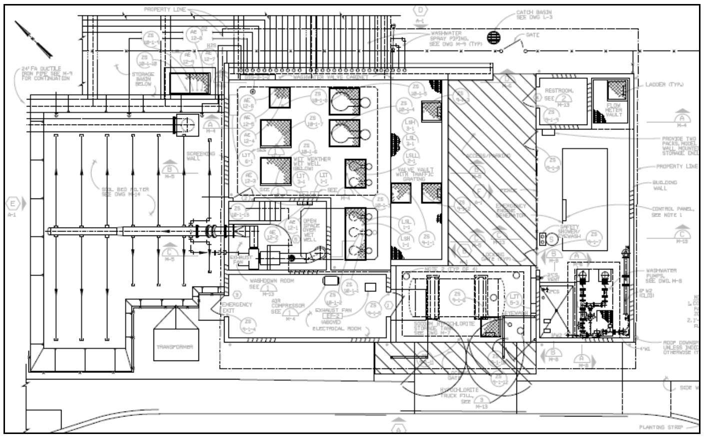
<u>Relative Risk:</u> Pump Station B is considered a medium risk among the pump station facilities. Refer to Section 5 for more information.

<u>1998 PSMP</u>: Pump Station B was not included in most sections of the 1998 PSMP since it was being upgraded at that time.

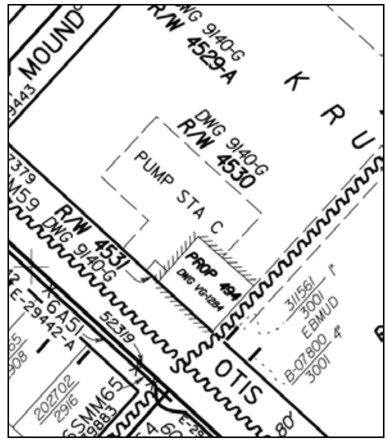
<u>Emergency Bypass Suction Pipe</u>: Installation of a permanent emergency bypass suction pipe from the wet well was reviewed and recommended under WER 132 Pump Station Modifications to Facilities Pump Arounds.

Pump Station C

Pump Station C is located on the Alameda Interceptor and is situated in a residential area adjacent to a park and elementary school.



Pump Station C Layout



Pump Station C – B Map Info

Pump Station C Notes:

Relative Risk: Pump Station C is considered a high risk among the pump station facilities, and has been included in the CIP. Refer to Section 5 for more information.

Notable Potential Improvements: See Appendix B for the Potential Improvement Matrix. Below is a general list of the more significant improvements.

- Dry weather pump replacement. Pumps are currently considered undersized.
- Wet well improvements to address grit accumulation and corrosion damage.
- Access improvements at site perimeter, hatches, and roof locations.
- High risk equipment replacements. See Section 5.

Soil Bed Odor Filter: The soil bed filter for odor control, installed in 1998, is not equipped with a moisture control system and is considered a “dry” soil bed filter. It is currently overgrown with ivy. Since there are no current odor issues, changing out the soil bed filter media may not be warranted.

In the 10% design report for the 1998 upgrade, there is no reference to this filter as a “bio-filter” and the media is not noted. The report includes the following notes in its recommendation:

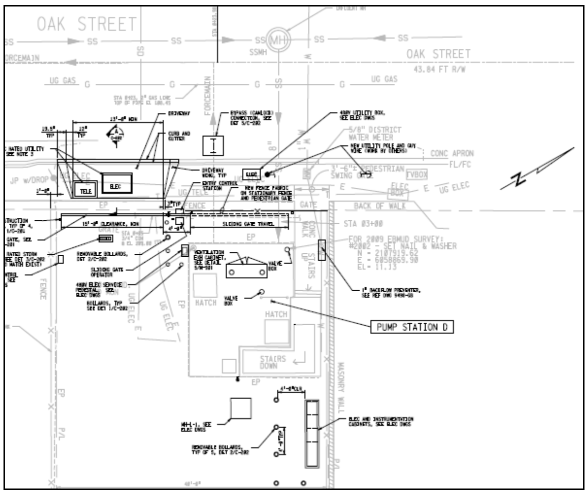
- Soil bed filter is cost effective compared with other alternatives.
- An area of 750 to 1500 square feet (SF) is needed for a normal surface loading rate from 1 to 2 cfm/SF. Short term loading rates of 2 to 4 cubic feet per minute (cfm)/SF while operator are in the pump station (dual mode ventilation note) would not be a problem.
- Media should last at least 10 years.
- Avoid loads on filter. If foot traffic, provide means for distributing loads.

- Plants are acceptable but should be maintained to avoid uneven loads

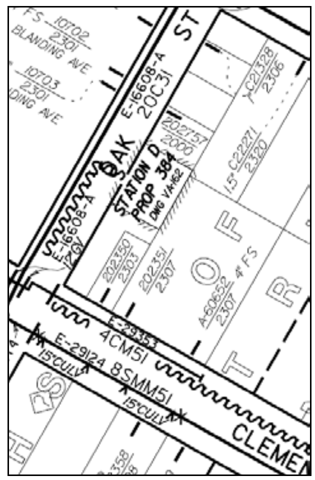
Emergency Bypass Suction Pipe: Installation of a permanent emergency bypass suction pipe from the wet well was reviewed and recommended under WER 132 Pump Station Modifications to Facilities Pump Arounds.

Pump Station D

Pump Station D is located on the Alameda Interceptor and is situated in a commercial area.



Pump Station D Layout



Pump Station D – B Map Info

Pump Station D Notes:

Relative Risk: Pump Station D is considered a low risk among the pump station facilities. Refer to Section 5 for more information. This is mainly due to the 2013 rehabilitation of the station.

Emergency Bypass Suction Pipe: Installation of a permanent emergency bypass suction pipe from the wet well was reviewed and recommended under WER 132 Pump Station Modifications to Facilities Pump Arounds.

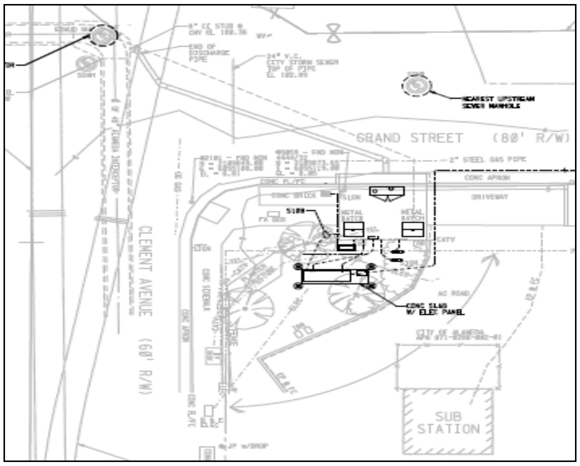
Pump Station E

Pump Station E is located on the Alameda Interceptor and is situated in a light industrial area. It is situated adjacent to a parking lot of an office building.

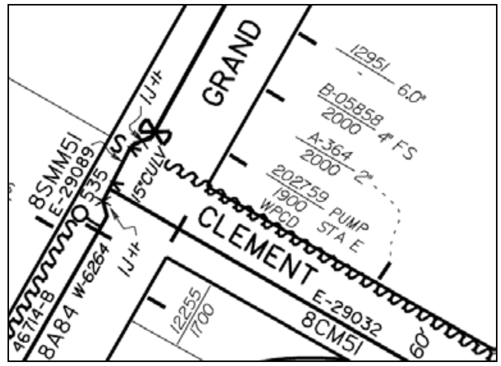
Pump Station E Notes:

Relative Risk: Pump Station E is considered a low risk among the pump station facilities. Refer to Section 5 for more information. This is mainly due to the 2013 rehabilitation of the station.

Emergency Bypass Suction Pipe: Installation of a permanent emergency bypass suction pipe from the wet well was reviewed and recommended under WER 132 Pump Station Modifications to Facilities Pump Arounds.



Pump Station E Layout



Pump Station E – B Map Info

Pump Station F

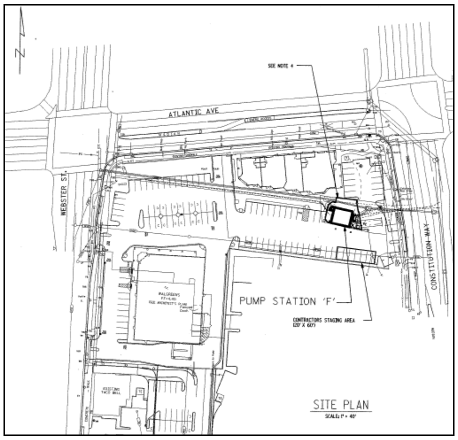
Pump Station F is located on the Alameda Interceptor and is situated in a commercial area. It is located in a parking area that serves a number of businesses.

Pump Station F Notes:

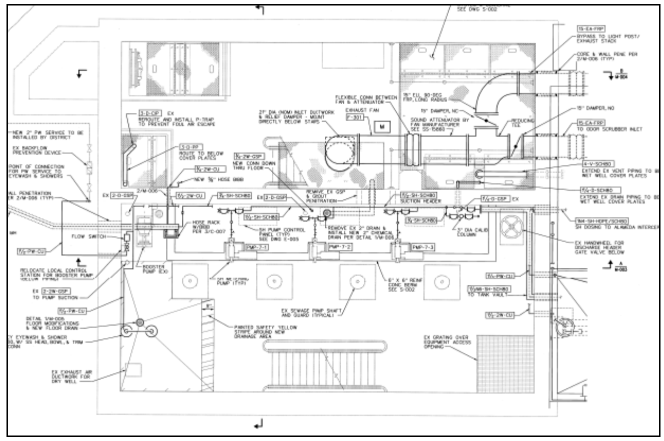
Relative Risk: Pump Station F is considered a medium risk among the pump station facilities. Refer to Section 5 for more information.

Roof Ventilation Equipment: For review of safety issues, reviews, and recommendation regarding roof mounted equipment, refer to WER 137 Pump Station Ventilation System Safety Hazard Abatement.

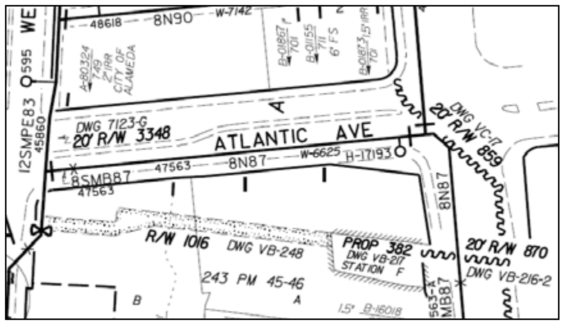
Removal of Phoenix Odor Scrubber: Refer to WER 138 Pump Station Odor Scrubber Removal for findings and recommendations.



Pump Station F Site Plan



Pump Station F Layout



Pump Station F – B Map Info

Pump Station G

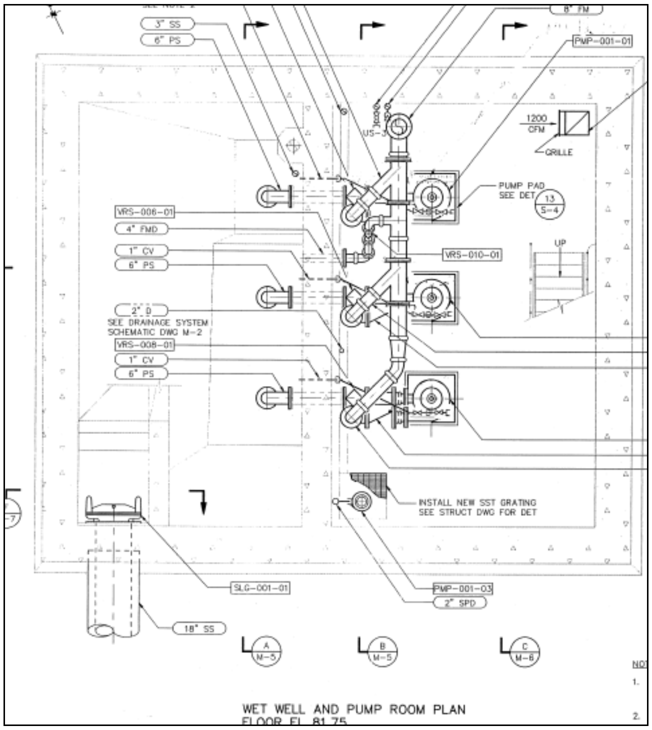
Pump Station G feed into the upstream end of the South Interceptor and is situated in a commercial area that generally serves the Oakland Airport.

Pump Station G Notes:

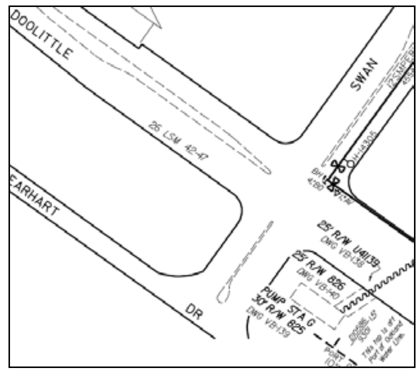
Relative Risk: Pump Station G is considered a medium risk among the pump station facilities. Refer to Section 5 for more information.

Emergency Bypass Suction Pipe: Installation of a permanent emergency bypass suction pipe from the wet well was reviewed and recommended under WER 132 Pump Station Modifications to Facilities Pump Arounds.

Roof Ventilation Equipment: For review of safety issues, reviews, and recommendation regarding roof mounted equipment, refer to WER 137 Pump Station Ventilation System Safety Hazard Abatement.



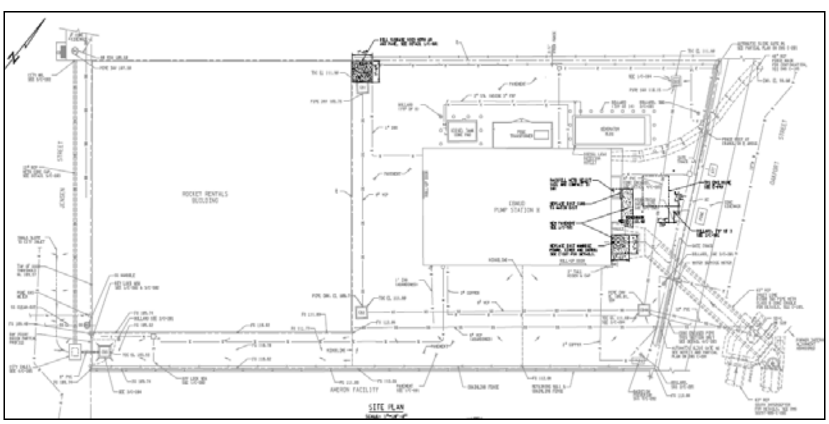
Pump Station G Layout



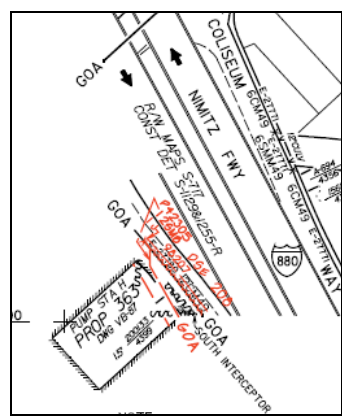
Pump Station G – B Map Info

Pump Station H

Pump Station H is located on the South Interceptor and is situated in a light industrial/commercial area adjacent to the I880 freeway. Pump Station H is the only in-line pump station that lifts all the flow in the South Interceptor.



Pump Station H Layout



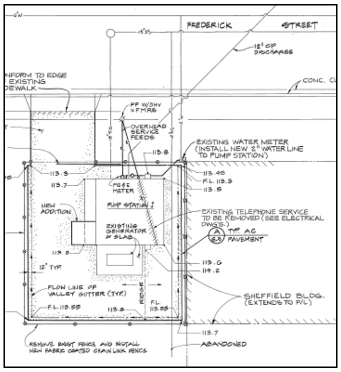
Pump Station H – B Map Info

Pump Station H Notes:

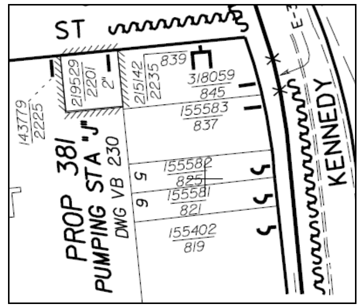
Relative Risk: Pump Station H is considered a low risk among the pump station facilities. Refer to Section 5 for more information. This is mainly due to the 2011 rehabilitation of the station.

Pump Station J

Pump Station J is located on the South Interceptor and is situated in a light industrial/commercial area adjacent to the I-880 freeway.



Pump Station J Layout



Pump Station J – B Map Info

Pump Station J Notes:

Relative Risk: Pump Station J is considered a low risk among the pump station facilities. Refer to Section 5 for more information.

Emergency Bypass Suction Pipe: Installation of a permanent emergency bypass suction pipe from the wet well was reviewed and recommended under WER 132 Pump Station Modifications to Facilities Pump Arounds.

Roof Ventilation Equipment: For review of safety issues, reviews, and recommendation regarding roof mounted equipment, refer to WER 137 Pump Station Ventilation System Safety Hazard Abatement.

Pump Station K

Pump Station K is located on the South Interceptor and is situated in a light industrial/commercial area adjacent to the Port of Oakland facilities.

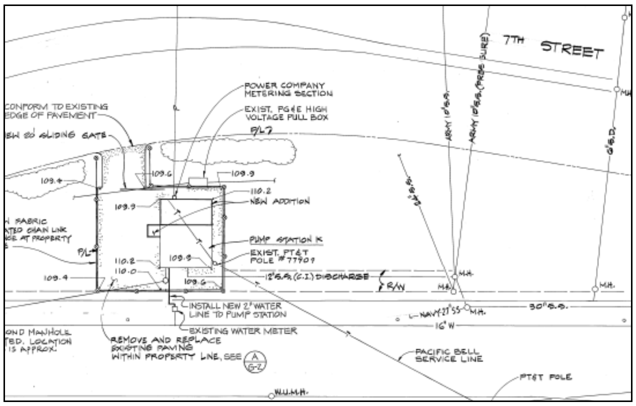
Pump Station K Notes:

Relative Risk: Pump Station K is considered a low risk among the pump station facilities. Refer to Section 5 for more information.

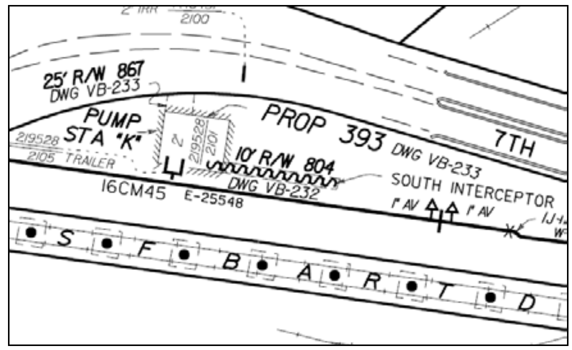
Navy Line: Prior to the acquisition of Pump Station R, there was a Navy line that crossed the estuary and connected into a city manhole just downstream of Pump Station K. This line is noted on record drawings. The Navy flows did not flow through the Pump Station K.

Emergency Bypass Suction Pipe: Installation of a permanent emergency bypass suction pipe from the wet well was reviewed and recommended under WER 132 Pump Station Modifications to Facilities Pump Arounds.

Roof Ventilation Equipment: For review of safety issues, reviews, and recommendation regarding roof mounted equipment, refer to WER 137 Pump Station Ventilation System Safety Hazard Abatement.



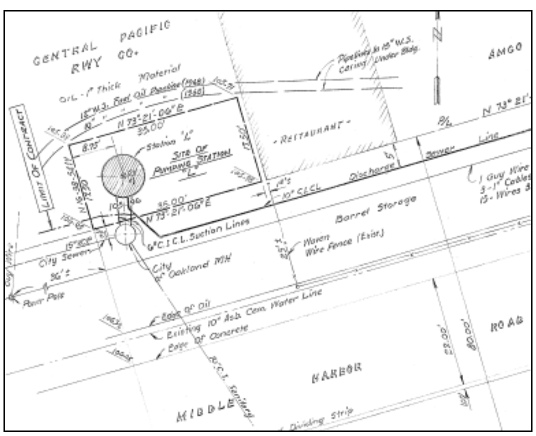
Pump Station K Layout



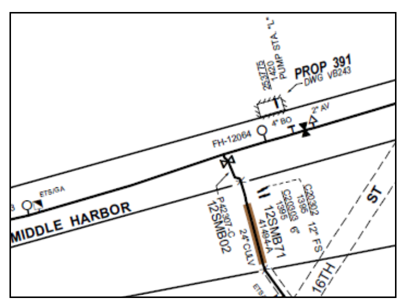
Pump Station K – B Map Info

Pump Station L

Pump Station L is located in an industrial area of West Oakland surrounded by Port of Oakland property.



Pump Station L Layout



Pump Station L – B Map Info

Pump Station L Notes:

Relative Risk: Pump Station L is considered a medium risk among the pump station facilities. Because of its higher likelihood of failure rating it has been included in the CIP. Refer to Section 5 for more information. Pump Station L was constructed in 1956 and never fully upgraded.

<u>Pump Station Ownership:</u> Since flows to Pump Station L appear to be exclusively from the Port of Oakland and the discharges are directly to the City of Oakland collection system and not a District interceptor, it seems reasonable that the Port of Oakland should take ownership of the station. There have been past discussion with the Port of Oakland on this issue.

<u>Railroad Impacts on Facility:</u> There are railroad track adjacent to the pump station which limits access and can pros a safety concern. Access improvements have been discussions Port of Oakland in the past.

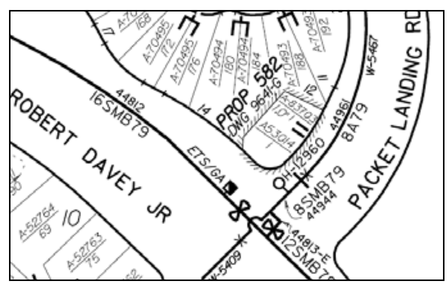
<u>Notable Potential Improvements:</u> See the Potential Improvement Matrix in Appendix B. Below is a general list of the more significant improvements.

- All equipment requires replacement. The equipment is past its useful life, and spare parts are not readily available.
- Access improvements to the facility need to be addressed. This will likely require property/easement acquisition. There have been past discussion with the Port of Oakland regarding need for better access. Additional access will have to be addressed for rehabilitation construction activities.

Pump Station M

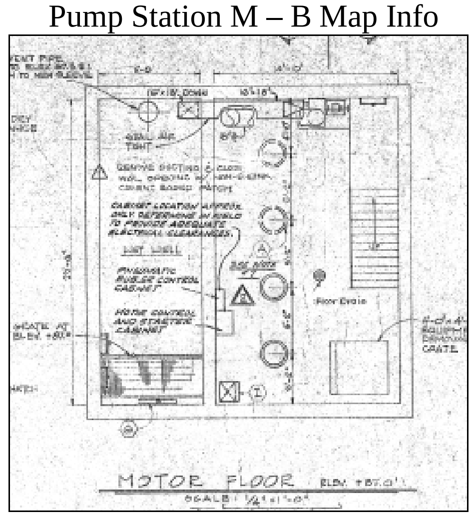
Pump Station M feeds into the upstream end of the Alameda Interceptor. It is located in a residential area on Bay Farm Island.

Pump Station M Photos



Pump Station M – B Map Info

Pump Station M Layout



Pump Station M Notes:

<u>Relative Risk:</u> Pump Station M is considered a medium risk among the pump station facilities. Because of its higher likelihood of failure rating it has been included in the CIP. Refer to Section 5 for more information.

<u>Notable Potential Improvements:</u> See the Potential Improvement Matrix in Appendix B. Below is a general list of the more significant improvements.

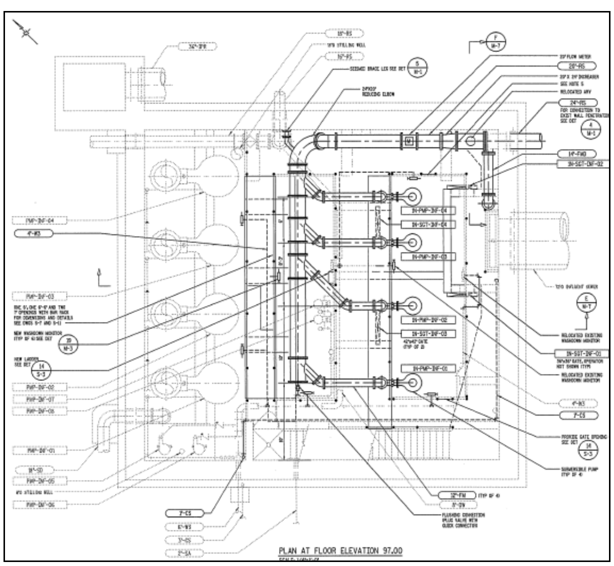
- Ventilation and wet well improvements to address corrosion damage.
- Chemical containment improvements.
- Site Access improvements.
- High risk equipment replacements. See Section 5.

<u>Emergency Bypass Suction Pipe</u>: Installation of a permanent emergency bypass suction pipe from the wet well was reviewed and recommended under WER 132 Pump Station Modifications to Facilitate Pump Arounds.

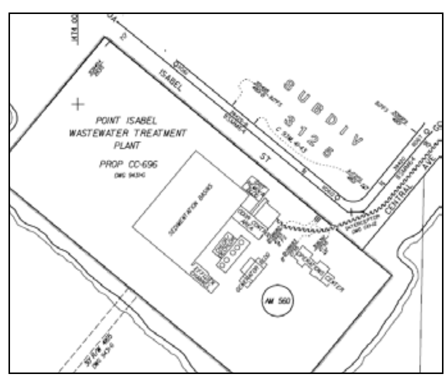
<u>Removal of Phoenix Odor Scrubber:</u> Refer to WER 138 Pump Station Odor Scrubber Removal for findings and recommendations.

Pump Station N

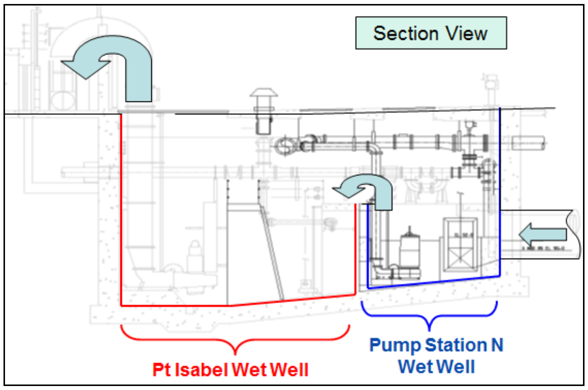
Pump Station N feeds into the upstream end of the North Interceptor and is located at the Pt Isabel WWF site which is situated on the bay shoreline.



Pump Station N Layout



Pump Station N – B Map Info



Pump Station N – Section

Pump Station N Notes:

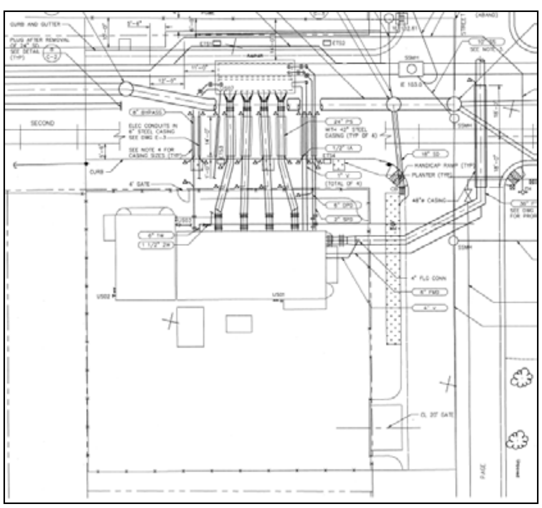
<u>Relative Risk:</u> Pump Station N is considered a medium risk among the pump station facilities. Refer to Section 5 for more information.

<u>Pump Maintenance Issues:</u> Refer to WER 89 Investigation into Remedies for the Pump Station N Pump Reliability Problems, which was completed in 2012.

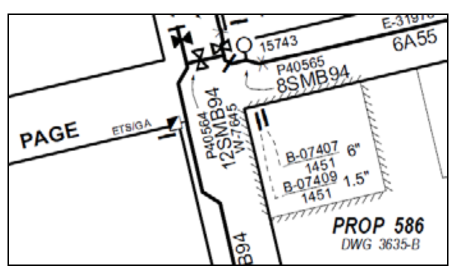
<u>Operation Controls and Automation</u>: Pump stations that are involved in wet weather operations (A,C, H, N and Q) should consider modifications to monitoring and controls and possibly automation to facilitate future operations as flow decrease. (Note for modeling consultant)

<u>Pump Station Q</u>

Pump Station Q is a dedicated wet weather pump station on the North Interceptor.



Pump Station Q Layout



Pump Station Q – B Map Info

Pump Station Q Notes:

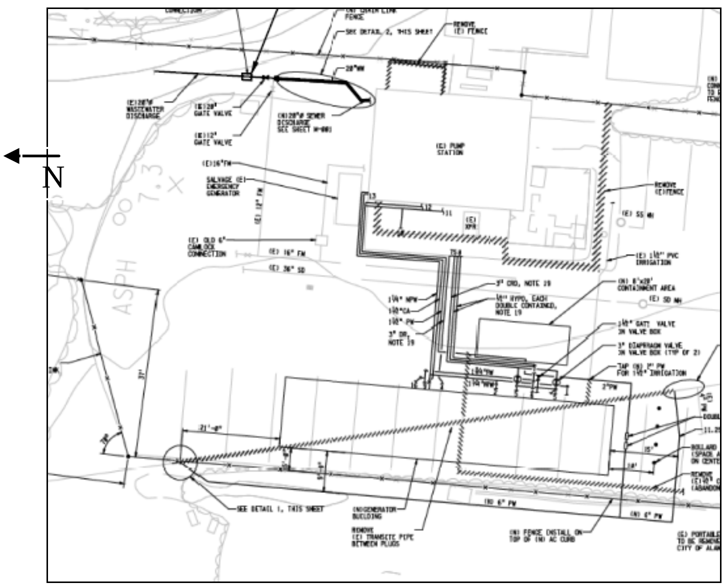
Relative Risk: Pump Station Q is considered a low risk among the pump station facilities. Refer to Section 5 for more information.

Operation Controls and Automation: Pump station that are involved in wet weather operations (A,C, H, N and Q) should consider modifications to monitoring and controls and possibly automation to facilitate future operations as flow decrease. (Note for modeling consultant)

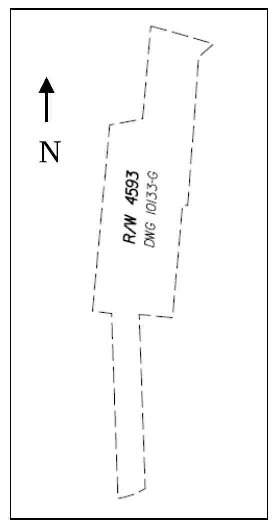
Pump Station Q Force Main to be Converted to Dual Mode: Refer to SD-377 Pump Station Q Sewer Force Main/Gravity Interceptor Reverse Flow Project, which is planned for construction in 2016.

Pump Station R

Pump Station R feeds into the upstream end of the North Interceptor and is located at the Pt Isabel WWF site which is situated on the bay shoreline.



Pump Station R Layout



Pump Station R – B Map Info

Pump Station R Notes:

Relative Risk: Pump Station R is considered a medium risk among the pump station facilities. Refer to Section 5 for more information.

Emergency Bypass Suction Pipe: Installation of a permanent emergency bypass suction pipe from the wet well was reviewed and recommended under WER 132 Pump Station Modifications to Facilitate Pump Arounds.

Settlement Monitoring of Chemical/Generator Building: In February 2015, cracks in the west wall and southwest corner of the chemical/generator building were observed. After review of the crack pattern, it appeared that the southwest corner of the building may be settling. Periodic settlement monitoring was recommended on a 6 to 12 month interval. Refer to WER 134 Pump Station R Structural Condition Assessment for additional information.

Roof Ventilation Equipment: The review of safety issues regarding roof mounted equipment may apply. Refer to WER 137 Pump Station Ventilation System Safety Hazard Abatement.

Removal of Phoenix Odor Scrubber: Refer to WER 138 Pump Station Odor Scrubber Removal for findings and recommendations.

6.2 Summary of Findings

Higher risk pump stations have been included in the District's CIP and are schedule for rehabilitation within the next five years. These include pump stations A, C, L, and M. Outside of rehabilitation projects, there are a number of WER generated recommendations for improvements. These WERs have been listed above under applicable pump station notes.

Below is a summary of pump station projects that were incorporated into the CIP prior to completion of this report. CIP scope and cost information can be found in the FY16-FY20 budget files.

Table 6-5 CIP Projects

CIP Projects (FY16-FY20)		**Total Cost $1000**
Pump Station A Improvements	Design	$349
	Construction	$1,580
	Total	**$1,929**
Pump Station C Improvements	Design	$350
	Construction	$1,514
	Total	**$1,864**
Pump Station L Improvements	Design	$304
	Construction	$1,231
	Total	**$1,535**
Pump Stations M Improvements	Design	$553
	Construction	$2,489
	Total	**$3,042**

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7 Public Outreach Plan

7.1 Objectives

The main objectives for development and implementation of this master plan update include:

- Providing reliable service by maintaining and rehabilitating the pump stations.
- Meeting regulatory requirements by fulfilling the Sewer System Management Plan requirements.
- Providing environmental protection by avoiding SSOs.

Specific objectives for public outreach include:

- Informing the public of District efforts to preserve the collection system.
- Communicate to the public the need for rehabilitation construction and other field work.
- Work to minimize the impacts to the communities during construction and other field work through public outreach efforts.

7.2 Master Plan Level Outreach

This master plan update concentrates on the condition of the pump stations and means to preserve them. It does not encompass the operation of the collection system, nor expansions and modifications to meet new or changing goals. The evaluations and recommendations are based on inspection results covering existing conditions. Public discussion and input is not a part of the evaluation and recommendation process because the efforts are focused, solely based on technical requirements and conditions related to the preservation of the system. On the other hand, resulting construction projects do need public involvement to minimize community impacts. Those efforts are discussed below.

To meet the above objective, the master plan has been, and likely will again be, brought before the Board Planning Committee. Information on preserving the pump stations will be provided to the public by means of meetings, flyers, web postings, or other communication means.

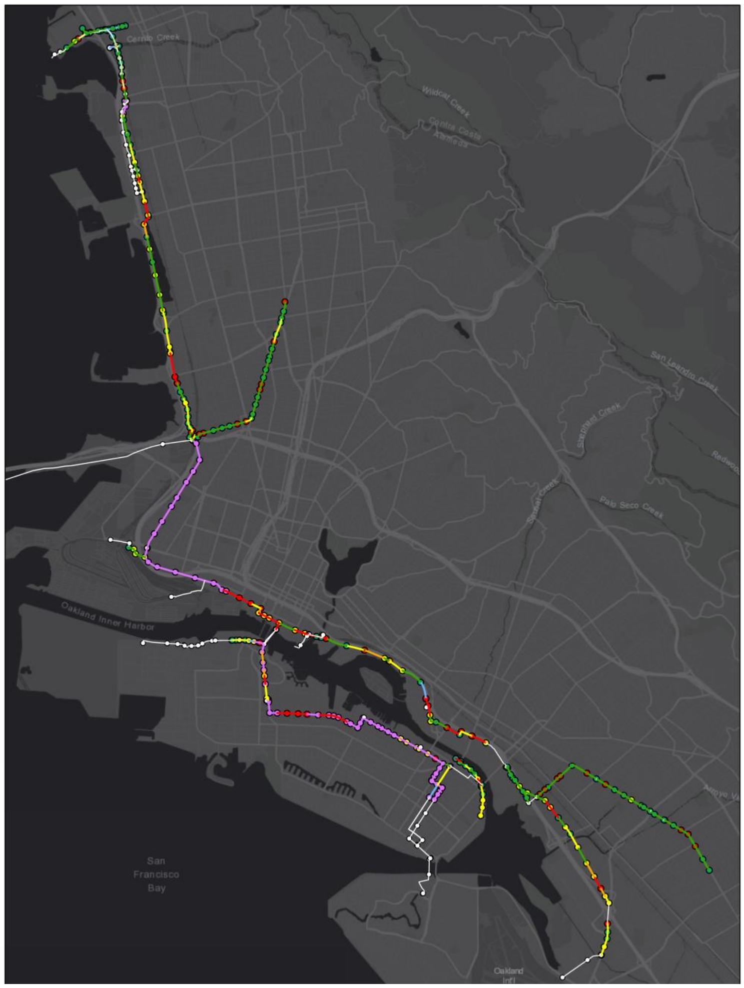
7.3 Project Level Outreach

The pump station rehabilitation work will include a number of construction projects throughout the collection system and will cause impacts to residential and commercial areas. The impacts to these communities need to be taken into account early in the design process. Some work may need to be done at night during low flow periods, which can have a significant impact on residential communities with respect to noise and lighting.

Project level outreach needs to start early during the design phase and involve the communities that will be affected. The project team will work with the Public Affairs Office to understand the impacts, identify stakeholders, develop a project specific outreach program to inform the communities, and set up a construction phase outreach action plan. The design team will also incorporate requirements and limitations aimed at minimizing impacts to the communities into the construction documents.

2022 Interceptor Pipes and Manholes Condition Assessment Report

East Bay Municipal Utility District



Prepared for:

Matt Hoeft, PE
Supervisor of Wastewater Planning
EBMUD
375 11th Street, MS 702
Oakland, CA 94607

Date: January 11, 2023

Prepared by:

V&A consulting engineers

V&A Project No. 22-0108

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Revision No.	Date	Description	Author	Reviewed
1	November 3, 2022	Draft	Noy Phannavong (Project Manager), Oliver Pohl, (Project Engineer), Leighton James (Graduate Engineer)	Glenn Willson, (Principal-in-Charge)
2	January 11, 2023	Final	Noy Phannavong (Project Manager), Oliver Pohl, (Project Engineer)	Glenn Willson, (Principal-in-Charge)

Table of Contents

Tables

Figures

Abbreviations and Acronyms

Abbreviations/Acronyms	Definition
ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AVG.	Average
CCTV	Closed circuit television
CSE	Confined space entry
DIA.	Diameter
DIP	Ductile Iron Pipe
DS	Downstream
DIRECT.	Direction
EBMUD	East Bay Municipal Utilities District
FT.	Feet
IN.	Inch
MAX.	Maximum
MH	Manhole
MIN.	Minimum
MSI	Multi-Sensor Inspection
N/A	Not applicable
NPS	National Plant Services
O&M	Operations & maintenance
PSI	Pounds per square inch
RCP	Reinforced concrete pipe
SPR	Surface penetrating radar
STA	Station
US	Upstream
V&A	V&A Consulting Engineers, Inc.
VANDA®	V&A Condition Index
VCP	Vitrified clay pipe

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Executive Summary

V&A Consulting Engineers (V&A) was retained by the East Bay Municipal Utility District (EBMUD) to perform a condition assessment on their interceptor system. The objective of the assessments was to assess the condition of portions of the EBMUD's interceptor system with a focus on gravity pipelines at locations previously classified as "Grade C" or worse by EBMUD. The previous condition grades were assigned by EBMUD in 2014 based on EBMUD's assessments between 2010 and 2012. The interceptor pipelines assessed as part of this project included select segments of the South Interceptor, Alameda Interceptor, and North Interceptor, which are located within the cities of Oakland, Alameda, Berkeley, and Emeryville, respectively. Corrosion-related issues have contributed to two sinkholes in 2022, accelerating the need to conduct this condition assessment project.

Assessment methods for this project included multi-sensor inspection (MSI), traditional closed-circuit television (CCTV), and physical confined space entry (CSE) drop-downs into manholes used for access for the MSI or CCTV assessment. V&A retained the services of National Plant Services (NPS) to provide MSI, CCTV, and hydro-jet flushing support on the project. The assessments were completed between March 2022 and September 2022.

The scope of the condition assessment included up to 15,000 linear feet of sewer pipes ranging in size from 12-inch to 105-inch in diameter. The optional task to include up to an additional 8,000 linear feet of pipes was authorized by EBMUD. V&A was tasked with using a balance of "traditional" CCTV, MSI, manhole drop-downs, and pipe walk-throughs to assess as much of the piping as possible within the constraints of the project. A total of 19,705 linear feet (32 segments of interceptor pipe) and 27 manholes were assessed, as summarized in Table ES-1.

Table ES-1. Length of Interceptor Pipe and Number of Manholes Assessed

Interceptor	Length of Pipes Assessed, feet	Number of Pipe Segments Assessed	Number of Manholes Assessed
Alameda	6,467	12	9
South	5,981	9	13
North	7,257	11[(1)]	5
Total	**19,705**	**32**	**27**

(1) Not including branch line from unidentified manhole (no manhole designation or identification number) to N32. The N32 branch line ties into the North Interceptor at manhole N32 via a 24-inch diameter vitrified clay pipe. The length of the branch line is approximately 10 feet between the unidentified manhole and manhole N32.

The assessed reinforced concrete interceptor pipes were in various states of deterioration due to corrosion. The predominant mechanism of corrosion of the interceptor pipes was hydrogen sulfide-induced corrosion (biogenic corrosion), which produces acid that attacks the cement and ultimately the reinforcing steel. The effects are characterized by a yellowish-white surface with roughness, exposed aggregate, and exposed and corroded reinforcing steel within the headspace of the pipe. The extent of corrosion ranged from ½-inch of concrete loss to three (3) inches of concrete loss. Once the deterioration reached the reinforcing steel, the bars rapidly corroded.

Table ES-2 summarizes the conditions and prioritizations for rehabilitation, repair, or reassessment of the assessed interceptor pipes. The timeframes below only consider the current condition of the pipes and do not include other objectives or constraints. These priorities were also established based on the information contained in this report and do not consider pipes that have not been inspected or new information obtained from future condition assessments.

Table ES-2. Condition Summary and Prioritization for Assessed Interceptor Pipes

Interceptor Segment ID	Diameter (inches)	Length (feet)	VANDA Rating[(1)]	Timeframe for Rehabilitation/Repair/Reassess
A33A341	57	320	5	As soon as possible, impending failure
A35A361	57	703	5	As soon as possible, impending failure
A39A401	60	640	5	As soon as possible, impending failure
N20N211	66	1581	5, 2 to 3	As soon as possible, impending failure[(3)]
S14S151	66	464	5, 3	As soon as possible, impending failure
S15S161	66	871	5, 3 to 4	As soon as possible, impending failure
A34A351	57	318	5	0 – 2 years
N32N331	105	326	5	0 – 2 years
A32A331	57	631	4	2 – 5 years
A37A381	60	591	4	2 – 5 years
A38A391	60	744	4	2 – 5 years
A47A481	60	691	4	2 – 5 years
S47S481	33	32	4	2 – 5 years
S48S491	66	188	4	2 – 5 years
S49S501	66	1161	4	2 – 5 years
S50S511	66	1084	4	2 – 5 years
S53S541	66	320	4	2 – 5 years
S54S551	66	102	4	2 – 5 years
N27N281	63	574	4	2 – 5 years
N29N301	105	716	4	2 – 5 years
N33N341	105	1000	4	2 – 5 years
N34N351	105	299	4	2 – 5 years
A07A081	12	404	Fair[(2)]	5 – 10 years
A45AA461	60	545	3	5 – 10 years
A46A46A1	60	380	3	5 – 10 years
N21N221	66	432	2 to 3	5 – 10 years
N26N271	63	857	2 to 3	5 – 10 years
N28N291	75	1424	3	5 – 10 years
N30N311	105	393	3	5 – 10 years
N31N321	105	392	3	5 – 10 years
A46AA471	60	500	1	Reassess in 10 years
S38S391	66	1022	2	Reassess in 10 years
N32 branch line	12	404	Good[(2)]	Reassess in 10 years

[(1)] VANDA rating based on the worst condition within a particular segment, which may not always apply to the entire segment. For example, segment N20N211 was mostly in VANDA Level 2 to Level 3 condition except for the 12-foot section just downstream of manhole N20. In this case, a spot repair near manhole N20 would bring down the condition rating to Level 2/3. Refer to the CCTV Review and Visual Assessment sections for details.

[(2)] VANDA rating does not apply to VCP – pipe noted as fair condition.

[(3)] Further investigation of segment N20N211 by EBMUD via confined space entry on December 11th, 2022 confirmed that this segment has an impending failure near manhole N20.

The assessed interceptor manholes were in VANDA Level 1 to Level 4 condition. Of the 27 manholes assessed, seven (7) manholes were in good condition (VANDA Level 2 or better), 11 manholes were in fair condition (VANDA Level 3), and nine (9) manholes were in poor condition (VANDA Level 4).

Table ES-3 summarizes the conditions and prioritizations for rehabilitation, repair, or reassessment of the assessed manholes.

Table ES-3. Condition Summary and Prioritization for Assessed Manholes

Manhole ID	VANDA Rating	Timeframe for Rehabilitation/Repair
A35	4	2 – 5 years
S15	4	2 – 5 years
S47	4	2 – 5 years
S48	4	2 – 5 years
S49	4	2 – 5 years
S50	4	2 – 5 years
S51	4	2 – 5 years
S53	4	2 – 5 years
S54	4	2 – 5 years
A32	3	5 – 10 years
A34	3	5 – 10 years
A37	3	5 – 10 years
A39	3	5 – 10 years
A40	3	5 – 10 years
A47	3	5 – 10 years
S14	3	5 – 10 years
S16	3	5 – 10 years
S38	3	5 – 10 years
S39	3	5 – 10 years
N22	3	5 – 10 years
A46A	2	Reassess in 10 years
A48	2	Reassess in 10 years
N19	2	Reassess in 10 years
N26	2	Reassess in 10 years
N31	2	Reassess in 10 years
S55	1	Reassess in 10 years
N35	1	Reassess in 10 years

In general, the interceptor pipelines should be assessed on a 10-year cycle. The interval can then be adjusted based on the results of such assessments. For unassessed portions of the interceptor (last assessments in 2010 to 2012), V&A recommends performing condition assessments on segments based on EBMUD's condition grades, prioritizing segments with the worse condition grades.

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1 Introduction

V&A Consulting Engineers (V&A) was retained by the East Bay Municipal Utility District (EBMUD) to provide condition assessment services on their interceptor system. The objective of the assessments was to assess the condition of portions of the EBMUD's interceptor system with a focus on gravity pipelines at locations previously classified as "Grade C" or worse by EBMUD. The interceptor pipelines assessed as part of this project included select segments of the South Interceptor, Alameda Interceptor, and North Interceptor, which are located within the cities of Oakland, Alameda, Berkeley, and Emeryville, respectively.

Assessment methods included multi-sensor inspection (MSI) comprised of video, sonar and LiDAR, traditional closed-circuit television (CCTV), and physical confined space entry (CSE) drop-downs into manholes used for access for the MSI or CCTV assessment. V&A retained the services of National Plant Services (NPS) to provide MSI, CCTV, and hydro-jet flushing support on the project. The assessments were completed between March 2022 and September 2022.

1.1 Interceptor System Background

EBMUD's collection system consists of approximately 29 miles of interceptor sewer pipes and 15 pump stations. The interceptor pipes range in size from 12-inch in diameter to 108-inch in diameter. The collection system collects domestic, commercial, and industrial wastewater for an 83-square mile area, which includes the cities of Alameda, Albany, Berkeley, Emeryville, Oakland, and Piedmont, and the Stege Sanitary District, which includes El Cerrito, Kensington and part of Richmond. The service area includes approximately 740,000 people. Five distinct segments make up the interceptor pipe network – the North Interceptor, Adeline Interceptor, Alameda Interceptor, South Interceptor, and Foothill Interceptors.

The interceptor pipes have experienced corrosion-related issues. In 2022, two sinkholes were discovered on the South Interceptor, which accelerated the need to perform condition assessments on the interceptor system.

1.2 Scope of Interceptor System Condition Assessment

The scope of the condition assessment included up to 15,000 linear feet of sewer pipes ranging in size from 12-inch to 105-inch in diameter. The optional task to include an additional 8,000 linear feet of pipes was authorized by EBMUD. V&A was tasked with using a balance of "traditional" CCTV, MSI, manhole drop-downs, and pipe walk-throughs to assess as much of the piping as possible within the constraints of the project. The assessments focused on the internal pipe conditions including the pipe lining and wall conditions, debris or other build-up, and configuration issues. In addition to assessment of the interceptor pipes, V&A also visually assessed the associated manholes that were used to access the interceptor pipes for CCTV and/or MSI.

Table 1-1 summarizes the scope of work for this condition assessment project. The four assessment methods included in the project allowed flexibility for the team to obtain good condition information as quickly as possible so that repairs/rehabilitation could be implemented before the 2022/2023 wet season, if warranted.

Table 1-1. Scope of Interceptor Condition Assessment

Method	Intended Usage	Actual Usage
CCTV	Smaller pipelines with less impediments due to flow, velocity, and sediment.	Used on 75% of the assessed pipes. More readily available than MSI and less costly than MSI. Video quality was improved by attaching GoPro camera to CCTV camera.
MSI	Large pipelines with high flow and sediment levels and where improved video quality and sonar/laser data were desired.	Used on 25% of the assessed pipes. Less availability compared to CCTV. More costly than CCTV due to specialty equipment, mobilization, and data processing.
CSE Manhole Drop-downs	Obtain physical data on the manhole and pipe from within 5 feet of the manhole. Data to be used to help calibrate the CCTV and MSI results, and provide a more comprehensive assessment.	As planned for manholes accessed for CCTV or MSI.
CSE Walk-throughs	Where there was less than 1.5 feet of water depth and less than 2 feet per second of flow, obtain physical condition data on segments of pipes between manholes.	Not used due to safety concerns. Able to get enough useful information with combination of CCTV and CSE manhole drop-downs.

1.3 Pipelines and Manholes Assessed as Part of Project

To manage their interceptor system, EBMUD assigns condition grades A, B, C, and D to each pipe segment in between manholes, with “Grade A” being good condition and “Grade D” being poor condition. A fifth category is designated as “Rehabilitated,” indicating that those segments have been rehabilitated. The condition grades were assigned by EBMUD in 2014 based on EBMUD’s assessments between 2010 and 2012.

Figure 1-1 on the next page shows an overview map of the condition grades assigned to the interceptor system by EBMUD.

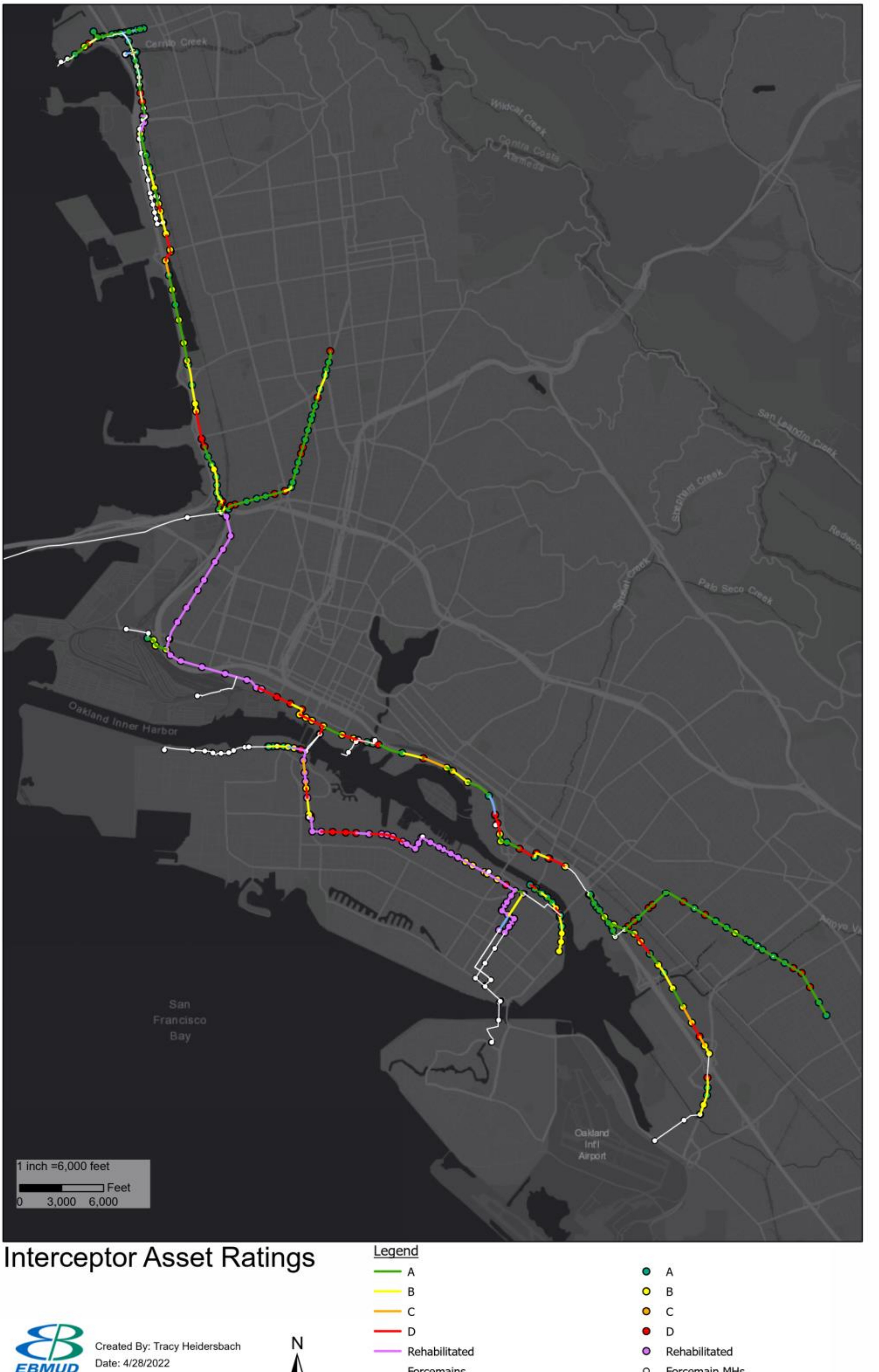

Figure 1-1. Map of Interceptor Condition Grades Assigned by EBMUD in 2014 (this project assessed most of the “D” and “C” segments)

EBMUD provided a list of some of the interceptor pipes that were either “Grade C” or “Grade D” for V&A to assess to the extent possible. V&A assessed 19,705 feet (86%) of the total of 22,757 linear feet of pipe on the list. The total tally of pipes includes the main priority and optional segments identified by EBMUD, as well as additional segments that may not have been “Grade C” or worse, but were assessed for access reasons (i.e., camera went through segment in order to reach segment in need of assessment). Table 1-2 lists the interceptor pipes that were assessed.

Table 1-2. List of Assessed Interceptor Pipe Segments

Count	Interceptor ID	Upstream MH	Downstream MH	Diameter (inches)	Approx. Length (feet)	Date Assessed	Assessment Method
1	A07A081	A07	A08	12	404	6/6/2022	CCTV
2	A32A331	A32	A33	57	631	6/7/2022	CCTV w/ GoPro
3	A33A341	A33	A34	57	320	6/7/2022	CCTV w/ GoPro
4	A34A351	A34	A35	57	318	6/7/2022	CCTV w/ GoPro
5	A35A361	A35	A36	57	703	6/8/2022	CCTV w/ GoPro
6	A37A381	A37	A38	60	591	6/8/2022	CCTV w/ GoPro
7	A38A391	A38	A39	60	744	6/8/2022	CCTV w/ GoPro
8	A39A401	A39	A40	60	640	6/9/2022	CCTV w/ GoPro
9	A45AA461	A45A	A46	60	545	6/9/2022	CCTV w/ GoPro
10	A46A46A1	A46	A46A	60	380	6/9/2022	CCTV w/ GoPro
11	A46AA471	A46A	A47	60	500	6/6/2022	CCTV w/ GoPro
12	A47A481	A47	A48	60	691	6/10/2022	CCTV w/ GoPro
13	N20N211	N20	N21	66	464	9/30/2022	CCTV w/ GoPro
14	N21N221	N21	N22	66	871	9/30/2022	CCTV
15	N26N271	N26	N27	66	1022	7/14/2022	CCTV w/ GoPro
16	N27N281	N27	N28	33	32	7/14/2022	CCTV w/ GoPro
17	N28N291	N28	N29	66	188	7/14/2022	CCTV w/ GoPro
18	N29N301	N29	N30	66	1161	7/14/2022	CCTV w/ GoPro
19	N30N311	N30	N31	66	1084	7/14/2022	CCTV w/ GoPro
20	N31N321	N31	N32	66	320	7/15/2022	CCTV w/ GoPro
21	N32N331	N32	N33	66	102	7/15/2022	CCTV w/ GoPro
22	N33N341	N33	N34	66	1581	7/15/2022 & 7/19/2022	CCTV w/ GoPro
23	N34N351	N34	N35	66	432	7/19/2022	CCTV w/ GoPro
24	S14S151	S14	S15	63	857	5/19/2022	MSI
25	S15S161	S15	S16	63	574	5/19/2022	MSI
26	S38S391	S38	S39	75	1424	5/20/2022	MSI
27	S47S481	S47	S48	105	716	5/18/2022	MSI w/ GoPro
28	S48S491	S48	S49	105	393	7/18/2022	CCTV w/ GoPro
29	S49S501	S49	S50	105	392	7/18/2022	CCTV w/ GoPro
30	S50S511	S50	S51	105	326	7/18/2022	CCTV w/ GoPro
31	S53S541	S53	S54	105	1000	5/17/2022	MSI w/ GoPro
32	S54S551	S54	S55	105	299	5/17/2022	MSI w/ GoPro
				Total	19,705		

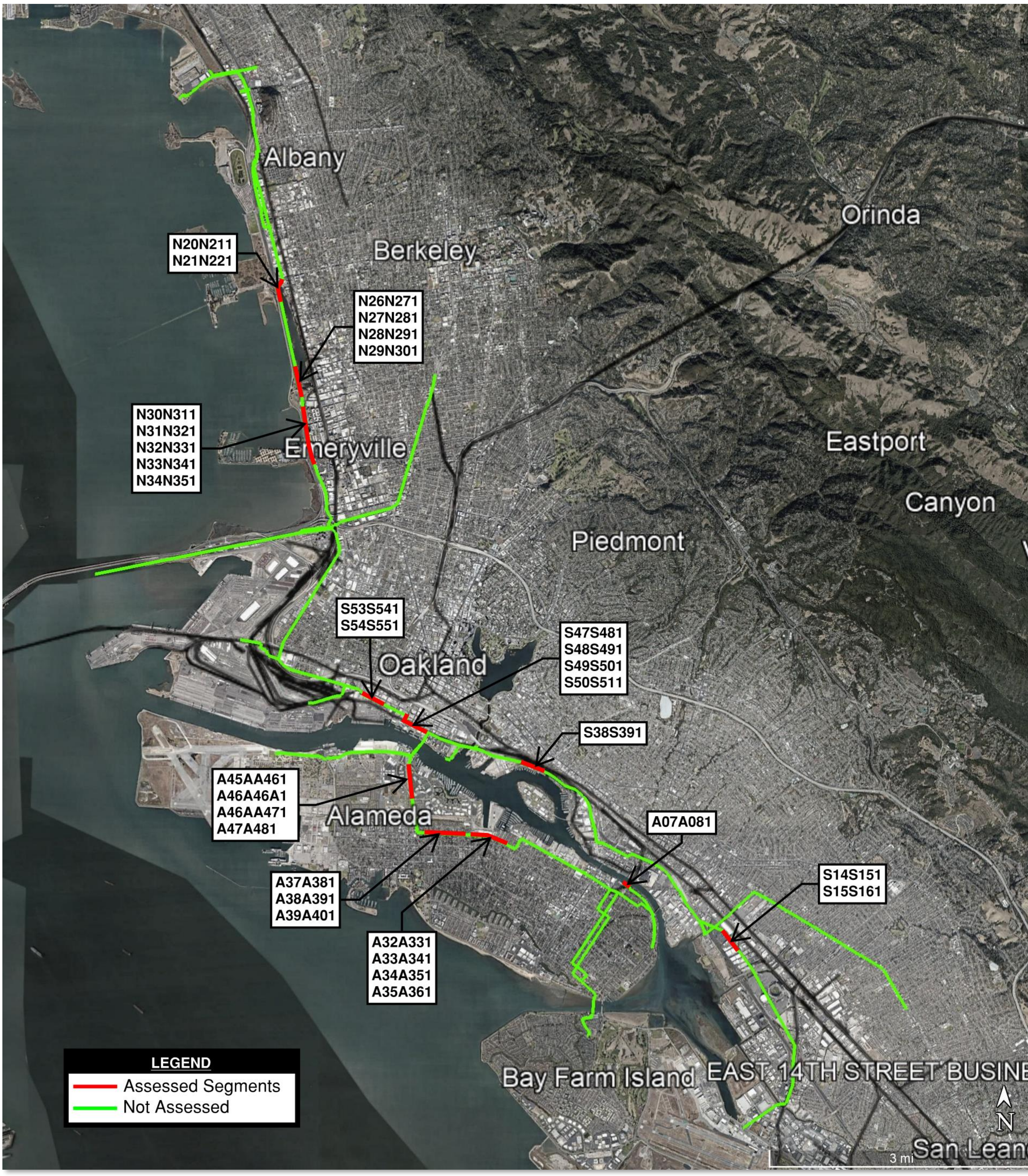

Figure 1-2. Map of Assessed Interceptor Pipes

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Table 1-3 lists the 27 manholes that were assessed while the manholes were being used for access to deploy the CCTV or MSI assessment platforms.

Table 1-3. List of Assessed Interceptor Manholes

Count	Manhole ID	Date Assessed	Methods of Assessment
1	A32	6/6/2022	Concrete surface testing
2	A34	6/7/2022	Concrete surface testing
3	A35	6/8/2022	Concrete surface testing
4	A37	6/8/2022	Concrete surface testing
5	A39	6/9/2022	Concrete surface testing
6	A40	6/9/2022	Concrete surface testing
7	A46A	6/9/2022	Concrete surface testing
8	A47	6/6/2022	Concrete surface testing
9	A48	6/6/2022	Concrete surface testing
10	N19	9/30/2022	Concrete surface testing
11	N22	9/30/2022	Concrete surface testing
12	N26	7/14/2022	Concrete surface testing
13	N31	7/14/2022	Concrete surface testing
14	N35	7/14/2022	Concrete surface testing
15	S14	5/19/2022	Concrete surface testing
16	S15	5/31/2022	Concrete surface testing
17	S16	5/31/2022	Concrete surface testing
18	S38	5/20/2022	Concrete surface testing
19	S39	5/31/2022	Concrete surface testing
20	S47	5/19/2022	Concrete surface testing
21	S48	5/19/2022	Concrete surface testing
22	S49	7/18/2022	Concrete surface testing
23	S50	7/18/2022	Concrete surface testing
24	S51	7/18/2022	Concrete surface testing
25	S53	5/17/2022	Concrete surface testing
26	S54	5/31/2022	Concrete surface testing
27	S55(1)	5/31/2022	Concrete surface testing

(1) S55 structure is lined and was not entered for assessment.

1.4 Background on Biogenic Corrosion in Sewers

A major contributor to the corrosivity of the environment in wastewater collection systems is the biological generation of sulfide in the wastewater. The first step in this process is the formation of an organic slime layer, or biofilm, below the waterline in the pipe. When this biofilm becomes thick enough to prevent dissolved oxygen from penetrating it, an anoxic zone develops within it. It is here that anaerobic (oxygen-depleted) bacterial activity occurs. Anaerobic sulfate-reducing bacteria use the sulfate ($SO4^-$) ion commonly present in wastewater as an oxygen source for the assimilation of organic matter in the same way dissolved oxygen is used by aerobic bacteria. This reduction process produces the sulfide (S^-) ion, which is released into the wastewater. A schematic representation of the slime layer buildup on the pipe wall below the waterline is shown in Figure 1-3.

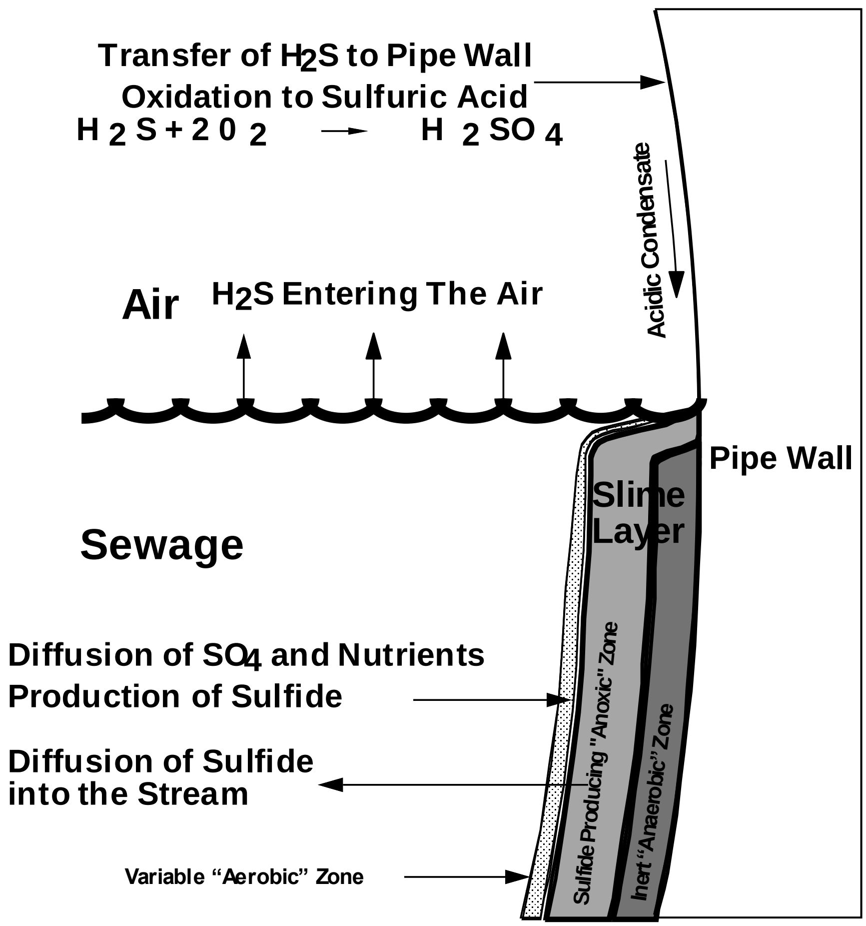


Figure 1-3. Sulfide Generation and Acid Production in Sewers

The retention of dissolved sulfide in the wastewater depends upon a dynamic chemical equilibrium between four forms of sulfide: the sulfide ion (S^-), the bisulfide ion (HS^-), aqueous hydrogen sulfide (H_2S_{aq}), and hydrogen sulfide gas (H_2S_g). By a series of chemical reactions driven by the wastewater sulfide ion concentration and other factors, dissolved hydrogen sulfide is produced. The rate at which hydrogen sulfide leaves the aqueous phase is governed by partial pressure, the amount of turbulence of the wastewater, and the pH of the solution.

In addition to the odor and the health risks posed by the gaseous hydrogen sulfide, it can also be oxidized to sulfuric acid (H2SO4) by aerobic bacteria that live on the wall surfaces above the waterline in sewer manholes and pipes. The conditions required for hydrogen sulfide to be oxidized to sulfuric acid are a moist humid environment, an adequate supply of hydrogen sulfide gas, and oxygen. These conditions exist in virtually all wastewater collection systems. Under the appropriate conditions of water temperature, pH, dissolved oxygen, flow velocity, turbulence, and organic matter, enough hydrogen sulfide gas can be generated and liberated from the waste stream to result in significantly corrosive conditions for concrete.

Concrete corrosion occurs when the sulfuric acid formed by oxidation of hydrogen sulfide on moist manhole and pipe surfaces attacks the Portland cement binder in the concrete. The cement binder is commonly composed of calcium silicate hydrate gel and un-reacted calcium hydroxide. Although the reaction products are complex and result in the formation of many different compounds, the primary product of concrete decomposition by sulfuric acid is calcium sulfate (CaSO4), commonly known by its mineral name, gypsum. In early stages of degradation, the affected near-surface areas crumble and scale off the manhole and pipe walls. Where sulfuric acid generation is intense, the concrete can become soft and pasty to depths of over an inch and spall off the surface in thick slabs.

The pH of corroded concrete becomes highly acidic, often as low as pH 1 or 2. This is a large pH shift from fresh-cured concrete, which has a pH of 11 to 13. For accelerated concrete corrosion to occur, the surface pH must drop from 11 or 12 to approximately 6, which allows sulfide-oxidizing aerobic bacteria to live. This initial pH drop is accomplished by slow cement carbonation by atmospheric carbon dioxide, and by weak sulfide-based acid formation from gaseous hydrogen sulfide dissolved in moisture on the concrete. Once bacterial colonies have been established, the pH drops rapidly as the organisms generate sulfuric acid. Under increasingly more acidic conditions, various acid-resistant strains of bacteria will replace their predecessors as the environment becomes favorable to their existence. There are species of bacteria that can tolerate conditions below pH 2.

2 Approach

V&A used both qualitative and quantitative means to conduct the condition assessment. The methods and techniques used to assess the condition of the pipes and manholes are described in this section.

2.1 Document Review

V&A reviewed plan and profile drawings, manhole detail drawings, and alignment maps to prepare for the field assessments. Additional background information that was reviewed includes:

- EBMUD Interceptor Condition Rating Map
- Flow projections based on EBMUD's hydraulic model
- EBMUD Sewer System Management Plan, dated May 5, 2020
- Alameda Siphon Cleaning Report, Power Jet Engineering, dated October 26, 2018
- Flow and site information from previous V&A projects

2.2 Health & Safety

V&A prepared a Health and Safety Plan to conduct the field work, which as reviewed by all team members prior to the assessment. The Health and Safety Plan was submitted to EBMUD for review before field work began.

The manhole structures and pipe segments are permit-required confined spaces (PRCS) due to the potential for hazardous atmosphere and the difficulty of ingress and egress into the structures. V&A implemented confined space protocols based on California Code of Regulations, Title 8, Section 5157, Permit Required Confined Spaces to enter the manholes for the purposes of conducting the condition assessments.

2.3 Visual Assessment

Qualitative visual evaluations were conducted from inside and outside of assessed structures, focusing on the condition of concrete surfaces and piping. Cracks, delamination, corrosion, and other concrete defects referenced in American Concrete Institute (ACI) 201.1R-92, "Guide for Making a Condition Survey of Concrete in Service" were documented with digital, still photographs. The condition of metal components and coatings were also evaluated and documented. It should be noted that much of the visual assessment data is subjective and is based upon V&A's extensive experience evaluating concrete in the water and wastewater industries. Standardized ratings used to characterize condition were assigned based on the VANDA Concrete Index, as shown in the subsequent section.

2.3.1 VANDA® Concrete Condition Index

V&A created the VANDA Concrete Condition Index (Table 2-1) to provide consistent reporting of corrosion damage based on objective criteria. Concrete condition is rated from Level 1 to Level 5 based upon field observations and measurements, with Level 1 indicating the best case and Level 5 indicating severe damage. The individual criteria are applied based on engineering judgment to arrive at the overall rating.

Table 2-1. VANDA® Concrete Condition Index

Condition Rating	Description	Representative Photograph
Level 1	**Little or no damage to concrete** ▪ Hardness .... hard surface ▪ Surface profile ...... smooth, apparently intact ▪ Cracks .... hairline width, minimal frequency ▪ Spalling .... none ▪ Reinforcement ...... not exposed or damaged	
Level 2	**Minor surface damage** ▪ Hardness .... soft surface layer to 1/8-inch depth ▪ Surface profile ...... fine aggregate exposed ▪ Cracks .... hairline width, moderate frequency ▪ Spalling .... shallow spalling, minimal frequency ▪ Reinforcement ...... not exposed or damaged	
Level 3	**Moderate surface damage** ▪ Hardness .... soft surface layer to 1/4-inch depth ▪ Surface profile ...... large aggregate exposed or protruding ▪ Cracks .... up to 1/32-inch width, moderate frequency ▪ Spalling .... shallow spalling, minimal frequency ▪ Reinforcement ...... exposed; minor damage, minimal frequency	
Level 4	**Loss of concrete mortar and damage to reinforcement** ▪ Hardness .... soft paste beyond 1/4-inch depth ▪ Surface profile ...... large aggregate exposed, loose, or missing ▪ Cracks .... 1/8- to 1/4-inch width, moderate frequency ▪ Spalling .... deep spalling, moderate frequency ▪ Reinforcement ...... exposed with damage, moderate frequency	
Level 5	**Bulk loss of concrete and reinforcement** ▪ Hardness .... soft paste beyond 1-inch depth ▪ Surface profile ...... large aggregate exposed, loose, or missing ▪ Cracks .... over 1/2-inch width, or narrower and frequent ▪ Spalling .... deep spalling, high frequency ▪ Reinforcement ...... consumed; loss of structural integrity	

2.4 Closed-Circuit Television Video

2.4.1 Pipeline CCTV

National Plant Services (NPS) was retained by V&A to perform closed-circuit television (CCTV) to visually examine the interior surfaces of the pipes. This method of traditional CCTV consists of a color high-definition CCTV camera and light system mounted to a wheeled crawler or floating pontoon (raft). The camera is equipped with tilt, rotation, and zoom capabilities to capture detailed observation of defects. Video images are captured via a recording console, and the camera is controlled from the CCTV truck at the surface access point through a coaxial cable that also allows the distance to be recorded in feet.

For added value, NPS mounted GoPro camera(s) onto the CCTV platform to simultaneously capture higher definition videos for most of the CCTV assessments. The GoPro camera provided a significant improvement in image resolution as compared with the traditional CCTV camera. While the improved image quality is noteworthy, the mounted GoPro has the following limitations:

- The GoPro camera is independent of the CCTV system and must be post-synchronized/merged with the CCTV footage to obtain distance counting.
- The GoPro video file sizes can be very large, which can make file management challenging.
- The GoPro does not have pan, tilt, or zoom capabilities.
- The GoPro is battery powered and can run out of power during long runs.

Defect observations were documented per the National Association of Sewer Services Companies (NASSCO) Pipeline Assessment Certification Program (PACP). Further details and explanation of the CCTV assessment protocols can be referenced in the NPS report provided in Appendix A.

2.5 Multi-sensor Inspection

NPS also provided a multi-sensor inspection (MSI) platform that was used to assess the interior surfaces of 25% of the interceptor pipes. Similar to CCTV, two different platforms were used – a floating pontoon and a crawler, depending on the flow and debris levels.

The MSI pontoon was equipped with sonar, a high-definition camera, and light detection and ranging (LiDAR) technology. The LiDAR measures pipe interior using laser beams to measure dimensions above the water surface with accuracy up to 1% of the pipe diameter. This data is used to quantify buildup, loss of pipe wall, or ovality changes. The LiDAR reporting is very detailed, as the laser collects hundreds of thousands of measurements. Sonar is used to measure debris and pipe cross-section below the water surface, and to determine if there are large defects on the pipe walls, as long as those defects are not obscured by debris. More detailed information on National Plant's equipment, inspection procedures, and reporting can be found in Appendix B.

2.6 Concrete Assessment Methods

2.6.1 Concrete Surface Evaluation

Several methods were used to evaluate the of the concrete surface and its exposure environment. The methods used for these assessments are described in this section.

2.6.1.1 Sounding

Sounding was performed within the structures at the evaluator's discretion to investigate for shallow, subsurface discontinuities. Using a hammer to strike accessible concrete surfaces, the sound can indicate if defects such as voids, delamination, or honeycombing are present. The sound returned from solid concrete without subsurface discontinuities is a sharp "ping" noise. A "hollow" sound generally means that a discontinuity exists beneath the sounding location. A soft "thud" typically results from deteriorated concrete.

2.6.1.2 Penetration Testing

Penetration testing was performed to estimate the depth of degradation from the existing surface of concrete. Typically, as concrete deteriorates the cement paste begins to lose alkalinity. A chipping hammer was used to remove loose and degraded material from the concrete surface until highly alkaline (solid) concrete was reached; the depth of the resulting cavity was then measured. Unless the concrete has become soft and chalky, V&A's penetration testing will not typically exceed 1/2-inch in depth. In this case, if the pH in the cavity is not greater than 10, then the extent of degradation has not been reached and concrete coring is recommended to determine the extent of degradation. The correlation between penetration measurements and concrete surface hardness is presented in Table 2-2.

Table 2-2 Concrete Surface Hardness Index

Penetration Depth (in.)	Surface Texture	Scaling (1)
< 1/16	Hard surface	No scaling
1/16 – 1/8	Softened surface and/or loose cementitious material	Light scaling
1/8 – 1/4	Soft surface and/or exposed and loose fine aggregate	Medium scaling
> 1/4	Soft paste and/or exposed and loose coarse aggregate	Severe scaling

(1) Scaling is defined by flaking or peeling away of near surface portion of hardened concrete or mortar, per ACI 201R, Condition Survey Guide.

2.6.1.3 Surface pH Measurements

V&A performed in-situ pH measurements on exposed concrete surfaces and coated concrete surfaces using a pH sensitive pencil. The pH of concrete exposed to wastewater is commonly altered by carbonation and hydrogen sulfide induced acid-attack (biogenic corrosion). Concrete carbonation refers to the reaction of atmospheric CO_2 with cement hydrates in the concrete, which can lower the pH of the concrete to as low as 8.5. Carbonation is typically a slow process and is harmless until its depth reaches embedded reinforcing steel. Hydrogen sulfide induced corrosion, on the other hand, can be an aggressive mechanism of concrete degradation where gaseous hydrogen sulfide is oxidized to sulfuric acid on surfaces within the sewer headspace. This process can severely deteriorate concrete and reduce the surface pH to as low as pH 1.

The surface pH of the concrete can indicate the rate of concrete deterioration due to environment exposure. The generally accepted ranges for corrosion categories and surface pH values are listed below:

- **Severe Corrosion.** This category of concrete corrosion is characterized by significant measurable concrete loss or active corrosion. There is exposed aggregate and occasional exposed reinforcing steel. The original concrete surface is not distinguishable. The surface is covered with soft, pasty corrosion products where active scouring is not present. There is generally a depressed wall pH (< 3.0) indicating active corrosion.
- **Moderate Corrosion.** This category of concrete corrosion is characterized by some concrete loss with aggregate slightly exposed, but the original concrete surface is still distinguishable. The surface may have a thin covering of pasty material which is easily penetrated. There is generally a depressed wall pH (< 5.0) indicating moderately corrosive conditions.
- **Light Corrosion.** This category of concrete corrosion is characterized by a slightly depressed pH (< 6.0) and a concrete surface that can be scratched with a sharp instrument under moderate hand pressure with the removal of some concrete material. The original concrete surface is fully recognizable, and aggregate may or may not be exposed.
- **Negligible Corrosion.** This category of concrete corrosion is characterized by normal pH ranges (>6.0) and a normal concrete surface which cannot be penetrated or removed by a sharp instrument under moderate hand pressure. The surface of the concrete may have biological growth and moisture, but the concrete is normal, and the aggregate is not exposed.

Another thing to note that is considered independent from exposure to the water, wastewater, or atmospheric environment is that concrete pH levels below 10 at the depth of embedded reinforcing steel bars can cause corrosion of the bars. This is typically analyzed by taking core samples or concrete samples for pH testing at various depths.

2.6.2 Surface Penetrating Radar

Concrete cover depth is an important element in corrosion protection of reinforced concrete structures and pipelines. The greater the thickness of concrete cover, the less likely that corrosive constituents have reached the embedded reinforcing steel.

Per ACI 350-06, "Code Requirements for Environmental Engineering Concrete Structures," the minimum concrete cover depth for corrosion protection of reinforcing steel in formed concrete surfaces exposed to earth, water, sewage, weather, or in contact with the ground should be at least two (2) inches (three inches for unformed concrete cast against soil). However, concrete cover for slabs and beams with reinforcing bar sizes #5 and smaller should have a minimum depth of 1.5 inches. Also, per ACI 350-06, the design spacing between reinforcing bars for rectangular members should not exceed 12 inches to mitigate flexural cracking.

Per AWWA C302 "Reinforced Concrete Pressure Pipe, Noncylinder Type", the minimum depth of cover for circumferential reinforcement in reinforced concrete pipe (RCP) should be one (1) inch where wall thickness exceeds three (3) inches and 0.75 inch where wall thickness is three (3) inches or less. Also, according to AWWA C302, longitudinal bar spacing should not exceed 42 inches.

Surface penetrating radar (SPR) was used to measure the depth and spacing of reinforcing steel and investigate for coarse voids and defects within the evaluated concrete pipes and manholes. Scanning is typically performed over a 3-foot by 3-foot area, and a radar beam scans up to 16 inches into the concrete. Scanning on rough and corroded surfaces can be difficult, which can yield relatively unreliable results.

The unit generates a 2-dimensional image of the underlying concrete member based on the measured radar reflections. The accuracy of depth and spacing measurements are no better than ¼-inch. Figure 2-1 shows a sample 2-dimensional image of the SPR scan with the distance scanned plotted on the x-axis and the depth scanned plotted on the y-axis.

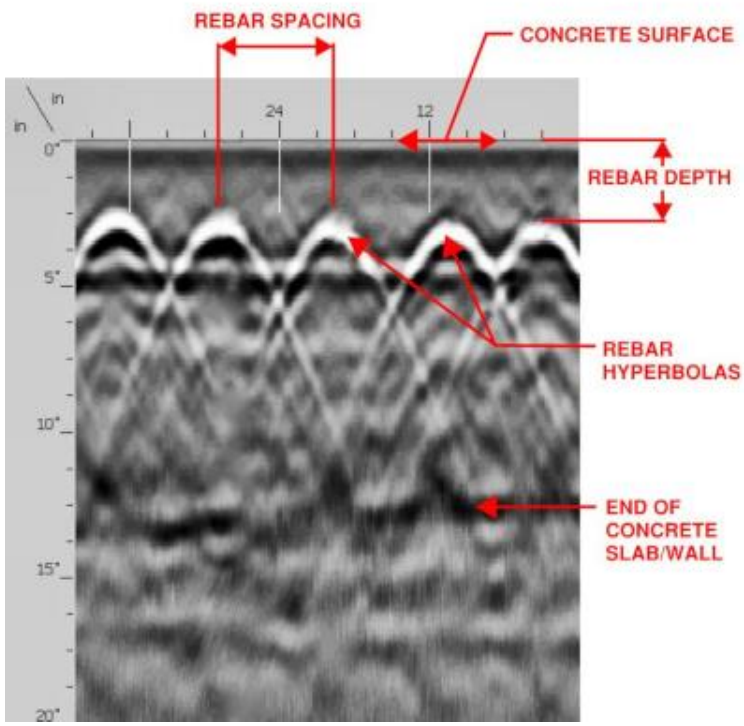


Figure 2-1. Sample Surface Penetrating Radar (SPR) Scan

3 Alameda Interceptor

3.1 Interceptor Pipe Condition

The assessed portions of the Alameda Interceptor run primarily along Buena Vista Avenue and Constitution Way in Alameda, California. There is one short segment (A07A081) near the Fruitvale Avenue Bridge that was also assessed. The assessed portions are primarily 57-inch and 60-inch reinforced concrete pipe (RCP) that was constructed circa 1953. The exception is the 12-inch vitrified clay pipe (VCP) segment, A07A081, which was put into service circa 1954. The Alameda Interceptor collects wastewater from the City of Alameda as well as Bay Farm Island and conveys it underneath the Oakland/Alameda Estuary via siphons into the South Interceptor at Jack London in Oakland.

The assessed segments of the Alameda Interceptor are listed in Table 3-1.

Table 3-1. List of Assessed Alameda Interceptor Segments

Count	Interceptor ID	Upstream MH	Downstream MH	Diameter (Inches)	Approx. Length (feet)	Pipe Material	Year Constructed
1	A07A081	A07	A08	12	404	VCP	1954
2	A32A331	A32	A33	57	631	RCP	1953
3	A33A341	A33	A34	57	320	RCP	1953
4	A34A351	A34	A35	57	318	RCP	1953
5	A35A361	A35	A36	57	703	RCP	1953
6	A37A381	A37	A38	60	591	RCP	1953
7	A38A391	A38	A39	60	744	RCP	1953
8	A39A401	A39	A40	60	640	RCP	1953
9	A45AA461	A45A	A46	60	545	RCP	1953
10	A46A46A1	A46	A46A	60	380	RCP	1953
11	A46AA471	A46A	A47	60	500	RCP	1953
12	A47A481	A47	A48	60	691	RCP	1953
				Total	6,467		

A map of the assessed segments of the Alameda Interceptor is shown in Figure 3-1. Methods of assessment for the Alameda Interceptor included CCTV and manhole drop-downs.

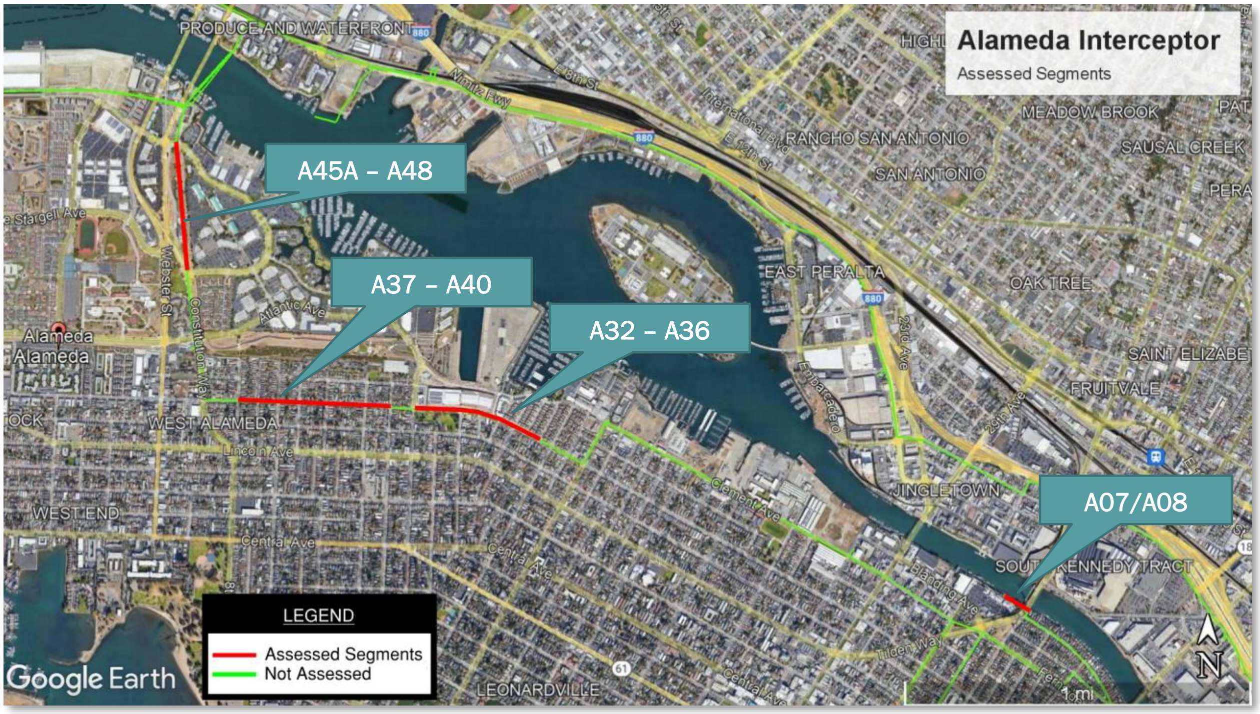


Figure 3-1. Map of Assessed Alameda Interceptor Segments

3.1.1 CCTV Review and Visual Assessment

3.1.1.1 Buena Vista Segments (A32 – A40)

The seven (7) segments and 3,497 linear feet assessed along Buena Vista Avenue were in VANDA Level 4 to Level 5 condition due to severe biogenic corrosion. Soft mushy yellowish concrete, exposed aggregate, and exposed and corroded reinforcing steel were strongly evident throughout these segments between A32 and A40. A36 to A37 is lined and was not assessed.

The segments A35A361 and A39A401 appeared to be in the worst condition with mostly continuous sections of exposed reinforcing steel. The extent of corrosion on the exposed reinforcing steel also appeared to be most severe in these sections with broken/missing bars in some areas. Some areas where the reinforcing steel bars were still present had deep artificial peaks and valleys that were created by corroded concrete extending past the bars. This suggests that most of the bar surface area is exposed to the highly corrosive environment, which generally indicates that the bars are corroded through or are close to being corroded through. Many of these areas also had the longitudinal bars exposed, which is further indication that the circumferential bars, being closer to the interior face of the pipe, were severely corroded. Segment A34A351 had a similar amount of exposed reinforcing steel; however, the extent of corrosion of the bars appeared to be slightly better than in segments A35A361 and A39A401. The segments A32A331, A33A341, A37A381, and A38A391 had more intermittent patches of exposed reinforcing steel and were in slightly better condition. However, A33A341 had two wet spots at the 10:00 and 2:00 clock positions that may be of serious structural deficiency.

The most alarming observation of all is the appearance of wetness or seepage on the surface of the pipe away from joints. Since infiltration typically occur at joints, wet areas away from joints are indicators of cracks or voids in the pipe, and possibly a significant structural deficiency in that area. This was observed at the following locations:

- A33A341
  - 0 feet to 5 feet downstream from A33 at 10:00 and 2:00 clock positions.
- A35A361
  - 12 feet downstream from A35 at 2:00.
  - 685 feet downstream from A35 at 3:00.
- A39A401
  - 317 feet downstream from A39 from 1:00 to 3:00.
  - 533 feet downstream from A39 at 12:00.
  - 550 feet downstream from A39 from 1:00 to 3:00.

Photo 3-1 through Photo 3-13 show the typical and notable observations for the Buena Vista segments of the Alameda Interceptor.

Photo 3-1. Missing/broken circumferential reinforcing steel bars just downstream of A39

Photo 3-2. Missing circumferential reinforcing steel bars downstream of manhole A35

Photo 3-3. Wetness along possible longitudinal crack at 12 feet from A35

Photo 3-4. Wetness/infiltration at 3:00 at 685 feet from A35

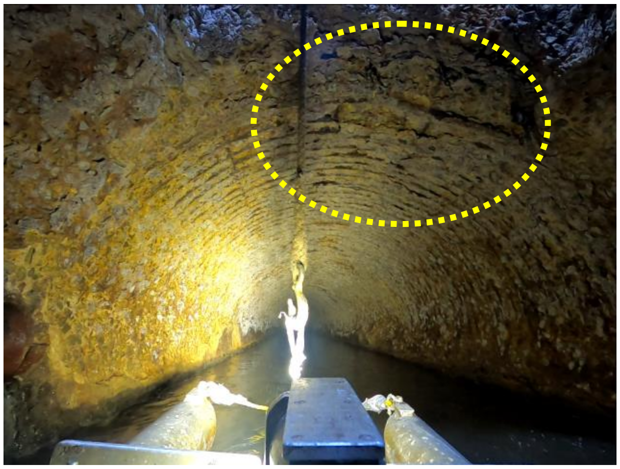


Photo 3-5. Missing circumferential bars at A39; longitudinal bars also exposed

Photo 3-6. Wetness from 1:00 to 3:00 at 317 feet from A39; shelf of soft deteriorated concrete on sides

Photo 3-7. Wetness at 12:00 along possible crack at 533 feet from A39; peaks and valleys between bars

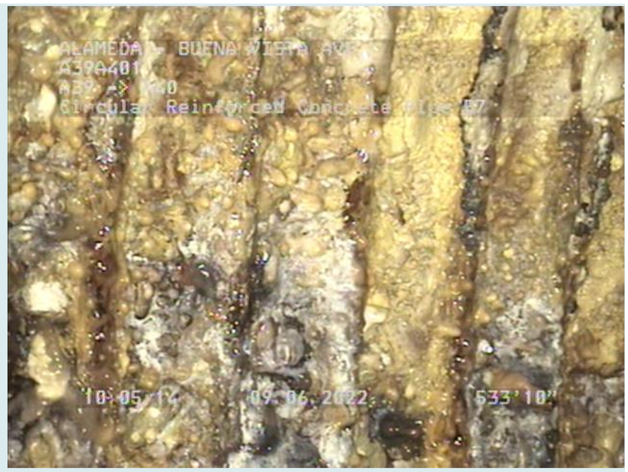


Photo 3-8. Close-up of wetness at 12:00 along possible crack at 533 feet from A39

Photo 3-9. Wetness from 1:00 to 3:00 at 550 feet from A39; peaks and valleys between bars

Photo 3-10. Close-up of wetness from 1:00 to 3:00 at 550 feet from A39; peaks and valleys between bars

Photo 3-11. Typical area with soft yellow concrete with no exposed reinforcing steel; A32A331 shown

Photo 3-12. Typical area with soft yellow concrete with no exposed reinforcing steel; A34A351 shown

Photo 3-13. Wetness/infiltration/encrustation at 10:00 and 2:00 clock positions at 5 feet downstream from A33; peaks and valleys between circumferential bars

3.1.1.2 Constitution Way Segments (A45A – A48)

The four (4) segments and 2,116 feet assessed along Buena Vista Avenue were in VANDA Level 3 to Level 4 condition due to moderate to severe biogenic corrosion. Soft mushy yellowish concrete, exposed aggregate, and exposed and corroded reinforcing steel were present amongst these segments between A45A and A48. A46A to A47 is lined and was in good condition.

The segments A45AA461, A46A46A1, and A47A481 showed moderate to severe surface damage with exposed reinforcing steel at minimal frequency. The extent of damage to the exposed reinforcing steel appeared to be less severe than in the Buena Vista segments. Several joints within these segments had infiltration and encrustations; however, these infiltration defects appear to be more of an operations and maintenance (O&M) issue, rather than a structural issue. The infiltration defects are shown in NPS's NASSCO PACP reports in Appendix A.

Typical and notable observations on the Alameda Interceptor along the Constitution Way corridor are shown in Photo 3-14 through Photo 3-19.

Photo 3-14. Moderate surface damage with outer mortar layer hanging from pipe surface

Photo 3-15. Severe surface mortar damage; no reinforcing steel exposed

Photo 3-16. Severe surface mortar damage; reinforcing steel exposed just downstream of A46

Photo 3-17. Severe surface mortar damage; reinforcing steel exposed downstream of A47

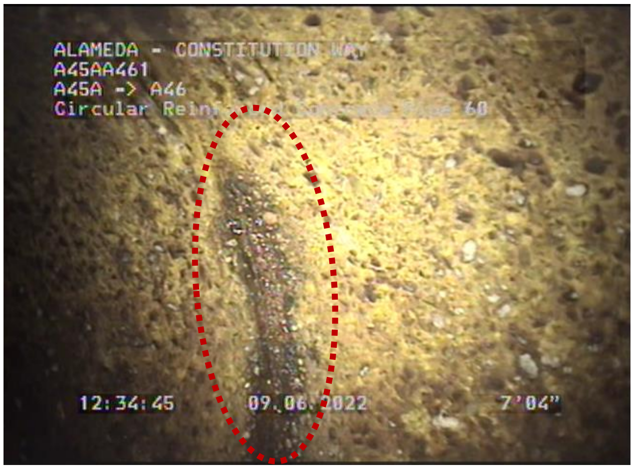


Photo 3-18. Infiltration at joint at 7 feet downstream from A45A

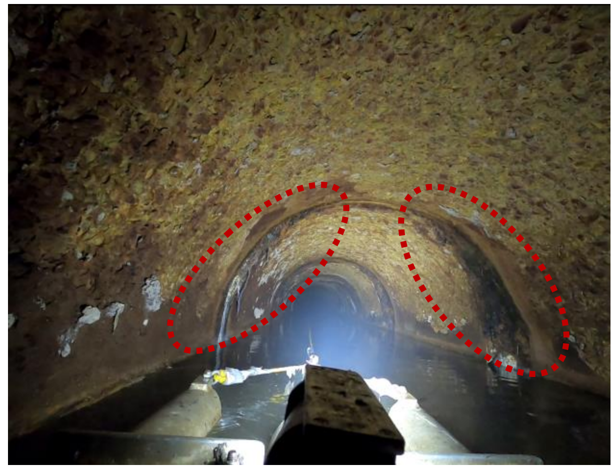


Photo 3-19. Infiltration and encrustation at joint at 454 feet downstream from A45A

3.1.1.3 Fruitvale Bridge Segment (A07 – A08)

The A07A081 segment is constructed of VCP and was in fair condition. There were four circumferential cracks along a 17-foot span starting from 128 feet upstream from A08. This span is located just outside (to the northwest) of where the pipe is encased and underneath the railroad crossing. Differential settlement between the encased section and adjacent segments to the northwest may be the cause of the cracks. The cracks occur at 128 feet, 132 feet, 138 feet, and 145 feet upstream from A08. The cracks vary from hairline width to open voids with soil and roots visible. The pipe and joints were in good condition otherwise. Joint spacing was typically 8 feet. There were a few taps entering the pipe from the south.

The notable and typical observations for the 12-inch VCP pipe of segment A07A081 of the Alameda Interceptor are shown in Photo 3-20 through Photo 3-25.

Photo 3-20. Typical VCP surfaces in good condition in majority of alignment

Photo 3-21. Typical VCP joint in good condition in majority of alignment

Photo 3-22. *Circumferential crack at 145 feet upstream of A08; 1 of 4 within 17-foot span*

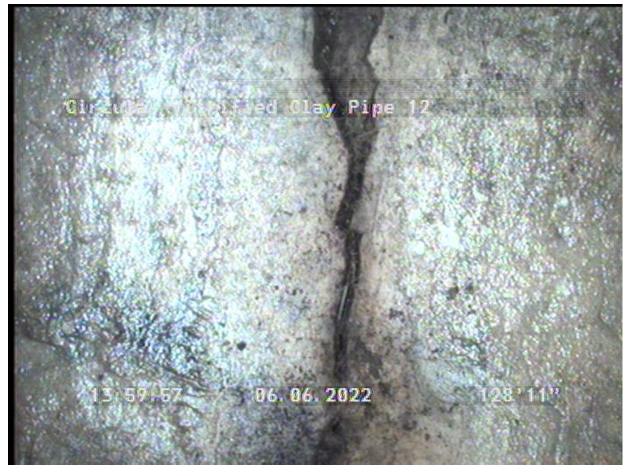


Photo 3-23. *Crack with void and soil visible at 128 feet upstream of A08*

Photo 3-24. *Crack at 138 feet upsteam of A08*

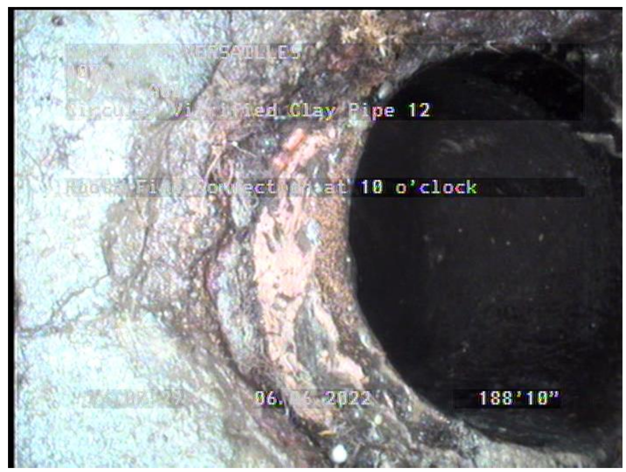


Photo 3-25. *Tap at 188 feet upstream of A08*

3.1.2 Physical Measurements

To assist with estimating the extent of corrosion overall, physical measurements on the pipe segments were obtained during the manhole drop-down assessments. These measurements include concrete pH, concrete penetration depth, surface penetrating radar (SPR) scans, and sediment measurements. The tests were only performed on the upstream or downstream pipe in manholes that were accessed for CCTV/MSI assessment and were accessible for physical entry.

The measurements were analyzed and compared with visual data to estimate the wall loss and remaining wall thickness for each segment. The results of the wall loss analysis are presented in Table 3-2. Wall loss ranged from 1 to 3 inches with an average of 1.7 inches. Segments A34A351, A35A361, and A39A401 exhibited the most wall losses due to corrosion.

Sediment levels ranged from five (5) to nine (9) inches with an average of seven (7) inches. The sediment in the Buena Vista segments had a gravely texture and was somewhat compacted – likely consisting of a lot of aggregate that had fallen from the pipe surface. The sediment in the Constitution Way segments had a soft and silty consistency.

Table 3-2. Physical Measurements and Wall Loss Analysis on Alameda Interceptor Pipes

Interceptor ID	Diameter (Inches)	Surface pH	pH at Depth	Penetration Depth(1)	Nominal Pipe Wall Thickness(2), Inches	Estimated Wall Loss(3), Inches	Remaining Wall Thickness, Inches	Sediment, Inches
A32A331	57	1	4	1/2	4.75	1.5	3.25	9
A34A351	57	1	4	1/2	4.75	2	2.75	9
A35A361	57	1	4	1	4.75	2	2.75	5
A37A381	60	1	4	1/2	5	1.5	3.5	8
A39A401	60	1	4	1	5	3	2	6
A46AA471	60	2	4	1/4	5	1	4	6
A47A481(4)	60	1	4	1/4	5	1	4	6
A47A481(5)	60	5	7	1/4	5	1.5	3.5	6

(1) Penetration depth to hard concrete measured from existing surface. Actual deterioration depth likely greater.
(2) Assumed pipe wall thickness based on review of as-built SD53-VG433.
(3) Based on penetration depth, estimated remaining thickness from SPR scans, and/or visual data.
(4) Measured in A47A481 from manhole A47.
(5) Measured in A47A481 from manhole A48.

3.1.3 Interceptor Pipe Condition Summary

The overall conditions of the assessed Alameda Interceptor segments are summarized in Table 3-3.

Table 3-3. Alameda Interceptor Pipe Condition Summary

Interceptor ID	Remaining RCP Wall Thickness[1], %	VANDA Rating	Remarks
A07A081	n/a	n/a[2]	12" VCP in fair condition with 4 circumferential cracks, possibly due to differential settlement adjacent to railroad tracks
A32A331	68%	4	Severely deteriorated concrete; estimated concrete loss = 1.5 inches; exposed reinforcing steel occurred intermittently
A33A341	68%	5	Severely deteriorated concrete; estimated concrete loss = 1.5 inches; exposed reinforcing steel occurred intermittently; two wet spots at 10:00 and 2:00 just downstream of A33 may be impending failure
A34A351	58%	5	Severely deteriorated concrete; estimated concrete loss = 2 inches; reinforcing steel occurred frequently
A35A361	58%	5	Severely deteriorated concrete; estimated concrete loss = 2 inches; reinforcing steel occurred frequently; wet spots at 12 feet and 685 feet downstream of A34 may be impending failures
A37A381	70%	4	Severely deteriorated concrete; estimated concrete loss = 1.5 inches; exposed reinforcing steel occurred intermittently
A38A391	70%	4	Severely deteriorated concrete; estimated concrete loss = 1.5 inches; exposed reinforcing steel occurred moderately
A39A401	40%	5	Severely deteriorated concrete; estimated concrete loss = 3 inches; reinforcing steel occurred frequently; wet spots at 317 feet, 533 feet, and 550 feet downstream of A39 may be impending failures
A45AA461	80%	3	Moderately to severely deteriorated concrete; estimated concrete loss = 1 inches; exposed reinforcing steel occurred at minimal frequency; infiltration at a few joints
A46A46A1	80%	3	Moderately to severely deteriorated concrete; estimated concrete loss = 1 inches; exposed reinforcing steel occurred at minimal frequency; infiltration with encrustations at a few joints
A46AA471	100%	1	Lined pipe; liner in good condition
A47A481	70%	4	Moderately to severely deteriorated concrete; estimated concrete loss = 1.5 inches; exposed reinforcing steel occurred intermittently; infiltration at a few joints

(1) The remaining wall thickness for A33A341, A38A391, A45AA461, and A46A46A1 were extrapolated from nearby pipe segments with physical measurements and visual assessment data.

(2) VANDA ratings only apply to concrete pipes or structures in this report.

3.2 Manhole Condition

The following section summarizes the results of the manhole conditions for the Alameda Interceptor. The manholes assessed included A32, A34, A35, A37, A39, A40, A46A, A47, and A48.

3.2.1 Visual Assessment

The interior of the manhole was visually assessed using photographs to document the condition and capture corrosion observations of the concrete surfaces. The conditions were rated using the VANDA® Concrete Condition Index.

A summary of the visual assessment results for each manhole is provided in Appendix C. In general, the manholes were lined with a spray-applied lining (except for A37, which was unlined). The lining for most of the manholes had failed or was beginning to fail (except for the lining for A46A and A48, which were in good condition). While the failed/failing lining appeared to be mostly intact, the surfaces would crumble under light pressure, revealing semi-soft deteriorated concrete underneath. Representative photos of the Alameda Interceptor manhole conditions are shown in Photo 3-26 through Photo 3-37. The manhole conditions ranged from VANDA Level 2 to VANDA Level 4.

- Manholes A46A and A48 were in good condition with an intact lining and minor concrete damage (VANDA Level 2).
- Manholes A32, A34, A39, A40, and A47 were in fair condition with a failing lining and moderate concrete damage (VANDA Level 3).
- Manhole A37 was unlined and in fair condition with moderate concrete damage (VANDA Level 3).
- Manhole A35 was lined but exhibited a crumbling/failed lining, moderate to severe surface damage, and exposed reinforcing steel on its ceiling (VANDA Level 4).

Photo 3-26. MH A47. Upper section of manhole, coating in good condtion.

Photo 3-27. MH A47. Upper section of manhole, coating in good condtion.

Photo 3-28. MH A48. Upper section of manhole, coating in good condtion.

Photo 3-29. MH A32. Upper section of manhole, coating crumbly and in poor condition.

Photo 3-30. MH A40. Upper section of manhole, coating appeared crumbly and in poor condition.

Photo 3-31. MH A37. Unlined concrete with moderate surface damage.

Photo 3-32. MH A35. Failed lining, exposed aggregate, and exposed reinforcing steel on ceiling.

Photo 3-33. MH A48. Lower section of manhole, coating in good condition.

Photo 3-34. MH A34. Bench section of manhole, coating in good condition.

Photo 3-35. MH A32, rough and crumbly lining around manhole inlet.

Photo 3-36. MH A37, moderate surface damage on manhole channel.

Photo 3-37. MH A39, Sever surface damage above inlet pipe. Concrete failure along inlet joint.

3.2.2 Physical Measurements

Surface pH and penetration measurements were not obtained from the Alameda manholes due to the presence of the lining. Based on the surface pH measurements on the interceptor pipes in the Alameda manholes, the manhole structures are also subjected to a severely corrosive environment for concrete (pH in the range of 1 – 2).

Table 3-4 presents the SPR data recorded on the concrete walls of manhole A48. The scan locations shown in red text had an average concrete cover depth less than the 2-inch minimum requirement per ACI 350. Except for the scan on the horizontal bar of the north wall, the average spacing of the scanned locations are below the design maximum spacing of 12 inches required by ACI 350 to mitigate flexural cracking. The other manhole walls were not scanned due to the rough lining surface. The SPR measurements are presented in Appendix D.

Table 3-4. Summary of SPR Measurements for the Alameda Interceptor Manhole

Manhole	Location	Bar Direction	Depth Max	Depth Avg	Depth Min	Space Max	Space Avg	Space Min
A48	North Wall	Vertical	1.6	1.3	0.9	-	11.3[1]	-
A48	West Wall	Vertical	2.7	2.7	2.4	11.3	10.9	10.7
A48	North Wall	Horizontal	2.9	2.5	1.9	-	16.2[2]	-
A48	West Wall	Horizontal	3.5	3.3	3.2	8.4	8.2	8.1

(1) Only two bars scanned.
(2)Red text indicates depth of cover and spacing values that are more than 10% less than the minimum 2-inch depth of cover or more than 10% of the 12-inch maximum design spacing.

3.2.3 Manhole Condition Summary

Taking the visual and physical assessment results into account, the overall condition of each manhole is summarized in Table 3-5.

Table 3-5. Alameda Interceptor Manhole Condition Summary

Structure	VANDA Rating	Overall Condition Summary
Manhole A32	3	Lining easily crumbles with light pressure, indicating failure and disbanding from concrete substrate. Moderate surface damage with exposed aggregate beneath coating.
Manhole A34	3	Lining mostly intact except for some blisters. Concrete at blistered/damaged lining was soft up to ½-inch.
Manhole A35	4	Lining easily crumbles with light pressure, indicating failure and disbanding from concrete substrate. Moderate surface damage with exposed aggregate beneath the lining and exposed reinforcing steel on the ceiling.
Manhole A37	3	Unlined concrete showed moderate surface deterioration, exposed aggregate, and soft surface layer of concrete.
Manhole A39	3	Lining easily crumbles with light pressure, indicating failure and disbanding from concrete substrate. Moderate surface damage with exposed aggregate beneath the lining.
Manhole A40	3	The lining on the wall was rough and may be crumbly like some of the other manholes along Buena Vista.
Manhole A46A	2	The lining had some blisters with soft concrete behind the failed spots of lining. The lining and concrete appeared to be in good condition overall.
Manhole A47	3	The lining and concrete of the structure walls and ceiling appeared to be in good condition overall. The bench was unlined and showed moderate surface damage.
Manhole A48	2	The lining and concrete of the structure walls and ceiling appeared to be in good condition overall. The bench was unlined and showed moderate surface damage.

4 South Interceptor

4.1 Interceptor Pipe Condition

The nine (9) segments of the South Interceptor that were assessed are spread out in Oakland, California. The segments include 63-inch diameter segments between manholes S14 and S15, a 78-inch diameter segment along Embarcadero between manholes S38 and S39, 105-inch segments between manholes S47 and S50 Embarcadero in Jack London, and 105-inch segments in Downtown Oakland (S50S511, S53S541, and S54S551). These segments were put in service circa 1952 and 1954. The South Interceptor collects wastewater from the City of Oakland and conveys it to EBMUD's Main Wastewater Treatment Plant (MWWTP). The assessed segments of the South Interceptor are listed in Table 4-1.

Table 4-1. List of Assessed South Interceptor Segments

Count	Interceptor ID	Upstream MH	Downstream MH	Diameter (inches)	Approx. Length (feet)	Pipe Material	Year Constructed
1	S14S151	S14	S15	63	857	RCP	1954
2	S15S161	S15	S16	63	574	RCP	1954
3	S38S391	S38	S39	78	1,424	RCP	1952
4	S47S481	S47	S48	105	716	RCP(1)	1954
5	S48S491	S48	S49	105	393	RCP(1)	1954
6	S49S501	S49	S50	105	392	RCP(1)	1954
7	S50S511	S50	S51	105	326	RCP(1)	1954
8	S53S541	S53	S54	105	1,000	RCP(1)	1954
9	S54S551	S54	S55	105	299	RCP(1)	1954
				Total	**5,981**		

(1) Cast-in-place reinforced concrete pipe.

A map of the assessed segments of the South Interceptor is shown in Figure 4-1. Methods of assessment for the South Interceptor included CCTV, MSI, and manhole drop-downs.

Figure 4-1. Map of Assessed Alameda Interceptor Segments

4.1.1 CCTV Review and Visual Assessment

4.1.1.1 Coliseum Way Segments (S14 – S16)

The two (2) segments and 1,431 linear feet assessed along Coliseum Way were mostly in VANDA Level 3 condition, except for a section around manhole S15, which was in VANDA Level 4 to Level 5 condition.

The approximate 74-foot stretch of VANDA Level 5 condition straddles manhole S15 with 27 feet on the upstream side and 47 feet on the downstream side. This stretch of pipe exhibited exposed aggregate and exposed and corroded reinforcing steel on the upper half of the pipe. The extent of corrosion on the exposed reinforcing steel appeared to be severe in these sections with broken/missing bars in some areas. Some areas where the reinforcing steel bars were still present had deep artificial peaks and valleys that were created by corroded concrete extending past the bars. This suggests that most of the surface area of the bars is exposed to the highly corrosive environment, which generally indicates that the bars are corroded through or are close to being corroded through. There was a 10-foot section just downstream of S15 that exhibited wetness and infiltration away from joints at the crown of the pipe. This section was rehabilitated by EBMUD in November of 2022. A piece of the RCP removed from the repaired section showed that there was approximately two (2) inches of pipe wall remaining (nominal of 5.25 inches).

The VANDA Level 4 condition stretches approximately 67 feet more downstream from the severely corroded zone downstream of S15. This area is also characterized by exposed aggregate and exposed reinforcing steel; however, the extent of corrosion of the reinforcement did not appear to be as severe. Similarly, the VANDA Level 4 condition extends approximately 12 feet upstream from the severely corroded zone upstream of S15.

The rest of segments S14S151 and S15S161 were in much better condition with moderate surface damage and no exposed reinforcing steel present. It is presumed that the localized deterioration around manhole S15 is due to the turbulence caused by the City of Oakland trunk sewer that flows into manhole S15.

Photo 4-1 through Photo 4-8 show the typical and notable observations for the Coliseum Way segments of the South Interceptor.

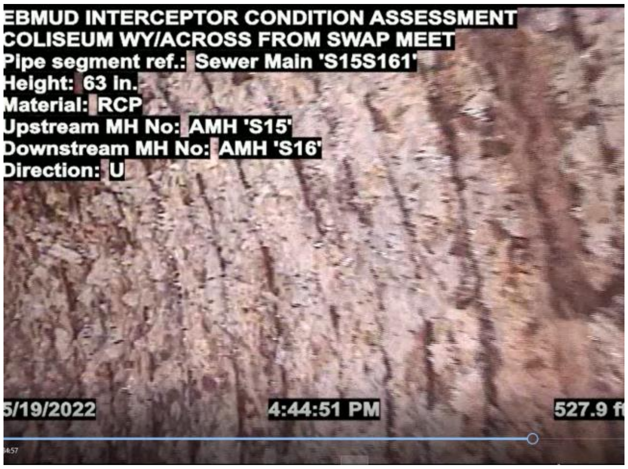


Photo 4-1. Severe VANDA Level 5 corrosion starts at appromately 47 feet downstream of S15

Photo 4-2. Missing reinforcing steel and wetness at crown of pipe up to approx. 10 feet downstream of S15

Photo 4-3. Wetness/dripping infiltration through pipe at crown just downstream of S15

Photo 4-4. Piece of RCP removed from just downstream of S15; approx. 2 inches of wall remained

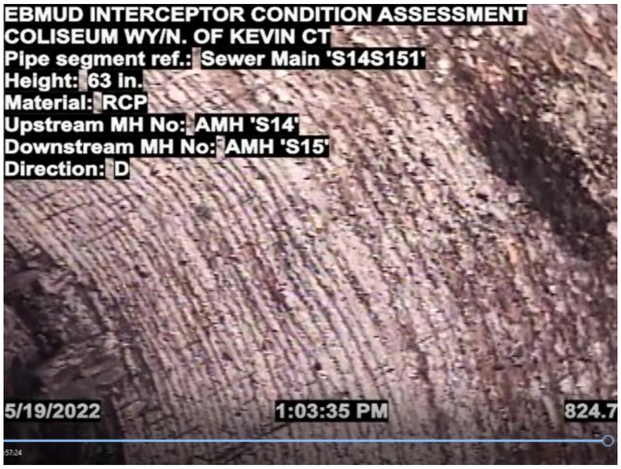


Photo 4-5. Severe corrosion (VANDA Level 5) started at approximately 12 feet from the upstream side of S15

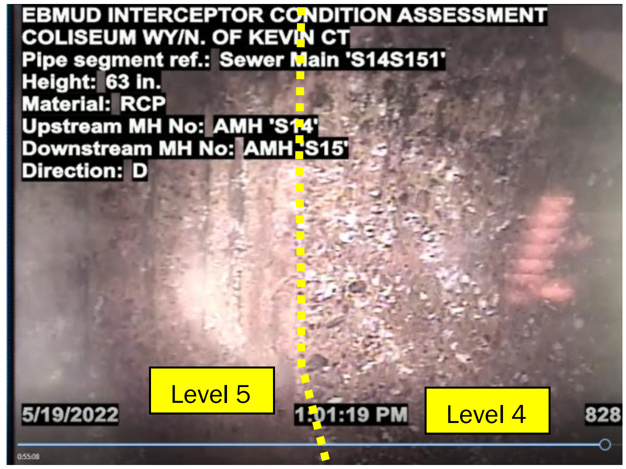


Photo 4-6. Approx. transision point between VANDA Level 4 to Level 5 at 12 feet upstream of S15

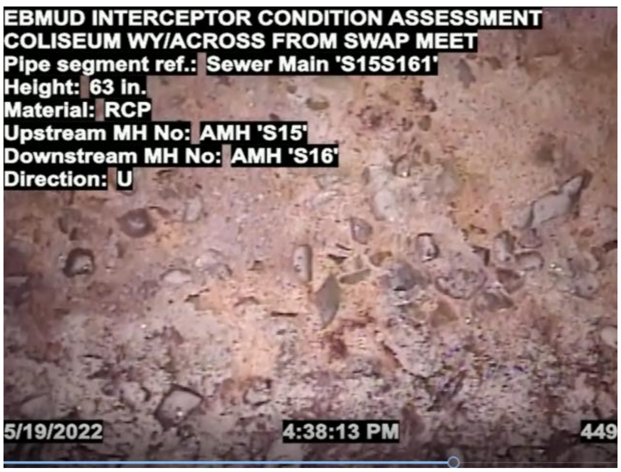


Photo 4-7. Yellowish concrete/exposed aggregate at the crown started at approximately 114 feet downstream of S15

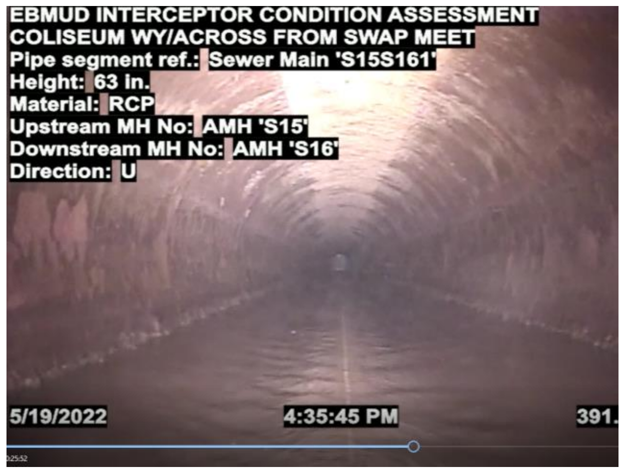


Photo 4-8. RCP in S14A151 and S15A161 mostly in VANDA Level 3 condition with moderate surface damage

4.1.1.2 Embarcadero East Segment (S38 – S39)

The one (1) segment and 1,424 feet assessed along Embarcadero East was in VANDA Level 2 condition due to minor surface damage. Surface roughness was prevalent and small diameter exposed aggregate was exposed at minimal frequency. No exposed reinforcing steel was observed. There was one location with weeping infiltration at a joint at 949 feet downstream from manhole S38.

Typical and notable observations on along Embarcadero East of the South Interceptor are shown in Photo 4-9 through Photo 4-12.

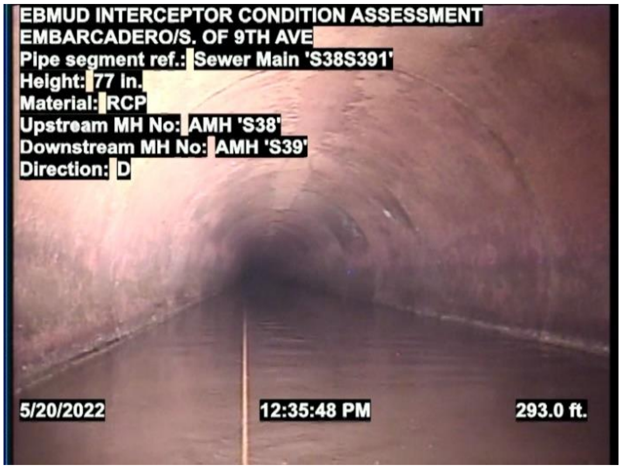


Photo 4-9. Typical minor surface damage in segment S38S391

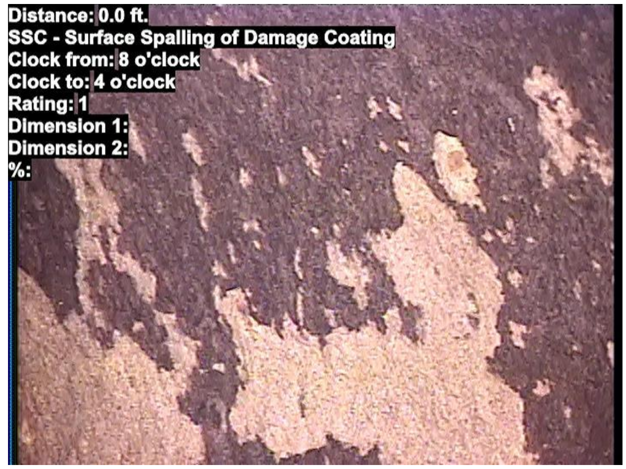


Photo 4-10. Close-up of typical minor surface damage in segment S38S391

Photo 4-11. Minor surface damage in segment S38S391 at manhole S39

Photo 4-12. Weeping infiltration at 949 feet downstream from S38

4.1.1.3 Embarcadero West and Broadway Segments (S47 – S51)

The four (4) segments and 1,827 feet assessed along Embarcadero West and Broadway were in VANDA Level 4 condition due to severe surface damage caused by biogenic corrosion. The 105-inch horseshoe-shaped cast-in-place concrete pipe was primarily characterized by yellowish-white concrete with exposed large-sized aggregate and exposed reinforcing steel at minimal frequency. The depth of concrete cover over the reinforcing steel should be 2.5 inches per record drawings (SD42 VG807); thus, the depth of corrosion has generally not reached the depth of the circumferential reinforcement. The exposed reinforcing steel occurred at the following locations:

- S47S481
  - 0 – 10 feet downstream of S47 at crown of pipe.
  - 364 feet downstream of S47 at crown of pipe near joint.
- S50S511
  - 0 – 5 feet downstream of S50 at crown of pipe.

Several joints had infiltration. Infiltration defects at joints are noted in NPS's NASSCO PACP reports in Appendix A.

The notable and typical observations for the 105-inch horseshoe-shaped pipe along Embarcadero West and Broadway are shown in Photo 4-13 through Photo 4-20.

Photo 4-13. Typical severely deteriorated yellowish-white surface of 105-inch pipe with exposed aggregate; S47S481 shown

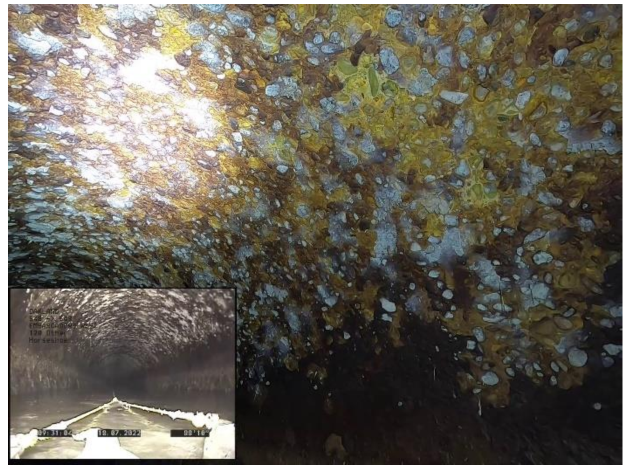


Photo 4-14. Typical severely deteriorated yellowish-white surface of 105-inch pipe with exposed aggregate; S48S491 shown

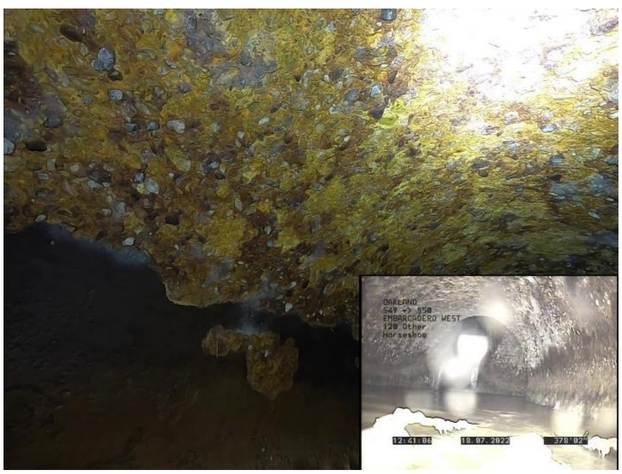


Photo 4-15. Typical severely deteriorated yellowish-white surface of 105-inch pipe with exposed aggregate; S49S501 shown

Photo 4-16. Typical severely deteriorated yellowish-white surface of 105-inch pipe with exposed aggregate; S50S511 shown

Photo 4-17. Exposed and corroded reinforcing steel from 0 – 10 feet downstream of S47

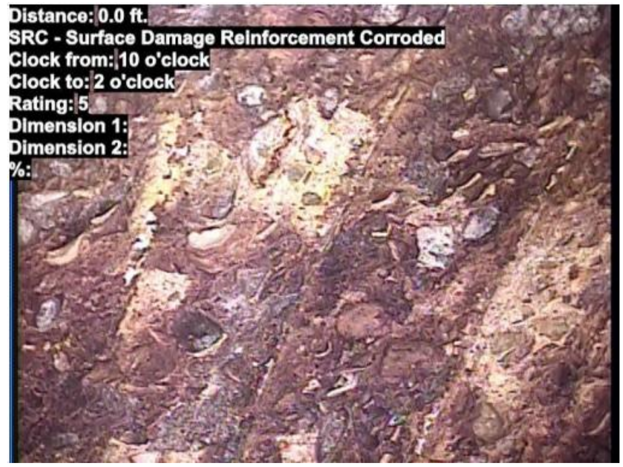


Photo 4-18. Exposed and corroded reinforcing steel from 0 – 10 feet downstream of S47

Photo 4-19. Isolated exposed reinforcing steel at 364 feet downstream of S47; near a joint

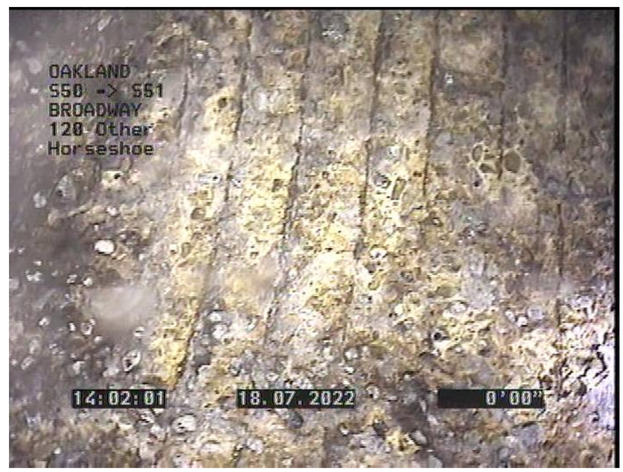


Photo 4-20. Exposed and corroded reinforcing steel from 0 – 5 feet downstream of S50

4.1.1.4 2nd Street Segments (S53 – S55)

The two (2) segments and 1,299 feet assessed along 2nd Street were in VANDA Level 4 condition due to severe surface damage caused by biogenic corrosion. The 105-inch horseshoe-shaped cast-in-place concrete pipe was primarily characterized by yellowish-white concrete with exposed large-sized aggregate.

Several circumferential cracks were observed on the pipe in segment S53S541. The cracks may be shrinkage cracks that are typical for cast-in-place structures, or they may be due to differential settlement. There were other observations that appeared to be cracks but may just be construction joints between the cast-in-place pipe sections. Apparent voids with infiltration were also observed in this section. The apparent voids with infiltration occurred away from joints and may be the result of inadequate consolidation during the initial cast. These cracks and spots of infiltration away from the joints do not appear to be as severe as what had occurred in the Buena Vista and Coliseum Way segments; however, they are worth mentioning for future monitoring, if not rehabilitation. These defects occurred at the following approximate locations:

- S53S541
  - Crack with infiltration at 76 feet downstream from S53.
  - Crack at 79 feet downstream from S53.
  - Crack at 699 feet downstream from S53
  - Void with infiltration at 914 feet downstream from S53
  - Void with infiltration at 920 feet downstream from S53
  - Void with infiltration at 942 feet downstream from S53

The notable and typical observations for the 105-inch horseshoe-pipe along 2nd Street of the South Interceptor are shown in Photo 4-21 through Photo 4-28. Infiltration defects at joints are shown in NPS's NASSCO PACP reports in Appendix A.

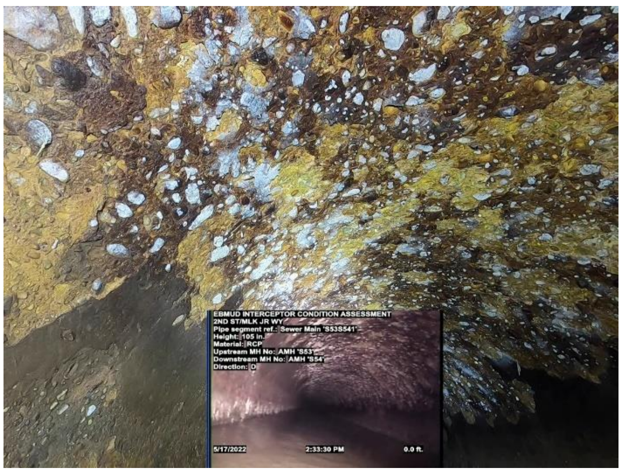


Photo 4-21. Typical severly deteriorated yellowish-white surface of 105-inch pipe with exposed aggregate; S53S541 shown

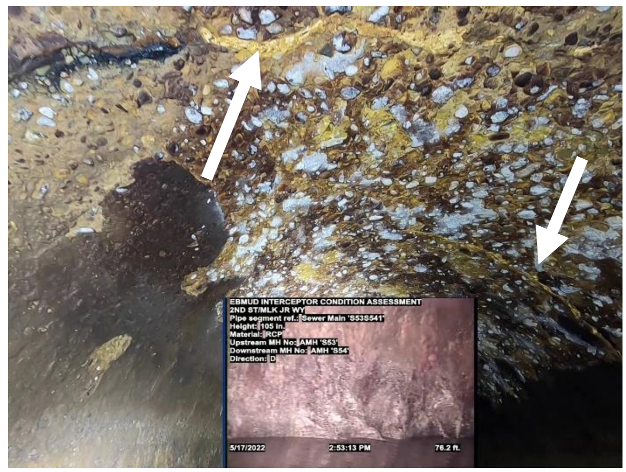


Photo 4-22. Circumferential cracks at 76 feet and 79 feet downstream from S53

Photo 4-23. Circumferential crack at 699 feet downstream from S53

Photo 4-24. Construction joint at 183 feet downstream of S53

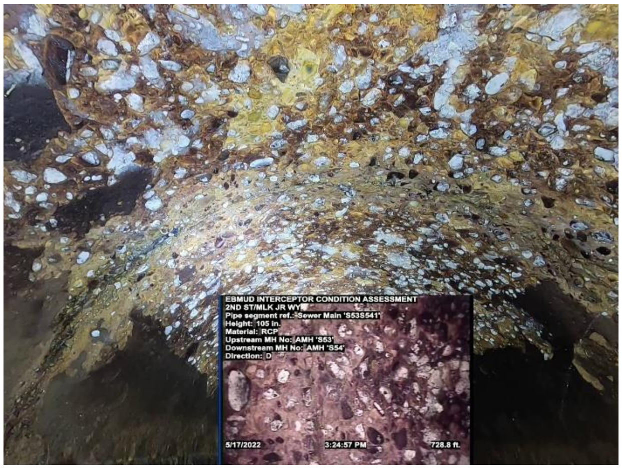


Photo 4-25. Construction joint at 729 feet downstream of S53

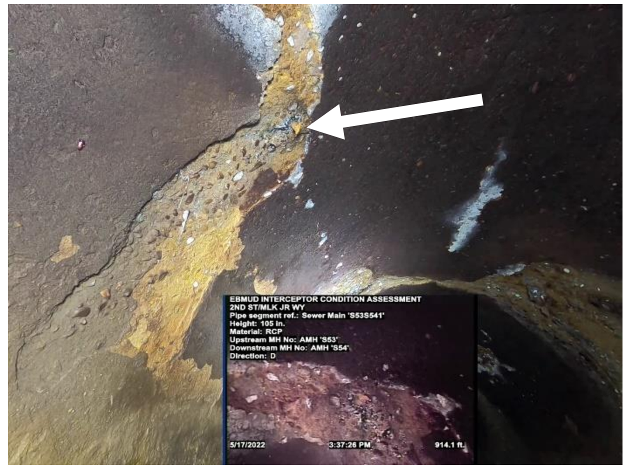


Photo 4-26. Small void with dripping infiltration at 914 feet downstream of S53

Photo 4-27. Voids with dripping infiltration at 920 feet downstream of S53

Photo 4-28. Voids with dripping infiltration at 942 feet downstream of S53

4.1.2 Physical Measurements

To assist with estimating the extent of corrosion overall, physical measurements on the pipe segments were obtained during the manhole drop-down assessments. These measurements include concrete pH, concrete penetration depth, SPR scans, and sediment measurements. The tests were only performed on the upstream or downstream pipe in manholes that were accessed for CCTV/MSI assessment and were accessible for physical entry.

The measurements were analyzed and compared with visual data to estimate the wall loss and remaining wall thickness for each segment. The results of the wall loss analysis are presented in Table 4-2. The estimated wall losses for segments S14S151 and S15S161 shown in the table are for the severe VANDA Level 5 section around manhole S14. A portion of this section was repaired by EBMUD in November 2022. The rest of the pipe in segments S14S151 and S15S161 had estimated wall losses of 0.25-inch and 0.5-inch, respectively.

Table 4-2. Physical Measurements and Wall Loss Analysis on South Interceptor Pipes

Interceptor ID	Diameter (Inches)	Surface pH	pH at Depth	Penetration Depth(1)	Nominal Pipe Wall Thickness(2), Inches	Estimated Wall Loss(3), Inches	Remaining Wall Thickness, Inches
S14S151(4)	63	4	10	1/16	5.25	3	2.25
S15S161(5)	63	--	--	--	5.25	3	2.25
S38S391	78	3	11	1/4	6.5	0.5	6
S47S481	105	2	11	1	10	2	8
S48S491	105	2	4	1	10	2	8
S49S501	105	2	6	2	10	2	8
S53S541	105	1	3	2	10	2	8

(1) Penetration depth to hard concrete measured from existing surface. Actual deterioration depth likely greater.

(2) Assumed pipe wall thickness based on review of as-builts.

(3) Based on penetration depth, estimated remaining thickness from SPR scans, and/or visual data.

(4) Values in table are presented for VANDA Level 5 condition near manhole S15 based on photos from repaired section. The majority of pipe was in VANDA Level 3 condition with 0.25-inch of estimated wall loss.

(5) Values in table are presented for VANDA Level 5 condition near manhole S15 based on photos from repaired section. The majority of pipe was in VANDA Level 3 to Level 4 condition with up to 0.5-inch of estimated wall loss.

4.1.3 MSI Results

During the week of May 16th, 2022, NPS performed an MSI assessment on some of the South Interceptor segments. Six (6) segments were assessed for a total of 4,787 linear feet. MSI has the ability to measure wall loss using laser above the water surface and sediment/debris levels using sonar below the water surface.

There are two primary types of measurements taken during the MSI laser and sonar scans. The laser scans measure the diameter of the existing pipe. When compared against the nominal pipe diameter, the difference between the two diameters provides the amount of wall thickness loss. Since the laser measures against the existing surface, the maximum corrosion wall loss may not aways be measured if there is debris or deteriorated concrete on the existing surface of the pipe.

The sonar scans provide a measure of the amount of sediment in the pipe, which can be helpful in determining if the capacity of a pipe is being diminished by debris or the extent of cleaning that may be required from an O&M perspective.

The data collected by the MSI scans are stitched together into 2-D (sonar) and 3-D (laser) representations of the deviations in pipe cross-section. The level of degradation is shown via colors with green denoting pipe that is largely nominal in thickness all the way to dark red, which indicates maximum wall loss observed. The subsequent sections provide some snapshots of the 3-D laser images. NPS's full MSI Assessment Report for the assessed segments is presented in Appendix B. Additionally, NPS provides 2-D and 3-D videos of the scans for viewing of the color-coded wall loss and sediment models.

Table 4-3 shows a summary of the MSI data for the assessed segments.

Table 4-3 Summary of Wall Thickness Loss Based on MSI Data

Pipeline Segment	Size of Pipe, Inches	Maximum Corrosion Over 1-foot Wide Scan (1), inch	Maximum Average Corrosion Over 1-foot Wide Scan (2), inch	Average Corrosion Over Entire Pipe
S14S151	63	4.3	2.3	1.2
S15S161	63	4.8	3.0	1.1
S38S391	78(3)	1.9	1.4	0.7
S47S481	105	5.9	3.4	1.3
S53S541	105	5.2	2.7	1.8
S54S551	105	4.3	2.2	1.0

(1) Maximum depth of corrosion in 1-foot section of pipe. These measurements can be deep gaps at joints, and may not be true representation of wall thickness loss.

(2) Maximum average corrosion for 1-foot section of pipe. Most representative value to compare across each 1-foot section of pipe.

(3) As-built dimension is shown as 78-inch diameter; model was run at 80-inch diameter. Thus, corrosion loss values from MSI may be higher since pipe surface appeared to be good throughout video and physical measurements at S38 and S39 only indicate approximately 0.5 inches of wall loss.

Based on the MSI results, available physical measurements, and V&A's experience in evaluating concrete corrosion in sewers, the following observations are presented to EBMUD for consideration when reviewing the MSI data for these segments:

- The maximum corrosion values in the table may not be representative of maximum wall loss due to the laser measuring joint gaps as well as the laser measuring against a soft, deteriorated surface that is often not sound concrete. The former seems to be more of a concern as the maximum values appear to be significantly greater than the observed wall losses, which can also skew the maximum average corrosion values.
- Although the maximum average corrosion values can be skewed by the artificial maximum corrosion values, the maximum average corrosion values appear to provide a good indication of the extent of corrosion, when compared with the estimated wall losses based on the physical measurements. In any case, the maximum average corrosion values provide a good indication of where the pipe may be experiencing the most corrosion along the length of the assessed pipe.
- Wall loss values from MSI should be compared with other data sets such as visual data and physical data when possible.
- Odd-shaped pipes, such as the 105-inch horseshoe-shaped South Interceptor, presents another variable to contend with while calculating wall thickness losses from laser data.
- MSI data would be useful for tracking corrosion wall loss over time.

The debris and sediment levels in the South Interceptor segments assessed with MSI are presented in Table 4-4. NPS's full MSI Assessment Report for the assessed segments is presented in Appendix B.

Table 4-4 Summary of Debris Levels Based on MSI Data

Pipeline Segment	Average Depth of Debris (inches)	Debris Volume (cubic feet)	Debris per foot of pipe (cubic feet)
S14S151	3.6	420.0	0.5
S15S161	2.5	164.0	0.3
S38S391	3.0	586.0	0.4
S47S481	N/A(1)	N/A	N/A
S53S541	9.2	6534.0	6.7
S54S551	14.3	2953.0	10.5

(1) Sonar head was obscured by rags or other debris. Thus, no sonar data was obtained.

4.1.3.1 S14 – S16 (S14S151 and S15S161)

The laser scans both ended at manhole S15 because traversing the manhole wasn't possible due to the cascading flows from the large City of Oakland trunk sewer. The condition of the pipe was much better outside of the affected zone (see Section 4.1.1) around manhole S15 (Figure 4-2 and Figure 4-3).

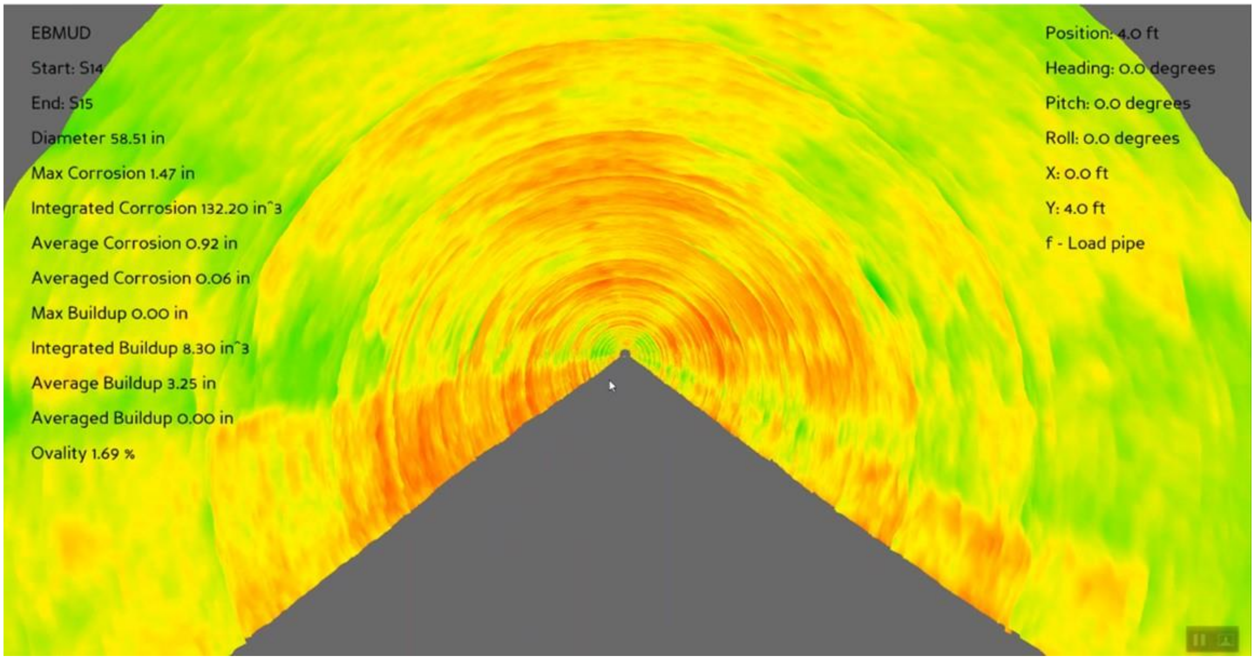


Figure 4-2. Laser Scan Still from S14 – S15 Scan @ 4.0 feet Downstream from S14

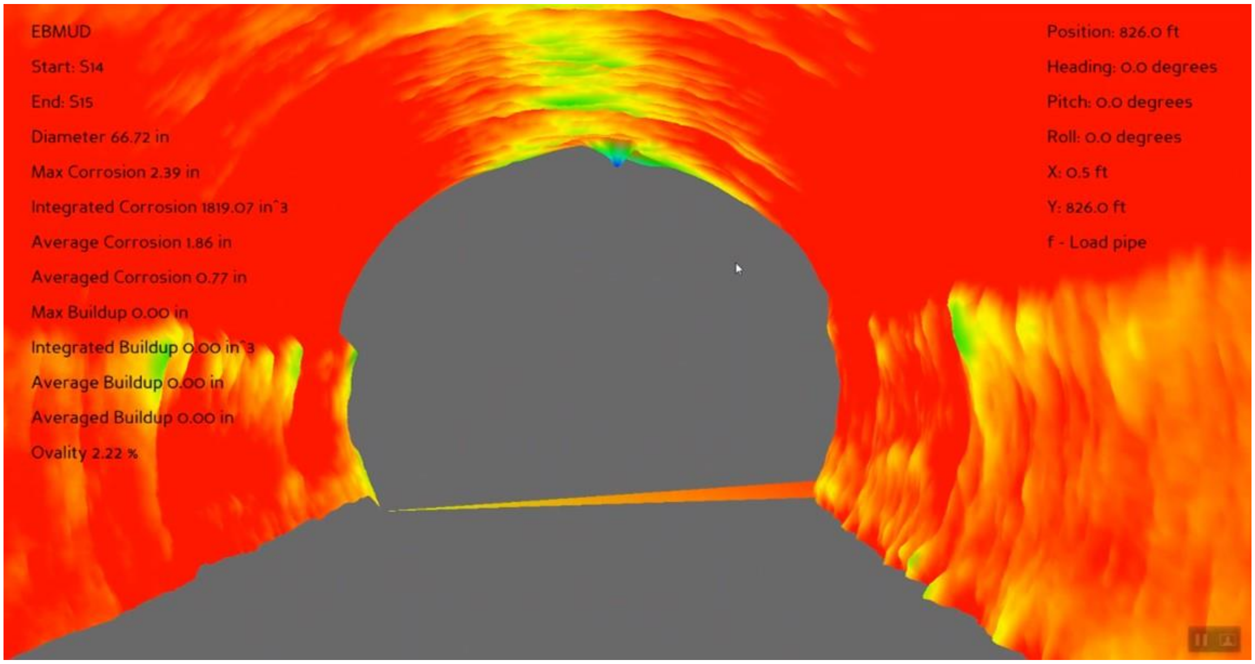


Figure 4-3. Laser Scan Still from S14 – S15 Scan @ 826 feet Downstream From S14, Approaching S15

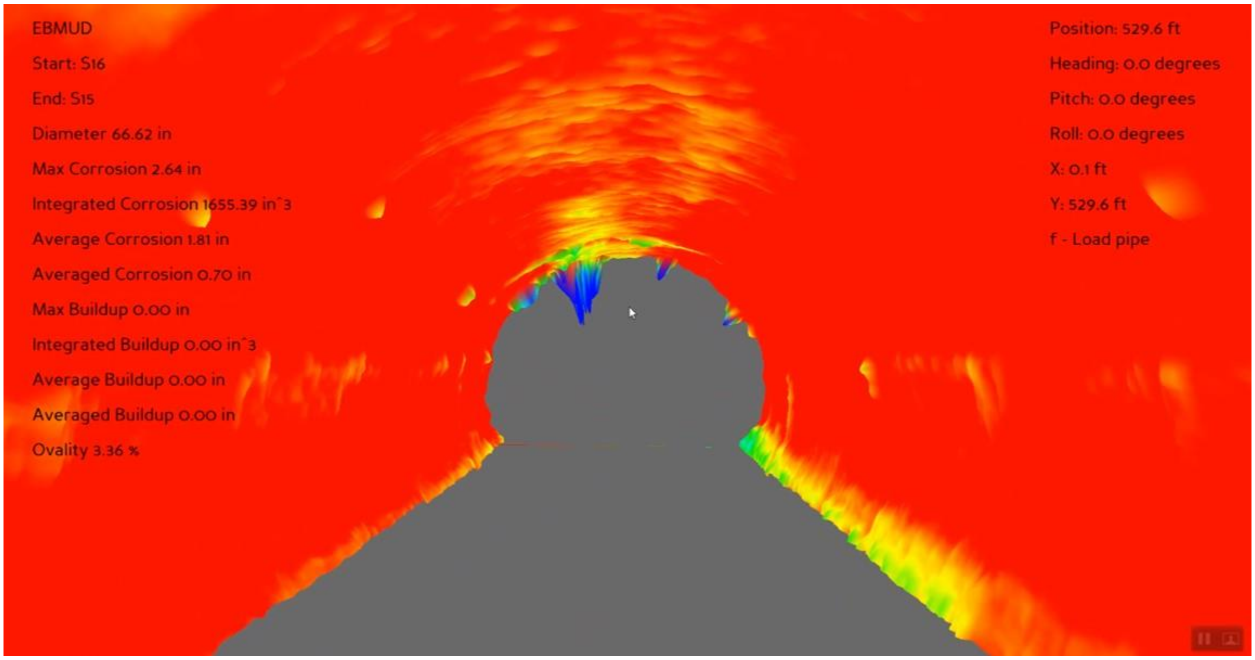


Figure 4-4. Laser Scan Still from S16 – S15 Scan @ 530 Feet Upstream From S16, Approaching S15

4.1.3.2 S38 – S39 (S38S391)

This section of the EBMUD interceptor runs along the Oakland-Alameda Estuary south of downtown Oakland and is downstream of a siphon. This segment is mostly green and yellow (Figure 4-5, Figure 4-6).

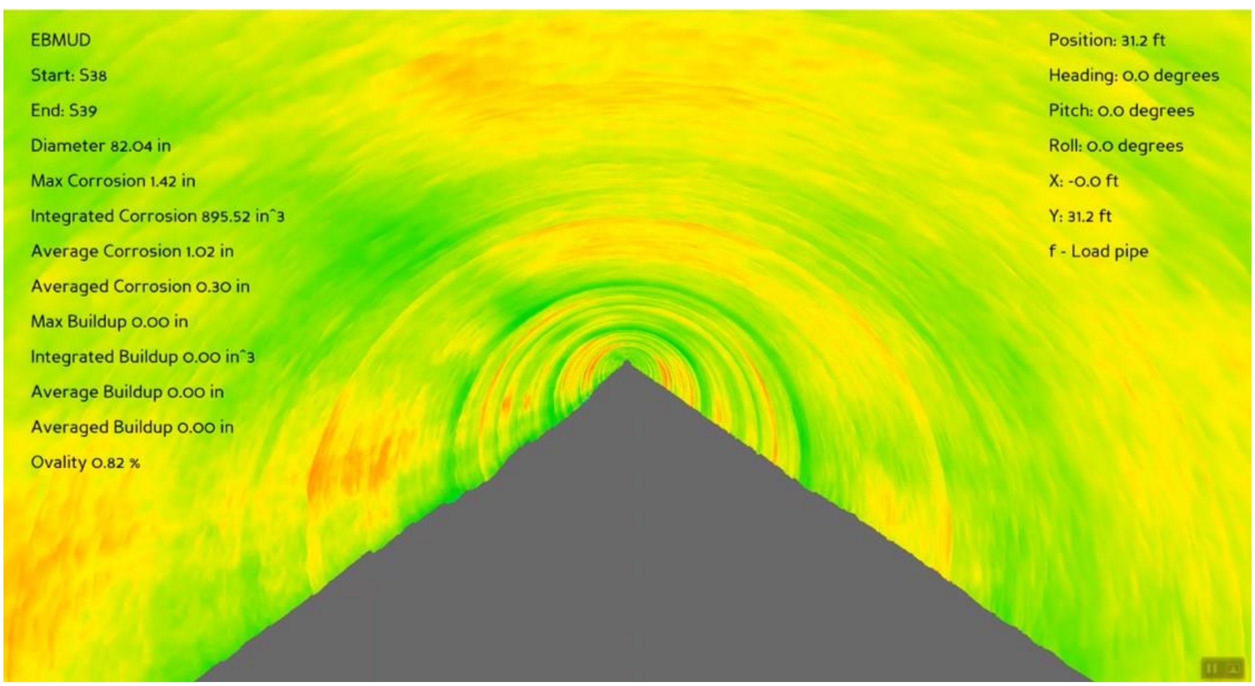


Figure 4-5. Laser Scan Still from S38 – S39 Scan @ 31.2 feet (almost @ beginning of scan)

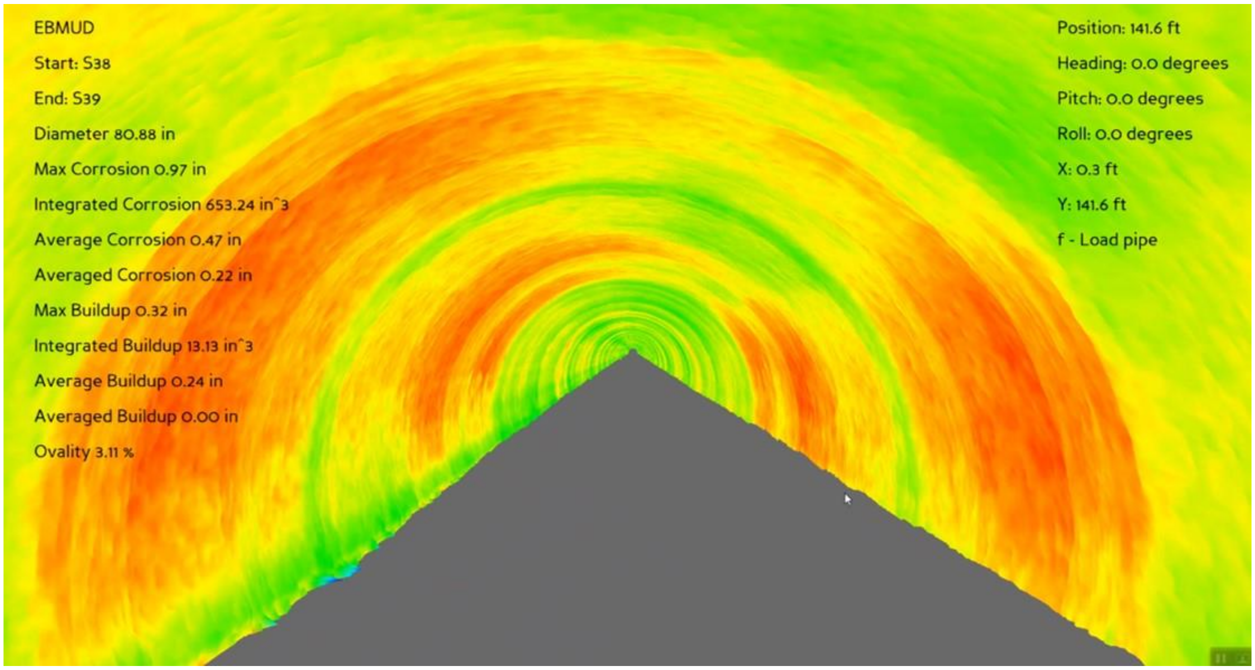


Figure 4-6. Laser Scan Still from S38 – S39 Scan @ 141.6 feet (almost @ end of scan)

4.1.3.3 S47 – S48 (S47S481)

This section was a fairly important section to be assessed as it runs next to several active train lines. Structure S47 is also where the Alameda interceptor ties into the South Interceptor. This confluence can sometimes lead to excessive turbulence, which can lead to corrosion. This section had the most corrosion wall loss according to the MSI laser scan (Figure 4-7). This is reinforced by findings during a manned entry into S47, where large diameter aggregate with soft concrete underneath was observed. As seen in the CCTV video and in the laser scans further downstream, the condition of the pipe improves closer to S48 (Figure 4-8).

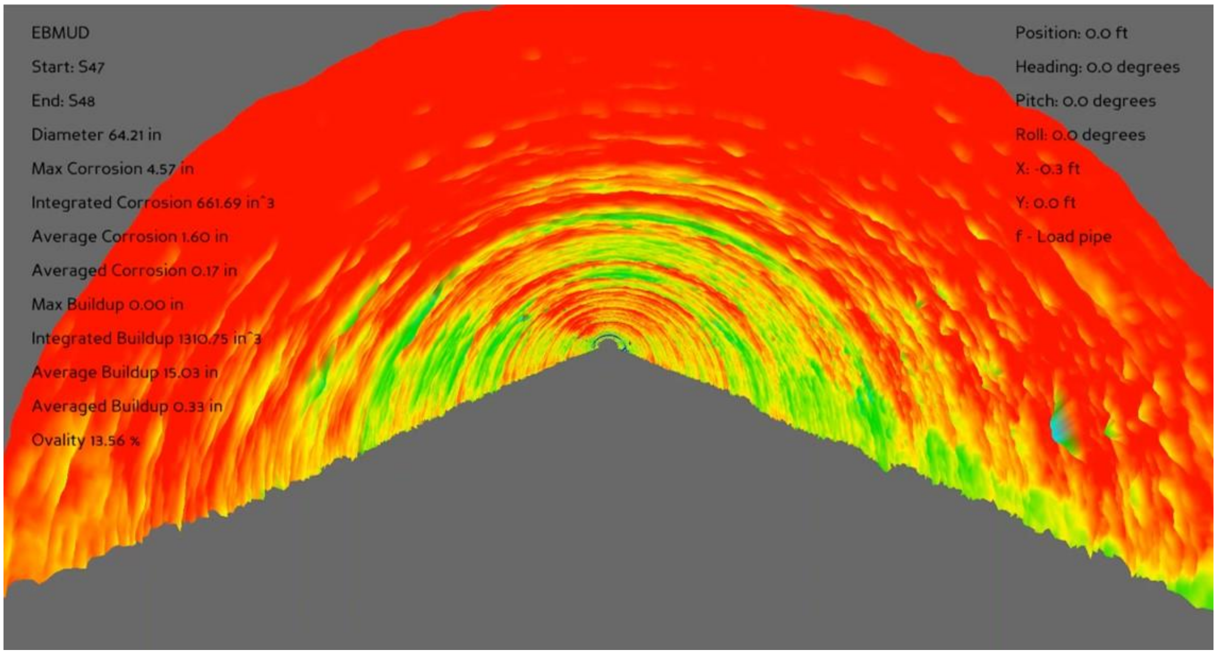


Figure 4-7. Laser Scan Still from S47 – S48 Scan @ at Manhole S47

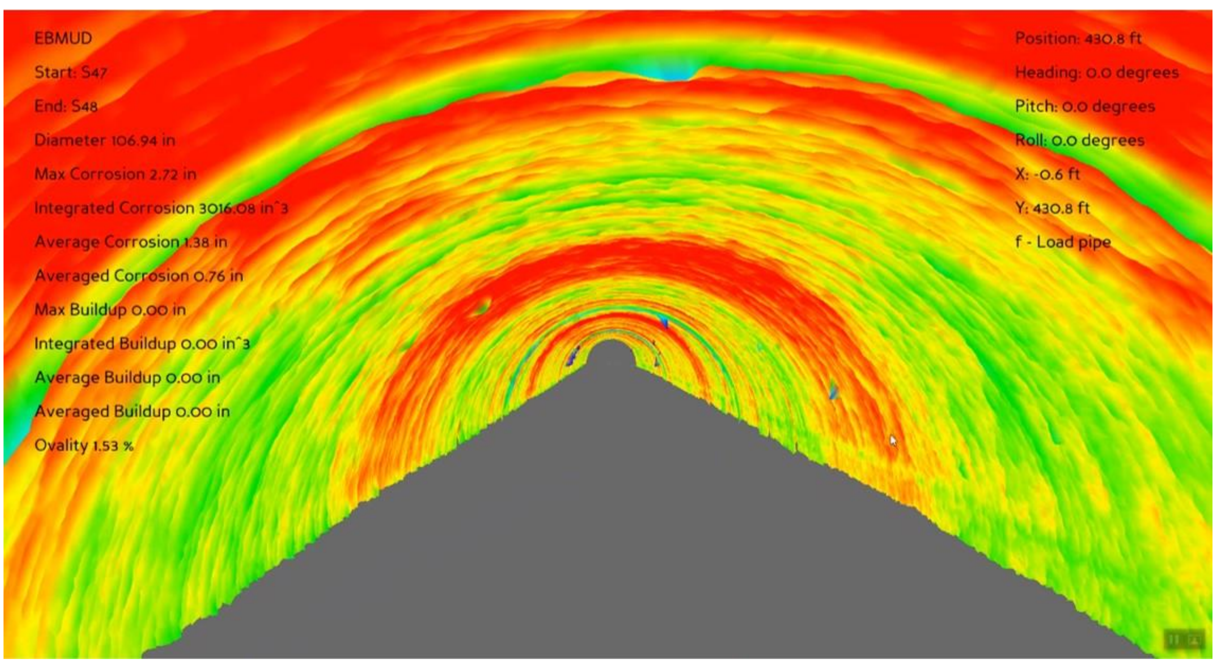


Figure 4-8. Laser Scan Still from S47 – S48 Scan @ 431 feet from S47

4.1.3.4 S53 – S55 (S53S541 and S54S551)

This section was completed in two runs. In general, according to review of the CCTV videos, the pipe had experienced severe degradation with medium and large diameter exposed aggregate but no exposed reinforcing steel. The degradation appeared to be most severe near manholes S54 and S55. The shelf that begins to form near the mean water line of the pipe as the pipe walls above the water line corrode can be seen in Figure 4-9. This section exhibited the largest amount of raw degradation and the most debris buildup in the pipeline. The scan can also determine later locations (Figure 4-10).

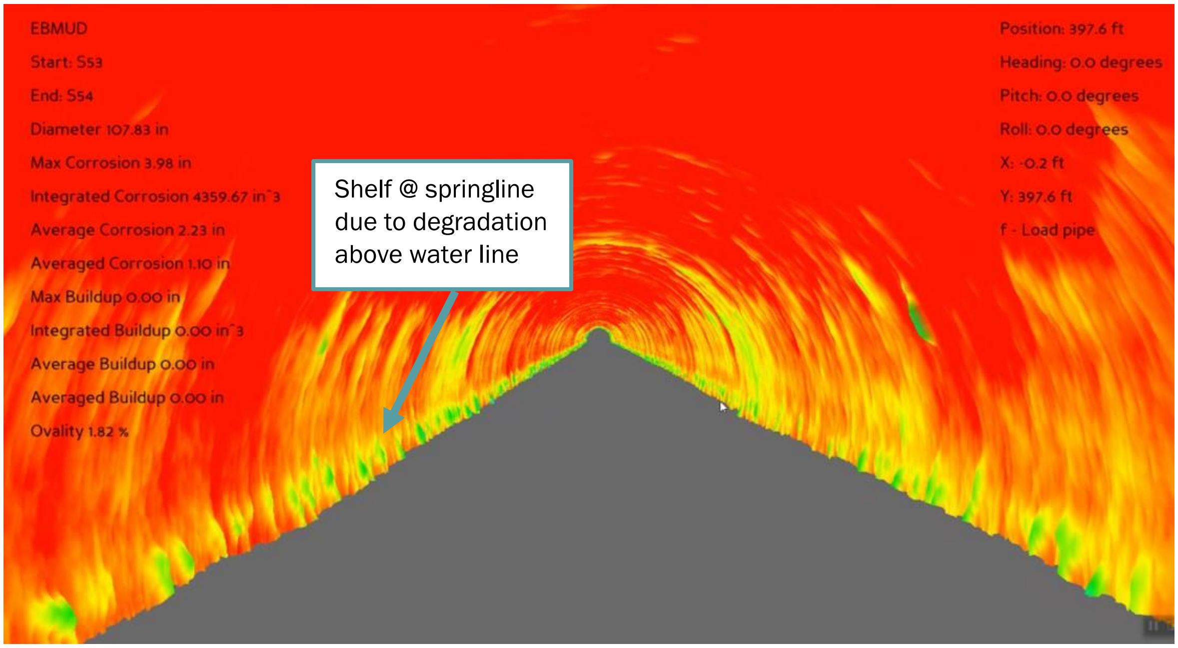


Figure 4-9. Laser Scan Still from S53 – S54 Scan at 398 feet downstream from S53

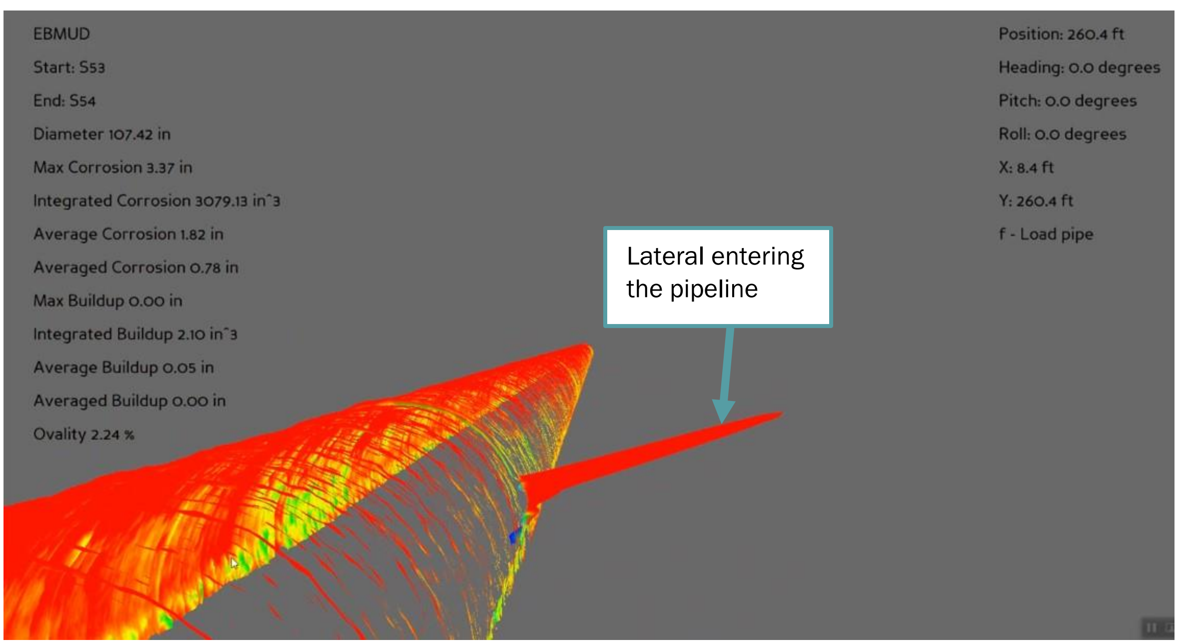


Figure 4-10. Laser Scan Still from S53 – S54 Scan – Lateral Entering Pipe

4.1.4 Interceptor Pipe Condition Summary

The overall conditions of the assessed South Interceptor segments are summarized in Table 4-5.

Table 4-5. South Interceptor Pipe Condition Summary

Interceptor ID	Remaining RCP Wall Thickness[(1)], %	VANDA Rating	Remarks
S14S151	43%, 95%	5, 3	Mostly in VANDA Level 3 condition, except for 27 feet upstream of manhole S15, which was in VANDA Level 5 condition.
S15S161	43%, 90%	5, 3 to 4	Mostly in VANDA Level 3 to Level 4 condition, except for 47 feet downstream of manhole S15, which was in VANDA Level 5 condition; VANDA Level 4 condition extends 67 feet downstream
S38S391	96%	2	Minor deterioration with minimal surface roughness and small diameter aggregates exposed
S47S481	80%	4	Severely deteriorated concrete; estimated concrete loss = 2 inches; reinforcing steel exposed at manhole S47 and at 347 feet downstream; more deterioration near S47 due to turbulence from Alameda Interceptor; infiltration at some joints
S48S491	80%	4	Severely deteriorated concrete; estimated concrete loss = 2 inches; no exposed reinforcing steel; infiltration at some joints
S49S501	80%	4	Severely deteriorated concrete; estimated concrete loss = 2 inches; no exposed reinforcing steel; infiltration at some joints
S50S511	80%	4	Severely deteriorated concrete; estimated concrete loss = 2 inches; no exposed reinforcing steel; infiltration at some joints
S53S541	80%	4	Severely deteriorated concrete; estimated concrete loss = 2 inches; no exposed reinforcing steel; three circumferential cracks; three apparent voids with infiltration; infiltration at some joints
S54S551	80%	4	Severely deteriorated concrete; estimated concrete loss = 2 inches; more deteriorated near S55; no exposed reinforcing steel; infiltration at some joints

(1) The remaining wall thickness were based on physical measurements, visual assessment data, and/or MSI data.

4.2 Manhole Condition

The following section summarizes the results of the manhole conditions for the South Interceptor. The manholes assessed included S14, S15, S16, S38, S39, S47, S48, S49, S50, S51, S53, S54, and S55.

4.2.1 Visual Assessment

The interior of the manhole was visually assessed using photographs to document the condition and capture corrosion observations of the concrete surfaces. The conditions were rated using the VANDA® Concrete Condition Index.

A summary of the visual assessment results for each manhole is provided in Appendix C. Representative photos of the South Interceptor manhole conditions are shown in Photo 4-29 through Photo 4-38. The surface condition ranged from VANDA Level 1 to VANDA Level 4.

- Manholes S14, S16, S38, and S39 were in fair condition with moderate surface damage (VANDA Level 3).
- Manholes S48, S49, S50, S53, and S54 had moderate to severe surface damage and loss of mortar lining (VANDA Level 4). Up to 1 inch layer of crumbly concrete present on surface.
- Manhole S15 had exposed reinforcing steel and soft concrete on the wall and ceiling (VANDA Level 4).
- Manhole S47 had spalled concrete on the walls and ceiling with large, exposed aggregate (VANDA Level 4). The concrete would fall off in sheets when hit with light force. This manhole may have been rehabilitated in the past, and the repaired layer may have delaminated from the original layer.
- Manhole S51 had up to four (4) inches of soft concrete (VANDA Level 4). Similar to S47, the concrete would fall off in sheets when hit with light force. This manhole may have been rehabilitated in the past, and the repaired layer may have delaminated from the original layer.
- Manhole S55 was lined with PVC and was in good condition (VANDA Level 1).

Photo 4-29. MH S48. Manhole walls in good condition.

Photo 4-30. MH S16. Minor surface damage on the manhole bench.

Photo 4-31. MH S53. Moderate surface damage and loss of mortar lining of bench.

Photo 4-32. MH S48. Moderate surface damage and lose of mortar lining of manhole bench.

Photo 4-33. MH S15. Severe surface damage on upper section of manhole, soft concrete surface.

Photo 4-34. MH S15. Loss of concrete mortar and damage to reinforcement on manhole walls.

Photo 4-35. MH S47. Spalled concrete and exposed on manhole ceiling.

Photo 4-36. MH S47. Spalled concrete and exposed aggregate on manhole wall.

Photo 4-37. MH S51. Spalled concrete and exposed on manhole ceiling.

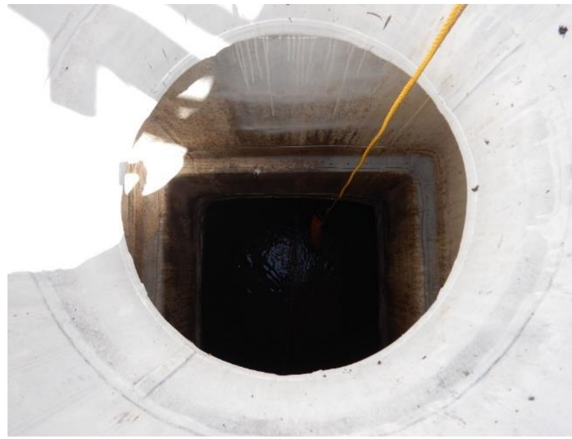


Photo 4-38. MH S55. PVC lined manhole structure in good condition.

4.2.2 Physical Measurements

The surface pH and penetration measurements for the South Interceptor manholes are summarized in Table 4-6. The surface pH ranged from 1 to 5 on the surface, which indicates a lightly to severely corrosive environment for concrete. The penetration depths ranged from ¼-inch to 2-inch deep, indicating severe scaling and degradation due to hydrogen-sulfide-induced acid-attack.

Table 4-6. Summary of pH and Penetration Measurements for the South Interceptor Manholes

Structure	Location	Surface pH	Depth pH	Penetration Depth (inch)	Degree of Corrosivity
Manhole S14	Lower wall	5	10	¾	Light
Manhole S15	Upper wall	1	8	1	Severe
Manhole S16	Lower wall	2	10	1	Severe
Manhole S16	Upper wall	3	10	¼	Severe
Manhole S38	Lower wall	2	11	1	Severe
Manhole S38	Lower wall	1	9	1	Severe
Manhole S39	Upper wall	4	10	3/8	Moderate
Manhole S39	Lower wall	2	11	1	Severe
Manhole S47	Upper wall	3	4	1	Severe
Manhole S47	Lower wall	3	11	½	Severe
Manhole S47	Ceiling	2	10	½	Severe
Manhole S48	Upper wall	2	12	¾	Severe
Manhole S48	Lower wall	2	11	1	Severe
Manhole S50	Upper wall	1	3	2	Severe
Manhole S51	Upper wall	1	5	2	Severe
Manhole S54	Lower wall	1	11	1	Severe
Manhole S54	Upper wall	1	4	1	Severe

Table 4-7 presents the SPR data recorded on the concrete walls and ceiling of the South Interceptor manholes. Several scan locations shown in red text had an average concrete cover depth less than the 2-inch minimum requirement per ACI 350 (some locations had concrete loss). The average spacing of the scanned locations are below or just slightly above the design maximum spacing of 12 inches required by ACI 350 to mitigate flexural cracking. The SPR measurements are presented in Appendix D.

Table 4-7. Summary of SPR Measurements for the South Interceptor Manholes

Manhole	Location	Bar Direction	Depth Max	Depth Avg	Depth Min	Space Max	Space Avg	Space Min
S14	East wall	Vertical	5.7	5.4	5.2	11.7	11.0	10.4
S14	East wall	Horizontal	4.5	4.3	4.1	7.7	7.2	6.3
S15	West wall	Horizontal	1.8	1.1	0.7	7.7	6.5	4.7
S15	West wall	Vertical	0.5	0.4	0.3	-	3.3(1)	-
S16	East wall	Vertical	3.7	3.5	3.5	12.7	12.0	11.5
S16	East wall	Horizontal	5.3	4.8	4.4	9.0	7.6	5.8
S38	East wall	Horizontal	3.7	3.2	3.0	30.6(2)	14.5	5.9
S38	East wall	Vertical	-	4.2	-	-	-(3)	-
S39	East wall	Vertical	5.5	5.3	5.0	-	11.0(1)	-
S39	East wall	Horizontal	2.0	1.8	1.5	6.5	5.2	3.0
S39	Ceiling	North-- South	4.7	4.6	4.5	18.2(2)	12.5	6.9
S39	Ceiling	East-- West	3.5	3.3	3.0	18.7(2)	9.9	4.3
S47	North wall	Vertical	3.1	3.0	2.9	5.9	4.9	3.8
S47	North wall	Horizontal	4.5	4.4	4.3	8.6	8.5	8.5
S47	Ceiling	North to South	3.7	3.5	3.2	11.1	10.9	10.8
S47	Ceiling	East to West	5.2	4.7	4.4	14.3	9.6	4.9
S48	West wall	Vertical	3.0	2.8	2.7	-	11.2(1)	-
S48	West wall	Horizontal	2.3	2.3	2.2	5.6	4.2	2.8
S53	East wall	Vertical	1.4	1.3	1.3	6.8	4.1	2.8
S54	North wall lower box	Horizontal	7.0	6.3	5.7	13.1	10.0	8.2
S54	North wall lower box	Vertical	5.3	4.9	4.5	11.8	10.7	9.6

(1) Only two bars scanned.
(2) The max values of 30.6, 18.2, and 18.7 appear to be valid. They are the result of two bars within the scan that appear to have an anomalous spacing. Bars may have shifted during construction.
(3) Only one bar scanned.
(3) Red text indicates depth of cover and spacing values that are more than 10% less than the minimum 2-inch depth of cover or more than 10% of the 12-inch maximum design spacing.

4.2.3 Manhole Condition Summary

Taking the visual and physical assessment results into account, the overall condition of each manhole is summarized in Table 4-8.

Table 4-8. South Interceptor Manhole Condition Summary

Structure	VANDA Rating	Overall Condition Summary
Manhole S14	3	Moderate surface damage with exposed aggregate.
Manhole S15	4	Severe surface damage with soft concrete up to 3 inches and exposed and corroded reinforcing steel.
Manhole S16	3	Moderate surface damage with exposed aggregate.
Manhole S38	3	Moderate surface damage with exposed aggregate.
Manhole S39	3	Moderate to severe surface damage with up to 1 inch of degradation.
Manhole S47	4	Severe surface damage with 1 – 2-inch sheets of concrete falling away may be repair material. An additional 1 inch of soft concrete exists beneath the crumbly sheets of concrete.
Manhole S48	4	Moderate to severe surface damage with exposed aggregate. No reinforcing steel observed; however, rust-colored stains observed on mortar.
Manhole S49	4	Severe surface damage with 1-inch layer of crumbly concrete present. No exposed reinforcing steel.
Manhole S50	4	Severe surface damage with 1-inch layer of crumbly concrete present. No exposed reinforcing steel.
Manhole S51	4	Severe surface damage with 1 – 2-inch sheets of concrete falling away may be repair material. An additional 0.5 to 1 inch of soft concrete exists beneath the crumbly sheets of concrete.
Manhole S53	4	Severe surface damage with 1-inch layer of crumbly concrete present. No exposed reinforcing steel, but bars may be hidden beneath soft concrete.
Manhole S54	4	Severe surface damage with 1 – 2-inch sheets of concrete falling away may be repair material. An additional 0.5 to 1 inch of soft concrete exists beneath the crumbly sheets of concrete.
Manhole S55	1	Lined with PVC and in good condition.

5 North Interceptor

5.1 Interceptor Pipe Condition

The 11 segments of the North Interceptor that were assessed are located along the Interstate 80 corridor in Berkeley and Emeryville, California. The segments are 66-inch diameter RCP with the exception of N27N281, which is a double barrel 33-inch diameter siphon. These segments were put in service circa 1953. The North Interceptor collects wastewater from the cities of Albany, Berkeley, Emeryville, Oakland, and Piedmont, and the Stege Sanitary District. The assessed segments of the North Interceptor are listed in Table 5-1.

Table 5-1. List of Assessed North Interceptor Segments

Count	Interceptor ID	Upstream MH	Downstream MH	Diameter (inches)	Approx. Length (feet)	Pipe Material	Year Constructed
1	N20N211	N20	N21	66	464	RCP	1953
2	N21N221	N21	N22	66	871	RCP	1953
3	N26N271	N26	N27	66	1022	RCP	1953
4	N27N281(1)	N27	N28	30	32	RCP	1953
5	N28N291	N28	N29	66	188	RCP	1953
6	N29N301	N29	N30	66	1161(2)	RCP	1953
7	N30N311	N30	N31	66	1084	RCP	1953
8	N31N321	N31	N32	66	320	RCP	1953
9	N32N331	N32	N33	66	102	RCP	1953
10	N33N341	N33	N34	66	1581	RCP	1953
11	N34N351	N34	N35	66	432	RCP	1953
12	--	Unknown(3)	N32	24	10(3)	VCP	Unknown
				Total	7,257		

(1) Record drawing VG319 shows segment as twin 30-inch pipes; however, CCTV video shows a reinforced concrete box structure.

(2) Assessed 680 feet from manhole N29 and 349 feet from manhole N30, which leaves an unassessed portion of 132 feet in the middle of the segment.

(3) EBMUD manhole with unknown manhole ID. 24-inch VCP assessed from this manhole, which is located in the parking lot of an apartment complex just to the east of N32, to N32 located on the shoulder of Interstate 80. 10 feet not included in total footage assessed.

A map of the assessed segments of the North Interceptor is shown in Table 5-1. Methods of assessment for the North Interceptor included CCTV and manhole drop-downs.

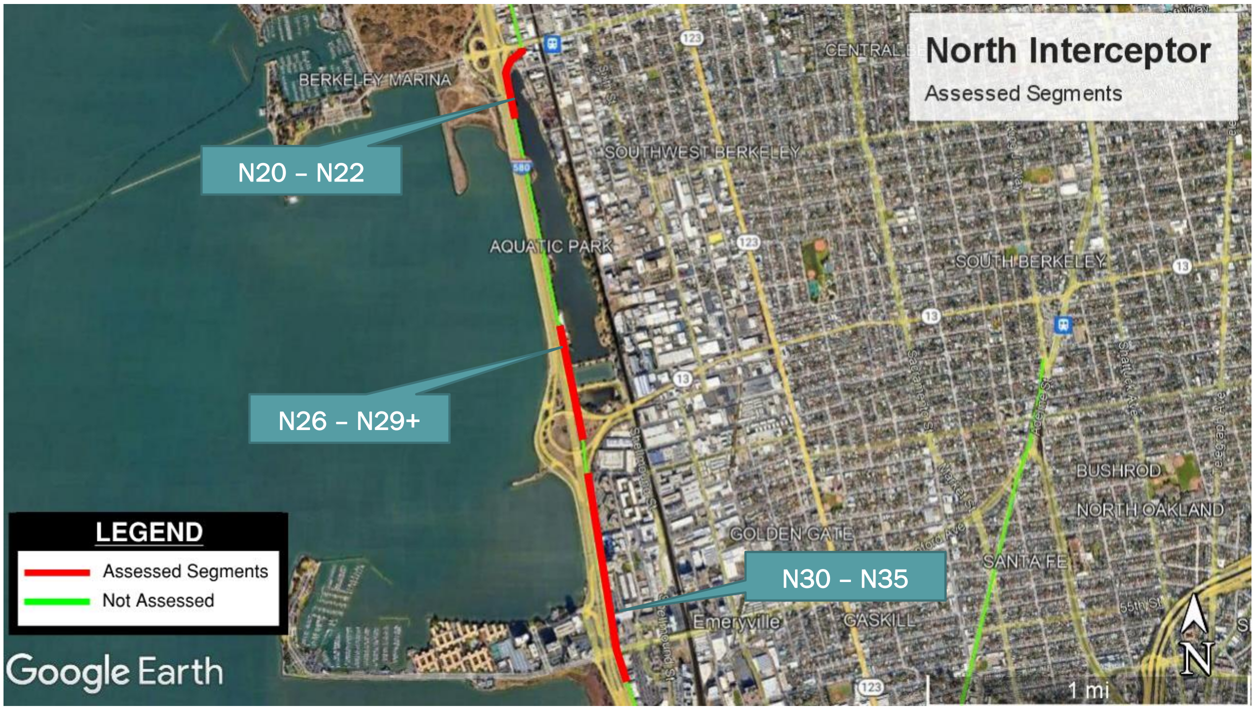


Figure 5-1. Map of Assessed North Interceptor Segments

5.1.1 CCTV Review and Visual Assessment

The 11 segments and 7,257 linear feet of the North Interceptor assessed along the Interstate 80 corridor were mostly in VANDA Level 2 to Level 3 condition, except for a few isolated sections of VANDA Level 4 to Level 5 conditions. The Level 4 to Level 5 conditions were generally characterized with exposed reinforcing steel, while the Level 2 to Level 3 conditions were characterized by minor to moderate surface roughness with minimal to frequent exposed aggregate, respectively.

The VANDA Level 4 and Level 5 conditions were observed in the following locations and were mostly near connections with large inlet pipes that cause turbulence (only exceptions are in N27N281, N29N301, and N30N311):

- N20N211 – Up to 12 feet downstream of manhole N20. Severe VANDA Level 5 deterioration with exposed and corroded reinforcing steel from the 12:00 to 4:00 clock positions (facing upstream).
- N27N281 – At 15 feet downstream from manhole N27. Exposed reinforcing steel and corrosion staining present on crown of one of siphon pipes, indicating VANDA Level 4 condition. Infiltration at wall/ceiling interface.
- N29N301
  - At 112 feet to 119 feet downstream from manhole N29. Severe VANDA Level 4 condition with exposed reinforcing steel at the crown from 1:00 to 11:00 clock positions.
  - At 528 feet to 535 feet downstream from manhole N29. Severe VANDA Level 4 condition with exposed reinforcing steel at the crown from 12:00 to 3:00 clock positions (facing downstream).
- N30N311 – At 887 feet upstream from N31. Appears to be small area of isolated occurrence possibly due to shallow concrete cover over the bars.

- N32N331 – At 8 feet to 20 feet downstream of N32. Severe VANDA Level 5 deterioration with exposed and corroded reinforcing steel from the 12:00 to 2:00 clock positions (facing downstream).
- N33N341
  - Up to 10 feet downstream of manhole N33. Severe VANDA Level 4 condition with exposed reinforcing steel at the crown from 1:00 to 11:00 clock positions.
  - Up to 10 feet upstream of manhole N34. Severe VANDA Level 4 condition with exposed reinforcing steel at the crown from 10:00 to 12:00 clock positions.
- N34N351 – At 318 feet upstream of manhole N35 to manhole N34. Severe VANDA Level 5 deterioration with exposed and corroded reinforcing steel from the 10:00 to 1:00 clock positions (facing upstream).

Though the observations above indicate severe corrosion and exposed/corroded reinforcing steel, there did not appear to be any abnormal wet spots or infiltration within the corroded areas that would indicate a potential impending failure.

The rest of the segments were in much better condition with minor to moderate surface damage and no exposed reinforcing steel present. However, there were several locations with infiltration, encrustations, grease, and other O&M type of observations within these segments.

A short 10-foot section of 24-inch VCP connecting an unknown (unidentified) EBMUD manhole to manhole N32 was also assessed per EBMUD's request. The 24-inch VCP pipe and drop connection to the North Interceptor appeared to be in good condition. Figure 5-2 shows an aerial view of the unknown manhole relative to the North Interceptor.

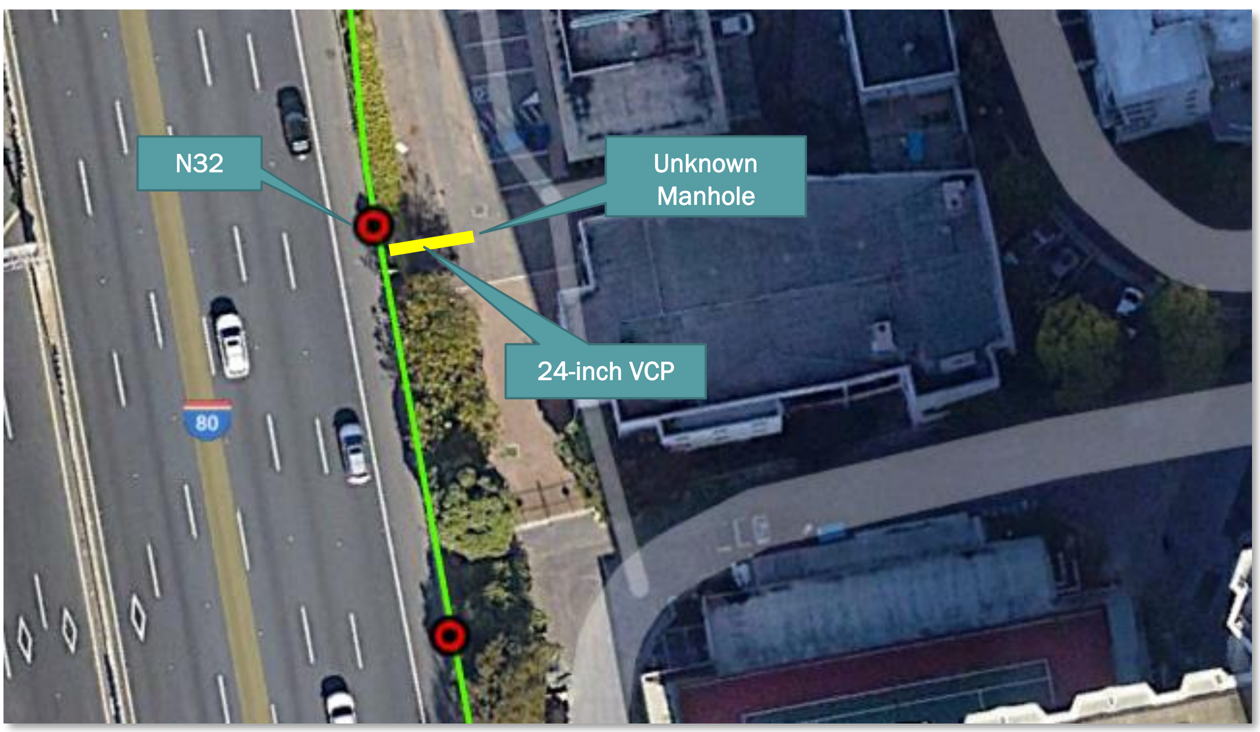


Figure 5-2. Aerial Map of Unknown EBMUD Manhole and Pipe Connection to North Interceptor at N32

Photo 5-1 through Photo 5-16 show the typical and notable observations for the Coliseum Way segments of the South Interceptor. The O&M defects are shown in NPS's NASSCO PACP Reports provided in Appendix A.

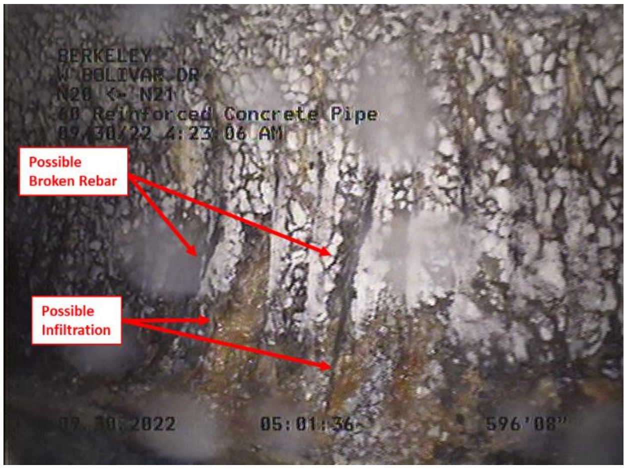


Photo 5-1. VANDA Level 5 corrosion in segment N20N211; up to 12 feet downstream of N20

Photo 5-2. VANDA Level 4 exposed reinforcing steel in segment N27N281; 15 feet downstream of N27; infiltration at wall/ceiling interface

Photo 5-3. VANDA Level 4 condition with exposed reinforcing steel at the crown; 112 to 119 feet downstream from N29

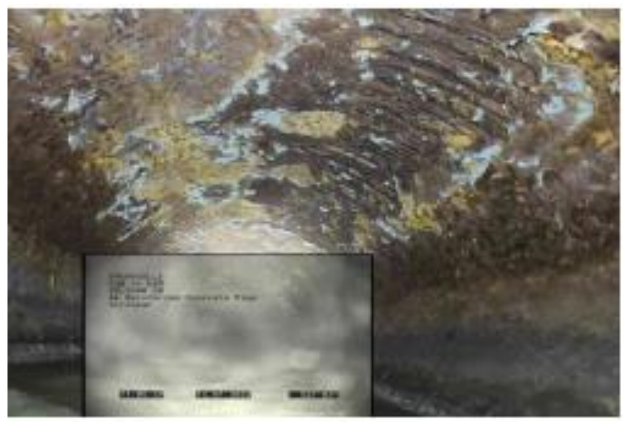


Photo 5-4. VANDA Level 4 condition with exposed reinforcing steel; 528 to 535 feet downstream from N29

Photo 5-5. VANDA Level 4 condition with exposed reinforcing steel; 887 feet upstream from N31

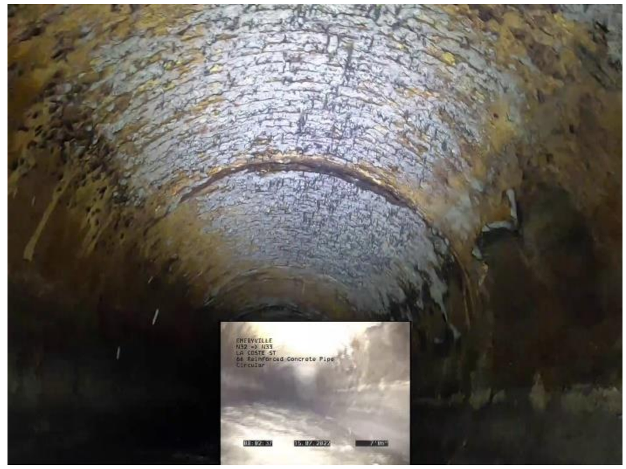


Photo 5-6. VANDA Level 5 condition with exposed reinforcing steel; 8 to 20 feet downstream from N32

Photo 5-7. VANDA Level 4 condition with exposed reinforcing steel; up to 10 feet downstream from N33

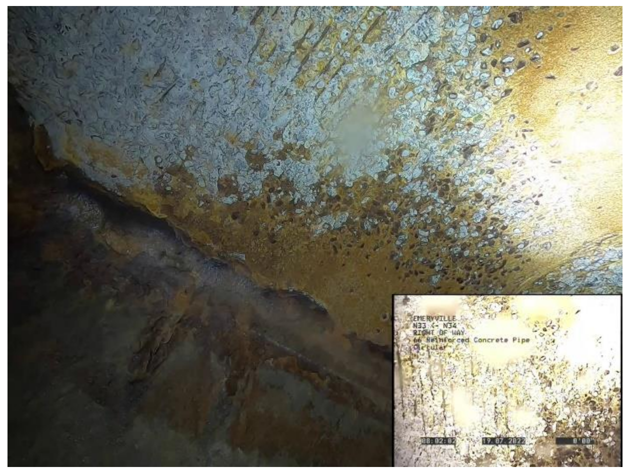


Photo 5-8. VANDA Level 4 condition with exposed reinforcing steel; up to 10 feet upstream from N34

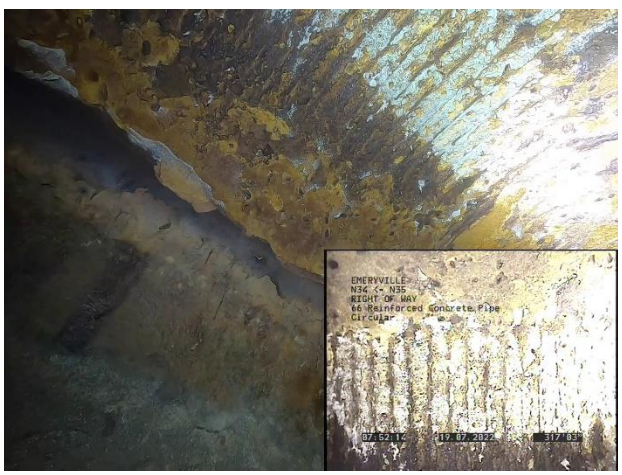


Photo 5-9. VANDA Level 5 condition with exposed reinforcing steel; 318 feet upstream from N35 up to manhole N34

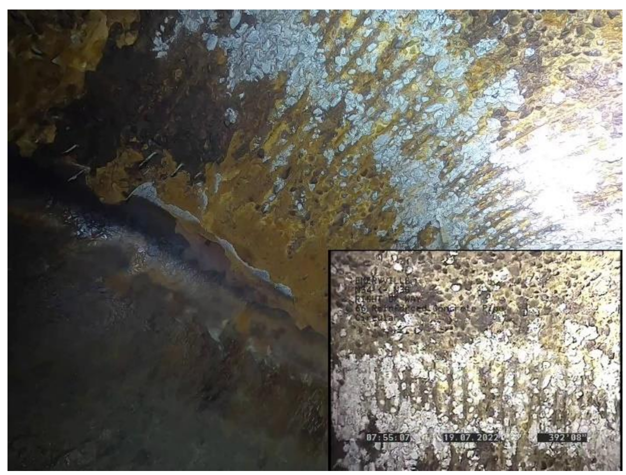


Photo 5-10. VANDA Level 5 condition with exposed reinforcing steel; 318 feet upstream from N35 up to manhole N34

Photo 5-11. Typical VANDA Level 2 condition with minor surface damage; N26N271 shown

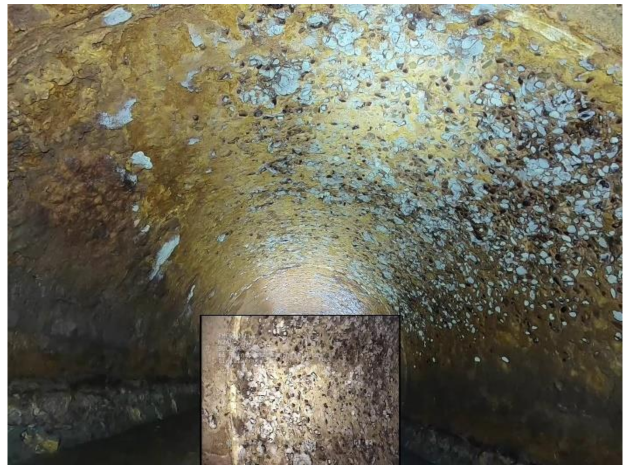


Photo 5-12. Typical VANDA Level 3 with yellowish concrete/exposed aggregate; N26N271 shown

Photo 5-13. Typical VANDA Level 3 with yellowish concrete/exposed aggregate; N26N271 shown with infiltration at joint

Photo 5-14. Typical VANDA Level 2 condition with minor surface damage; N34N351 shown

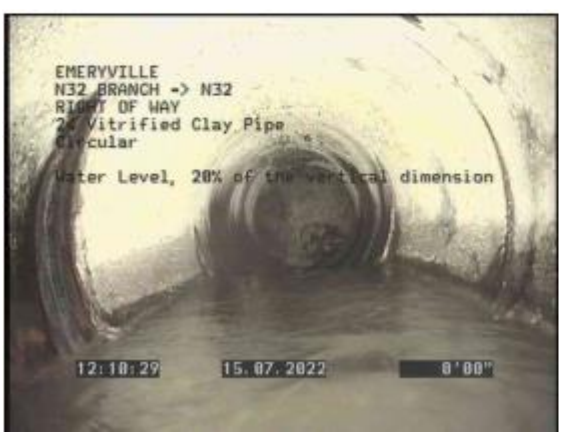


Photo 5-15. 24-inch VCP branch line from unknown EBMUD manhole to N32; pipe stained but in good condition

Photo 5-16. Drop inlet into N32 from 24-inch VCP branch line

5.1.2 Physical Measurements

To assist with estimating the extent of corrosion overall, physical measurements on the pipe segments were obtained during the manhole drop-down assessments. These measurements include concrete pH, concrete penetration depth, SPR scans, and sediment measurements. The tests were only performed on the upstream or downstream pipe in manholes that were accessed for CCTV/MSI assessment and were accessible for physical entry.

The measurements were analyzed and compared with visual data to estimate the wall loss and remaining wall thickness for each segment. The results of the wall loss analysis are presented in Table 5-2. Since the physical measurements in this table were obtained far away from the deteriorated areas of the North Interceptor segments, the overall maximum estimated wall losses for these segments will be greater based on the available visual data. The maximum estimated wall losses for the North Interceptor are presented in Section 5.1.3.

Table 5-2. Physical Measurements for North Interceptor Pipes

Interceptor ID	Diameter (Inches)	Surface pH	pH at Depth	Penetration Depth(1)	Nominal Pipe Wall Thickness(2), Inches	Estimated Wall Loss(3), Inches	Remaining Wall Thickness, Inches
N21N221	66	3	10	1/8	5.5	0.5	5
N26N271	66	4	10	1/16	5.5	0.25	5.25
N31N321	66	4	10	1/16	5.5	0.25	5.25
N34N351	66	2	10	1/8	5.5	0.5	5

(1) Penetration depth to hard concrete measured from existing surface. Actual deterioration depth likely greater.

(2) Assumed pipe wall thickness based on review of as-builts (VG327 and North w0100fullset).

(3) Based on penetration depth, estimated remaining thickness from SPR scans, and/or visual data.

5.1.3 Interceptor Pipe Condition Summary

The overall conditions of the assessed North Interceptor segments are summarized in Table 5-3.

Table 5-3. North Interceptor Pipe Condition Summary

Interceptor ID	Remaining RCP Wall Thickness(1), %	VANDA Rating	Remarks
N20N211	50%	5	Mostly in VANDA Level 2 to Level 3 condition, except for 12 feet downstream of manhole N20, which was in VANDA Level 5 condition
N21N221	91%	2 to 3	Minor to moderate surface damage with aggregate exposed in places; estimated concrete loss up to 0.5 inch
N26N271	91%	2 to 3	Minor to moderate surface damage with aggregate exposed in places; estimated concrete loss up to 0.5 inch
N27N281	--(2)	4	Moderately deteriorated concrete; reinforcing steel exposed 15 feet downstream of N27; infiltration at wall/ceiling interface
N28N291	86%	3	Moderate surface damage with aggregate exposed in places
N29N301	73%	4	Mostly in VANDA Level 3 condition, except for two short 7-foot stretches with severe deterioration and exposed reinforcing steel; these VANDA Level 4 observations are located at 112 to 119 feet and 528 to 535 feet downstream from N29
N30N311	91%	3	Minor to moderate surface damage with aggregate exposed in places; isolated exposed reinforcing steel at 887 feet upstream of N31
N31N321	91%	3	Minor to moderate surface damage with aggregate exposed in places; estimated concrete loss up to 0.5 inch
N32N331	64%	5	Mostly in VANDA Level 3 condition, except from 8 to 20 feet downstream of N32 where there were severe VANDA Level 5 deterioration and exposed reinforcing steel
N33N341	73%	4	Mostly in VANDA Level 2 to Level 3 condition, except for 10-foot section just downstream of N33 and 10-foot section upstream of N34, which were in VANDA Level 4 condition with exposed reinforcing steel
N34N351	73%	4	Mostly in VANDA Level 2 to Level 3 condition, except for section with VANDA Level 4 deterioration and exposed reinforcing steel starting from 318 feet upstream of N35 up to N34
Branch line	--	--	VCP pipe from unknown EBMUD manhole up to N32 appeared to be in good condition

(1) The remaining wall thickness were based on either physical measurement if the measurement apply or visual assessment data if the physical measurements were obtained far from the areas of deterioration.
(2) Nominal thickness of pipe unknown.

5.2 Manhole Condition

The following section summarizes the results of the manhole conditions for the North Interceptor. The manholes assessed included N19, N22, N26, N31, and N35.

5.2.1 Visual Assessment

The interior of the manhole was visually assessed using photographs to document the condition and capture corrosion observations of the concrete surfaces. The interior of the interceptor was also visually assessed to extent possible from the vantagepoint of the manhole. The conditions were rated using the VANDA® Concrete Condition Index.

A summary of the visual assessment results for each manhole is provided in Appendix C. The concrete of the manholes assessed on the North Interceptor line was in fair condition with the highest level of degradation recorded as a VANDA Level 3.

Typical and notable observations of the manholes are detailed below:

- Minor surface damage was observed on the walls of manhole N26. Fine aggregate was visible along the walls and bench, but the concrete was hard with no visible reinforcement, see Photo 5-17 and Photo 5-18.
- The walls of MH N31 were in good condition with no signs of major surface damage, see Photo 5-19. The bench had experienced minor surface damage with fine aggregate visible above the inlet pipe, see Photo 5-20.
- The concrete of MH N35 had a protective liner cover. Signs of liner failure were visible near the top of the manhole, see Photo 5-21. Besides that, the liner was in good condition with a black discoloration along the surface, see Photo 5-22.

Photo 5-17. MH N26. Minor surface damage on manhole wall.

Photo 5-18. MH N26. Minor surface damage on manhole bench near drop inlet.

Photo 5-19. MH N31, Manhole walls in good condition.

Photo 5-20. MH N31, Minor surface damage on manhole bench above inlet.

Photo 5-21. MH N35, Liner on upper section of the manhole. Signs of liner failure near top of manhole.

Photo 5-22. MH N35, Liner on lower section of manhole in good conditin, black discoloration.

5.2.2 Physical Measurements

The concrete surfaces of manholes N19 and N22 were tested during manhole dropdowns. Physical measurements included the following:

- Penetration measurements with a chipping hammer to find the depth to sound material. The penetration depth at manhole N19 was 1/8 inch, which indicates medium scaling. The penetration depth at manhole N22 was 1/16 inch, which indicates light scaling. Results for each manhole are summarized in Table 5-4.
- Surface pH measurements to characterize the prevalence of concrete corrosion. The surface pH for manholes N19 and N22 were 4, which indicates a moderately corrosive environment for concrete. The pH measured in the penetration cavities was 10. Results for each manhole are summarized in Table 5-4.

Table 5-4. Summary of pH and Penetration Measurements for the North Interceptor Manholes

Structure	Location	Surface pH	Depth pH	Penetration Depth (inch)
Manhole N19	MH Wall lower	4	10	1/8
Manhole N22	MH Wall lower	4	10	1/16

5.2.3 Manhole Condition Summary

Taking the visual and physical assessment results into account, the overall condition of each manhole is summarized in Table 5-5.

Table 5-5. North Interceptor Manhole Condition Summary

Structure	VANDA Rating	Overall Condition Summary
Manhole N19	2	Concrete in good condition with minor surface damage.
Manhole N22	3	Concrete in fair condition with moderate surface damage and large diameter aggregate exposed. Manhole frame exhibited moderate corrosion.
Manhole N26	2	Concrete in good condition with minor surface damage.
Manhole N31	2	Concrete in good condition with minor surface damage.
Manhole N35	1	PVC lining in good condition. Concrete beneath presumed to be in good condition.

6 Conclusions and Recommendations

The assessed reinforced concrete interceptor pipes were in various states of deterioration due to corrosion. The predominant mechanism of corrosion of the interceptor pipes was biogenic corrosion, which produces acid that attacks the cement and ultimately the reinforcing steel. The effects are characterized by a yellowish-white surface with roughness, exposed aggregate, and exposed and corroded reinforcing steel within the headspace of the pipe. The extent of corrosion ranged from ½-inch of concrete loss to three (3) inches of concrete loss. Once the deterioration reached the reinforcing steel, the bars rapidly corroded.

Of the 32 segments of interceptor pipe assessed, two (2) segments were in good condition (VANDA Level 2 or better), eight (8) segments were in fair condition (VANDA Level 3), 14 segments were in poor condition (VANDA Level 4), and eight (8) segments were in very poor condition (VANDA Level 5). Of the eight (8) segments that were in VANDA Level 5 condition, five (5) segments (A33A341, A35A361, A39A401, S14S151, and S15S161) exhibited conditions that are conducive to impending failure.

Table 6-1 summarizes the conditions and timeframes for rehabilitation, repair, or reassessment of the assessed interceptor pipes. The timeframes below only consider the current condition of the pipes and do not include other objectives or constraints. These priorities were also established based on the information contained in this report and do not consider pipes that have not been inspected or new information obtained from future condition assessments.

Table 6-1. Condition Summary and Recommendations for Assessed Interceptor Pipes

Interceptor Segment ID	Diameter (inches)	Length (feet)	VANDA Rating[(1)]	Timeframe for Rehabilitation/Repair/Reassess
Alameda Interceptor				
A07A081	12	404	Fair[(2)]	5 – 10 years
A32A331	57	631	4	2 – 5 years
A33A341	57	320	5	As soon as possible, impending failure
A34A351	57	318	5	0 – 2 years
A35A361	57	703	5	As soon as possible, impending failure
A37A381	60	591	4	2 – 5 years
A38A391	60	744	4	2 – 5 years
A39A401	60	640	5	As soon as possible, impending failure
A45AA461	60	545	3	5 – 10 years
A46A46A1	60	380	3	5 – 10 years
A46AA471	60	500	1	Reassess in 10 years
A47A481	60	691	4	2 – 5 years
South Interceptor				
S14S151	66	464	5, 3	As soon as possible, impending failure
S15S161	66	871	5, 3 to 4	As soon as possible, impending failure
S38S391	66	1022	2	Reassess in 10 years
S47S481	33	32	4	2 – 5 years
S48S491	66	188	4	2 – 5 years
S49S501	66	1161	4	2 – 5 years
S50S511	66	1084	4	2 – 5 years
S53S541	66	320	4	2 – 5 years
S54S551	66	102	4	2 – 5 years
North Interceptor				
N20N211	66	1581	5, 2 to 3	As soon as possible, impending failure[(3)]
N21N221	66	432	2 to 3	5 – 10 years
N26N271	63	857	2 to 3	5 – 10 years
N27N281	63	574	4	2 – 5 years
N28N291	75	1424	3	5 – 10 years
N29N301	105	716	4	2 – 5 years
N30N311	105	393	3	5 – 10 years
N31N321	105	392	3	5 – 10 years
N32N331	105	326	5	0 – 2 years
N33N341	105	1000	4	2 – 5 years
N34N351	105	299	4	2 – 5 years
N32 branch line	12	404	Good[(2)]	Reassess in 10 years

(1) VANDA rating based on the worst condition within a particular segment, which may not always apply to the entire segment. For example, segment N20N211 was mostly in VANDA Level 2 to Level 3 condition except for the 12-foot section just downstream of manhole N20. In this case, a spot repair near manhole N20 would bring down the condition rating to Level 2/3. Refer to the CCTV Review and Visual Assessment sections for details.

(2) VANDA rating does not apply to VCP – pipe noted as fair condition.

(3) Further investigation of segment N20N211 by EBMUD via confined space entry on December 11th, 2022 confirmed that this segment has an impending failure near manhole N20.

The assessed interceptor manholes were in VANDA Level 1 to Level 4 condition. Of the 27 manholes assessed, seven (7) manholes were in good condition (VANDA Level 2 or better), 11 manholes were in fair condition (VANDA Level 3), and nine (9) manholes were in poor condition (VANDA Level 4).

Table 6-1 summarizes the conditions and timeframes for rehabilitation, repair, or reassessment of the assessed manholes. The timeframes below only consider the current condition of the manholes and do not include other objectives or constraints. These priorities were also established based on the information contained in this report and do not consider manholes that have not been inspected or new information obtained from future condition assessments.

Table 6-2. Condition Summary and Recommendations for Assessed Manholes

Manhole ID	VANDA Rating	Timeframe for Rehabilitation/Repair
Alameda Interceptor Manholes		
A32	3	5 – 10 years
A34	3	5 – 10 years
A35	4	2 – 5 years
A37	3	5 – 10 years
A39	3	5 – 10 years
A40	3	5 – 10 years
A46A	2	Reassess in 10 years
A47	3	5 – 10 years
A48	2	Reassess in 10 years
South Interceptor Manholes		
S14	3	5 – 10 years
S15	4	2 – 5 years
S16	3	5 – 10 years
S38	3	5 – 10 years
S39	3	5 – 10 years
S47	4	2 – 5 years
S48	4	2 – 5 years
S49	4	2 – 5 years
S50	4	2 – 5 years
S51	4	2 – 5 years
S53	4	2 – 5 years
S54	4	2 – 5 years
S55	1	Reassess in 10 years
North Interceptor Manholes		
N19	2	Reassess in 10 years
N22	3	5 – 10 years
N26	2	Reassess in 10 years
N31	2	Reassess in 10 years
N35	1	Reassess in 10 years

Appendix A
NASSCO PACP Reports

WinCan

Inspection report

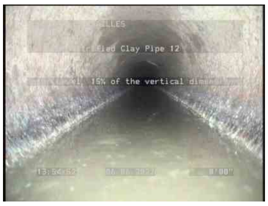
Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/6/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A07A081**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Upstream**			

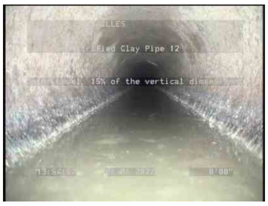
City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**AO7**
Street:	**VERSAILLES**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Easement/Right of way**	Flow Control:	**Not Controlled**	Downstream MH:	**A08**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**12**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Vitrified Clay Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:2804	Distance	Code	Observation	Grade
A08				
	0.0	AMH	Manhole / A08	
	0.0	MWL	Water Level, 15% of the vertical dimension	
	129.0	FC	Fracture Circumferential from 7 o'clock to 5 o'clock	S2
	132.6	CC	Crack Circumferential from 2 o'clock to 5 o'clock	S1
	138.5	CC	Crack Circumferential from 7 o'clock to 5 o'clock	S1
	146.0	CC	Crack Circumferential from 7 o'clock to 5 o'clock	S1
	146.0	RFJ	Roots Fine Joint from 11 o'clock to 1 o'clock, within 8 inch	M1
	188.9	TB	Tap Break-in/Hammer at 10 o'clock, dia/height: 4inch, within 8 inch	
	188.9	RFC	Roots Fine Connection at 10 o'clock	M1
	236.1	TSA	Tap Saddle Activity at 9 o'clock, dia/height: 4inch, within 8 inch	
	371.4	AMH	Manhole / AO7	
AO7				


AMH - 0.00


AMH - 0.00


MWL - 0.00


MWL - 0.00


FC - 128.95

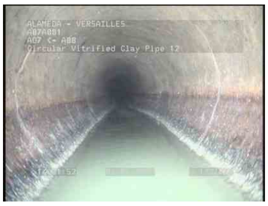
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/6/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A07A081**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Upstream**			


FC - 128.95

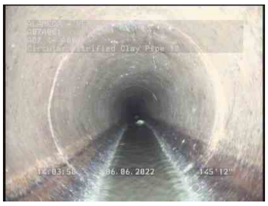

CC - 132.56


CC - 132.56


CC - 138.47


CC - 138.47


CC - 145.99


CC - 145.99

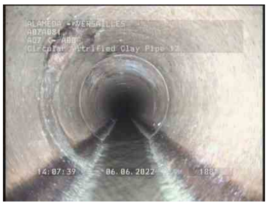

RFJ - 145.99


RFJ - 145.99


TB - 188.87


TB - 188.87


RFC - 188.87


RFC - 188.87


TSA - 236.06


TSA - 236.06


AMH - 371.43


AMH - 371.43

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
2113	1200	2115	5.0	2.0	7.0	1.2	1.0	1.2

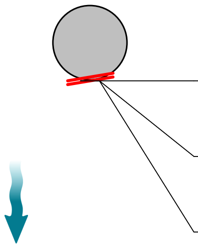
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/10/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A13A141**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A13**
Street:	**MARINA DR**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Secondary roads, non-numbered suburban/rural**	Flow Control:	**Not Controlled**	Downstream MH:	**A14**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**12**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Vitrified Clay Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:50	Distance	Code	Observation	Grade
A13				
	0.0	AMH	Manhole / A13	
	0.0	MWL	Water Level, 70% of the vertical dimension	
	0.0	MSA	Miscellaneous Survey Abandoned / END OF SURVEY DUE TO WATER LEVEL AND DEBRIS	



AMH - 0.00

AMH - 0.00

MWL - 0.00

MWL - 0.00

MSA - 0.00

MSA - 0.00

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
0000	0000	0000	0.0	0.0	0.0	0.0	0.0	0.0

WinCan

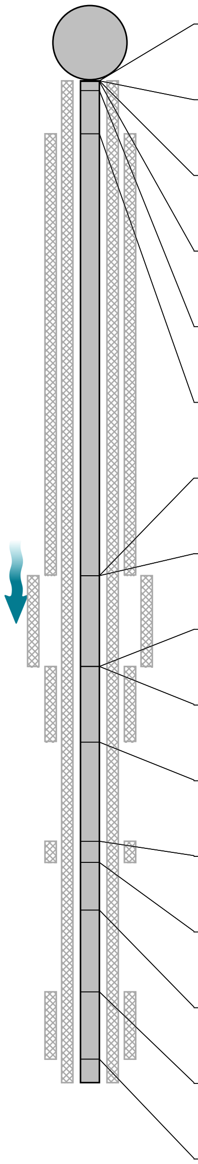
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A32A331**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A32**
Street:	**BUENA VISTA AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Primary major arterial roac**	Flow Control:	**Not Controlled**	Downstream MH:	**A33**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**57**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:4549

A32



Distance		Code	Observation	Grade
0.0		AMH	Manhole / A32	
0.0		MWL	Water Level, 35% of the vertical dimension	
0.0	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
0.9		SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock	S4
6.2		SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock	S4
32.2	S02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Start	S4
297.7	F02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Finish	S4
297.7	S03	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 1 o'clock, Start	
352.3	F03	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 1 o'clock, Finish	S4
352.3	S04	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Start	
397.8	F04	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Finish	S4
457.4	S05	SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock, Start	
470.2	F05	SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock, Finish	S4
498.9		SRV	Surface Damage Reinforcement Visible from 8 o'clock to 11 o'clock	S4
547.8	S06	SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock, Start	
588.6	F06	SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock, Finish	S4


AMH - 0.00


AMH - 0.00


MWL - 0.00

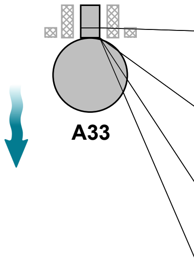

MWL - 0.00


SAP - 0.00

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A32A331**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			



A33

1:4549 Distance		Code	Observation	Grade
616.7	S07	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, Start	
622.2	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
622.2	F07	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, Finish	S4
622.4		AMH	Manhole / A33	


SAP - 0.00


SRV - 0.90


SRV - 0.90


SRV - 6.21


SRV - 6.21


SRV - 32.16


SRV - 32.16


SRV - 297.68


SRV - 297.68


SRV - 297.68


SRV - 297.68


SRV - 352.29


SRV - 352.29


SRV - 352.29


SRV - 352.29


SRV - 397.78


SRV - 397.78


SRV - 457.40

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A32A331**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SRV - 457.40


SRV - 470.22


SRV - 470.22


SRV - 498.88


SRV - 498.88


SRV - 547.78


SRV - 547.78


SRV - 588.56


SRV - 588.56


SRV - 616.71


SRV - 616.71


SAP - 622.22


SAP - 622.22


SRV - 622.22


SRV - 622.22


AMH - 622.42


AMH - 622.42

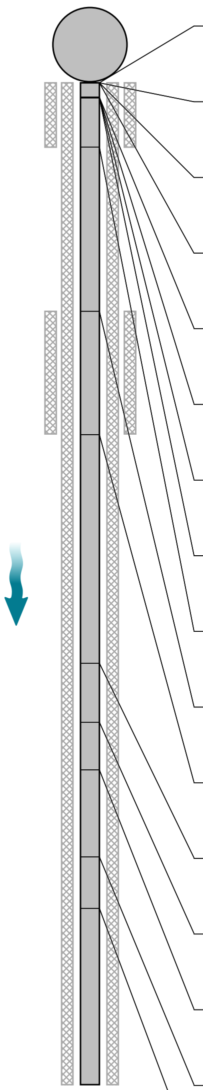
QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
4F3W	0000	4F3W	516.0	0.0	516.0	3.2	0.0	3.2

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A33A341**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A33**
Street:	**BUENA VISTA AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Primary major arterial roac**	Flow Control:	**Not Controlled**	Downstream MH:	**A34**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**57**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					



1:1979	Distance		Code	Observation	Grade
A33	0.0		AMH	Manhole / A33	
	0.0		MWL	Water Level, 35% of the vertical dimension	
	0.0	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
	0.0	S02	SRP	Surface Damage Reinforcement Projecting from 8 o'clock to 4 o'clock, Start	
	3.9		ID	Infiltration Dripper from 9 o'clock to 10 o'clock	M3
	3.9		SRC	Surface Damage Reinforcement Corroded from 8 o'clock to 10 o'clock	S5
	3.9		SRC	Surface Damage Reinforcement Corroded from 2 o'clock to 3 o'clock	S5
	4.0		ID	Infiltration Dripper from 2 o'clock to 3 o'clock	M3
	16.8	F02	SRP	Surface Damage Reinforcement Projecting from 8 o'clock to 4 o'clock, Finish	S5
	59.9	S03	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 1 o'clock, Start	
	92.1	F03	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 1 o'clock, Finish	S4
	151.8		SRV	Surface Damage Reinforcement Visible from 2 o'clock to 4 o'clock	S4
	167.3		SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock	S4
	179.8		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 10 o'clock	S4
	202.6		SRV	Surface Damage Reinforcement Visible at 9 o'clock	S4
	216.0		SRP	Surface Damage Reinforcement Projecting from 1 o'clock to 3 o'clock	S5


AMH - 0.00


AMH - 0.00


MWL - 0.00


MWL - 0.00

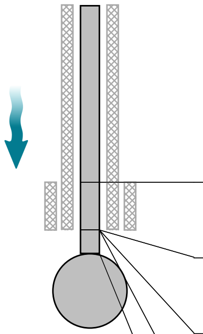

SAP - 0.00

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A33A341**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

1:1979


A34

Distance		Code	Observation	Grade
308.4	S04	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 12 o'clock, Start	
320.9	F04	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 12 o'clock, Finish	S4
320.9	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
320.9		SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock	S4
327.0		AMH	Manhole / A34	


SAP - 0.00


SRP - 0.00


SRP - 0.00


ID - 3.91


ID - 3.91


SRC - 3.91


SRC - 3.91


SRC - 3.91


SRC - 3.91


ID - 4.00


ID - 4.00


SRP - 16.83


SRP - 16.83


SRV - 59.92


SRV - 59.92

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A33A341**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SRV - 92.08


SRV - 92.08


SRV - 151.80


SRV - 151.80


SRV - 167.33


SRV - 167.33


SRV - 179.75


SRV - 179.75


SRV - 202.60


SRV - 202.60


SRP - 216.02


SRP - 216.02


SRV - 308.41


SRV - 308.41


SRV - 320.93


SRV - 320.93


SAP - 320.93


SAP - 320.93


SRV - 320.93


SRV - 320.93


AMH - 327.04

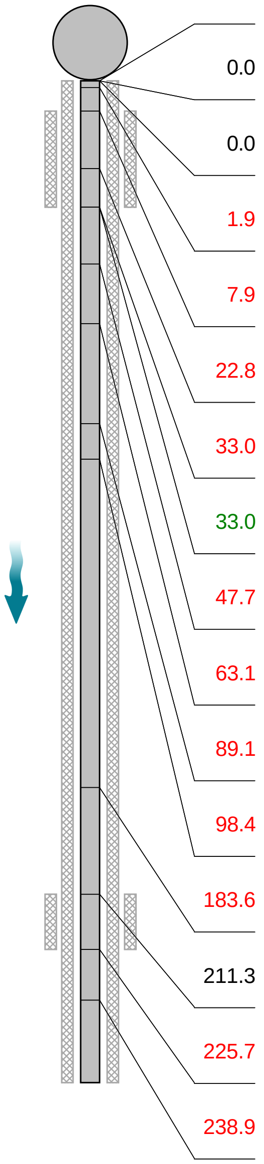
QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
564A	3200	564A	278.0	6.0	284.0	3.3	3.0	3.3

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A34A351**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A34**
Street:	**BUENA VISTA AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Primary major arterial road**	Flow Control:	**Not Controlled**	Downstream MH:	**A35**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**57**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					



1:1965	Distance		Code	Observation	Grade
A34	0.0		AMH	Manhole / A34	
	0.0		MWL	Water Level, 35% of the vertical dimension	
	0.0	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
	1.9		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock	S4
	7.9	S02	SRP	Surface Damage Reinforcement Projecting from 2 o'clock to 4 o'clock, Start	S5
	22.8		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 10 o'clock	S4
	33.0	F02	SRP	Surface Damage Reinforcement Projecting from 2 o'clock to 4 o'clock, Finish	S5
	33.0		IW	Infiltration Weeper from 2 o'clock to 5 o'clock, within 8 inch	M2
	47.7		SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock	S4
	63.1		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 10 o'clock	S4
	89.1		SRV	Surface Damage Reinforcement Visible from 2 o'clock to 4 o'clock	S4
	98.4		SRV	Surface Damage Reinforcement Visible from 2 o'clock to 3 o'clock	S4
	183.6		SAV	Surface Damage Aggregate Visible from 2 o'clock to 3 o'clock	S2
	211.3	S03	SRP	Surface Damage Reinforcement Projecting from 2 o'clock to 3 o'clock, Start	
	225.7	F03	SRP	Surface Damage Reinforcement Projecting from 2 o'clock to 3 o'clock, Finish	S5
	238.9		SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock	S4

AMH - 0.00

AMH - 0.00


MWL - 0.00

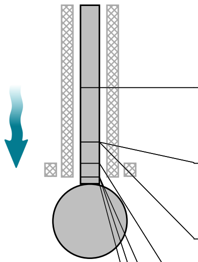

MWL - 0.00


SAP - 0.00

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A34A351**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			



1:1965

A35

Distance		Code	Observation	Grade
281.9		SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock	S4
296.1		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 11 o'clock	S4
296.1		SRV	Surface Damage Reinforcement Visible from 12 o'clock to 2 o'clock	S4
301.6	S04	SRP	Surface Damage Reinforcement Projecting from 9 o'clock to 3 o'clock, Start	
305.1	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
305.1	F04	SRP	Surface Damage Reinforcement Projecting from 9 o'clock to 3 o'clock, Finish	S5
306.9		AMH	Manhole / A35	


SAP - 0.00


SRV - 1.90


SRV - 1.90


SRP - 7.92


SRV - 22.84


SRV - 22.84


SRP - 32.96


SRP - 32.96


IW - 32.96


IW - 32.96


SRV - 47.69


SRV - 47.69


SRV - 63.12


SRV - 63.12


SRV - 89.07

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A34A351**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SRV - 89.07


SRV - 98.39


SRV - 98.39


SAV - 183.56


SAV - 183.56


SRP - 211.31


SRP - 211.31


SRP - 225.74


SRP - 225.74


SRV - 238.87


SRV - 238.87


SRV - 281.85


SRV - 281.85


SRV - 296.08


SRV - 296.08


SRV - 296.08


SRV - 296.08


SRP - 301.59


SRP - 301.59


SAP - 305.10


SAP - 305.10


SRP - 305.10


SRP - 305.10


AMH - 306.90

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/7/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A34A351**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

AMH - 306.90

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
554A	2100	554A	250.0	2.0	252.0	3.2	2.0	3.2

WinCan

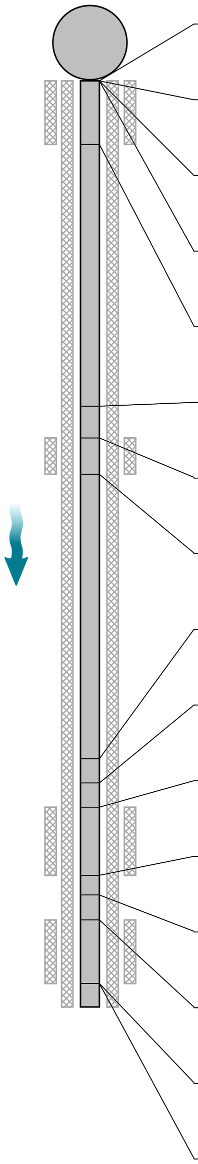
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A35A361**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A35**
Street:	**BUENA VISTA AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Primary major arterial roac**	Flow Control:	**Not Controlled**	Downstream MH:	**A36**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**57**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:2223

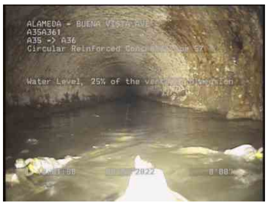
A35



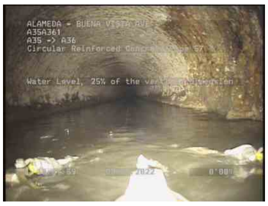
Distance		Code	Observation	Grade
0.0		AMH	Manhole / A35	
0.0		MWL	Water Level, 25% of the vertical dimension	
0.0	S01	SRP	Surface Damage Reinforcement Projecting from 9 o'clock to 3 o'clock, Start	
0.0	S02	SAP	Surface Damage Aggregate Projecting from 9 o'clock to 3 o'clock, Start	
18.7	F01	SRP	Surface Damage Reinforcement Projecting from 9 o'clock to 3 o'clock, Finish	S5
95.8		SRP	Surface Damage Reinforcement Projecting from 1 o'clock to 4 o'clock	S5
105.0	S04	SRV	Surface Damage Reinforcement Visible from 1 o'clock to 3 o'clock, Start	
115.7	F04	SRV	Surface Damage Reinforcement Visible from 1 o'clock to 3 o'clock, Finish	S4
199.3		SRV	Surface Damage Reinforcement Visible from 2 o'clock to 4 o'clock	S4
206.5		SRV	Surface Damage Reinforcement Visible from 10 o'clock to 11 o'clock	S4
213.4	S05	SRP	Surface Damage Reinforcement Projecting from 1 o'clock to 3 o'clock, Start	
233.6	F05	SRP	Surface Damage Reinforcement Projecting from 12 o'clock to 3 o'clock, Finish	S5
239.4		SRP	Surface Damage Reinforcement Projecting from 10 o'clock to 2 o'clock	S5
246.6	S06	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 4 o'clock, Start	
265.4	F06	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 4 o'clock, Finish	S4
265.4		SRV	Surface Damage Reinforcement Visible from 8 o'clock to 11 o'clock	S4

AMH - 0.00

AMH - 0.00



MWL - 0.00



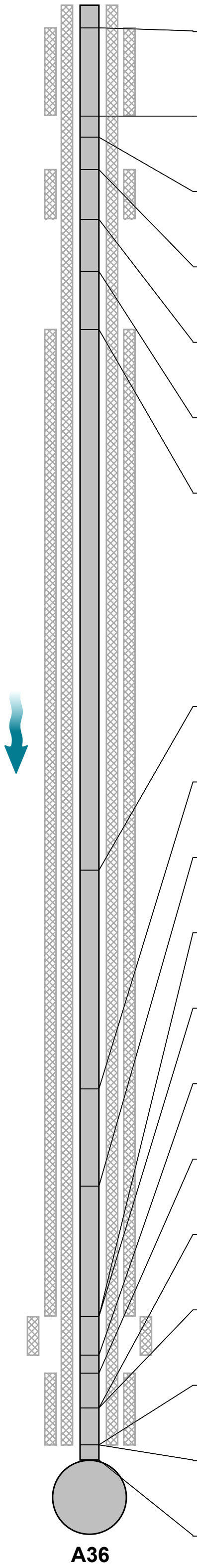
MWL - 0.00

SRP - 0.00

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A35A361**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

1:2223



Distance		Code	Observation	Grade
279.1	S07	SRP	Surface Damage Reinforcement Projecting from 11 o'clock to 4 o'clock, Start	
305.0	F07	SRP	Surface Damage Reinforcement Projecting from 11 o'clock to 4 o'clock, Finish	S5
311.2		SRV	Surface Damage Reinforcement Visible from 8 o'clock to 2 o'clock	S4
320.8	S08	SRP	Surface Damage Reinforcement Projecting from 11 o'clock to 4 o'clock, Start	
335.5	F08	SRP	Surface Damage Reinforcement Projecting from 11 o'clock to 4 o'clock, Finish	S5
350.8		SRP	Surface Damage Reinforcement Projecting from 12 o'clock to 4 o'clock	S5
368.0	S09	SRP	Surface Damage Reinforcement Projecting from 11 o'clock to 4 o'clock, Start	
527.3		SRV	Surface Damage Reinforcement Visible at 9 o'clock	S4
591.9		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 10 o'clock	S4
620.5		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 10 o'clock	S4
659.0	F09	SRP	Surface Damage Reinforcement Projecting from 11 o'clock to 4 o'clock, Finish	S5
659.0	S10	SRP	Surface Damage Reinforcement Projecting from 9 o'clock to 4 o'clock, Start	
670.4	F10	SRP	Surface Damage Reinforcement Projecting from 9 o'clock to 4 o'clock, Finish	S5
675.6	S11	SRP	Surface Damage Reinforcement Projecting from 8 o'clock to 4 o'clock, Start	
685.8		IW	Infiltration Weeper from 3 o'clock to 5 o'clock	M2
685.8		SRC	Surface Damage Reinforcement Corroded from 3 o'clock to 4 o'clock	S5
696.9	F02	SAP	Surface Damage Aggregate Projecting from 9 o'clock to 3 o'clock, Finish	S3
696.9	F11	SRP	Surface Damage Reinforcement Projecting from 8 o'clock to 4 o'clock, Finish	S5
701.3		AMH	Manhole / A36	


SRP - 0.00


SAP - 0.00


SAP - 0.00


SRP - 18.74


SRP - 18.74


SRP - 95.79

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A35A361**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SRP - 95.79


SRV - 105.01


SRV - 105.01


SRV - 115.73


SRV - 115.73


SRV - 199.29


SRV - 199.29


SRV - 206.51


SRV - 206.51


SRP - 213.42


SRP - 213.42


SRP - 233.56


SRP - 233.56


SRP - 239.37


SRP - 239.37


SRV - 246.58


SRV - 246.58


SRV - 265.42


SRV - 265.42


SRV - 265.42


SRV - 265.42


SRP - 279.15


SRP - 279.15


SRP - 305.00

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A35A361**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

SRP - 305.00

SRV - 311.21

SRV - 311.21

SRP - 320.83

SRP - 320.83

SRP - 335.46

SRP - 335.46

SRP - 350.79

SRP - 350.79

SRP - 368.02

SRP - 368.02

SRV - 527.33

SRV - 527.33

SRV - 591.86

SRV - 591.86

SRV - 620.52

SRV - 620.52

SRP - 658.99

SRP - 658.99

SRP - 658.99

SRP - 658.99

SRP - 670.42


SRP - 670.42

SRP - 675.63

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A35A361**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SRP - 675.63


IW - 685.85


IW - 685.85


SRC - 685.85


SRC - 685.85


SAP - 696.87


SAP - 696.87


SRP - 696.87


SRP - 696.87


AMH - 701.28


AMH - 701.28

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
5O4A	2100	5O4A	889.0	2.0	891.0	3.8	2.0	3.8

WinCan

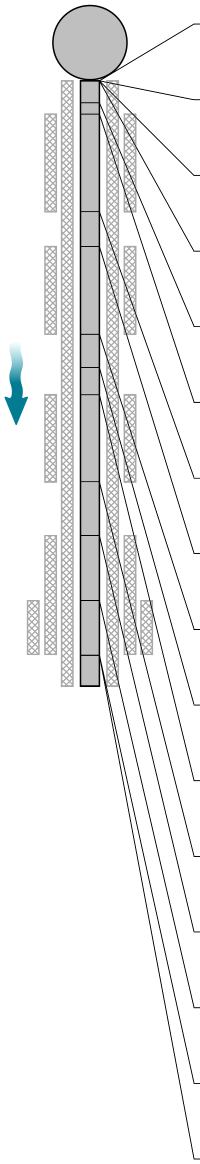
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A37A381**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A37**
Street:	**BUENA VISTA AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Primary major arterial roac**	Flow Control:	**Not Controlled**	Downstream MH:	**A38**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**57**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:2158

A37



Distance		Code	Observation	Grade
0.0		AMH	Manhole / A37	
0.0		MWL	Water Level, 20% of the vertical dimension	
0.0		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock	S4
0.0	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
6.3		SRV	Surface Damage Reinforcement Visible at 12 o'clock	S4
9.6	S02	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Start	
37.5	F02	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Finish	S4
47.4	S03	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, Start	
72.4	F03	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, Finish	S4
81.9		SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock	S4
89.6	S04	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Start	S4
114.5	F04	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Finish	S4
129.9	S05	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Start	
148.3	S06	SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock, Start	S4
163.8	F05	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Finish	S4
163.8	F06	SRV	Surface Damage Reinforcement Visible from 8 o'clock to 10 o'clock, Finish	S4

AMH - 0.00

AMH - 0.00

MWL - 0.00

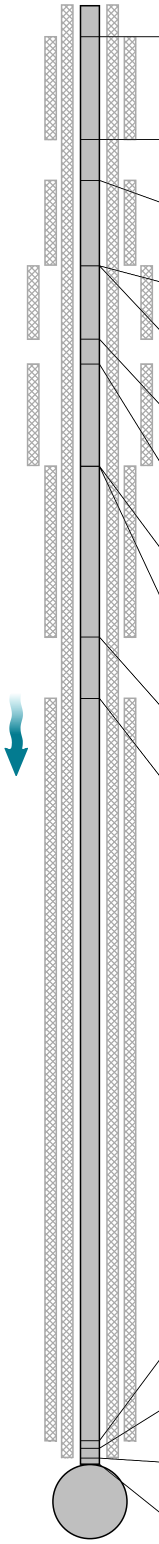
MWL - 0.00

SRV - 0.00

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A37A381**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			



A38

1:2158 Distance		Code	Observation	Grade
181.7	S07	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Start	
211.0	F07	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Finish	S4
222.7	S08	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Start	
247.0	F08	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Finish	S4
247.0	S09	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Start	
268.0	F09	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Finish	S4
275.2	S10	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Start	
304.2	F10	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Finish	S4
304.2	S11	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, Start	
353.1	F11	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, Finish	S4
370.4	S12	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Start	
582.4	F12	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, Finish	S4
584.5		SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock	S4
587.4	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
589.2		AMH	Manhole / A38	

SRV - 0.00

SAP - 0.00

SAP - 0.00

SRV - 6.31

SRV - 6.31

SRV - 9.62

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A37A381**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SRV - 9.62


SRV - 37.47


SRV - 37.47


SRV - 47.39


SRV - 47.39


SRV - 72.44


SRV - 72.44


SRV - 81.86


SRV - 81.86


SRV - 89.58


SRV - 89.58


SRV - 114.52


SRV - 114.52


SRV - 129.85


SRV - 129.85


SRV - 148.29


SRV - 148.29


SRV - 163.82


SRV - 163.82


SRV - 163.82


SRV - 163.82


SRV - 181.66


SRV - 181.66


SRV - 211.01

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A37A381**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SRV - 211.01


SRV - 222.74


SRV - 222.74


SRV - 246.98


SRV - 246.98


SRV - 246.98


SRV - 246.98


SRV - 268.03


SRV - 268.03


SRV - 275.24


SRV - 275.24


SRV - 304.20


SRV - 304.20


SRV - 304.20


SRV - 304.20


SRV - 353.09


SRV - 353.09


SRV - 370.43


SRV - 370.43


SRV - 582.44


SRV - 582.44


SRV - 584.55


SRV - 584.55


SAP - 587.35

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A37A381**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SAP - 587.35


AMH - 589.16


AMH - 589.16

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
4R3V	0000	4R3V	739.0	0.0	739.0	3.5	0.0	3.5

WinCan

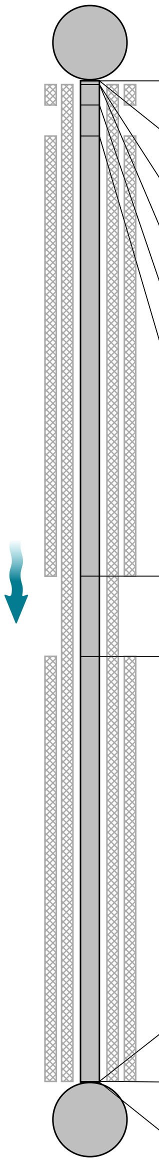
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A38A391**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A38**
Street:	**BUENA VISTA AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Primary major arterial roac**	Flow Control:	**Not Controlled**	Downstream MH:	**A39**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**57**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:5585

A38



A39

Distance		Code	Observation	Grade
0.0		AMH	Manhole / A38	
0.0		MWL	Water Level, 20% of the vertical dimension	
2.9	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
2.9	S02	SRP	Surface Damage Reinforcement Projecting from 9 o'clock to 3 o'clock, Start	
18.2	F02	SRP	Surface Damage Reinforcement Projecting from 9 o'clock to 3 o'clock, Finish	S5
40.8	S03	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 4 o'clock, Start	
366.0	F03	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 4 o'clock, Finish	S4
425.2	S04	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 2 o'clock, Start	
739.3	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
739.3	F04	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 2 o'clock, Finish	S4
740.0		AMH	Manhole / A39	


AMH - 0.00


AMH - 0.00


MWL - 0.00


MWL - 0.00


SAP - 2.91

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/8/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A38A391**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SAP - 2.91


SRP - 2.91


SRP - 2.91


SRP - 18.24


SRP - 18.24


SRV - 40.78


SRV - 40.78


SRV - 366.02


SRV - 366.02


SRV - 425.23


SRV - 425.23


SAP - 739.25


SAP - 739.25


SRV - 739.25


SRV - 739.25


AMH - 739.95


AMH - 739.95

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
534X	0000	534X	968.0	0.0	968.0	3.5	0.0	3.5

WinCan

Inspection report

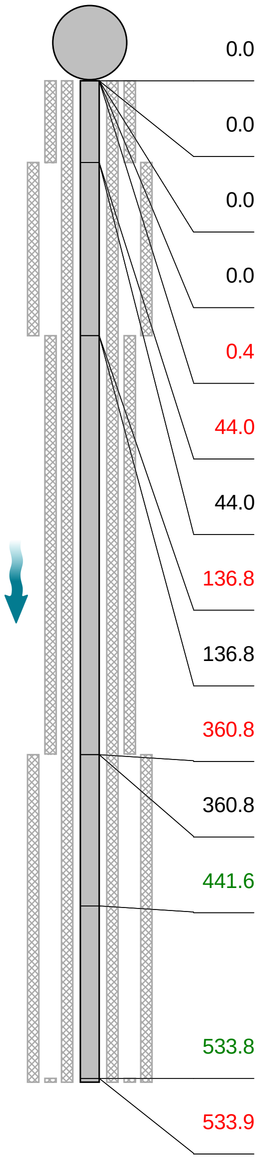
Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A39A401**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A39**
Street:	**BUENA VISTA AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Primary major arterial roac**	Flow Control:	**Not Controlled**	Downstream MH:	**A40**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**57**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			

Additional Info:

1:4047

A39

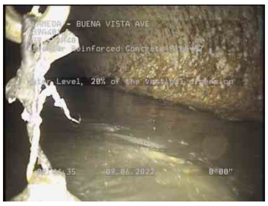


Distance		Code	Observation	Grade
0.0		AMH	Manhole / A39	
0.0		MWL	Water Level, 20% of the vertical dimension	
0.0	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
0.0	S02	SRP	Surface Damage Reinforcement Projecting from 8 o'clock to 4 o'clock, Start	
0.4		SAM	Surface Damage Aggregate Missing at 12 o'clock	S4
44.0	F02	SRP	Surface Damage Reinforcement Projecting from 8 o'clock to 4 o'clock, Finish	S5
44.0	S03	SRP	Surface Damage Reinforcement Projecting from 11 o'clock to 4 o'clock, Start	
136.8	F03	SRP	Surface Damage Reinforcement Projecting from 11 o'clock to 4 o'clock, Finish	S5
136.8	S04	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 3 o'clock, Start	
360.8	F04	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 3 o'clock, Finish	S4
360.8	S05	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, Start	
441.6		IW	Infiltration Weeper from 4 o'clock to 5 o'clock, within 8 inch	M2
533.8		ID	Infiltration Dripper at 12 o'clock	M3
533.9	S06	SRC	Surface Damage Reinforcement Corroded from 10 o'clock to 2 o'clock, Start	S5


AMH - 0.00


AMH - 0.00


MWL - 0.00

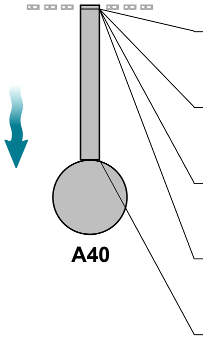

MWL - 0.00


SAP - 0.00

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A39A401**
Year laid:	Pre-cleaning: **No Pre-Cleaning**	Direction: **Downstream**	Pipe Joint Length:	Total Length:	Length Surveyed:



Distance		Code	Observation	Grade
538.6	F05	SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, Finish	S4
538.6	F06	SRC	Surface Damage Reinforcement Corroded from 10 o'clock to 2 o'clock, Finish	S5
538.6	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
538.6		MMC	Miscellaneous Material Change, Other (State in comments) / LINER	
619.0		AMH	Manhole / A40	


SAP - 0.00


SRP - 0.00


SRP - 0.00


SAM - 0.40


SAM - 0.40


SRP - 43.99


SRP - 43.99


SRP - 43.99


SRP - 43.99


SRP - 136.77


SRP - 136.77


SRV - 136.77


SRV - 136.77


SRV - 360.81


SRV - 360.81

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A39A401**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SRV - 360.81


SRV - 360.81


IW - 441.57


IW - 441.57


ID - 533.85


SRC - 533.85


SRC - 533.85


SRV - 538.56


SRV - 538.56


SRC - 538.56


SRC - 538.56


SAP - 538.56


SAP - 538.56


MMC - 538.56


MMC - 538.56


AMH - 619.01


AMH - 619.01

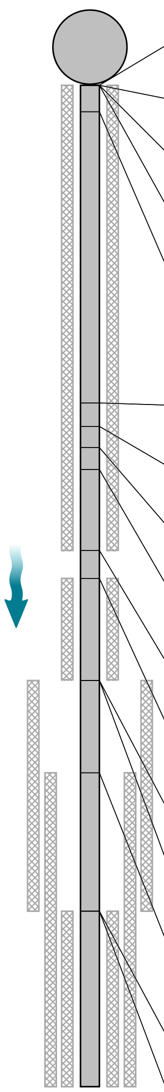
QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
5D4O	3121	5D4O	797.0	5.0	802.0	3.6	2.5	3.6

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A45AA461**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A45A**
Street:	**CONSTITUTION WAY**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Primary major arterial roac**	Flow Control:	**Not Controlled**	Downstream MH:	**A46**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**60**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					



1:2904	Distance		Code	Observation	Grade
A45A	0.0		AMH	Manhole / A45A	
	0.0		MWL	Water Level, 40% of the vertical dimension	
	0.0		SRV	Surface Damage Reinforcement Visible at 12 o'clock	S4
	0.0	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
	10.3		IW	Infiltration Weeper from 2 o'clock to 5 o'clock, within 8 inch	M2
	122.1		ID	Infiltration Dripper from 3 o'clock to 5 o'clock, within 8 inch	M3
	131.1		IW	Infiltration Weeper at 4 o'clock	M2
	139.3		IW	Infiltration Weeper from 3 o'clock to 5 o'clock, within 8 inch	M2
	147.6		IW	Infiltration Weeper from 3 o'clock to 5 o'clock, within 8 inch	M2
	178.7	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
	189.6	S02	SSC	Surface Spalling of Damage Coating from 8 o'clock to 4 o'clock, Start	
	228.5	F02	SSC	Surface Spalling of Damage Coating from 8 o'clock to 4 o'clock, Finish	S1
	228.5	S03	SAV	Surface Damage Aggregate Visible from 9 o'clock to 3 o'clock, Start	
	264.2	S04	MWLS	Miscellaneous Water Level, Sag, 45% of the vertical dimension, Start	
	317.2	F03	SAV	Surface Damage Aggregate Visible from 9 o'clock to 3 o'clock, Finish	S2
	317.2	S05	SAP	Surface Damage Aggregate Projecting from 9 o'clock to 3 o'clock, Start	

AMH - 0.00

AMH - 0.00

MWL - 0.00

MWL - 0.00

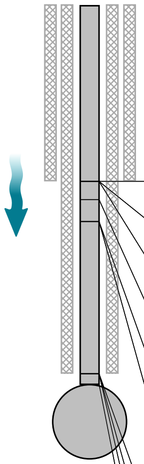
SRV - 0.00

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A45AA461**
Year laid:	Pre-cleaning: **No Pre-Cleaning**	Direction: **Downstream**	Pipe Joint Length:	Total Length:	Length Surveyed:

1:2904



A46

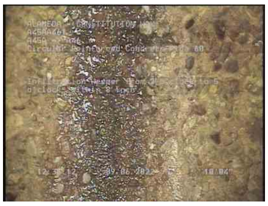
Distance		Code	Observation	Grade
452.3		IW	Infiltration Weeper from 8 o'clock to 10 o'clock, within 8 inch	M2
452.3		IS	Infiltration Stain from 3 o'clock to 5 o'clock, within 8 inch	M1
452.3	F04	MWLS	Miscellaneous Water Level, Sag, 45% of the vertical dimension, Finish	S3
459.3		ID	Infiltration Dripper from 8 o'clock to 4 o'clock, within 8 inch	M3
467.6		ID	Infiltration Dripper at 10 o'clock, within 8 inch	M3
467.6		ID	Infiltration Dripper from 11 o'clock to 1 o'clock, within 8 inch	M3
525.9		SRV	Surface Damage Reinforcement Visible at 12 o'clock	S4
525.9	F05	SAP	Surface Damage Aggregate Projecting from 9 o'clock to 3 o'clock, Finish	S3
525.9		SRV	Surface Damage Reinforcement Visible from 1 o'clock to 2 o'clock	S4
530.2		AMH	Manhole / A46	

SRV - 0.00

SAP - 0.00

SAP - 0.00

IW - 10.32



IW - 10.32

ID - 122.14

ID - 122.14

IW - 131.06

IW - 131.06

IW - 139.27

IW - 139.27

IW - 147.59

WinCan

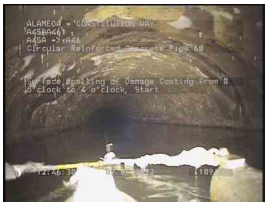
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A45AA461**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


IW - 147.59


SAP - 178.65


SAP - 178.65


SSC - 189.57


SSC - 189.57


SSC - 228.55


SSC - 228.55


SAV - 228.55


SAV - 228.55


MWLS - 264.22


MWLS - 264.22


SAV - 317.22


SAV - 317.22


SAP - 317.22


SAP - 317.22


IW - 452.29


IW - 452.29


IS - 452.29


IS - 452.29


MWLS - 452.29


MWLS - 452.29


ID - 459.30


ID - 459.30


ID - 467.62

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A45AA461**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


ID - 467.62


ID - 467.62


ID - 467.62


SRV - 525.93


SRV - 525.93


SAP - 525.93


SAP - 525.93


SRV - 525.93


SRV - 525.93


AMH - 530.24


AMH - 530.24

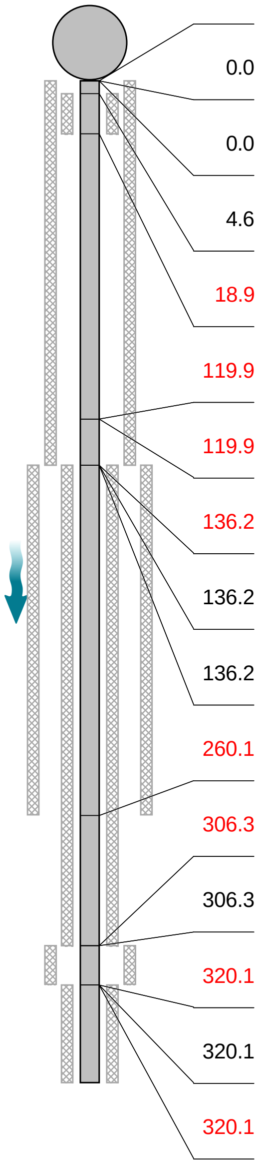
QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
433V	3425	433W	404.0	23.0	427.0	2.8	2.3	2.8

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A46A46A1**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A46**
Street:	**EASEMENT**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Primary major arterial roac**	Flow Control:	**Not Controlled**	Downstream MH:	**A46A**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**60**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					



1:2678	Distance		Code	Observation	Grade
A46	0.0		AMH	Manhole / A46	
	0.0		MWL	Water Level, 20% of the vertical dimension	
	0.0	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
	4.6	S02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Start	
	18.9	F02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Finish	S4
	119.9		SRV	Surface Damage Reinforcement Visible from 11 o'clock to 12 o'clock, within 8 inch	S4
	119.9		SRV	Surface Damage Reinforcement Visible from 1 o'clock to 2 o'clock, within 8 inch	S4
	136.2	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
	136.2	S03	SSC	Surface Spalling of Damage Coating from 8 o'clock to 4 o'clock, Start	
	136.2	S04	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, Start	
	260.1	F03	SSC	Surface Spalling of Damage Coating from 8 o'clock to 4 o'clock, Finish	S1
	306.3	F04	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, Finish	S2
	306.3	S05	SAP	Surface Damage Aggregate Projecting from 1 o'clock to 4 o'clock, Start	
	320.1	F05	SAP	Surface Damage Aggregate Projecting from 1 o'clock to 4 o'clock, Finish	S3
	320.1	S06	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
	320.1		SRV	Surface Damage Reinforcement Visible from 3 o'clock to 4 o'clock, within 8 inch	S4


AMH - 0.00


AMH - 0.00


MWL - 0.00

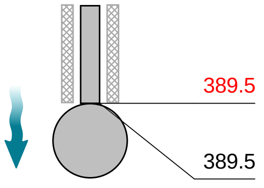

MWL - 0.00


SAP - 0.00

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A46A46A1**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			



1:2678	Distance		Code	Observation	Grade
	389.5	F06	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
	389.5		AMH	Manhole / A46A	


SAP - 0.00


SRV - 4.61


SRV - 4.61


SRV - 18.94


SRV - 18.94


SRV - 119.94


SRV - 119.94


SRV - 119.94


SRV - 119.94


SAP - 136.17


SAP - 136.17


SSC - 136.17


SSC - 136.17


SAV - 136.17


SAV - 136.17


SSC - 260.11


SSC - 260.11


SAV - 306.30

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/9/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A46A46A1**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SAV - 306.30


SAP - 306.30


SAP - 306.30


SAP - 320.13


SAP - 320.13


SAP - 320.13


SAP - 320.13


SRV - 320.13


SRV - 320.13


SAP - 389.46


SAP - 389.46


AMH - 389.46


AMH - 389.46

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
463G	0000	463G	249.0	0.0	249.0	2.3	0.0	2.3

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/6/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A46AA471**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A46A**
Street:	**TYNAN AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Easement/Right of way**	Flow Control:	**Not Controlled**	Downstream MH:	**A47**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**60**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			

Additional Info:

A46A

1:1466	Distance	Code	Observation	Grade
	0.0	AMH	Manhole / A46A	
	0.0	MWL	Water Level, 35% of the vertical dimension	
	119.3	MSA	Miscellaneous Survey Abandoned / END OF SURVEY. PONTOON IS NOT MOVING DUE TO FLOW.	
	194.2		End of pipe	

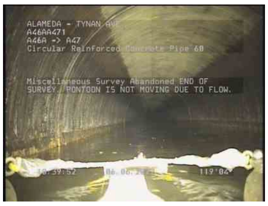
A47


AMH - 0.00


AMH - 0.00


MWL - 0.00

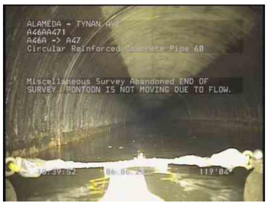

MWL - 0.00


MSA - 119.33

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/6/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A46AA471**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			



MSA - 119.33

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
0000	0000	0000	0.0	0.0	0.0	0.0	0.0	0.0

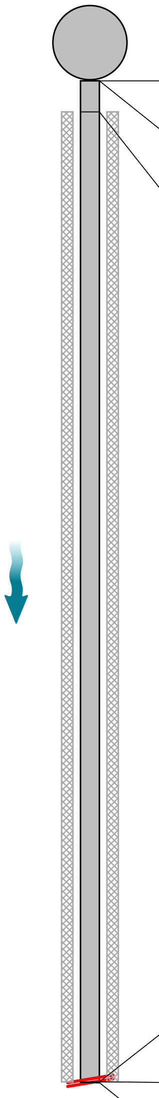
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/6/2022	**6.6.22**		**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A46AA471**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

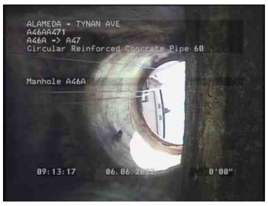
City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A46A**
Street:	**TYNAN AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Easement/Right of way**	Flow Control:	**Not Controlled**	Downstream MH:	**A47**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**60**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

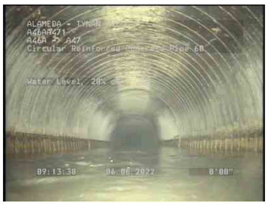
A46A

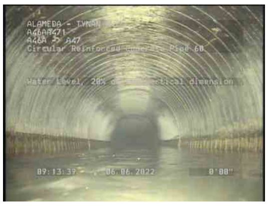


1:1466	Distance	Code	Observation	Grade
	0.0	AMH	Manhole / A46A	
	0.0	MWL	Water Level, 20% of the vertical dimension	
S01	6.1	DAGS	Deposits Attached Grease, 5% of cross sectional area from 8 o'clock to 4 o'clock, Start	
F01	194.1	DAGS	Deposits Attached Grease, 5% of cross sectional area from 8 o'clock to 4 o'clock, Finish	M2
	194.1	DAZ	Deposits Attached Other, 5% of cross sectional area from 5 o'clock to 7 o'clock / UNKOWN DEBRIS BELOW WATER LINE. CRAWLER	M2
	194.2	MSA	Miscellaneous Survey Abandoned / DAZ	


AMH - 0.00


AMH - 0.00


MWL - 0.00


MWL - 0.00


DAGS - 6.11

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/6/2022	**6.6.22**		**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A46AA471**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


DAGS - 6.11


DAGS - 194.08


DAGS - 194.08


DAZ - 194.08

DAZ - 194.08

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
0000	2F00	2F00	0.0	78.0	78.0	0.0	2.0	2.0

WinCan

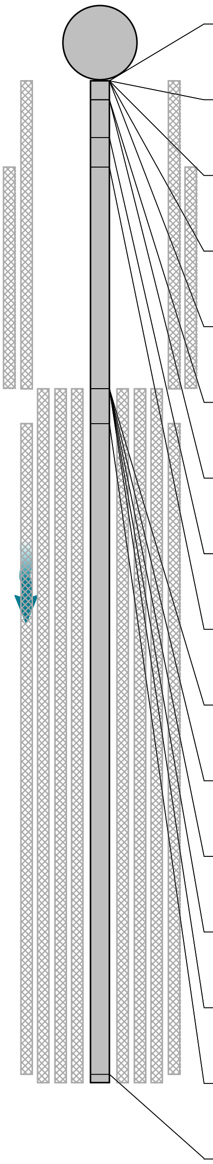
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/10/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A47A481**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A47**
Street:	**TYNAN AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Easement/Right of way**	Flow Control:	**Not Controlled**	Downstream MH:	**A48**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**60**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:3192

A47



Distance		Code	Observation	Grade
0.0		AMH	Manhole / A47	
0.0		MWL	Water Level, 25% of the vertical dimension	
0.0		SRP	Surface Damage Reinforcement Projecting from 11 o'clock to 1 o'clock	S5
0.0		SRC	Surface Damage Reinforcement Corroded from 11 o'clock to 1 o'clock	S5
0.0	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
8.0		IR	Infiltration Runner from 7 o'clock to 10 o'clock, within 8 inch	M4
8.0		IR	Infiltration Runner from 2 o'clock to 5 o'clock, within 8 inch	M4
24.2		SRV	Surface Damage Reinforcement Visible from 2 o'clock to 3 o'clock, within 8 inch	S4
36.7	S02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 3 o'clock, Start	S4
130.1	F02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 3 o'clock, Finish	S4
130.1	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
130.1	S03	SAP	Surface Damage Aggregate Projecting from 10 o'clock to 2 o'clock, Start	
130.1	S04	SSC	Surface Spalling of Damage Coating from 8 o'clock to 11 o'clock, Start	
130.1	S05	SSC	Surface Spalling of Damage Coating from 2 o'clock to 4 o'clock, Start	
144.8	S06	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, Start	
419.4	F06	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, Finish	S4

AMH - 0.00


AMH - 0.00


MWL - 0.00


MWL - 0.00

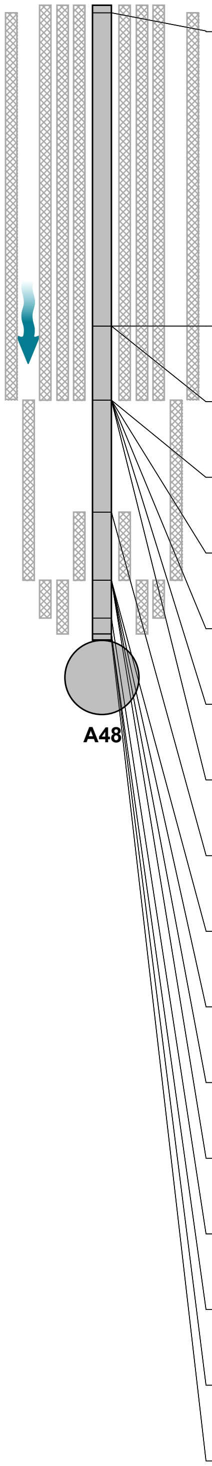

SRP - 0.00

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/10/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A47A481**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

1:3192



Distance		Code	Observation	Grade
426.2	S07	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, Start	
558.2		IR	Infiltration Runner from 11 o'clock to 1 o'clock, within 8 inch	M4
558.2		IS	Infiltration Stain from 8 o'clock to 4 o'clock, within 8 inch	M1
589.5	F07	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, Finish	S4
589.5	F03	SAP	Surface Damage Aggregate Projecting from 10 o'clock to 2 o'clock, Finish	S3
589.5	F04	SSC	Surface Spalling of Damage Coating from 8 o'clock to 11 o'clock, Finish	S1
589.5	F05	SSC	Surface Spalling of Damage Coating from 2 o'clock to 4 o'clock, Finish	S1
589.5	S08	SSC	Surface Spalling of Damage Coating from 8 o'clock to 4 o'clock, Start	
636.7	S09	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, Start	
665.5	F08	SSC	Surface Spalling of Damage Coating from 8 o'clock to 4 o'clock, Finish	S1
665.5	S10	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, Start	
665.5	F09	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, Finish	S2
665.5	S11	SAP	Surface Damage Aggregate Projecting from 9 o'clock to 3 o'clock, Start	
681.5	F10	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, Finish	S4
688.3		SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock	S4
688.3	F11	SAP	Surface Damage Aggregate Projecting from 9 o'clock to 3 o'clock, Finish	S3
690.9		AMH	Manhole / A48	


SRP - 0.00


SRC - 0.00


SRC - 0.00


SAP - 0.00


SAP - 0.00


IR - 8.02

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/10/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A47A481**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


IR - 8.02


IR - 8.02


IR - 8.02


SRV - 24.25


SRV - 24.25


SRV - 36.67


SRV - 36.67


SRV - 130.06


SRV - 130.06


SAP - 130.06


SAP - 130.06


SSC - 130.06


SSC - 130.06


SSC - 130.06


SSC - 130.06


SRV - 144.78


SRV - 144.78


SRV - 419.42


SRV - 419.42


SRV - 426.24


SRV - 426.24


IR - 558.20


IR - 558.20


IS - 558.20

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/10/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A47A481**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


IS - 558.20


SRV - 589.46


SRV - 589.46


SAP - 589.46


SAP - 589.46


SSC - 589.46


SSC - 589.46


SSC - 589.46


SSC - 589.46


SAV - 636.75


SAV - 636.75


SSC - 665.51


SSC - 665.51


SRV - 665.51


SRV - 665.51


SAV - 665.51


SAV - 665.51


SAP - 665.51


SAP - 665.51


SRV - 681.54


SRV - 681.54


SRV - 688.25


SRV - 688.25


SAP - 688.25

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/10/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A47A481**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SAP - 688.25


AMH - 690.86


AMH - 690.86

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
524Q	4311	524R	966.0	13.0	979.0	2.3	3.2	2.3

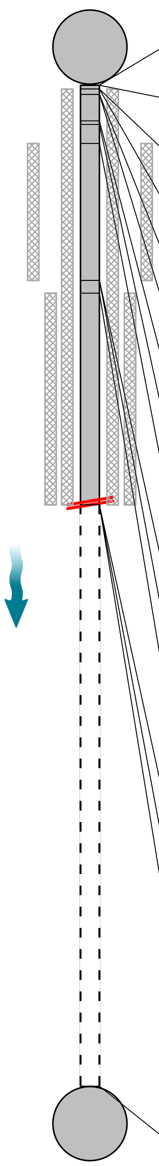
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/6/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A47A481**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			

City:	**ALAMEDA**	Drainage Area:		Upstream MH:	**A47**
Street:	**TYNAN AVE**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Easement/Right of way**	Flow Control:	**Not Controlled**	Downstream MH:	**A48**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**60**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:	**Routine Assessment**	Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:5215



Distance		Code	Observation	Grade
0.0		AMH	Manhole / A47	
0.0		MWL	Water Level, 35% of the vertical dimension	
2.9		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock	S4
2.9	S01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Start	
6.6		IS	Infiltration Stain from 3 o'clock to 5 o'clock, within 8 inch	M1
6.6		IS	Infiltration Stain from 8 o'clock to 10 o'clock, within 8 inch	M1
24.6		SRV	Surface Damage Reinforcement Visible from 1 o'clock to 2 o'clock	S4
27.4		SRV	Surface Damage Reinforcement Visible at 2 o'clock	S4
40.4	S02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 3 o'clock, Start	
135.1		IW	Infiltration Weeper from 2 o'clock to 4 o'clock, within 8 inch	M2
135.1	F02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 3 o'clock, Finish	S4
143.5	S03	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Start	
289.9	F01	SAP	Surface Damage Aggregate Projecting from 8 o'clock to 4 o'clock, Finish	S3
289.9	F03	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, Finish	S4
289.9		MSA	Miscellaneous Survey Abandoned / END OF SURVEY. PONTOON CANNOT CONTINUE DUE TO LACK OF FLOW / DEBRIS	
690.9			End of pipe	

MWL - 0.00

MWL - 0.00

SRV - 2.91

SRV - 2.91

SAP - 2.91

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
6/6/2022	**6.6.22**	**Dry**	**NIKOLAI KORHUMMELSTONE**	**U-0517-07007861**	**A47A481**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**			


SAP - 2.91


IS - 6.61


IS - 6.61


IS - 6.61


IS - 6.61


SRV - 24.65


SRV - 24.65


SRV - 27.35


SRV - 27.35


SRV - 40.38


SRV - 40.38


IW - 135.07


SRV - 135.07


SRV - 135.07


SRV - 143.48


SRV - 143.48


SAP - 289.87


SAP - 289.87


SRV - 289.87


SRV - 289.87


MSA - 289.87


MSA - 289.87

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
4I3J	2112	4I3J	375.0	4.0	379.0	3.5	1.3	3.4

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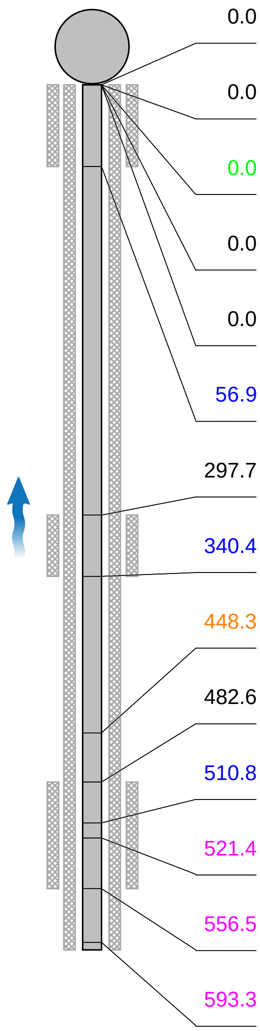
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
9/30/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**09/30/22 4:23:06 AM**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Upstream**		**604.6 '**	**604.6 '**

City:	**BERKELEY**	Drainage Area:		Upstream MH:	**N20**
Street:	**W BOLIVAR DR**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:		Flow Control:		Downstream MH:	**N21**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**60 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

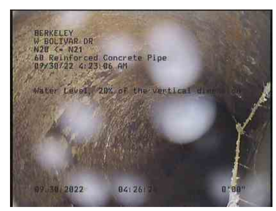
1:5231

N21

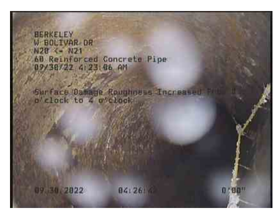


Distance		Code	Observation	Grade
0.0		AMH	Manhole / N21	
0.0		MWL	Water Level, 20% of the vertical dimension	
0.0		SRI	Surface Damage Roughness Increased from 8 o'clock to 4 o'clock	S1
0.0	S01	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, Start	
0.0	S02	LR	Line Right, change to: 20%, Start	
56.9	F02	LR	Line Right, change to: 20%, Finish	M2
297.7	S03	LR	Line Right, change to: 15%, Start	
340.4	F03	LR	Line Right, change to: 15%, Finish	M2
448.3		ID	Infiltration Dripper at 12 o'clock	M3
482.6	S04	LL	Line Left, change to: 25%, Start	
510.8		DSGV	Deposits Settled Gravel, 10% of cross sectional area from 6 o'clock to 7 o'clock	M2
521.4		IRJ	Infiltration Runner Joint from 1 o'clock to 2 o'clock, within 8 inch	M4
556.5	F04	LL	Line Left, change to: 25%, Finish	M4
593.3		SRV	Surface Damage Reinforcement Visible from 1 o'clock to 3 o'clock	S4

AMH - 0.00 ft



MWL - 0.00 ft



SRI - 0.00 ft

SAV - 0.00 ft

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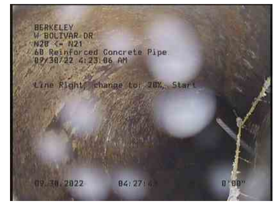
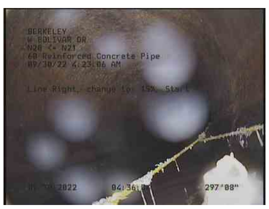
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
9/30/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**09/30/22 4:23:06 AM**
Year laid:	Pre-cleaning: **No Pre-Cleaning**	Direction: **Upstream**	Pipe Joint Length:	Total Length: **604.6 '**	Length Surveyed: **604.6 '**

1:5231	Distance		Code	Observation	Grade
	604.6	F01	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, Finish	S2
N20	604.6		AM	Meter / N20	


LR - 0.00 ft


LR - 56.92 ft


LR - 297.70 ft


LL - 482.56 ft


DSGV - 510.77 ft


IRJ - 521.37 ft


LL - 556.48 ft


SRV - 593.29 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
412W	4B31	4B31	247.0	109.0	356.0	2.0	2.9	2.2

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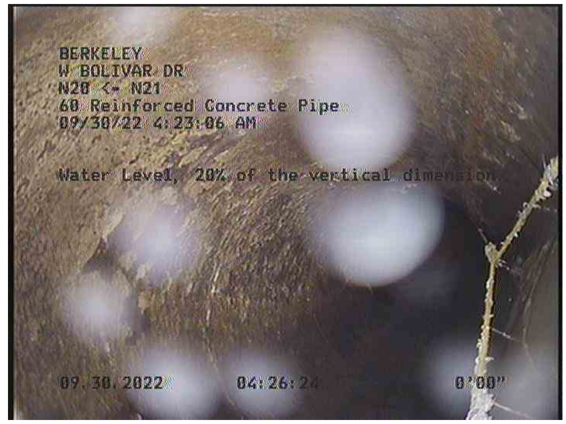
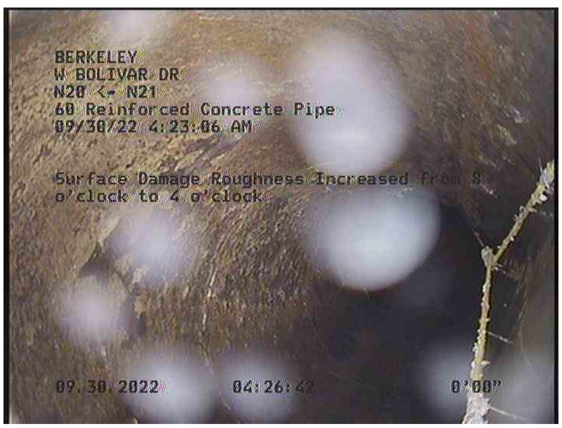
Section Pictures - 9/30/2022 - 09/30/22 4:23:06 AM

City	Street	Date	Pipe Segment Reference	Section No.
BERKELEY	**W BOLIVAR DR**	**9/30/2022**	**09/30/22 4:23:06 AM**	**2**

1, 00:00:27, 0.00ft
Manhole / N21

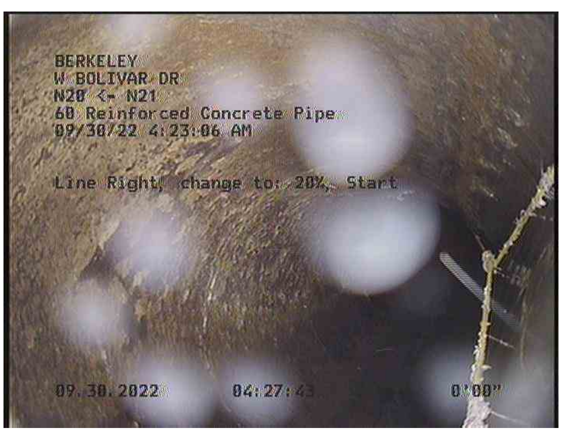


2, 00:00:48, 0.00ft
Water Level, 20% of the vertical dimension



3, 00:00:54, 0.00ft
Surface Damage Roughness Increased from 8 o'clock to 4 o'clock

4, 00:01:00, 0.00ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, Start



5, 00:01:18, 0.00ft
Line Right, change to: 20%, Start

6, 00:04:12, 56.92ft
Line Right, change to: 20%, Finish

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Section Pictures - 9/30/2022 - 09/30/22 4:23:06 AM

City	Street	Date	Pipe Segment Reference	Section No.
BERKELEY	**W BOLIVAR DR**	**9/30/2022**	**09/30/22 4:23:06 AM**	**2**

7, 00:10:10, 297.70ft
Line Right, change to: 15%, Start

8, 00:15:31, 482.56ft
Line Left, change to: 25%, Start

9, 00:17:02, 510.77ft
Deposits Settled Gravel, 10% of cross sectional area from 6 o'clock to 7 o'clock

10, 00:26:51, 521.37ft
Infiltration Runner Joint from 1 o'clock to 2 o'clock, within 8 inch

11, 00:31:12, 556.48ft
Line Left, change to: 25%, Finish

12, 00:32:37, 593.29ft
Surface Damage Reinforcement Visible from 1 o'clock to 3 o'clock

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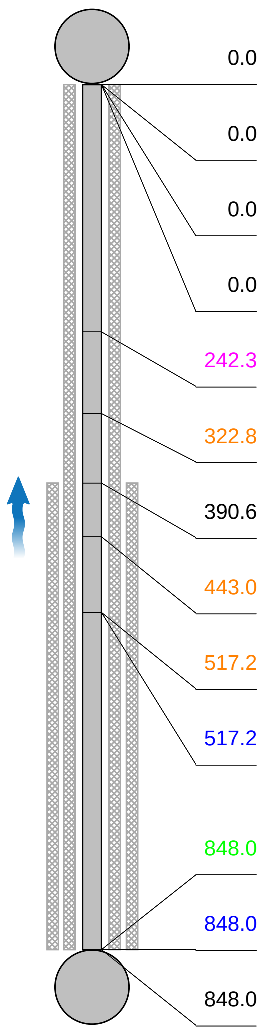
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
9/30/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**09/30/22 3:42:08 AM**
Year laid:	Pre-cleaning: **No Pre-Cleaning**	Direction: **Upstream**	Pipe Joint Length:	Total Length: **848.0 '**	Length Surveyed: **848.0 '**

City:	**BERKELEY**	Drainage Area:		Upstream MH:	**N21**
Street:	**W BOLIVAR DR**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:		Flow Control:		Downstream MH:	**N22**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**60 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:7406

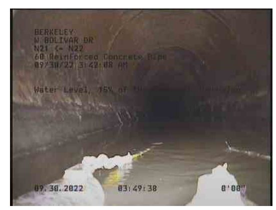
N22



N21

Distance		Code	Observation	Grade
0.0		AMH	Manhole / N22	
0.0		MWL	Water Level, 15% of the vertical dimension	
0.0		MWM	Miscellaneous Water Mark, 45% of the vertical dimension	
0.0	S01	SRI	Surface Damage Roughness Increased from 8 o'clock to 4 o'clock, Start	
242.3		IRJ	Infiltration Runner Joint at 4 o'clock, within 8 inch	M4
322.8		IDJ	Infiltration Dripper Joint at 11 o'clock, within 8 inch	M3
390.6	S02	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Start	
443.0		IDJ	Infiltration Dripper Joint at 10 o'clock, within 8 inch	M3
517.2		IDJ	Infiltration Dripper Joint at 11 o'clock, within 8 inch	M3
517.2		DAE	Deposits Attached Encrustation, 5% of cross sectional area from 10 o'clock to 11 o'clock	M2
848.0	F01	SRI	Surface Damage Roughness Increased from 8 o'clock to 4 o'clock, Finish	S1
848.0	F02	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Finish	S2
848.0		AMH	Manhole / N21	

AMH - 0.00 ft



MWL - 0.00 ft

MWM - 0.00 ft

SRI - 0.00 ft

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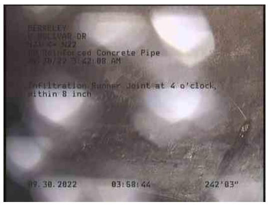
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
9/30/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**09/30/22 3:42:08 AM**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Upstream**		**848.0 '**	**848.0 '**


IRJ - 242.28 ft


IRJ - 242.28 ft


IDJ - 322.81 ft


SAV - 390.63 ft


SAV - 390.63 ft


IDJ - 443.04 ft


DAE - 517.17 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
2Q1Z	4133	4133	352.0	15.0	367.0	1.3	3.0	1.4

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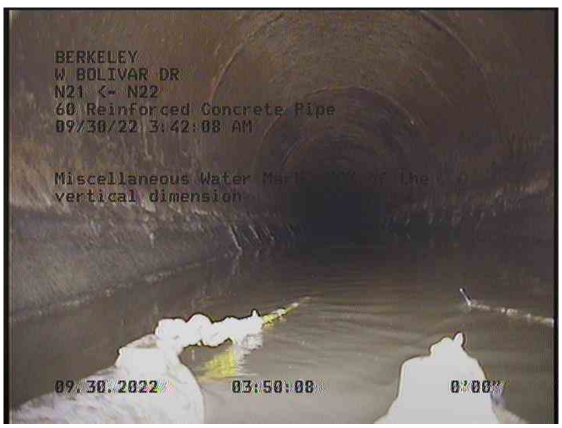
Section Pictures - 9/30/2022 - 09/30/22 3:42:08 AM

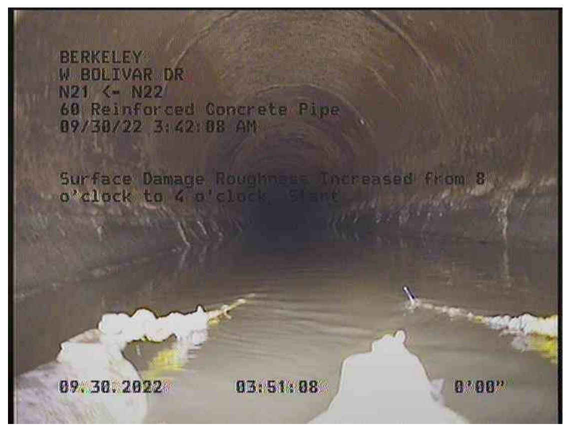
City	Street	Date	Pipe Segment Reference	Section No.
BERKELEY	**W BOLIVAR DR**	**9/30/2022**	**09/30/22 3:42:08 AM**	**1**

1, 00:00:22, 0.00ft
Manhole / N22

2, 00:00:37, 0.00ft
Water Level, 15% of the vertical dimension



3, 00:00:51, 0.00ft
Miscellaneous Water Mark, 45% of the vertical dimension



4, 00:01:25, 0.00ft
Surface Damage Roughness Increased from 8 o'clock to 4 o'clock, Start

5, 00:08:33, 242.28ft
Infiltration Runner Joint at 4 o'clock, within 8 inch

6, 00:08:33, 242.28ft
Infiltration Runner Joint at 4 o'clock, within 8 inch

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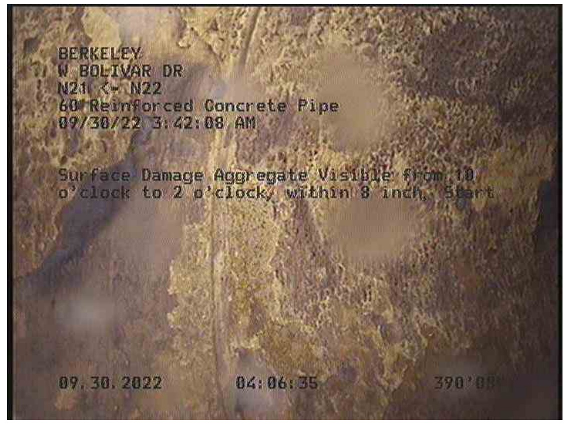
Section Pictures - 9/30/2022 - 09/30/22 3:42:08 AM

City	Street	Date	Pipe Segment Reference	Section No.
BERKELEY	**W BOLIVAR DR**	**9/30/2022**	**09/30/22 3:42:08 AM**	**1**

7, 00:13:41, 322.81ft
Infiltration Dripper Joint at 11 o'clock, within 8 inch



8, 00:16:11, 390.63ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Start

9, 00:16:11, 390.63ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Start

10, 00:18:17, 443.04ft
Infiltration Dripper Joint at 10 o'clock, within 8 inch

11, 00:20:59, 517.17ft
Deposits Attached Encrustation, 5% of cross sectional area from 10 o'clock to 11 o'clock

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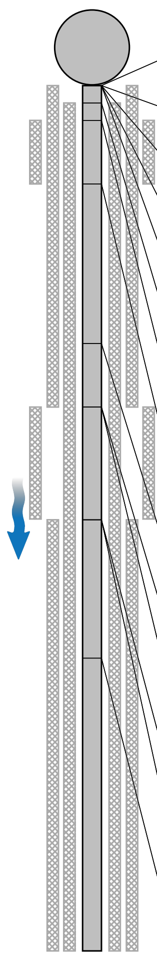
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/14/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N26-N27**
Year laid:	Pre-cleaning: **Not Known**	Direction: **Downstream**	Pipe Joint Length:	Total Length: **1234.0 '**	Length Surveyed: **1015.0 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N26**
Street:	**BOLIVAR DR**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N27**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			

Additional Info:

1:5833 N26



Distance		Code	Observation	Grade
0.0		AMH	Manhole / N26	
0.0		MWL	Water Level, 25% of the vertical dimension	
0.0		MGO	Miscellaneous General Observation / GO PRO ONLY	
0.0		MWM	Miscellaneous Water Mark, 40% of the vertical dimension	
0.0	S02	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Start	
13.5	S01	DSZ	Deposits Settled Other, 15% of cross sectional area at 6 o'clock, Start / UNKNOWN MATERIAL	
27.0	S07	SAP	Surface Damage Aggregate Projecting from 11 o'clock to 2 o'clock, within 8 inch, Start / PROJECTING	
76.0	F07	SAP	Surface Damage Aggregate Projecting from 11 o'clock to 2 o'clock, within 8 inch, Finish / PROJECTING	S3
199.0		SAP	Surface Damage Aggregate Projecting at 2 o'clock	S3
248.2	F02	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Finish	S2
248.2	S03	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Start	
335.0	F03	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Finish	S1
335.0	S08	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start	
442.1		SAP	Surface Damage Aggregate Projecting at 12 o'clock	S3

MWM - 0.00 ft

MWM - 0.00 ft

SAV - 0.00 ft

SAV - 0.00 ft

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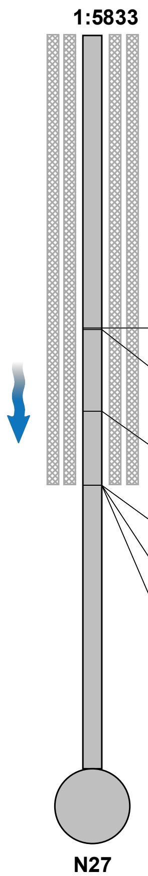
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/14/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N26-N27**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**1234.0 '**	**1015.0 '**



Distance		Code	Observation	Grade
893.7		MGO	Miscellaneous General Observation / CCTV CAMERA GOES UNDERWATER	
894.8		ISB	Infiltration Stain Barrel at 11 o'clock	M1
958.1		IS	Infiltration Stain from 9 o'clock to 2 o'clock, within 8 inch	M1
1015.0	F08	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Finish	S2
1015.0	F01	DSZ	Deposits Settled Other, 15% of cross sectional area at 6 o'clock, Finish / UNKNOWN MATERIAL	M3
1015.0		AMH	Manhole / N27	


DSZ - 13.53 ft


SAP - 27.00 ft


SAP - 76.00 ft


SAP - 199.01 ft


SAV - 248.19 ft


SRI - 248.19 ft

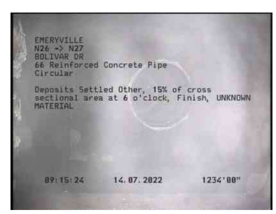

SRI - 335.00 ft


SAV - 335.00 ft


SAP - 442.06 ft


ISB - 894.80 ft


IS - 958.10 ft



DSZ - 1015.00 ft

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Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/14/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N26-N27**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**1234.0 '**	**1015.0 '**

AMH - 1015.00 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
3A2Z	3Z12	3Z2Z	425.0	602.0	1027.0	2.0	3.0	2.5

WinCan

Section Pictures - 7/14/2022 - N26-N27

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**7/14/2022**	**N26-N27**	**1**

1, 00:02:12, 0.00ft
Miscellaneous Water Mark, 40% of the vertical dimension

2, 00:02:12, 0.00ft
Miscellaneous Water Mark, 40% of the vertical dimension

3, 00:07:00, 0.00ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Start

4, 00:07:00, 0.00ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Start

5, 00:04:44, 13.53ft
Deposits Settled Other, 15% of cross sectional area at 6 o'clock, Start / UNKNOWN MATERIAL

6, 00:05:17, 27.00ft
Surface Damage Aggregate Projecting from 11 o'clock to 2 o'clock, within 8 inch, Start / PROJECTING

WinCan

Section Pictures - 7/14/2022 - N26-N27

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**7/14/2022**	**N26-N27**	**1**

7, 00:08:22, 76.00ft
Surface Damage Aggregate Projecting from 11 o'clock to 2 o'clock, within 8 inch, Finish / PROJECTING

8, 00:14:53, 199.01ft
Surface Damage Aggregate Projecting at 2 o'clock

9, 00:17:42, 248.19ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Finish

10, 00:18:17, 248.19ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Start

11, 00:21:32, 335.00ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Finish

12, 00:21:32, 335.00ft
Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start

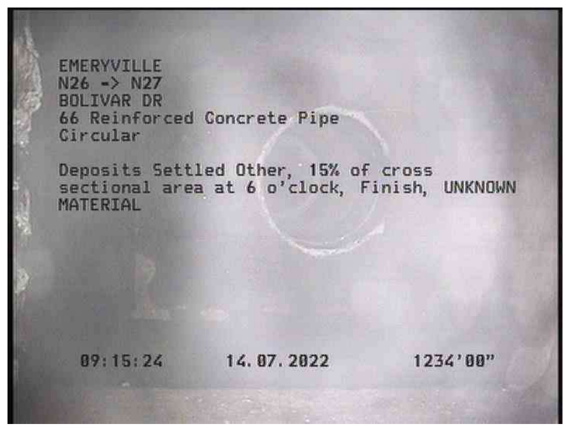
Section Pictures - 7/14/2022 - N26-N27

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**7/14/2022**	**N26-N27**	**1**

13, 00:23:25, 442.06ft
Surface Damage Aggregate Projecting at 12 o'clock

14, 00:39:37, 894.80ft
Infiltration Stain Barrel at 11 o'clock

15, 00:40:58, 958.10ft
Infiltration Stain from 9 o'clock to 2 o'clock, within 8 inch



16, 00:53:54, 1015.00ft
Deposits Settled Other, 15% of cross sectional area at 6 o'clock, Finish / UNKNOWN MATERIAL

17, 00:54:10, 1015.00ft
Manhole / N27

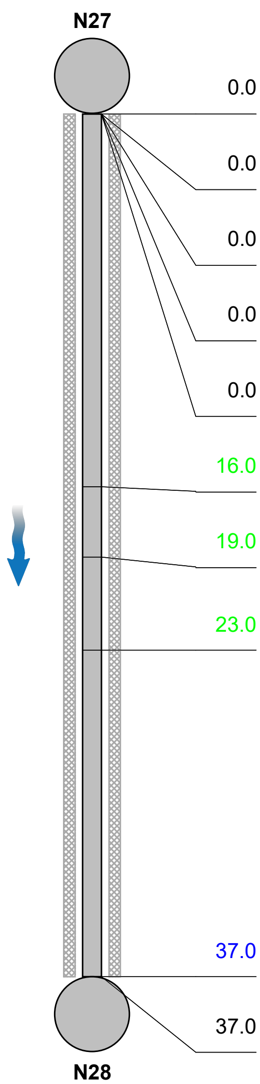
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
8/7/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N27-N28**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**37.0 '**	**37.0 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N27**
Street:	**BOLIVAR DR**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N28**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Square**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 x 66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:	**PIPE SIZE UNKNOWN**				

1:324



Distance		Code	Observation	Grade
0.0		AMH	Manhole / N27	
0.0		MWL	Water Level, 50% of the vertical dimension	
0.0	S01	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start	
0.0		MGO	Miscellaneous General Observation / UNKNOWN PIPE SIZE. CCTV CAMERA WAS UNDER WATER.	
0.0		MWM	Miscellaneous Water Mark, 55% of the vertical dimension	
16.0		IS	Infiltration Stain from 1 o'clock to 2 o'clock, within 8 inch	M1
19.0		IS	Infiltration Stain from 1 o'clock to 3 o'clock	M1
23.0		IS	Infiltration Stain from 1 o'clock to 3 o'clock	M1
37.0	F01	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Finish	S2
37.0		AMH	Manhole / N28	

AMH - 0.00 ft

MWL - 0.00 ft

SAV - 0.00 ft

MGO - 0.00 ft

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
8/7/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N27-N28**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**37.0 '**	**37.0 '**

MWM - 0.00 ft

IS - 16.00 ft

IS - 19.00 ft

IS - 23.00 ft

SAV - 37.00 ft

AMH - 37.00 ft

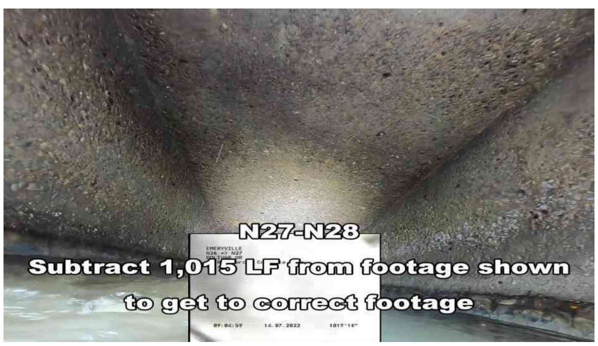
QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
2700	1300	2713	14.0	3.0	17.0	2.0	1.0	1.7

Section Pictures - 8/7/2022 - N27-N28

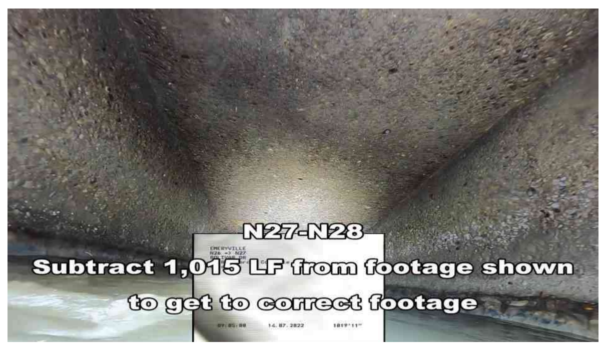
City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**8/7/2022**	**N27-N28**	**14**

1, 00:00:00, 0.00ft
Manhole / N27

2, 00:00:05, 0.00ft
Water Level, 50% of the vertical dimension

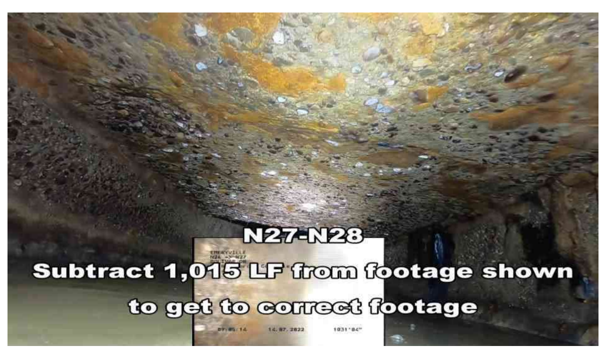


3, 00:00:05, 0.00ft
Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start



4, 00:00:06, 0.00ft
Miscellaneous General Observation / UNKNOWN PIPE SIZE. CCTV CAMERA WAS UNDER WATER.

5, 00:00:06, 0.00ft
Miscellaneous Water Mark, 55% of the vertical dimension



6, 00:00:20, 16.00ft
Infiltration Stain from 1 o'clock to 2 o'clock, within 8 inch

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Section Pictures - 8/7/2022 - N27-N28

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**8/7/2022**	**N27-N28**	**14**

7, 00:00:23, 19.00ft
Infiltration Stain from 1 o'clock to 3 o'clock

8, 00:00:25, 23.00ft
Infiltration Stain from 1 o'clock to 3 o'clock

9, 00:00:36, 37.00ft
Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Finish

10, 00:00:37, 37.00ft
Manhole / N28

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
8/7/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N28-N29**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**181.0 '**	**181.0 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N28**
Street:	**BOLIVAR DR**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N29**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:1581	Distance		Code	Observation	Grade
N28					
	0.0		AMH	Manhole / N28	
	0.0		MWL	Water Level, 50% of the vertical dimension	
	0.0	S01	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start	
	0.0		MWM	Miscellaneous Water Mark, 55% of the vertical dimension	
	35.2		IS	Infiltration Stain from 11 o'clock to 12 o'clock	M1
	42.9		ID	Infiltration Dripper from 9 o'clock to 11 o'clock, within 8 inch	M3
	139.9		ISJ	Infiltration Stain Joint from 9 o'clock to 11 o'clock, within 8 inch	M1
	181.0	F01	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Finish	S2
	181.0		AMH	Manhole / N29	
N29					

AMH - 0.00 ft

MWL - 0.00 ft

SAV - 0.00 ft

MWM - 0.00 ft

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
8/7/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N28-N29**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**181.0 '**	**181.0 '**

IS - 35.20 ft

ID - 42.90 ft

ISJ - 139.90 ft

SAV - 181.00 ft

AMH - 181.00 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
2F00	3112	312F	72.0	5.0	77.0	2.0	1.7	2.0

WinCan

Section Pictures - 8/7/2022 - N28-N29

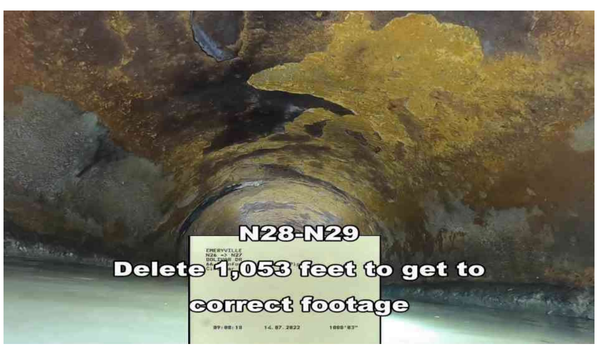
City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**8/7/2022**	**N28-N29**	**15**

1, 00:00:00, 0.00ft
Manhole / N28

2, 00:00:02, 0.00ft
Water Level, 50% of the vertical dimension

3, 00:00:04, 0.00ft
Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start

4, 00:00:04, 0.00ft
Miscellaneous Water Mark, 55% of the vertical dimension

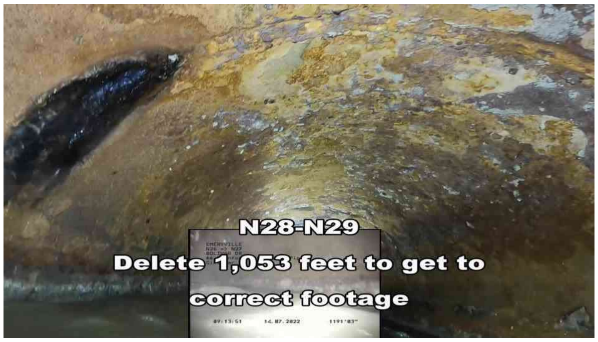


5, 00:02:46, 35.20ft
Infiltration Stain from 11 o'clock to 12 o'clock

6, 00:03:06, 42.90ft
Infiltration Dripper from 9 o'clock to 11 o'clock, within 8 inch

Section Pictures - 8/7/2022 - N28-N29

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**8/7/2022**	**N28-N29**	**15**



7, 00:08:19, 139.90ft
Infiltration Stain Joint from 9 o'clock to 11 o'clock, within 8 inch

8, 00:09:36, 181.00ft
Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Finish

9, 00:09:36, 181.00ft
Manhole / N29

WinCan

Inspection report

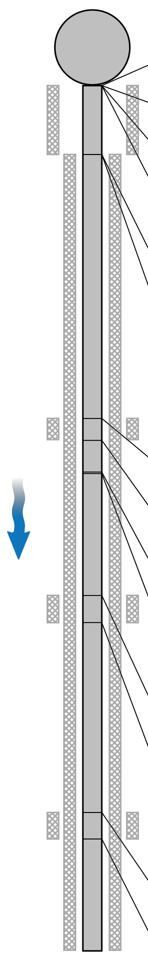
Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/14/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N29-N30**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**680.0 '**	**680.0 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N29**
Street:	**BOLIVAR DR**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N30**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			

Additional Info:

1:2533

N29



Distance		Code	Observation	Grade
0.0		AMH	Manhole / N29	
0.0		MWL	Water Level, 30% of the vertical dimension	
0.0		MWM	Miscellaneous Water Mark, 35% of the vertical dimension	
0.0	S02	SRI	Surface Damage Roughness Increased from 8 o'clock to 4 o'clock, within 8 inch, Start	
23.3	F02	SRI	Surface Damage Roughness Increased from 8 o'clock to 4 o'clock, within 8 inch, Finish	S1
23.3	S03	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start	
111.7	S04	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, within 8 inch, Start	
119.0	F04	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, within 8 inch, Finish	S4
129.5		IS	Infiltration Stain from 9 o'clock to 3 o'clock, within 8 inch	M1
130.0		SAP	Surface Damage Aggregate Projecting from 9 o'clock to 10 o'clock, within 8 inch	S3
170.8	S05	SAP	Surface Damage Aggregate Projecting from 12 o'clock to 3 o'clock, within 8 inch, Start	
180.0	F05	SAP	Surface Damage Aggregate Projecting from 12 o'clock to 3 o'clock, within 8 inch, Finish	S3
243.5	S06	SAP	Surface Damage Aggregate Projecting from 10 o'clock to 11 o'clock, within 8 inch, Start	
252.5	F06	SAP	Surface Damage Aggregate Projecting from 10 o'clock to 11 o'clock, within 8 inch, Finish	S3

AMH - 0.00 ft

MWL - 0.00 ft

MWM - 0.00 ft

SRI - 0.00 ft

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/14/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N29-N30**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**680.0 '**	**680.0 '**

1:2533

Distance		Code	Observation	Grade
327.5		ID	Infiltration Dripper at 11 o'clock, within 8 inch	M3
377.4		IDJ	Infiltration Dripper Joint from 9 o'clock to 12 o'clock, within 8 inch	M3
377.4		IDJ	Infiltration Dripper Joint from 1 o'clock to 3 o'clock, within 8 inch	M3
390.6		IS	Infiltration Stain from 9 o'clock to 12 o'clock, within 8 inch	M1
401.7		IS	Infiltration Stain from 9 o'clock to 3 o'clock, within 8 inch	M1
527.8	S07	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, within 8 inch, Start	
534.9	F07	SRV	Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, within 8 inch, Finish	S4
672.9		IS	Infiltration Stain from 1 o'clock to 2 o'clock, within 8 inch	M1
680.0	F03	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Finish	S2
680.0		AMH	Manhole / N29	

N30

SRI - 23.30 ft

SAV - 23.30 ft

SRV - 111.70 ft

SRV - 119.00 ft

IS - 129.50 ft

SAP - 130.00 ft

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/14/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N29-N30**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**680.0 '**	**680.0 '**


SAP - 170.80 ft


SAP - 180.00 ft


SAP - 243.50 ft


SAP - 252.50 ft

ID - 327.54 ft


IDJ - 377.40 ft


IDJ - 377.40 ft


IS - 390.60 ft


IS - 401.70 ft


SRV - 527.80 ft


SRV - 534.90 ft


IS - 672.90 ft


SAV - 680.00 ft

AMH - 680.03 ft

AMH - 680.03 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
4235	3314	4238	290.0	13.0	303.0	2.0	1.9	2.0

WinCan

Section Pictures - 7/14/2022 - N29-N30

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**7/14/2022**	**N29-N30**	**3**

1, 00:00:00, 0.00ft
Manhole / N28

2, 00:00:01, 0.00ft
Water Level, 30% of the vertical dimension

3, 00:00:34, 0.00ft
Miscellaneous Water Mark, 35% of the vertical dimension

4, 00:00:34, 0.00ft
Surface Damage Roughness Increased from 8 o'clock to 4 o'clock, within 8 inch, Start

5, 00:02:31, 23.30ft
Surface Damage Roughness Increased from 8 o'clock to 4 o'clock, within 8 inch, Finish

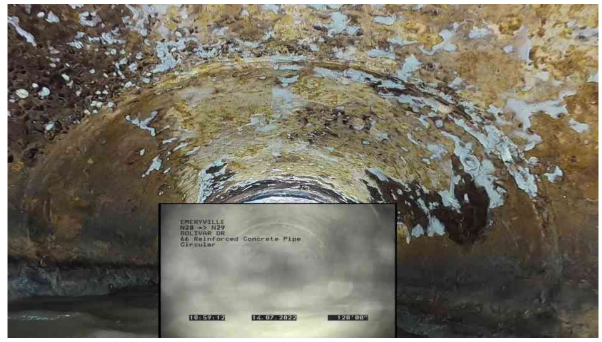
6, 00:02:31, 23.30ft
Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start

WinCan

Section Pictures - 7/14/2022 - N29-N30

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**7/14/2022**	**N29-N30**	**3**

7, 00:03:43, 111.70ft
Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, within 8 inch, Start



8, 00:03:49, 119.00ft
Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, within 8 inch, Finish

9, 00:03:57, 129.50ft
Infiltration Stain from 9 o'clock to 3 o'clock, within 8 inch

10, 00:03:58, 130.00ft
Surface Damage Aggregate Projecting from 9 o'clock to 10 o'clock, within 8 inch

11, 00:04:31, 170.80ft
Surface Damage Aggregate Projecting from 12 o'clock to 3 o'clock, within 8 inch, Start

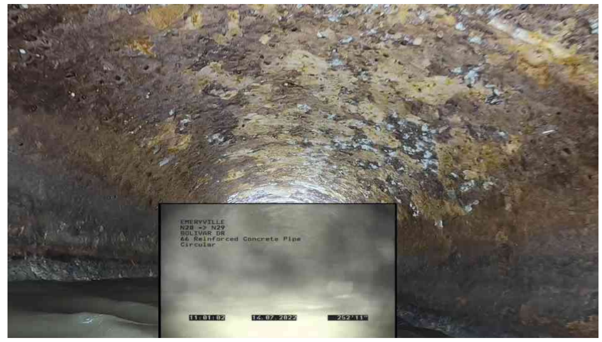
12, 00:04:39, 180.00ft
Surface Damage Aggregate Projecting from 12 o'clock to 3 o'clock, within 8 inch, Finish

WinCan

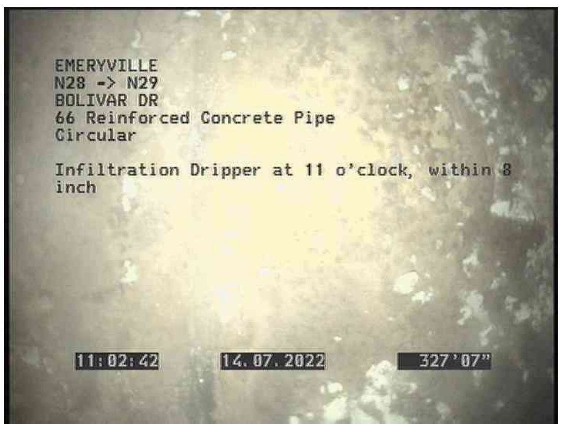
Section Pictures - 7/14/2022 - N29-N30

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**7/14/2022**	**N29-N30**	**3**

13, 00:05:32, 243.50ft
Surface Damage Aggregate Projecting from 10 o'clock to 11 o'clock, within 8 inch, Start



14, 00:05:39, 252.50ft
Surface Damage Aggregate Projecting from 10 o'clock to 11 o'clock, within 8 inch, Finish



15, 00:07:15, 327.54ft
Infiltration Dripper at 11 o'clock, within 8 inch

16, 00:08:09, 377.40ft
Infiltration Dripper Joint from 9 o'clock to 12 o'clock, within 8 inch

17, 00:08:09, 377.40ft
Infiltration Dripper Joint from 1 o'clock to 3 o'clock, within 8 inch

18, 00:08:21, 390.60ft
Infiltration Stain from 9 o'clock to 12 o'clock, within 8 inch

Section Pictures - 7/14/2022 - N29-N30

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**7/14/2022**	**N29-N30**	**3**

19, 00:08:33, 401.70ft
Infiltration Stain from 9 o'clock to 3 o'clock, within 8 inch

20, 00:10:27, 527.80ft
Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, within 8 inch, Start

21, 00:10:34, 534.90ft
Surface Damage Reinforcement Visible from 12 o'clock to 3 o'clock, within 8 inch, Finish

22, 00:12:55, 672.90ft
Infiltration Stain from 1 o'clock to 2 o'clock, within 8 inch

23, 00:15:33, 680.00ft
Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Finish

24, 00:15:34, 680.03ft
Manhole / N29

Section Pictures - 7/14/2022 - N29-N30

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**BOLIVAR DR**	**7/14/2022**	**N29-N30**	**3**

25, 00:15:34, 680.03ft
Manhole / N29

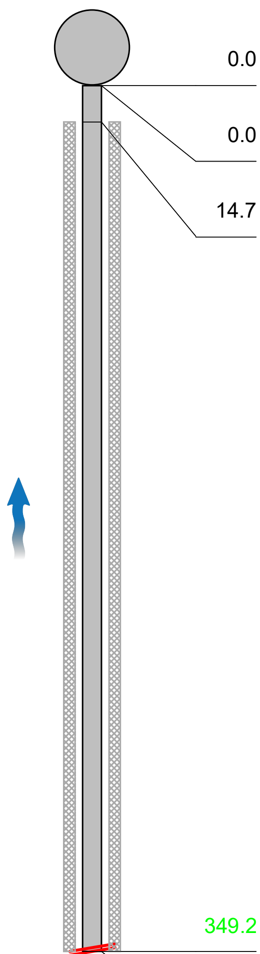
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/14/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N29-N30**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Upstream**		**349.2 '**	**349.2 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N29**
Street:	**LA COSTE ST**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N30**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			

Additional Info:

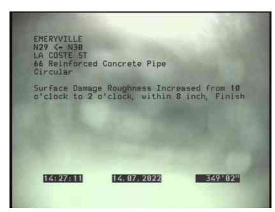


Distance		Code	Observation	Grade
0.0		AMH	Manhole / N30	
0.0		MWL	Water Level, 30% of the vertical dimension	
14.7	S01	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Start	
349.2	F01	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Finish	S1
349.2		MSA	Miscellaneous Survey Abandoned / CRAWLER WILL NOT TRAVEL ANY FARTHER	


AMH - 0.00 ft


MWL - 0.00 ft

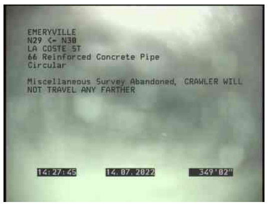

SRI - 14.73 ft


SRI - 349.19 ft

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/14/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N29-N30**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Upstream**		**349.2 '**	**349.2 '**



MSA - 349.19 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
1L00	0000	1L00	67.0	0.0	67.0	1.0	0.0	1.0

WinCan

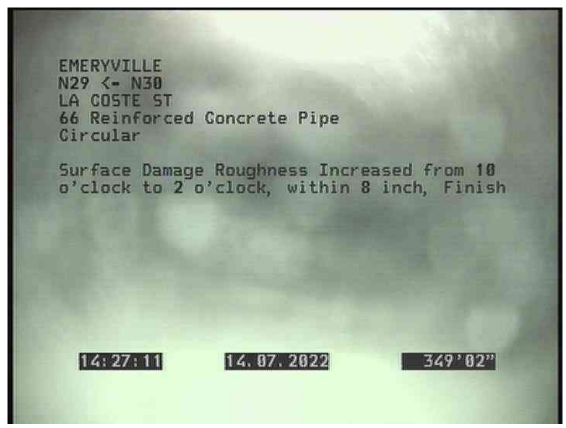
Section Pictures - 7/14/2022 - N29-N30

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**LA COSTE ST**	**7/14/2022**	**N29-N30**	**4**

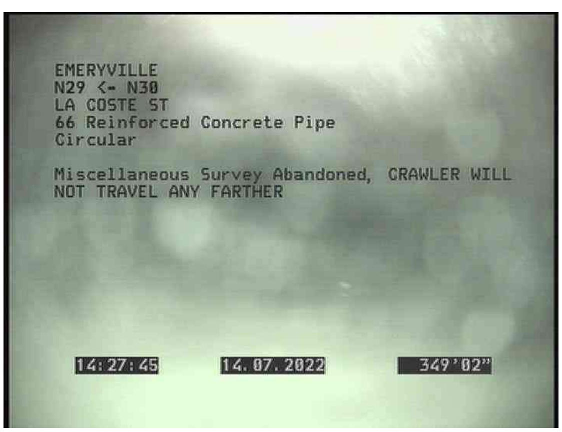
1, 00:00:25, 0.00ft
Manhole / N30

2, 00:01:08, 0.00ft
Water Level, 30% of the vertical dimension

3, 00:06:56, 14.73ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Start



4, 00:23:09, 349.19ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Finish



5, 00:23:42, 349.19ft
Miscellaneous Survey Abandoned / CRAWLER WILL NOT TRAVEL ANY FARTHER

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/14/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N30-N31**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Upstream**		**1081.7 '**	**1081.7 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N30**
Street:	**LA COSTE ST**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N31**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			

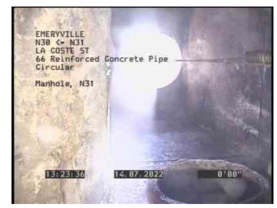
Additional Info:

1:9448

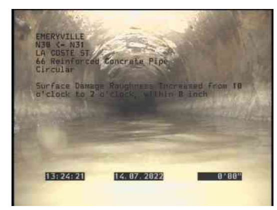
N31

Distance	Code	Observation	Grade
0.0	AMH	Manhole / N31	
0.0	MWL	Water Level, 25% of the vertical dimension	
0.0	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch	S1
886.6	SRV	Surface Damage Reinforcement Visible at 12 o'clock	S4
1081.7	AMH	Manhole / N30	

N30



AMH - 0.00 ft



SRI - 0.00 ft

SRV - 886.64 ft

AMH - 1081.72 ft

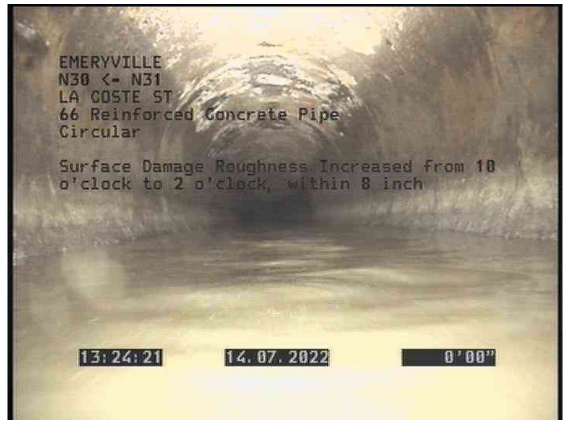
QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
4111	0000	4111	5.0	0.0	5.0	2.5	0.0	2.5

WinCan

Section Pictures - 7/14/2022 - N30-N31

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**LA COSTE ST**	**7/14/2022**	**N30-N31**	**2**

1, 00:00:22, 0.00ft
Manhole / N31



2, 00:01:05, 0.00ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch

3, 00:24:58, 886.64ft
Surface Damage Reinforcement Visible at 12 o'clock

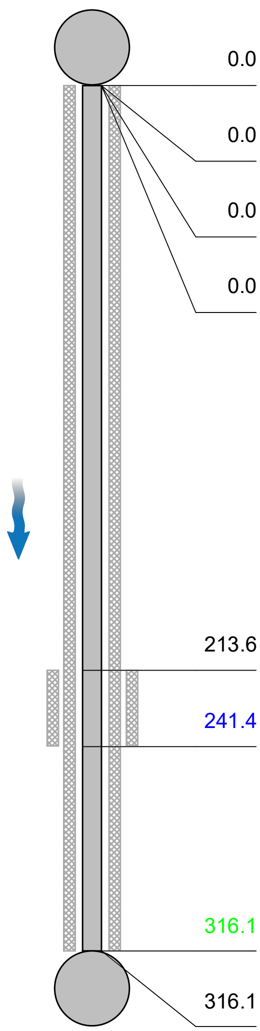
4, 00:38:35, 1081.72ft
Manhole / N30

WinCan

Inspection report

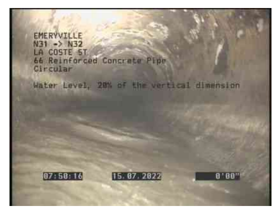
Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/15/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N31-N32**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**316.1 '**	**316.1 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N31**
Street:	**LA COSTE ST**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N32**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					



Distance		Code	Observation	Grade
0.0		AMH	Manhole / N31	
0.0		MWL	Water Level, 20% of the vertical dimension	
0.0		MWM	Miscellaneous Water Mark, 50% of the vertical dimension	
0.0	S01	SRI	Surface Damage Roughness Increased from 9 o'clock to 3 o'clock, within 8 inch, Start	
213.6	S02	SAV	Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, within 8 inch, Start	
241.4	F02	SAV	Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, within 8 inch, Finish	S2
316.1	F01	SRI	Surface Damage Roughness Increased from 9 o'clock to 3 o'clock, within 8 inch, Finish	S1
316.1		AMH	Manhole / N32	

AMH - 0.00 ft



MWL - 0.00 ft

MWM - 0.00 ft

SRI - 0.00 ft

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/15/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N31-N32**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**316.1 '**	**316.1 '**

SAV - 213.62 ft

AMH - 316.12 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
261K	0000	261K	75.0	0.0	75.0	1.1	0.0	1.1

WinCan

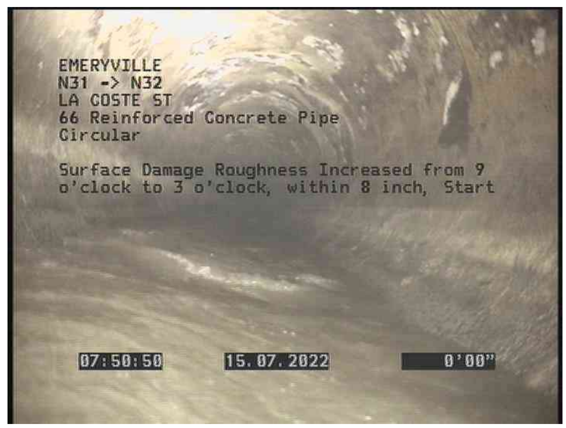
Section Pictures - 7/15/2022 - N31-N32

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**LA COSTE ST**	**7/15/2022**	**N31-N32**	**6**

1, 00:00:47, 0.00ft
Manhole / N31

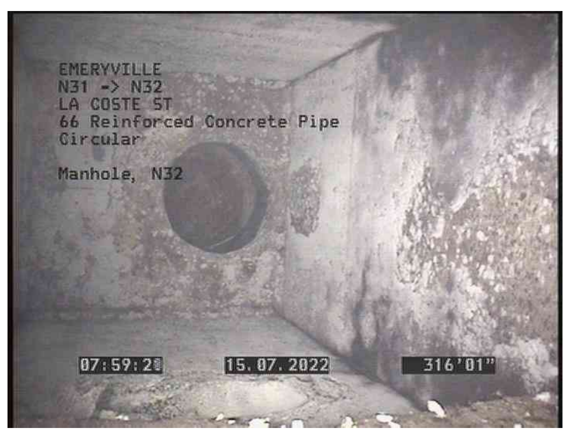
2, 00:00:00, 0.00ft
Water Level, 20% of the vertical dimension

3, 00:01:37, 0.00ft
Miscellaneous Water Mark, 50% of the vertical dimension



4, 00:01:58, 0.00ft
Surface Damage Roughness Increased from 9 o'clock to 3 o'clock, within 8 inch, Start

5, 00:07:06, 213.62ft
Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, within 8 inch, Start



6, 00:10:27, 316.12ft
Manhole / N32

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/15/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N32 BRANCH-N32**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**		**10.0 '**	**10.0 '**

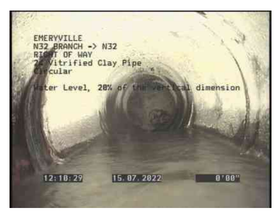
City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N32 BRANCH**
Street:	**RIGHT OF WAY**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:		Flow Control:	**Not Controlled**	Downstream MH:	**N32**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**24 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Vitrified Clay Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			

Additional Info:

1:88	Distance	Code	Observation	Grade
N32 BRANCH				
	0.0	AMH	Manhole / N32 BRANCH	
	0.0	MWL	Water Level, 20% of the vertical dimension	
	0.0	MWM	Miscellaneous Water Mark, 25% of the vertical dimension	
	5.5	TFA	Tap Factory Activity at 6 o'clock, dia/height: 15inch, within 8 inch / DROP CONNECTION	
	10.0	AMH	Manhole / N32	
N32				

AMH - 0.00 ft

AMH - 0.00 ft


MWL - 0.00 ft


MWM - 0.00 ft

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/15/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N32 BRANCH-N32**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**		**10.0 '**	**10.0 '**

TFA - 5.51 ft

AMH - 10.02 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
0000	0000	0000	0.0	0.0	0.0	0.0	0.0	0.0

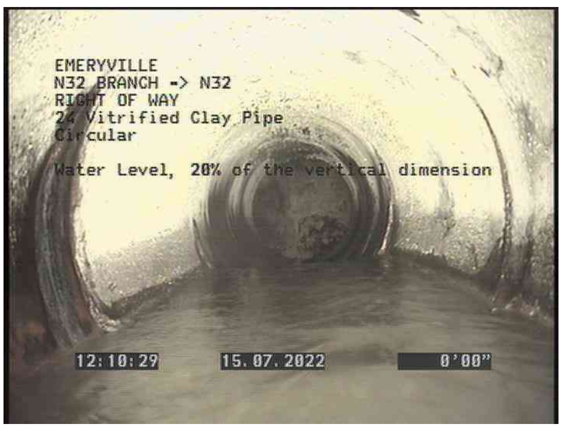
WinCan

Section Pictures - 7/15/2022 - N32 BRANCH-N32

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**RIGHT OF WAY**	**7/15/2022**	**N32 BRANCH-N32**	**5**

1, 00:00:25, 0.00ft
Manhole / N32 BRANCH

2, 00:00:25, 0.00ft
Manhole / N32 BRANCH



3, 00:01:17, 0.00ft
Water Level, 20% of the vertical dimension

4, 00:01:34, 0.00ft
Miscellaneous Water Mark, 25% of the vertical dimension

5, 00:04:32, 5.51ft
Tap Factory Activity at 6 o'clock, dia/height: 15inch, within 8 inch / DROP CONNECTION

6, 00:05:57, 10.02ft
Manhole / N32

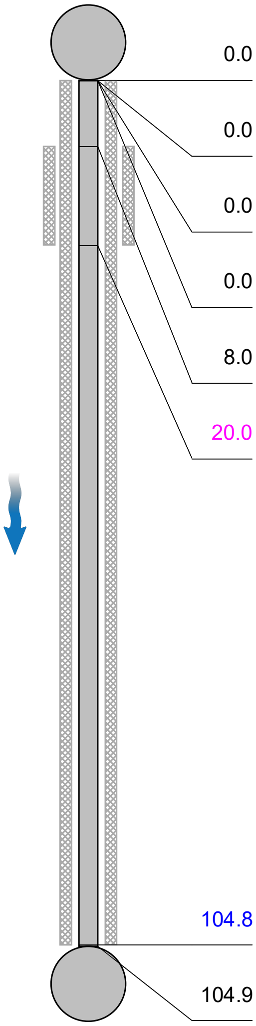
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
8/7/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N32-N33**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**104.9 '**	**104.9 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N32**
Street:	**LA COSTE ST**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N33**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

N32



N33

1:917	Distance		Code	Observation	Grade
N32	0.0		AMH	Manhole / N32	
	0.0		MWL	Water Level, 20% of the vertical dimension	
	0.0		MWM	Miscellaneous Water Mark, 50% of the vertical dimension	
	0.0	S01	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start	
	8.0	S02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, within 8 inch, Start	
	20.0	F02	SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock, within 8 inch, Finish	S4
	104.8	F01	SAV	Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Finish	S2
N33	104.9		AMH	Manhole / N33	

AMH - 0.00 ft

MWL - 0.00 ft

MWM - 0.00 ft

SAV - 0.00 ft

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
8/7/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N32-N33**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**104.9 '**	**104.9 '**

AMH - 104.91 ft

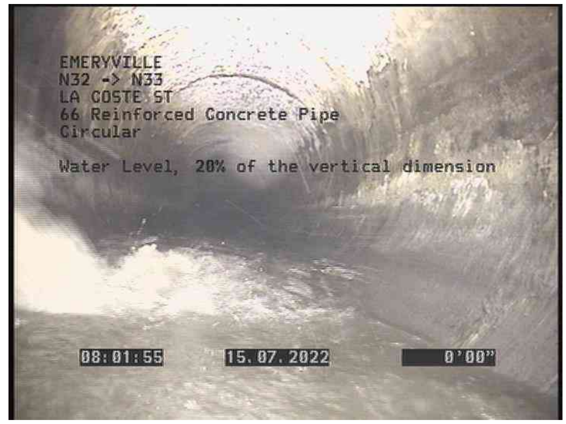
QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
422C	0000	422C	50.0	0.0	50.0	2.2	0.0	2.2

WinCan

Section Pictures - 8/7/2022 - N32-N33

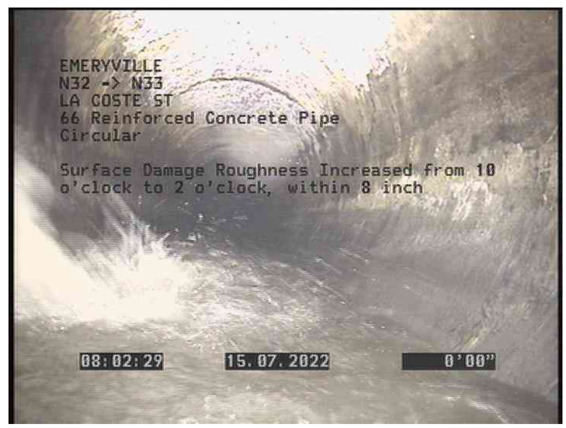
City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**LA COSTE ST**	**8/7/2022**	**N32-N33**	**7**

1, 00:00:00, 0.00ft
Manhole / N32



2, 00:00:01, 0.00ft
Water Level, 20% of the vertical dimension

3, 00:01:22, 0.00ft
Miscellaneous Water Mark, 50% of the vertical dimension



4, 00:01:39, 0.00ft
Surface Damage Aggregate Visible from 8 o'clock to 4 o'clock, within 8 inch, Start

5, 00:04:13, 104.91ft
Manhole / N33

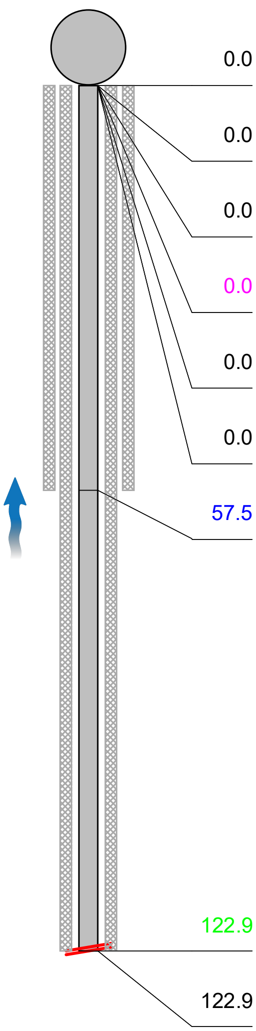
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/19/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N33-N34**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Upstream**		**122.9 '**	**122.9 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N33**
Street:	**RIGHT OF WAY**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N34**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

N34



1:1074	Distance		Code	Observation	Grade
	0.0		AMH	Manhole / N34	
	0.0		MWL	Water Level, 30% of the vertical dimension	
	0.0		MWM	Miscellaneous Water Mark, 80% of the vertical dimension	
	0.0		SRV	Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock	S4
	0.0	S01	SAV	Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Start	
	0.0	S02	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, Start	
	57.5	F01	SAV	Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Finish	S2
	122.9	F02	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, Finish	S1
	122.9		MSA	Miscellaneous Survey Abandoned / END OF INSPECTION	

AMH - 0.00 ft

MWL - 0.00 ft

MWM - 0.00 ft

MWM - 0.00 ft

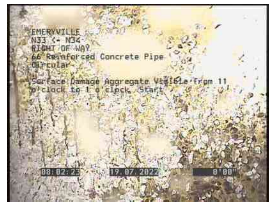
WinCan

Inspection report

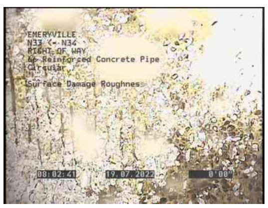
Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/19/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N33-N34**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Upstream**		**122.9 '**	**122.9 '**


SRV - 0.00 ft

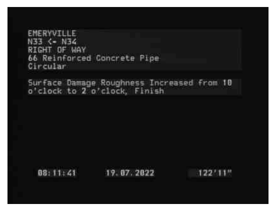

SRV - 0.00 ft


SAV - 0.00 ft


SRI - 0.00 ft


SRI - 0.00 ft


SAV - 57.51 ft



SRI - 122.94 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
412A	0000	412A	53.0	0.0	53.0	1.4	0.0	1.4

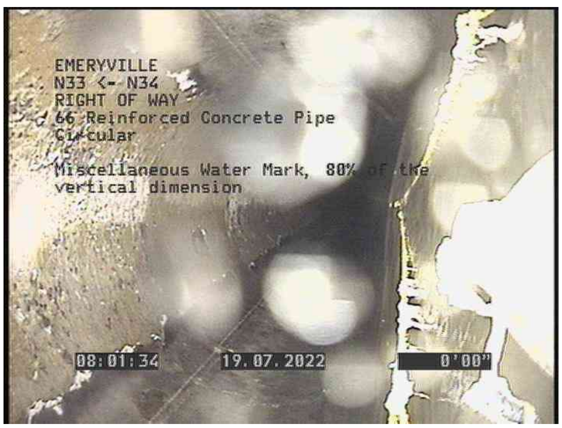
WinCan

Section Pictures - 7/19/2022 - N33-N34

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**RIGHT OF WAY**	**7/19/2022**	**N33-N34**	**12**

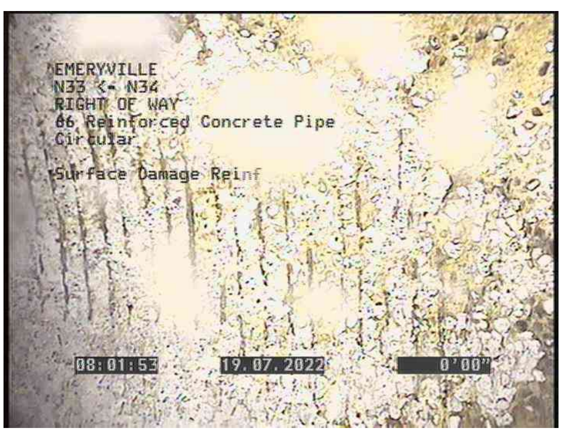
1, 00:00:00, 0.00ft
Manhole / N34

2, 00:00:00, 0.00ft
Water Level, 30% of the vertical dimension

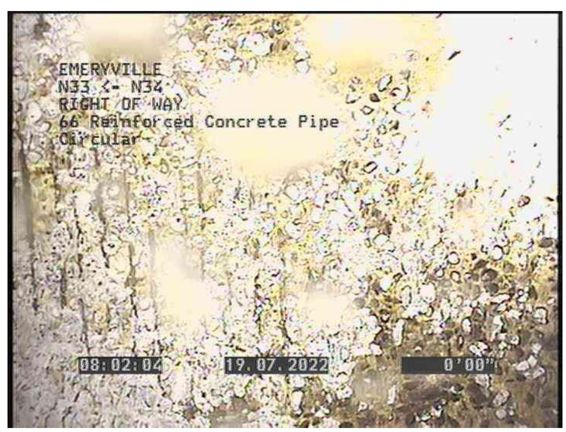


3, 00:00:00, 0.00ft
Miscellaneous Water Mark, 80% of the vertical dimension

4, 00:00:00, 0.00ft
Miscellaneous Water Mark, 80% of the vertical dimension



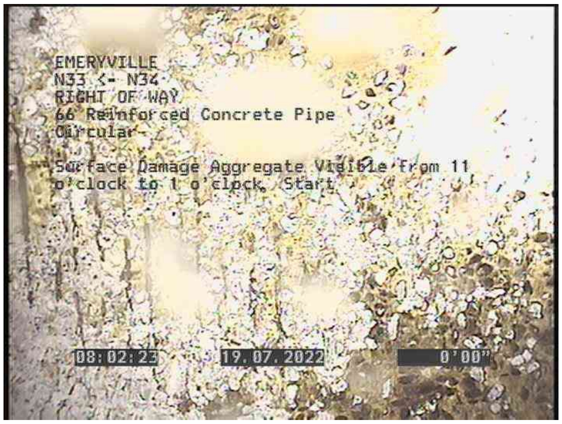
5, 00:01:50, 0.00ft
Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock



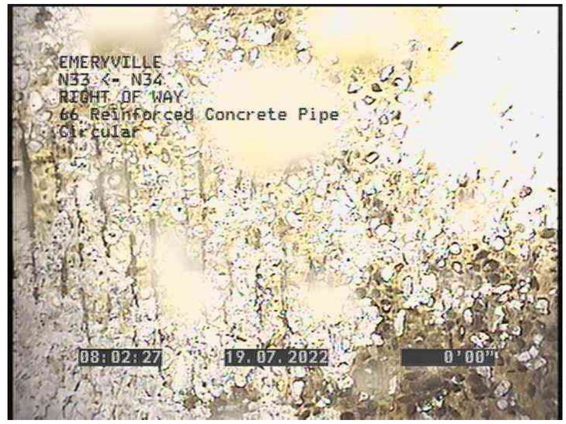
6, 00:01:50, 0.00ft
Surface Damage Reinforcement Visible from 10 o'clock to 2 o'clock

Section Pictures - 7/19/2022 - N33-N34

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**RIGHT OF WAY**	**7/19/2022**	**N33-N34**	**12**



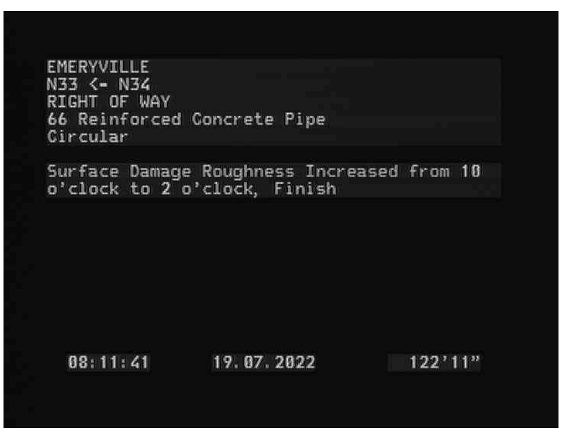
7, 00:02:17, 0.00ft
Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Start



8, 00:02:37, 0.00ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, Start

9, 00:02:37, 0.00ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, Start

10, 00:03:45, 57.51ft
Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Finish



11, 00:05:19, 122.94ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, Finish

WinCan

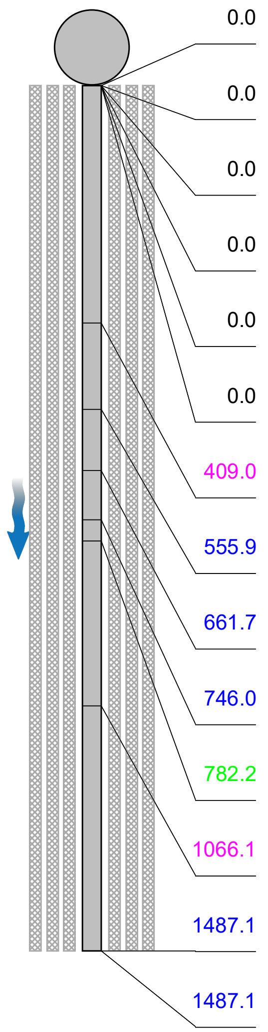
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/15/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N33-N34**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**1487.1 '**	**1487.1 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N33**
Street:	**RIGHT OF WAY**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N34**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			

Additional Info:

N33



1:12988	Distance		Code	Observation	Grade
	0.0		AMH	Manhole / N33	
	0.0		MWL	Water Level, 20% of the vertical dimension	
	0.0		MWM	Miscellaneous Water Mark, 50% of the vertical dimension	
	0.0	S01	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Start	
	0.0	S02	SAV	Surface Damage Aggregate Visible from 8 o'clock to 10 o'clock, within 8 inch, Start	
	0.0	S03	SAV	Surface Damage Aggregate Visible from 3 o'clock to 5 o'clock, within 8 inch, Start	
	409.0		IR	Infiltration Runner from 10 o'clock to 11 o'clock, within 8 inch	M4
	555.9		DAZ	Deposits Attached Other, 5% of cross sectional area from 9 o'clock to 3 o'clock, within 8 inch / UNKNOWN	M2
	661.7		DAZ	Deposits Attached Other, 5% of cross sectional area from 12 o'clock to 3 o'clock, within 8 inch / UNKNOWN	M2
	746.0		DAE	Deposits Attached Encrustation, 5% of cross sectional area from 8 o'clock to 4 o'clock	M2
	782.2		ISJ	Infiltration Stain Joint from 8 o'clock to 4 o'clock, within 8 inch	M1
	1066.1		DSGV	Deposits Settled Gravel, 30% of cross sectional area at 6 o'clock	M4
	1487.1	F02	SAV	Surface Damage Aggregate Visible from 8 o'clock to 10 o'clock, within 8 inch, Finish	S2
	1487.1	F03	SAV	Surface Damage Aggregate Visible from 3 o'clock to 5 o'clock, within 8 inch, Finish	S2

AMH - 0.00 ft

MWL - 0.00 ft

MWM - 0.00 ft

SRI - 0.00 ft

WinCan

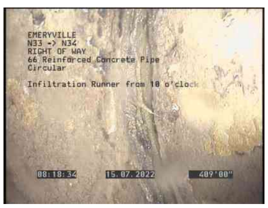
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/15/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N33-N34**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**1487.1 '**	**1487.1 '**

1:12988	Distance		Code	Observation	Grade
	1487.1	F01	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Finish	S1
	1487.1		MSA	Miscellaneous Survey Abandoned / RAN OUT OF CABLE ON TRUCK	

SAV - 0.00 ft

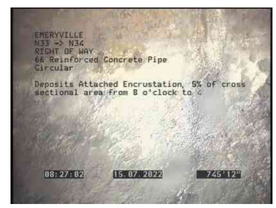
SAV - 0.00 ft



IR - 409.00 ft

DAZ - 555.90 ft

DAZ - 661.70 ft



DAE - 745.96 ft

ISJ - 782.20 ft

DSGV - 1066.09 ft

SAV - 1487.10 ft

SAV - 1487.10 ft

SRI - 1487.12 ft

MSA - 1487.12 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
2Z1Z	4223	422Z	1485.0	15.0	1500.0	1.7	2.5	1.7

WinCan

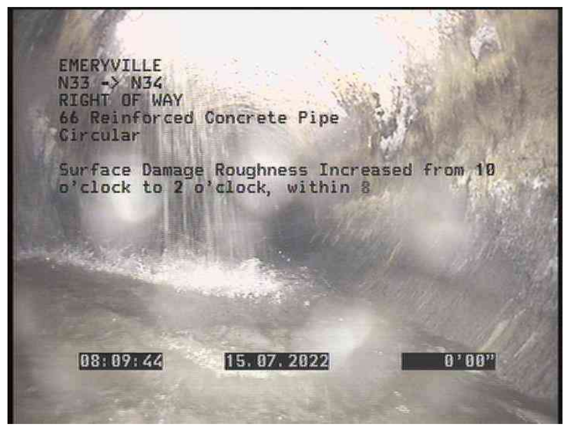
Section Pictures - 7/15/2022 - N33-N34

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**RIGHT OF WAY**	**7/15/2022**	**N33-N34**	**8**

1, 00:00:00, 0.00ft
Manhole / N33

2, 00:00:01, 0.00ft
Water Level, 20% of the vertical dimension

3, 00:01:20, 0.00ft
Miscellaneous Water Mark, 50% of the vertical dimension



4, 00:01:38, 0.00ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Start

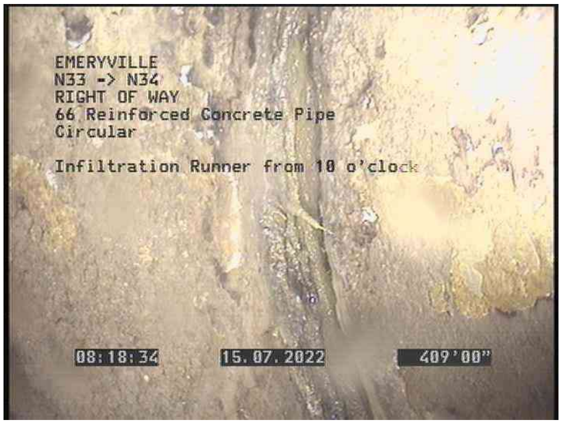
5, 00:01:39, 0.00ft
Surface Damage Aggregate Visible from 8 o'clock to 10 o'clock, within 8 inch, Start

6, 00:01:39, 0.00ft
Surface Damage Aggregate Visible from 3 o'clock to 5 o'clock, within 8 inch, Start

WinCan

Section Pictures - 7/15/2022 - N33-N34

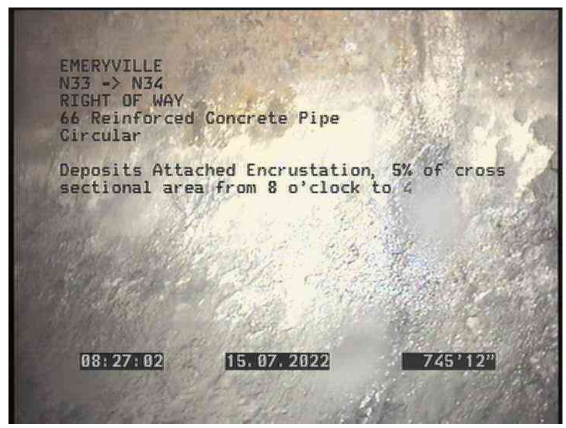
City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**RIGHT OF WAY**	**7/15/2022**	**N33-N34**	**8**



7, 00:10:28, 409.00ft
Infiltration Runner from 10 o'clock to 11 o'clock, within 8 inch

8, 00:15:35, 555.90ft
Deposits Attached Other, 5% of cross sectional area from 9 o'clock to 3 o'clock, within 8 inch / UNKNOWN

9, 00:17:33, 661.70ft
Deposits Attached Other, 5% of cross sectional area from 12 o'clock to 3 o'clock, within 8 inch / UNKNOWN



10, 00:18:56, 745.96ft
Deposits Attached Encrustation, 5% of cross sectional area from 8 o'clock to 4 o'clock

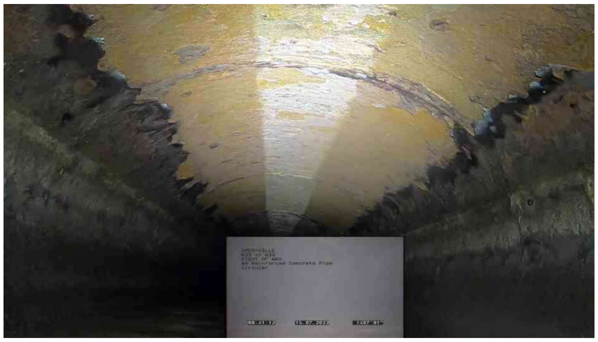
11, 00:19:32, 782.20ft
Infiltration Stain Joint from 8 o'clock to 4 o'clock, within 8 inch

12, 00:26:12, 1066.09ft
Deposits Settled Gravel, 30% of cross sectional area at 6 o'clock

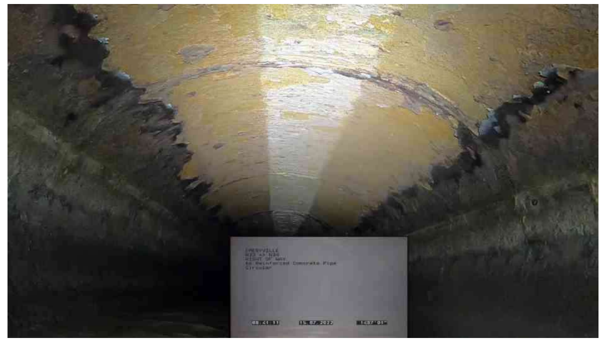
WinCan

Section Pictures - 7/15/2022 - N33-N34

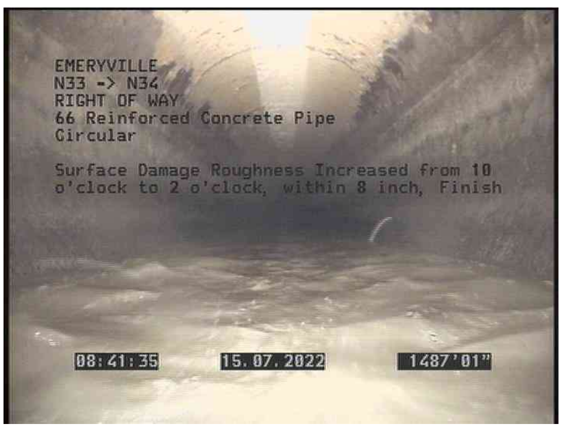
City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**RIGHT OF WAY**	**7/15/2022**	**N33-N34**	**8**



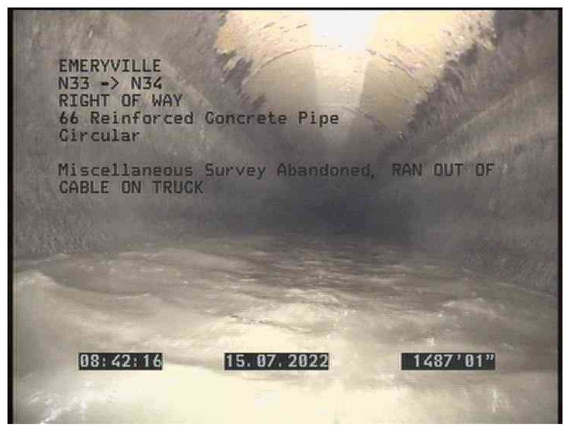
13, 00:33:10, 1487.10ft
Surface Damage Aggregate Visible from 8 o'clock to 10 o'clock, within 8 inch, Finish



14, 00:33:10, 1487.10ft
Surface Damage Aggregate Visible from 3 o'clock to 5 o'clock, within 8 inch, Finish



15, 00:33:28, 1487.12ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, within 8 inch, Finish



16, 00:34:10, 1487.12ft
Miscellaneous Survey Abandoned / RAN OUT OF CABLE ON TRUCK

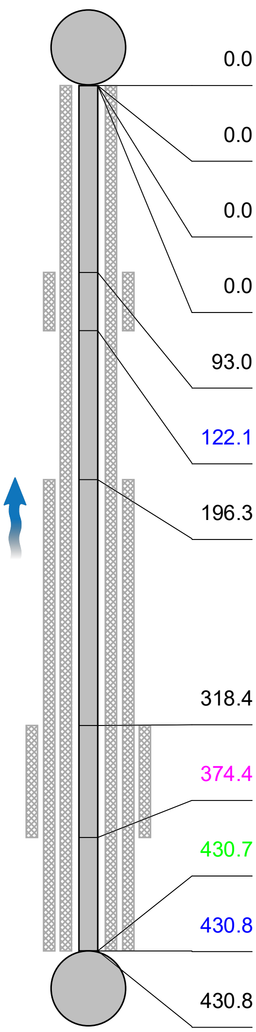
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/19/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N34-N35**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Upstream**		**430.8 '**	**430.8 '**

City:	**EMERYVILLE**	Drainage Area:		Upstream MH:	**N34**
Street:	**RIGHT OF WAY**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Other**	Flow Control:	**Not Controlled**	Downstream MH:	**N35**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Circular**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**66 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Reinforced Concrete Pipe**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			

Additional Info:



1:3763	Distance		Code	Observation	Grade
N35					
	0.0		AMH	Manhole / N35	
	0.0		MWL	Water Level, 45% of the vertical dimension	
	0.0		MWM	Miscellaneous Water Mark, 80% of the vertical dimension	
	0.0	S01	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, Start	
	93.0	S02	SAV	Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Start	
	122.1	F02	SAV	Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Finish	S2
	196.3	S03	SAV	Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Start	
	318.4	S04	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, within 8 inch, Start	
	374.4	F04	SRV	Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, within 8 inch, Finish	S4
	430.7	F01	SRI	Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, Finish	S1
	430.8	F03	SAV	Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Finish	S2
	430.8		AMH	Manhole / N34	
N34					

AMH - 0.00 ft

MWL - 0.00 ft

MWM - 0.00 ft

SRI - 0.00 ft

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/19/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**N34-N35**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Upstream**		**430.8 '**	**430.8 '**


SAV - 92.98 ft


SAV - 92.98 ft


SAV - 122.14 ft


SAV - 196.29 ft


SAV - 196.29 ft


SRV - 318.42 ft


SRV - 374.40 ft


SRI - 430.75 ft


SAV - 430.85 ft


AMH - 430.85 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
4A2I	0000	4A2I	236.0	0.0	236.0	1.6	0.0	1.6

WinCan

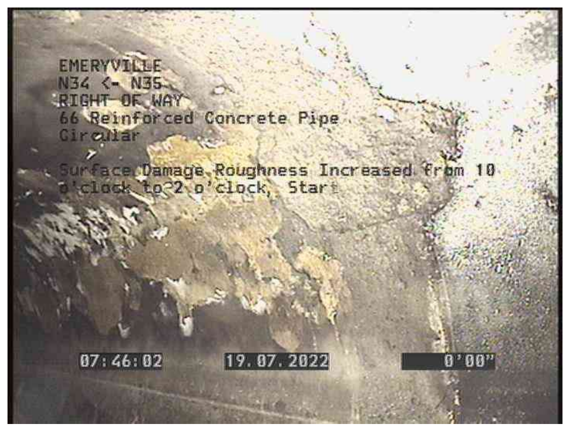
Section Pictures - 7/19/2022 - N34-N35

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**RIGHT OF WAY**	**7/19/2022**	**N34-N35**	**13**

1, 00:00:00, 0.00ft
Manhole / N35

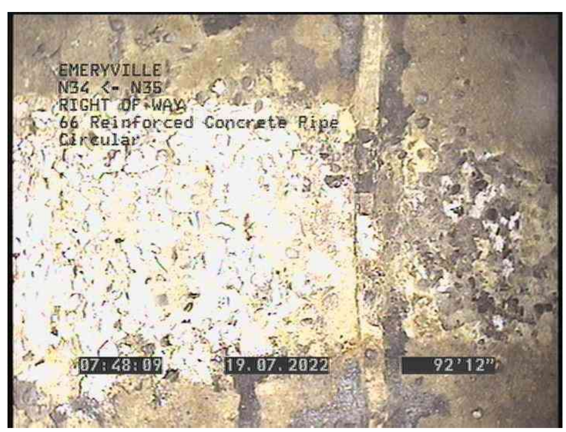
2, 00:00:01, 0.00ft
Water Level, 45% of the vertical dimension

3, 00:00:02, 0.00ft
Miscellaneous Water Mark, 80% of the vertical dimension



4, 00:01:57, 0.00ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, Start

5, 00:03:57, 92.98ft
Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Start



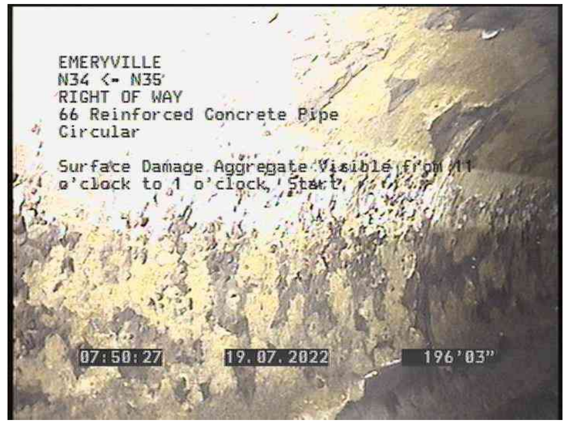
6, 00:03:57, 92.98ft
Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Start

WinCan

Section Pictures - 7/19/2022 - N34-N35

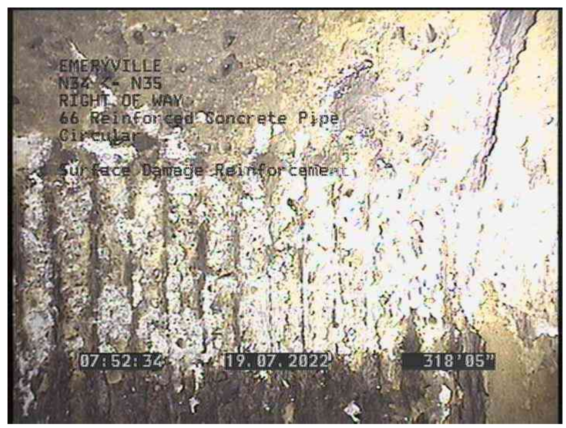
City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**RIGHT OF WAY**	**7/19/2022**	**N34-N35**	**13**

7, 00:05:01, 122.14ft
Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Finish



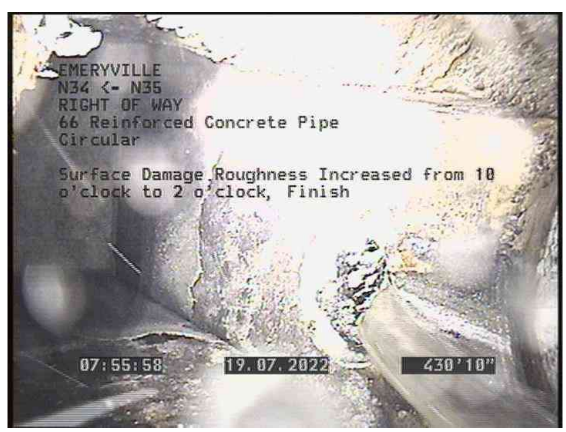
8, 00:06:22, 196.29ft
Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Start

9, 00:06:22, 196.29ft
Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Start



10, 00:08:29, 318.42ft
Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, within 8 inch, Start

11, 00:08:29, 374.40ft
Surface Damage Reinforcement Visible from 11 o'clock to 1 o'clock, within 8 inch, Finish



12, 00:11:53, 430.75ft
Surface Damage Roughness Increased from 10 o'clock to 2 o'clock, Finish

Section Pictures - 7/19/2022 - N34-N35

City	Street	Date	Pipe Segment Reference	Section No.
EMERYVILLE	**RIGHT OF WAY**	**7/19/2022**	**N34-N35**	**13**

13, 00:12:03, 430.85ft
Surface Damage Aggregate Visible from 11 o'clock to 1 o'clock, Finish

14, 00:12:14, 430.85ft
Manhole / N34

Main Inspections Large Photos

Mainline ID:	City:	Street:	Project name:
S14S151	**OAKLAND**	**COLISEUM WY/N. OF KEVIN CT**	**EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022**
Start date/time:	Total length:	Weather:	Surveyed by:
5/19/2022 10:48 AM	**847.600 ft.**	**1**	**F MORENO/NPS**
Upstream MH No:	Depth US:	Downstream MH No:	Depth DS:
S14		**S15**	
Shape:	Material:	Height:	Width:
C	**RCP**	**63 in.**	
Additional info:			

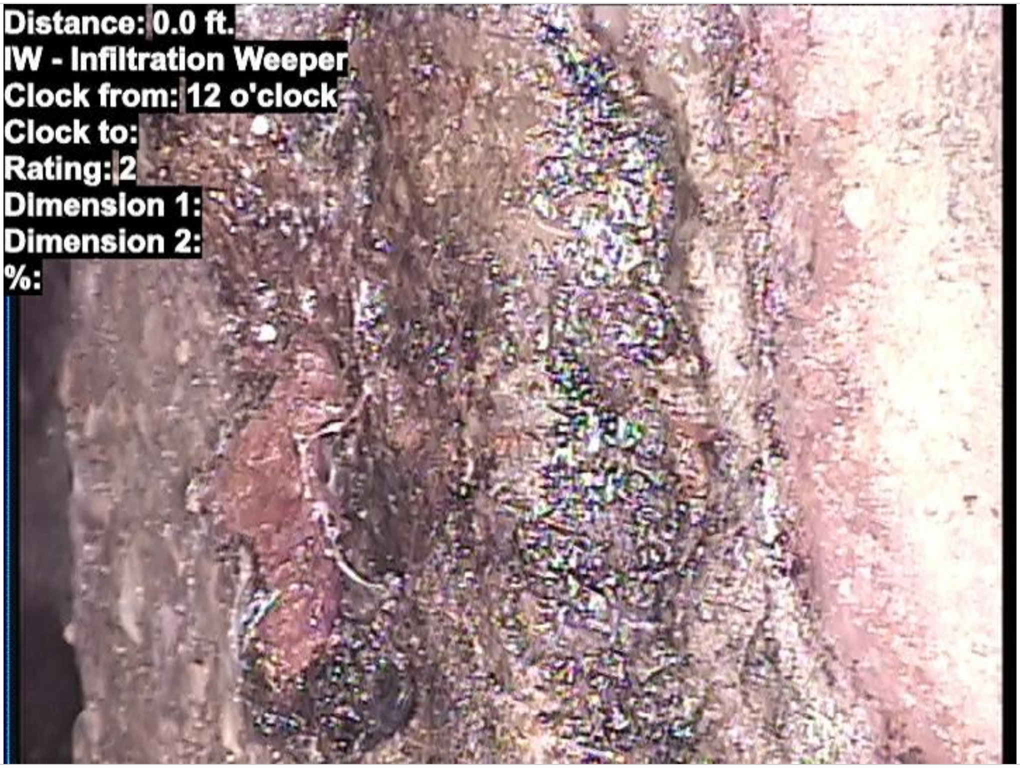
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**/**	**AMH**			**S14**

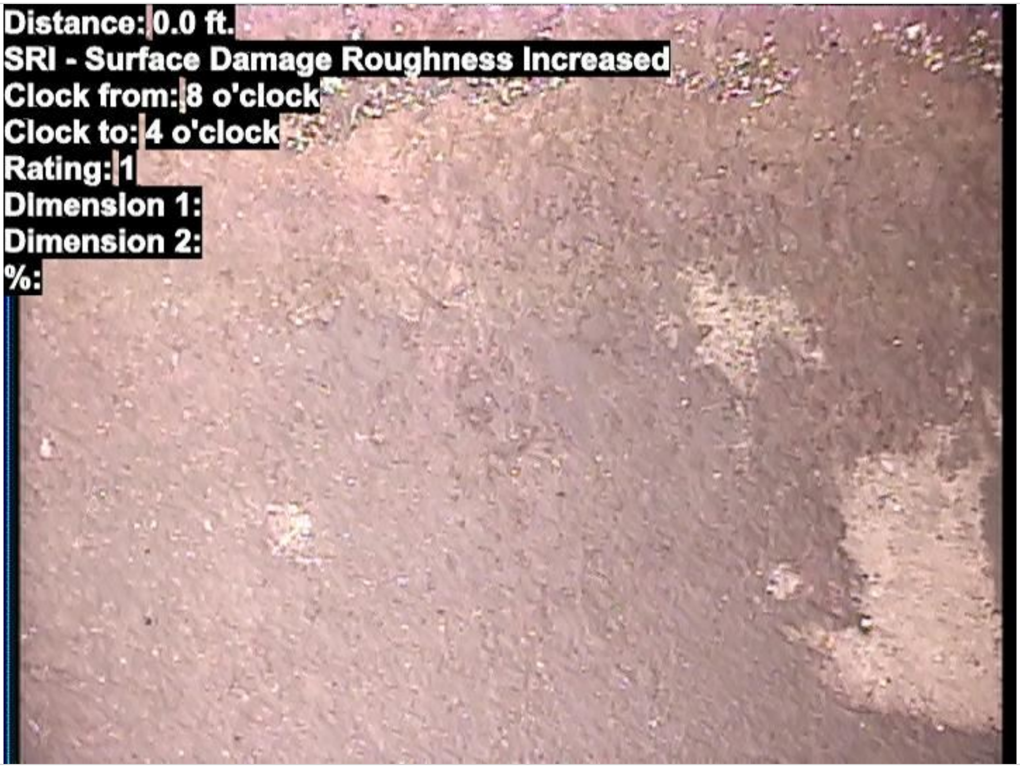
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		/	MWL			

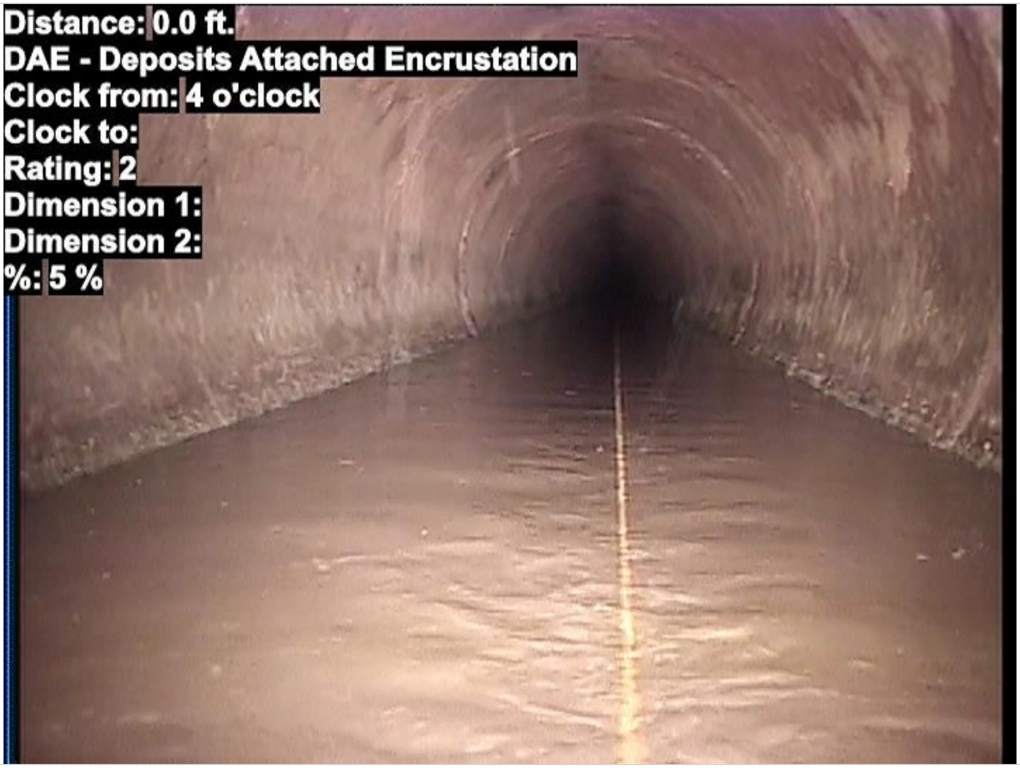
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		12 /	IW		2	

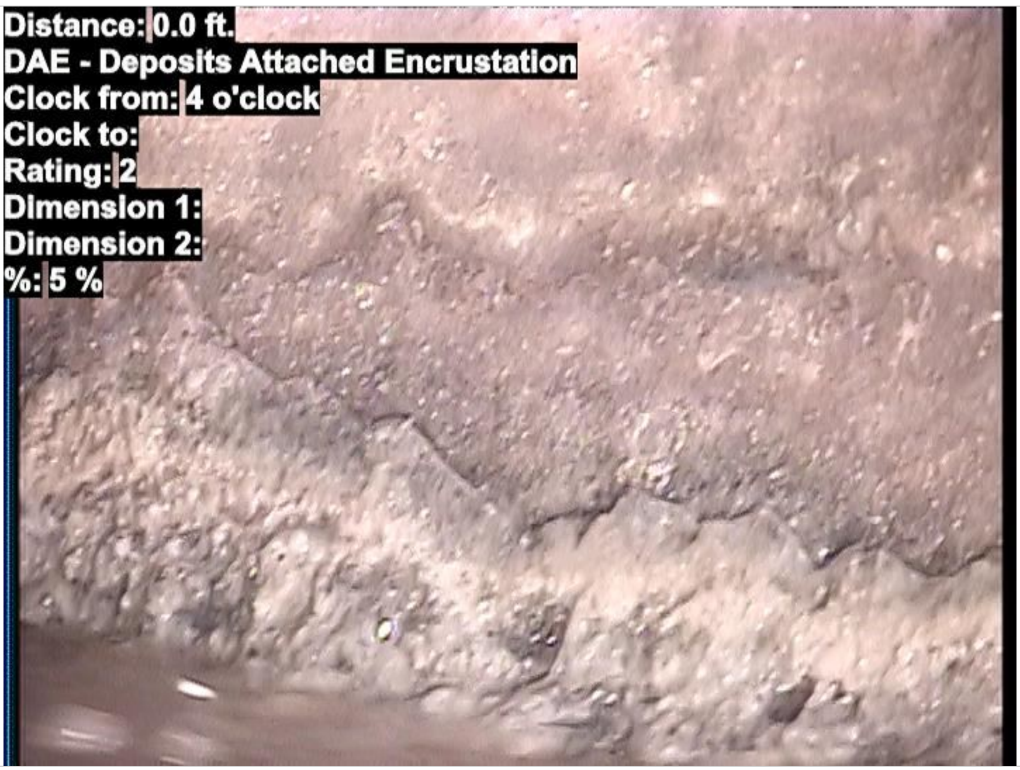


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		8 / 4	SRI		1	

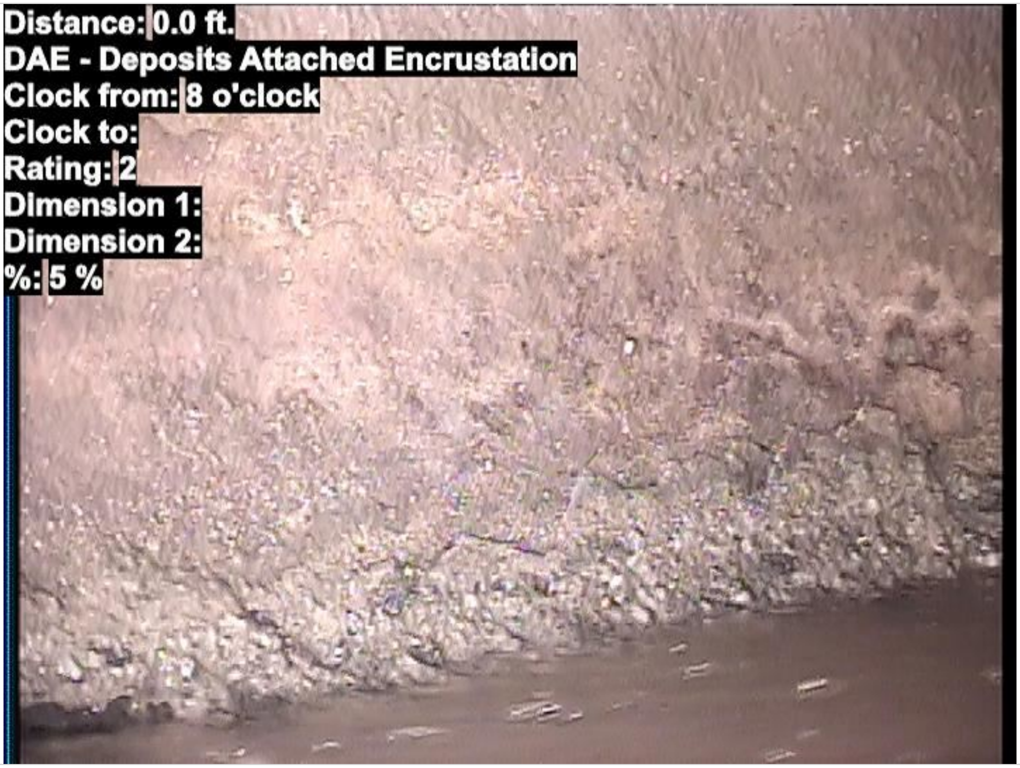


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		4 /	DAE		2	





Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		8 /	DAE		2	

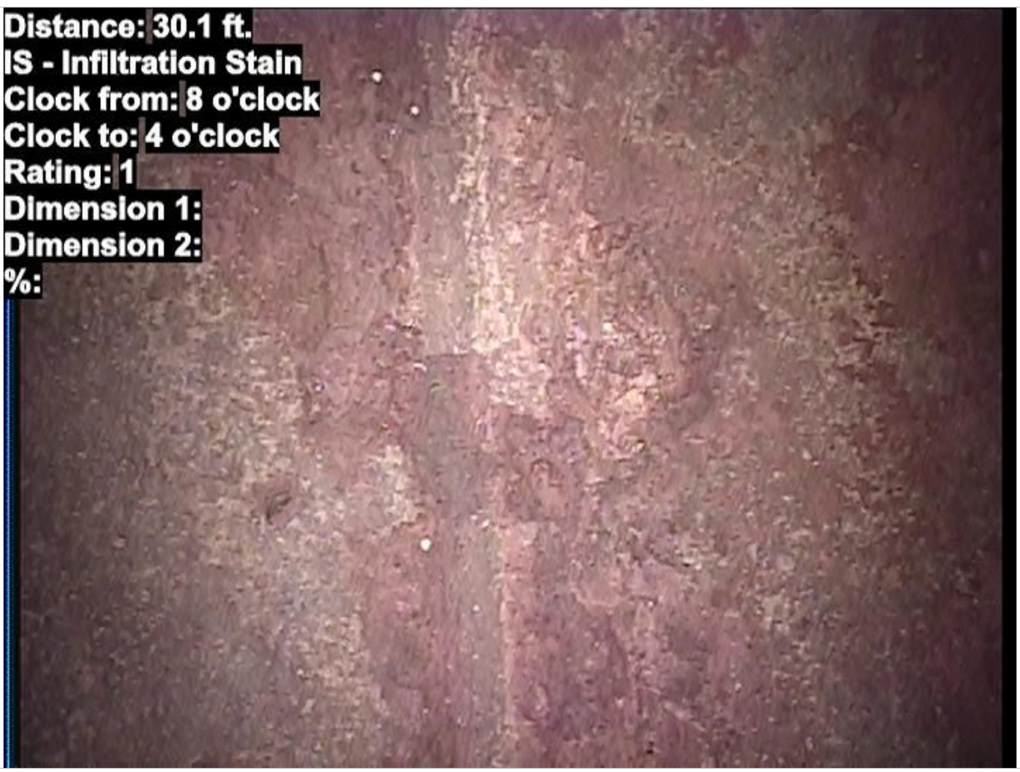


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	D		8 / 4	SSC		1	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
19.8 ft.	**D**		**9 / 3**	**IW**		**2**	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
19.8 ft.	D		8 / 10	DAE		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
30.1 ft.	D		8 / 4	IS		1	

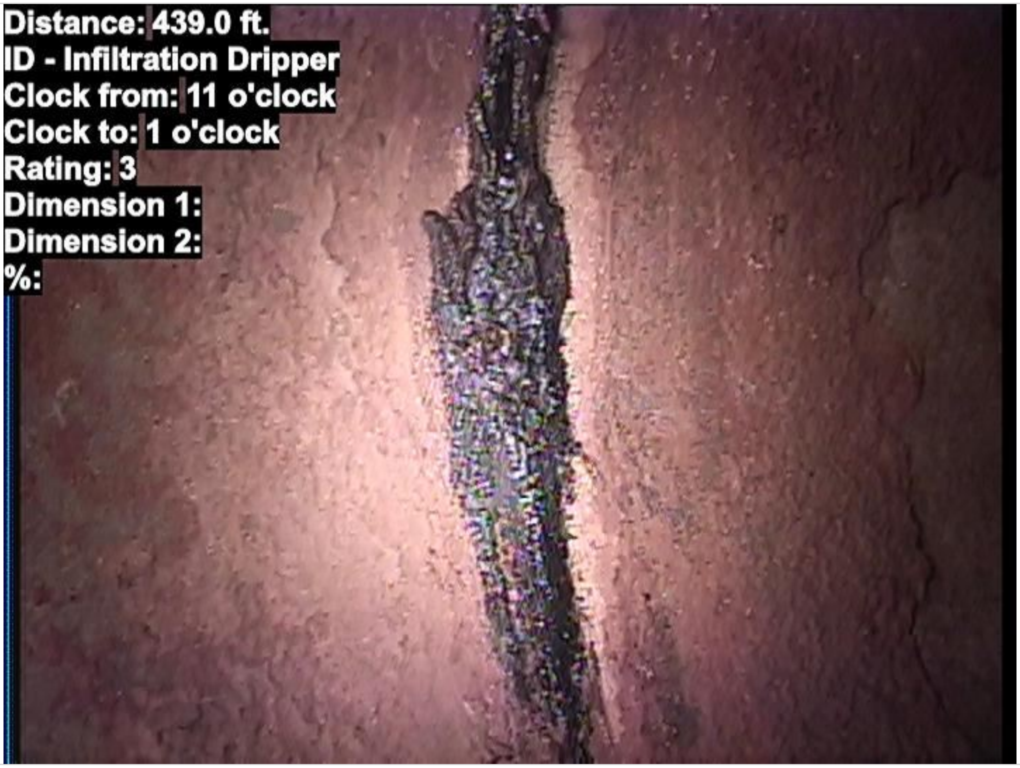


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
36.0 ft.	D		8 / 4	IS		1	

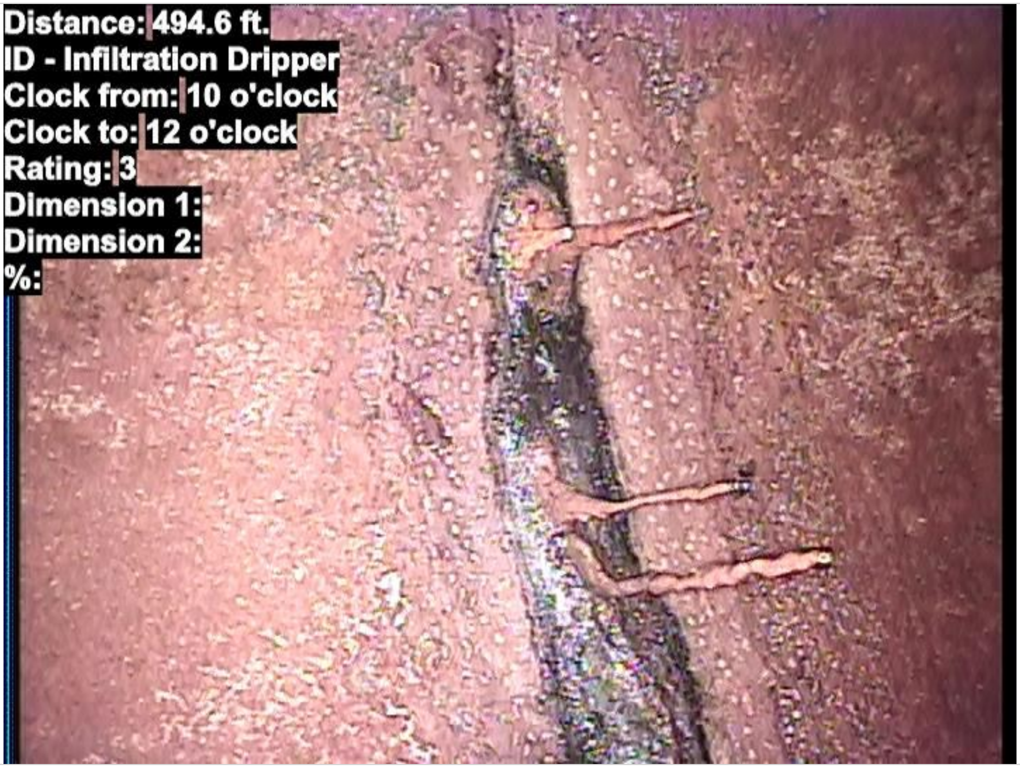
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
45.4 ft.	D		8 / 4	IS		1	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
269.4 ft.	D		12 /	ID		3	

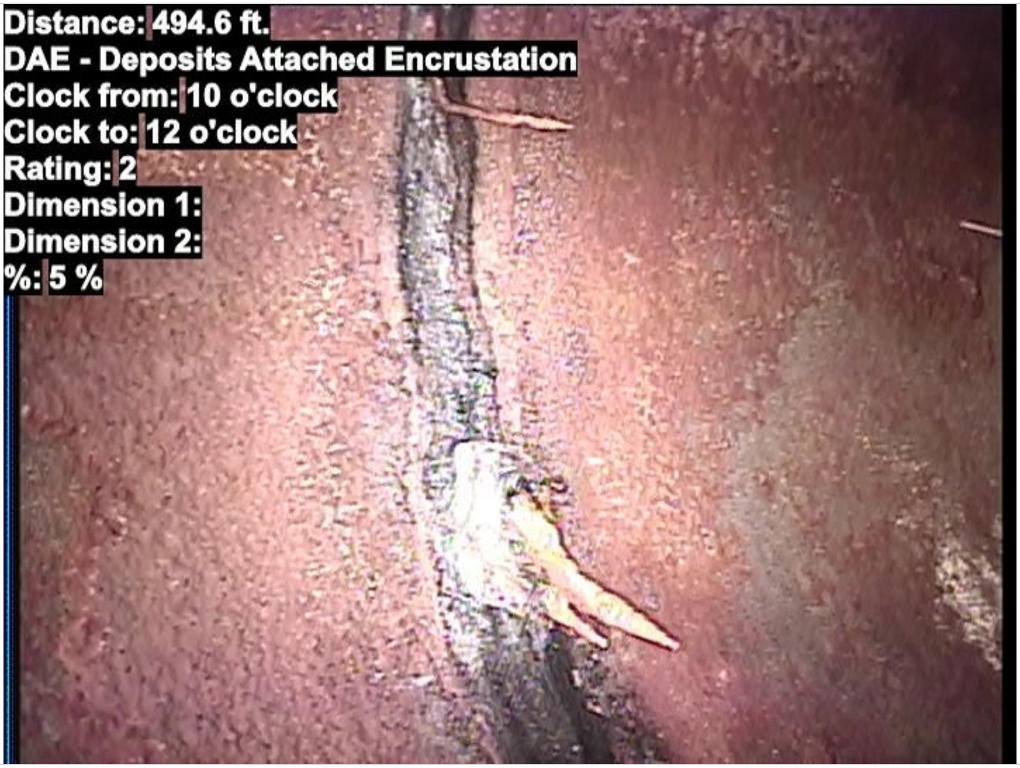
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
439.0 ft.	**D**		**11 / 1**	**ID**		**3**	

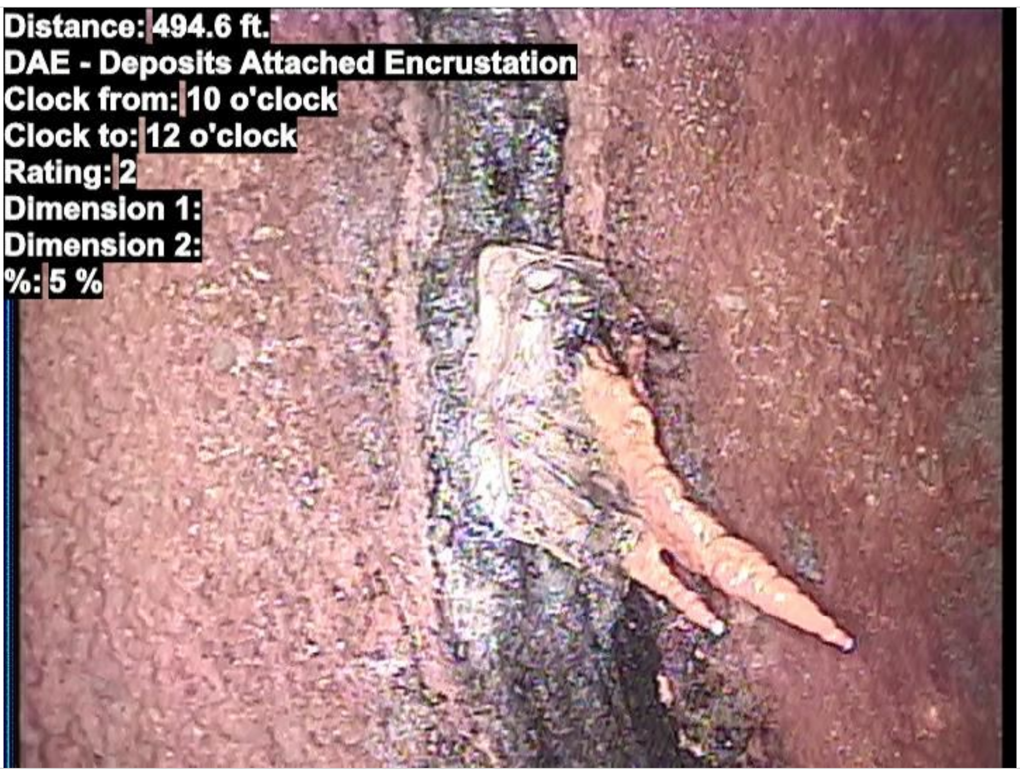


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
494.6 ft.	D		10 / 12	ID		3	

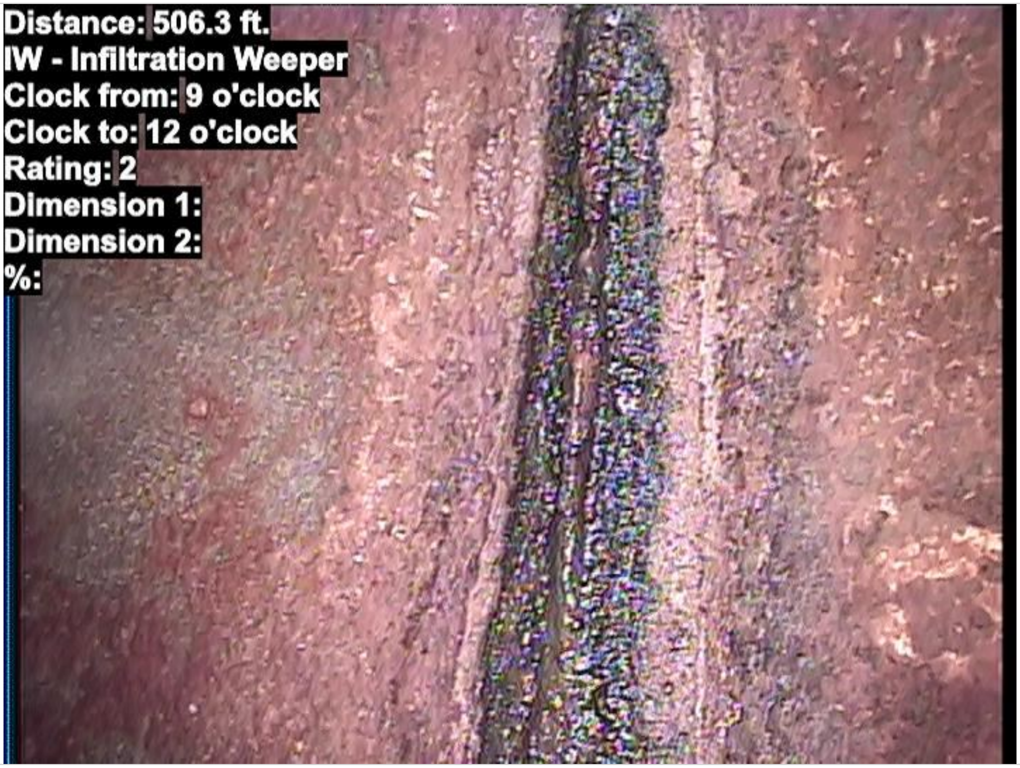


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
494.6 ft.	D		10 / 12	DAE		2	



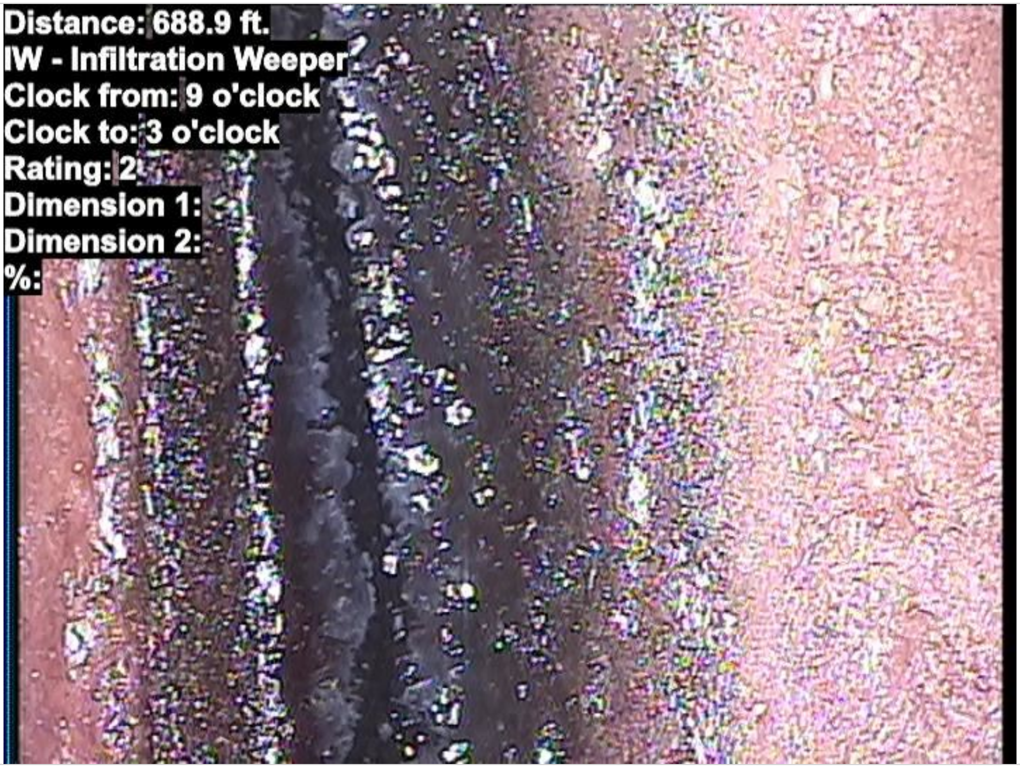


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
506.3 ft.	D		9 / 12	IW		2	



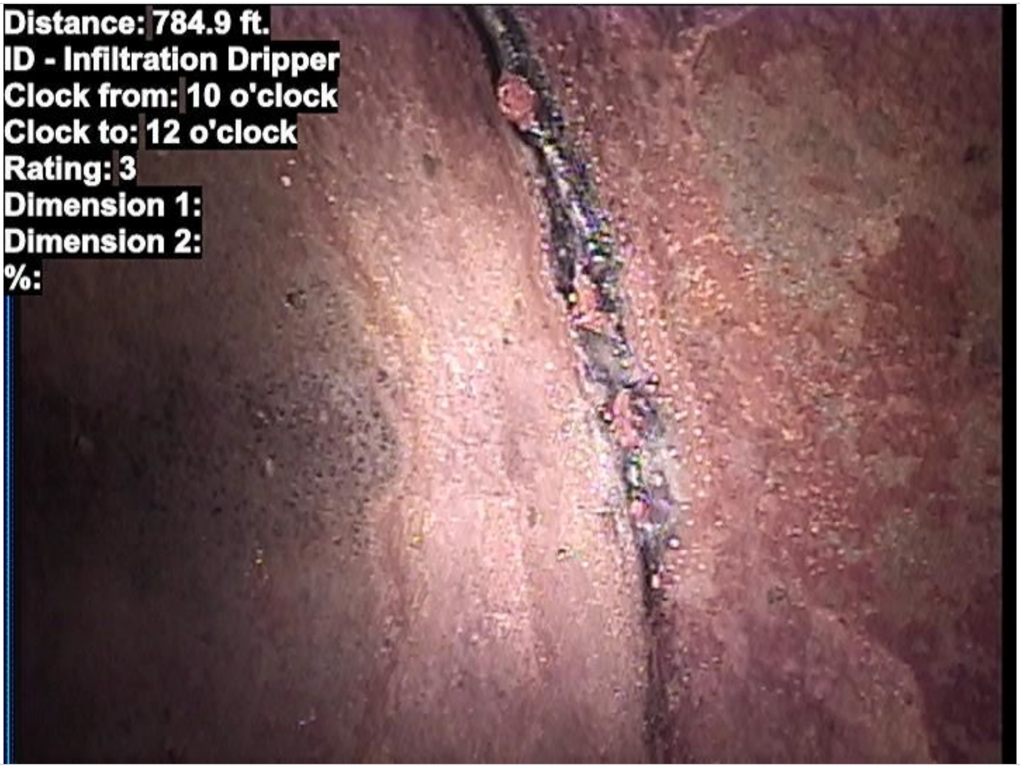
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
688.9 ft.	**D**		**9 / 3**	**IW**		**2**	

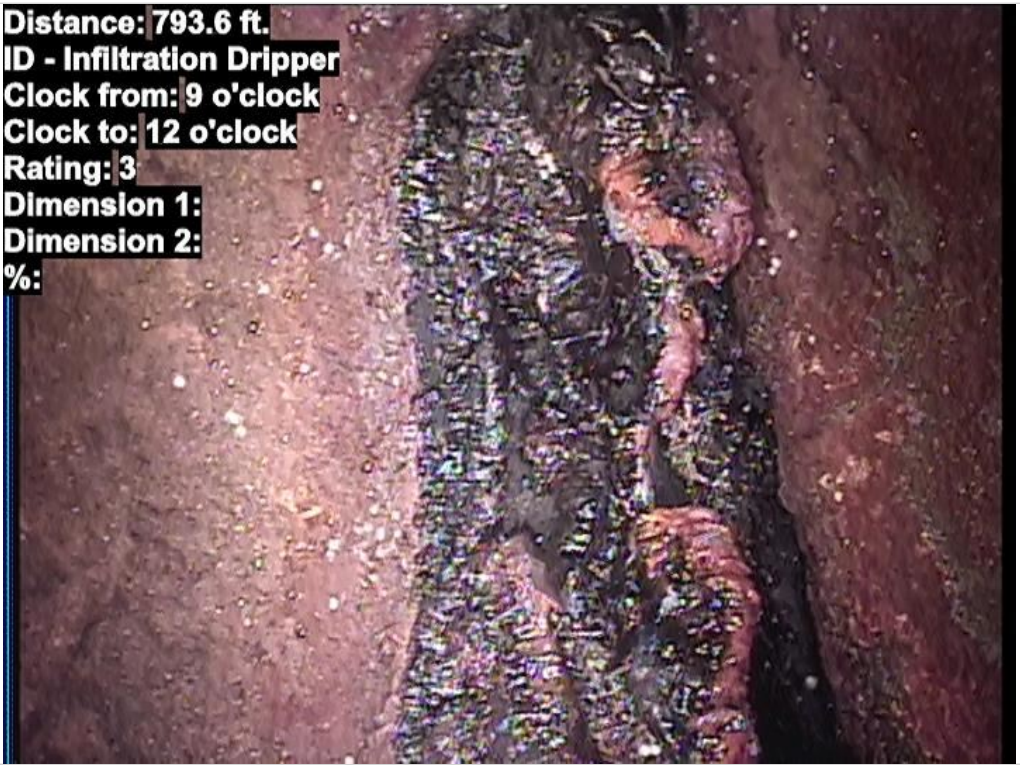


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
752.6 ft.	D		12 /	ID		3	

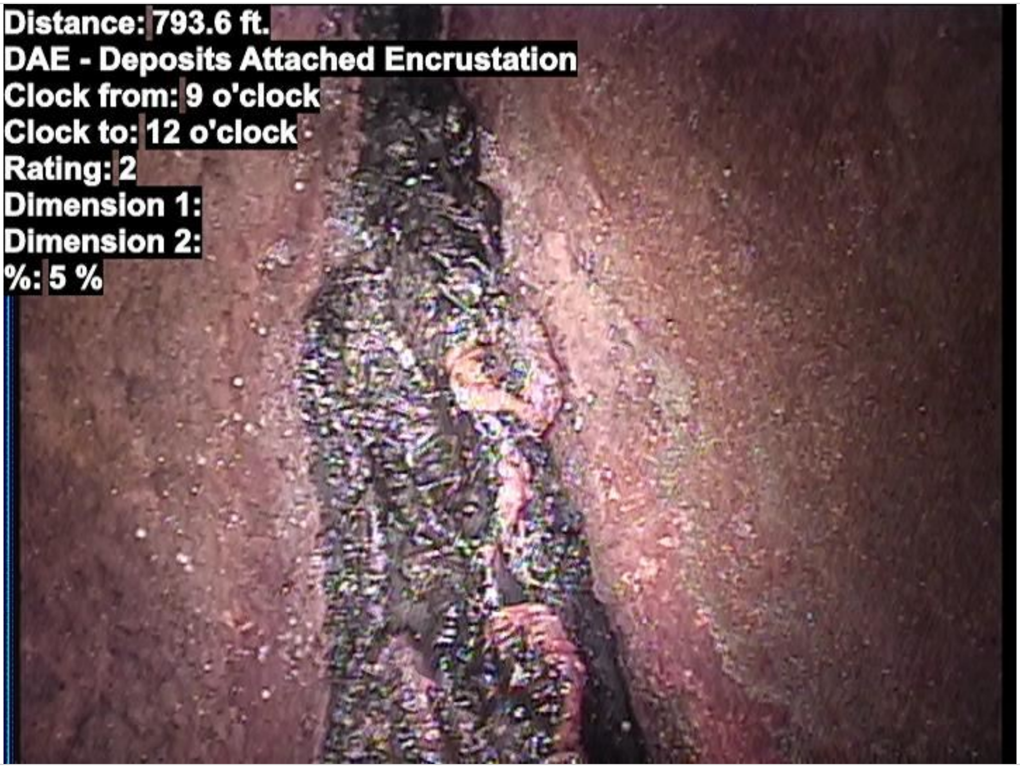
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
784.9 ft.	D		10 / 12	ID		3	

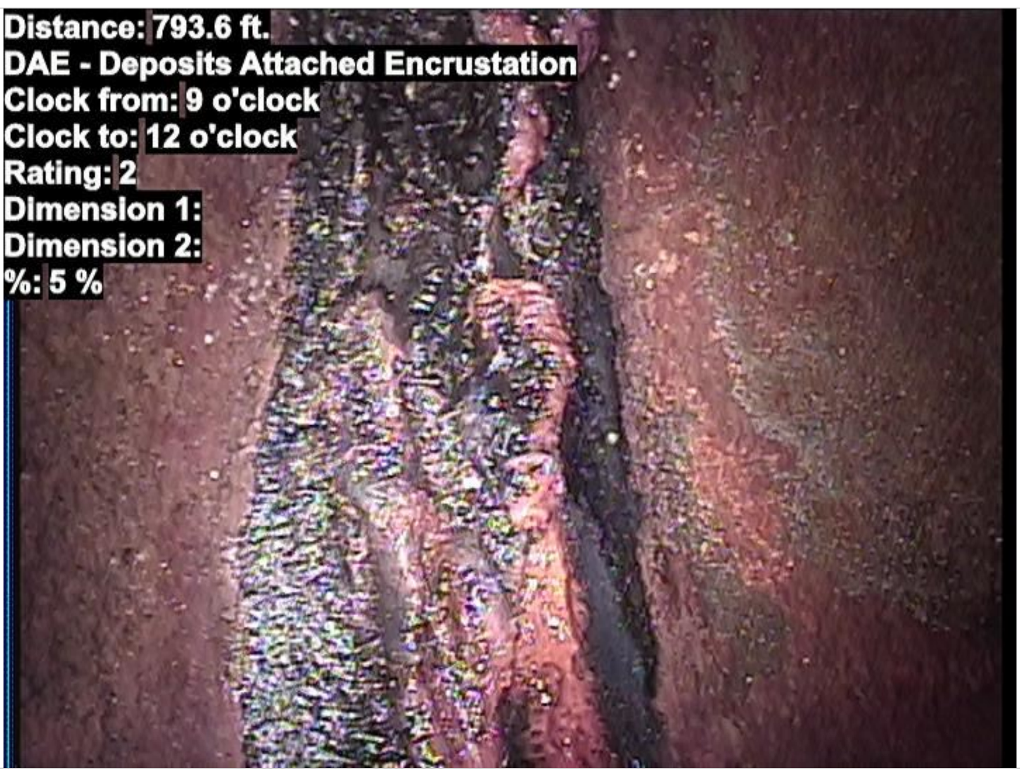


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
793.6 ft.	D		9 / 12	ID		3	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
793.6 ft.	D		9 / 12	DAE		2	

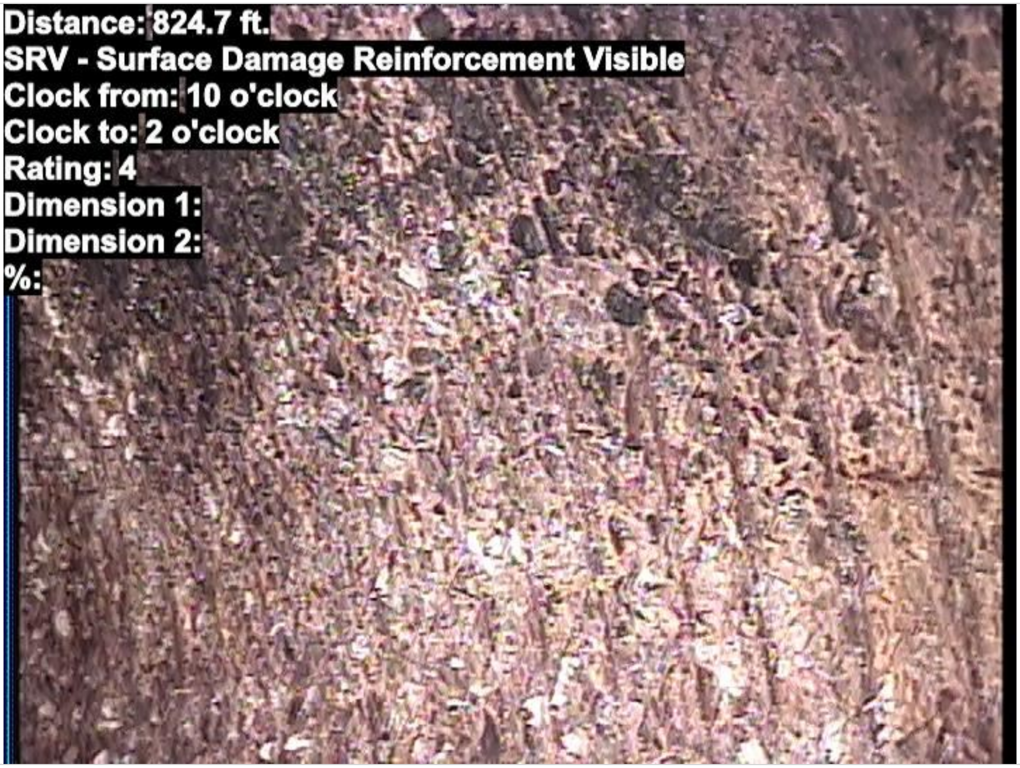


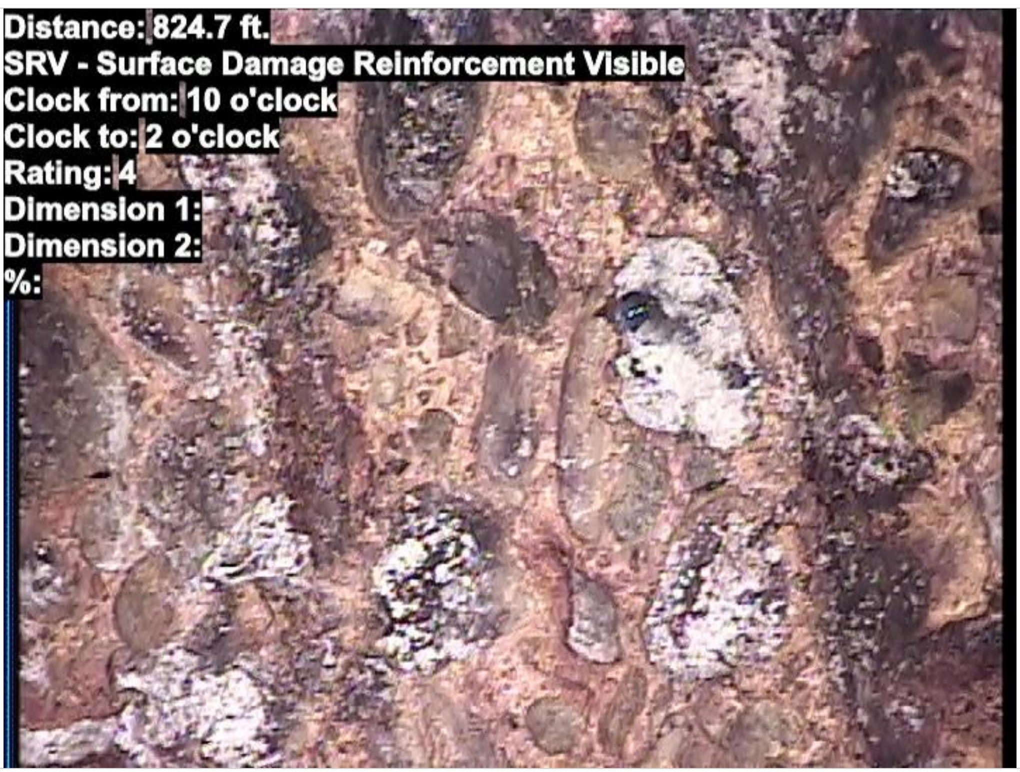


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
801.7 ft.	D		12 /	ID		3	

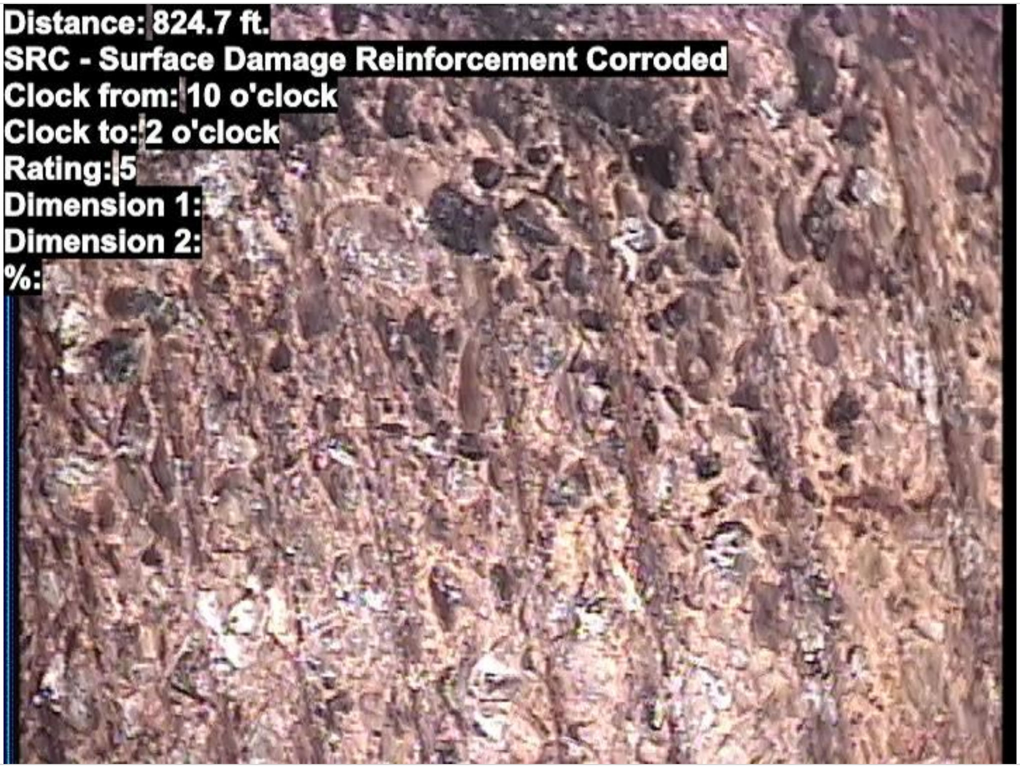
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
818.7 ft.	D		9 / 3	SAP		3	

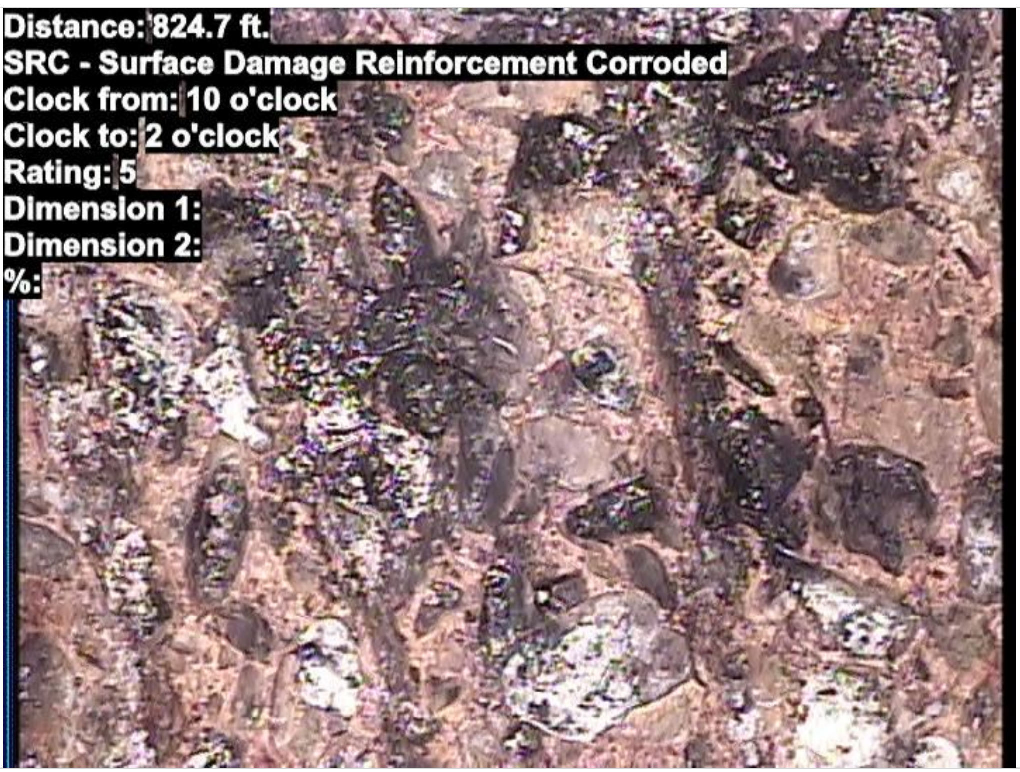
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
824.7 ft.	D		10 / 2	SRV		4	



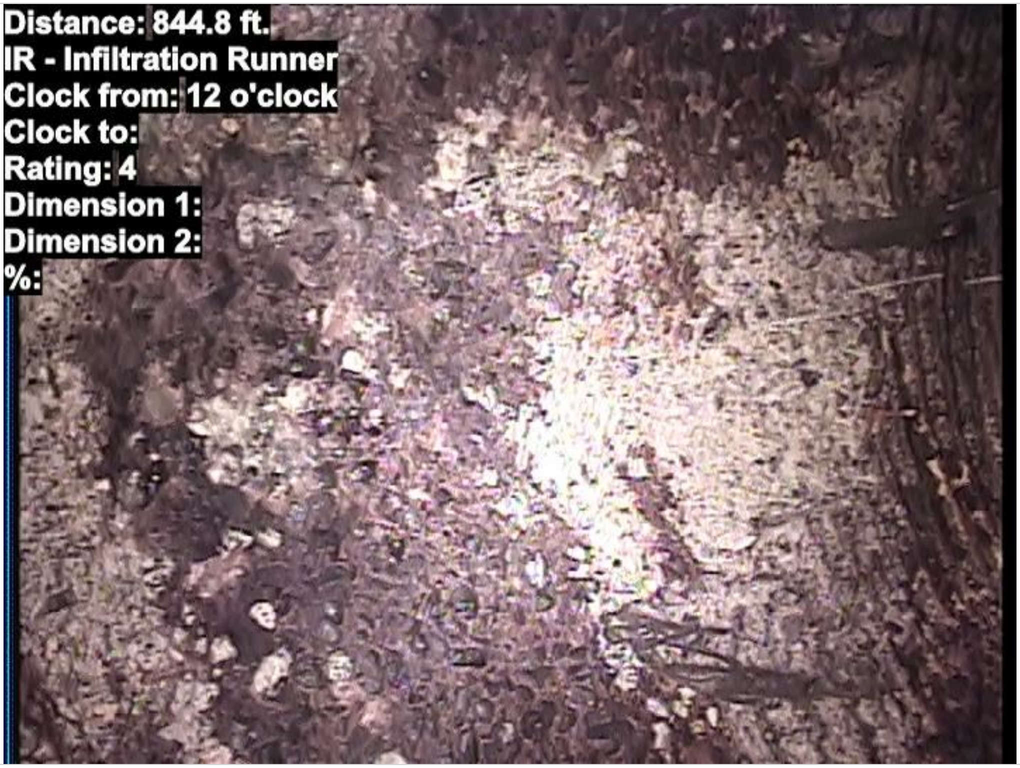


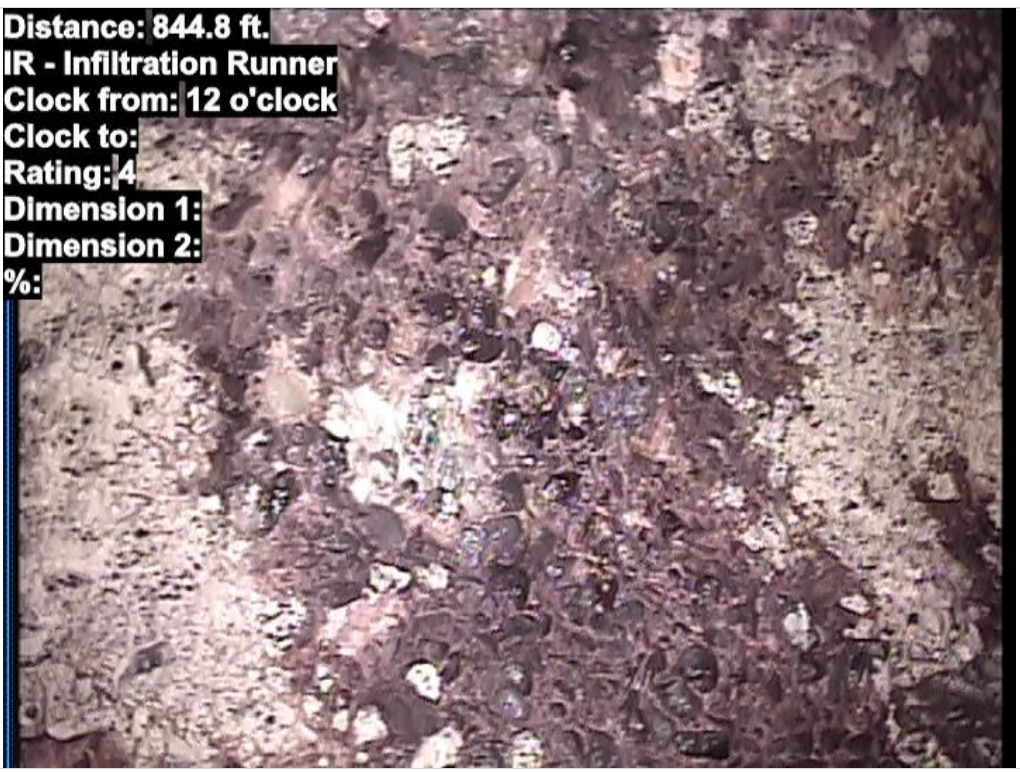
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
824.7 ft.	D		10 / 2	SRC		5	



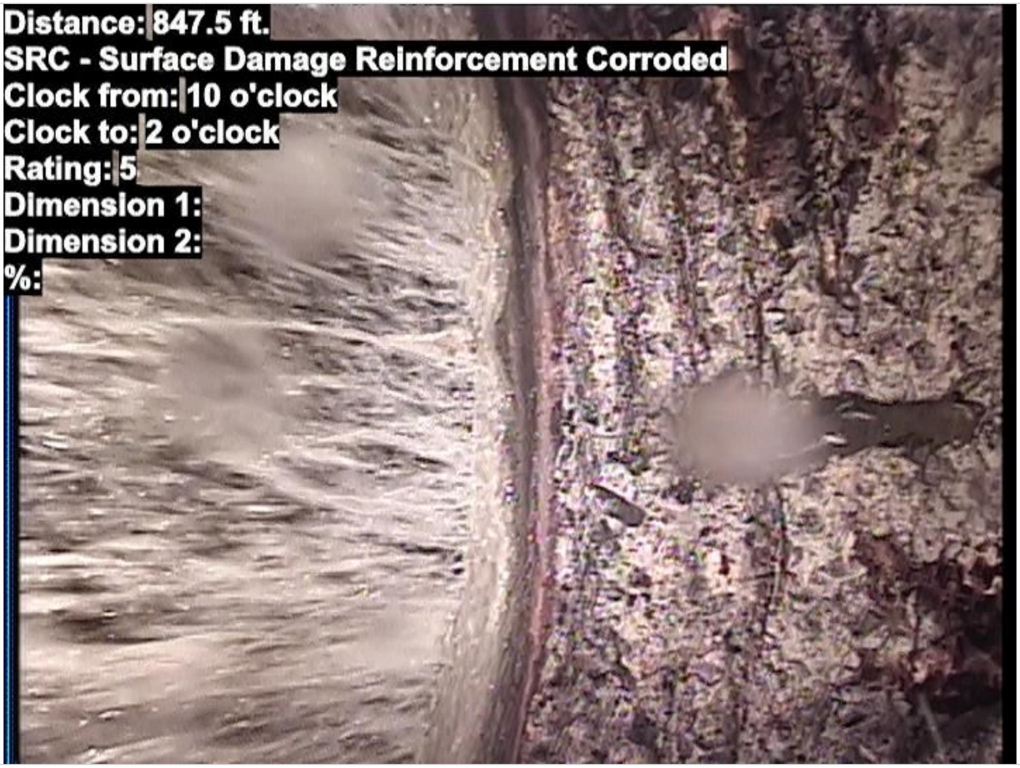


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
844.8 ft.	D		12 /	IR		4	



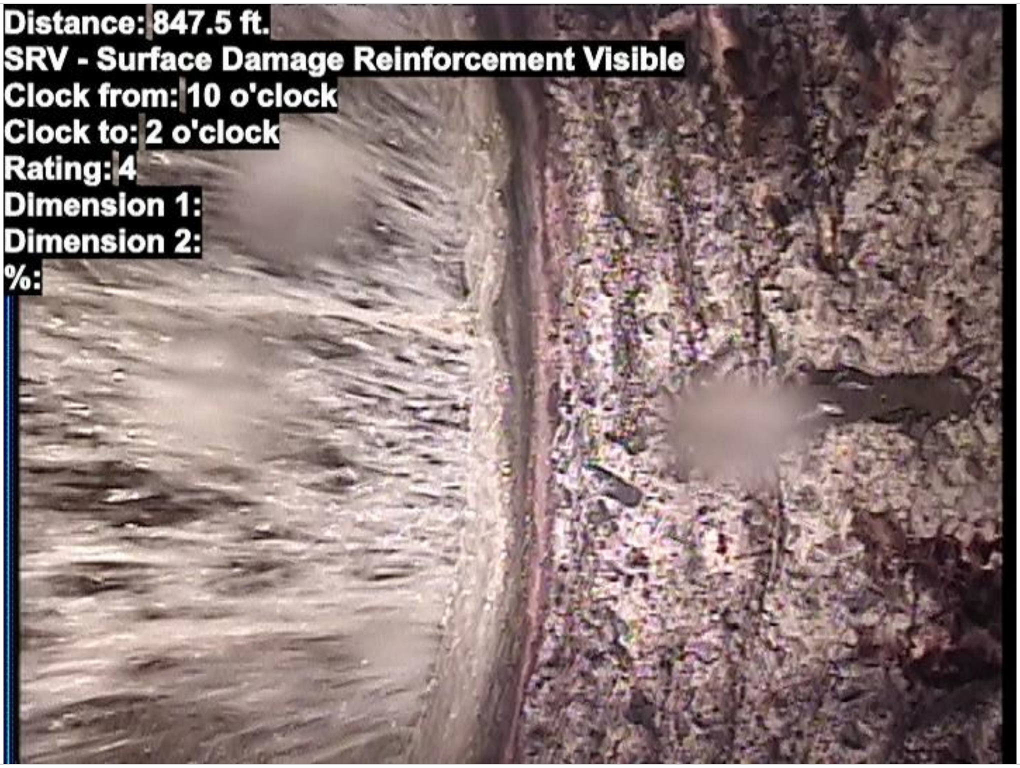


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
847.5 ft.	D		10 / 2	SRC		5	



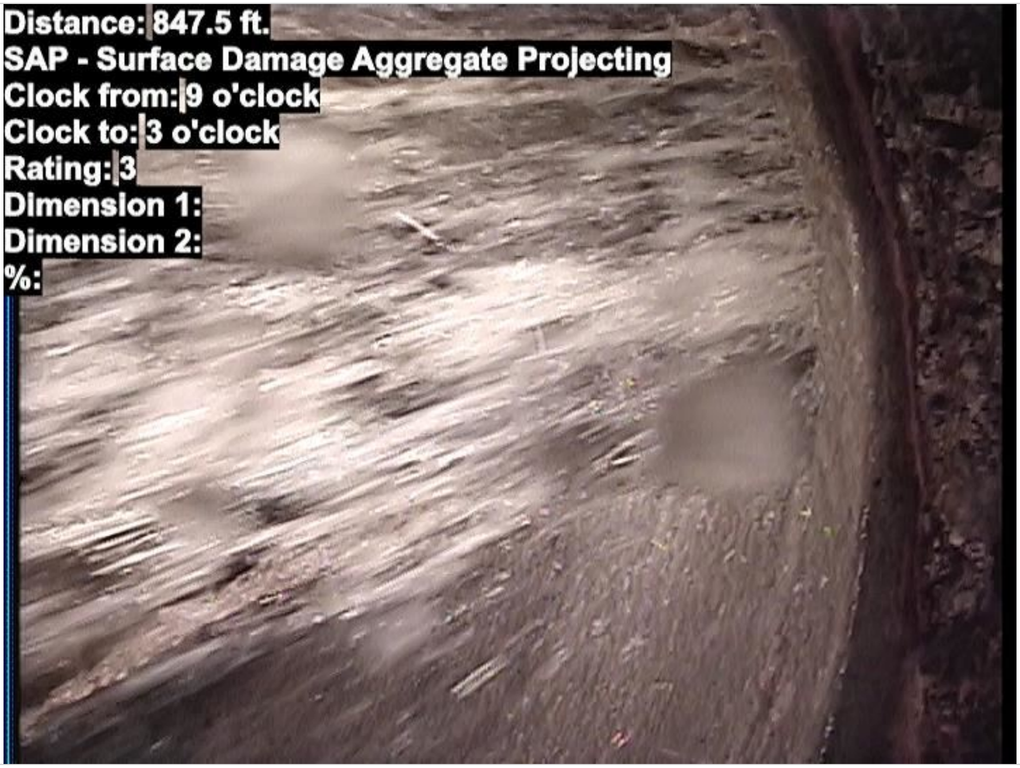
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
847.5 ft.	**D**		**10 / 2**	**SRV**		**4**	

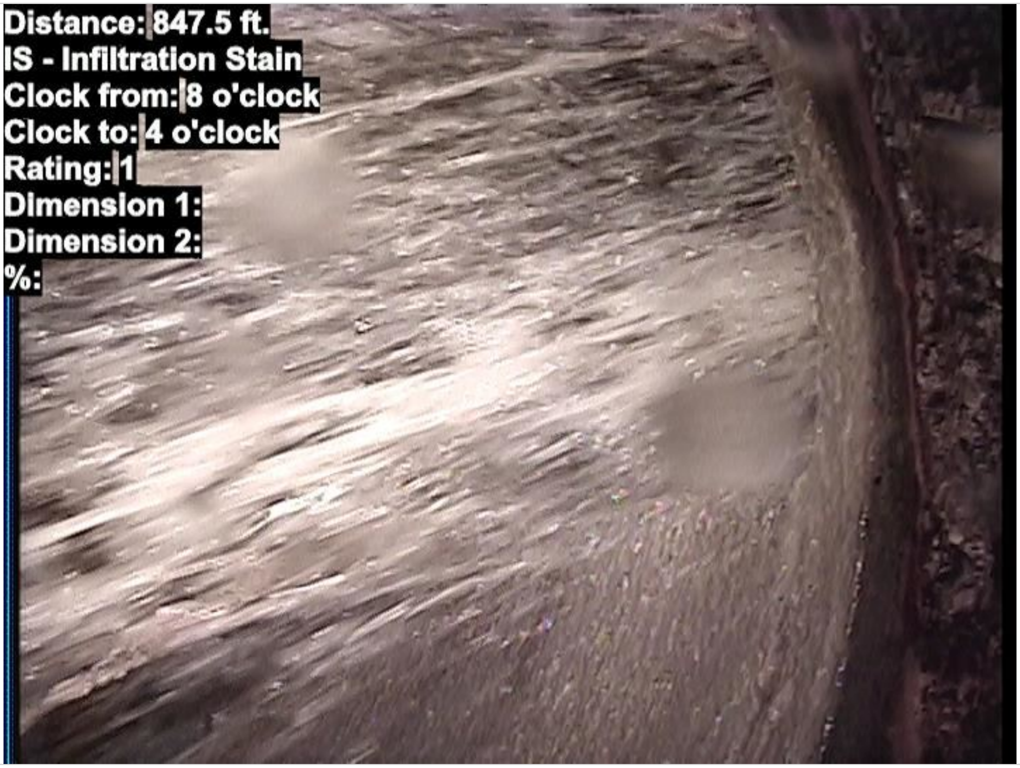


Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
847.5 ft.	D		9 / 3	SAP		3	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
847.5 ft.	D		8 / 4	IS		1	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
847.5 ft.	D		8 / 4	SSC		1	

Observations

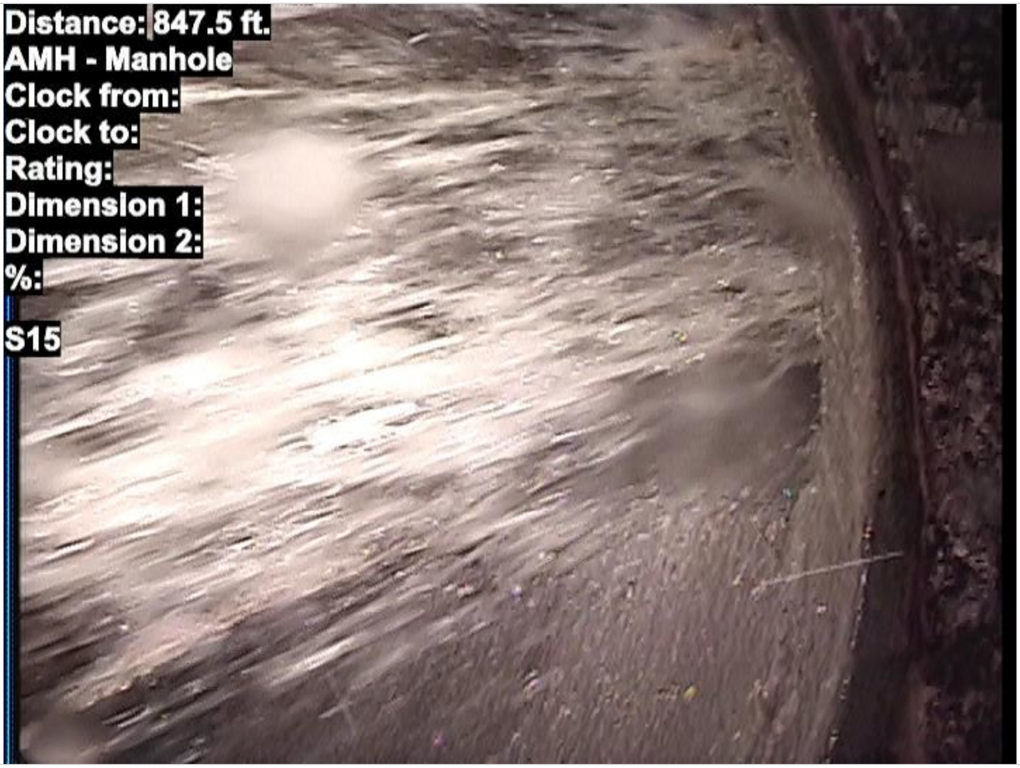
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
847.5 ft.	D		8 /	DAE		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
847.5 ft.	D		4 /	DAE		2	

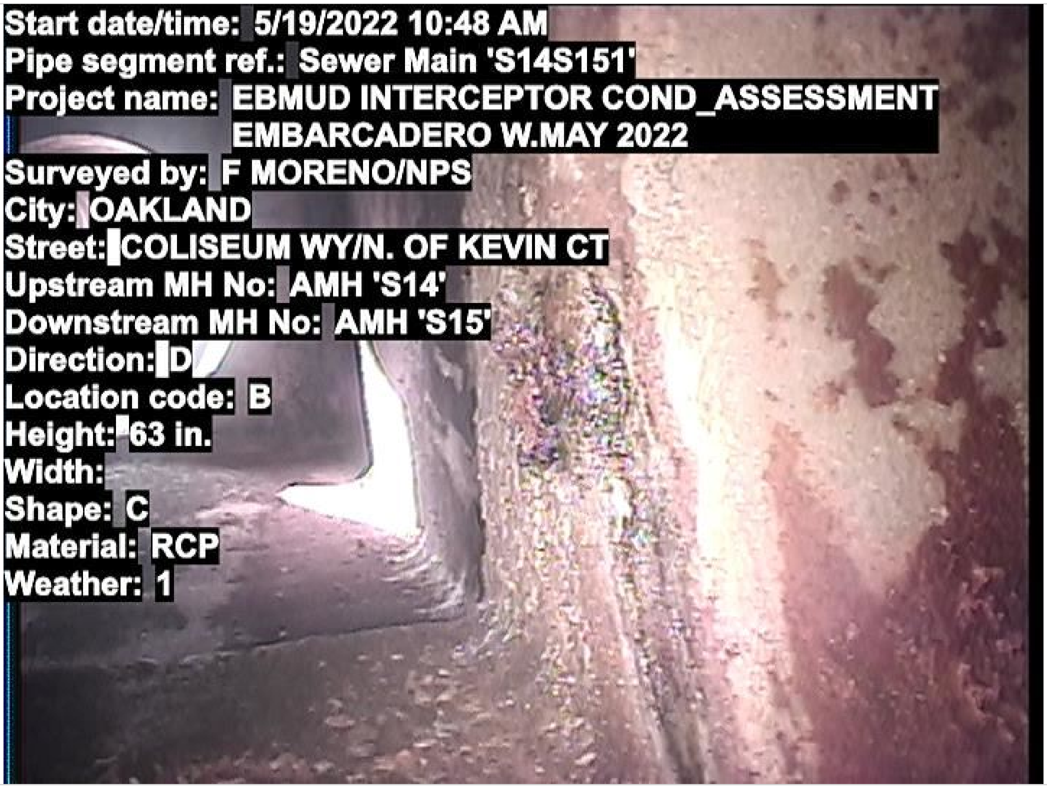
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
847.5 ft.	**D**		**8 / 4**	**SRI**		**1**	

Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
847.5 ft.	**D**		**/**	**AMH**			**S15**



Inspection's photos



Main Inspections Large Photos

Mainline ID:	City:	Street:	Project name:
S15S161	**OAKLAND**	**COLISEUM WY/ACROSS FROM SWAP MEET**	**EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022**
Start date/time:	Total length:	Weather:	Surveyed by:
5/19/2022 2:50 PM	**566.000 ft.**	**1**	**F MORENO/NPS**
Upstream MH No:	Depth US:	Downstream MH No:	Depth DS:
S15		**S16**	
Shape:	Material:	Height:	Width:
C	**RCP**	**63 in.**	

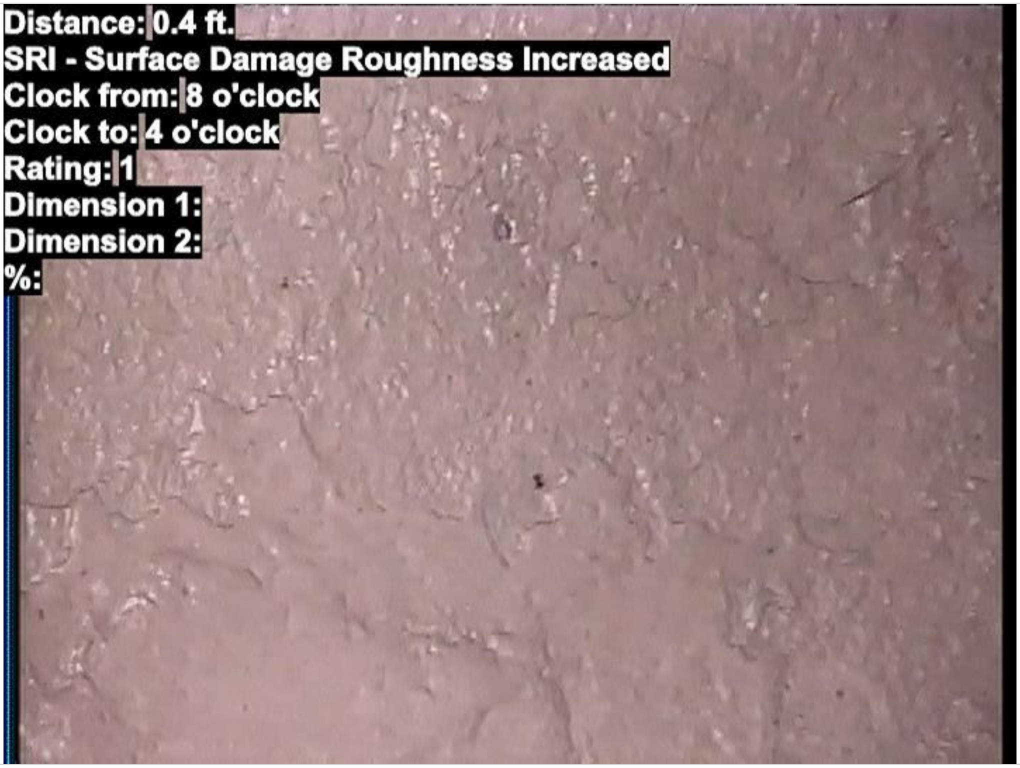
Additional info:

Observations

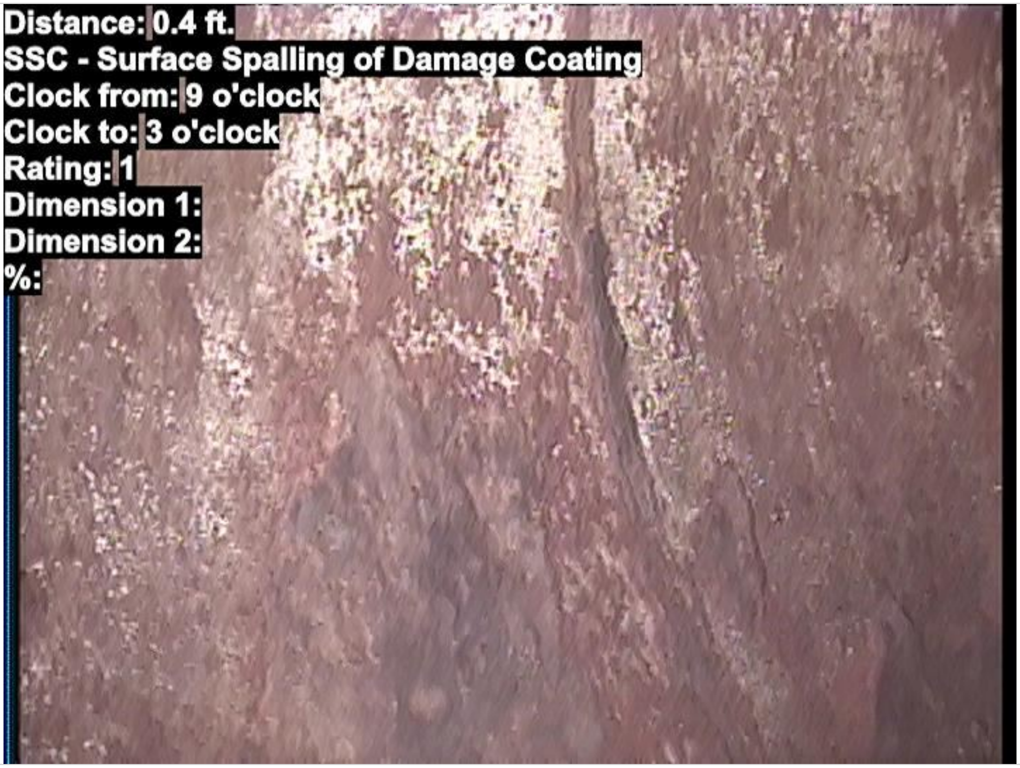
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**U**		**/**	**AMH**			**S16**

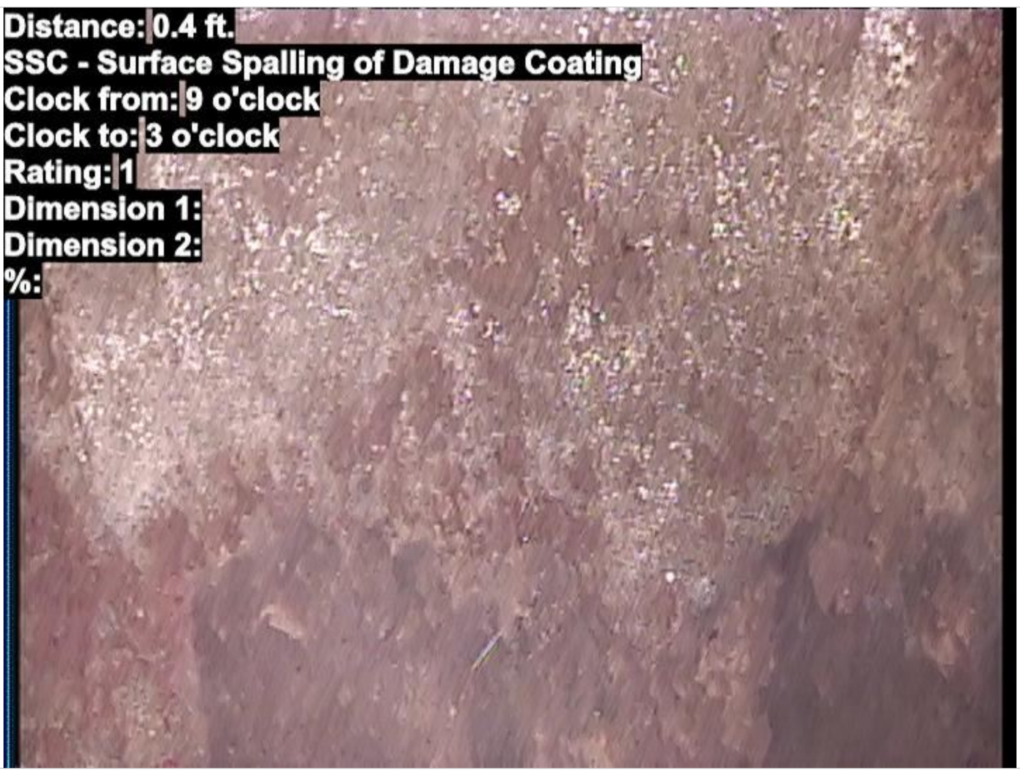
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**U**		**/**	**MWL**			

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.4 ft.	U		8 / 4	SRI		1	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.4 ft.	**U**		**9 / 3**	**SSC**		**1**	





Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
24.8 ft.	U		/	MGO			LIGHT STEAM

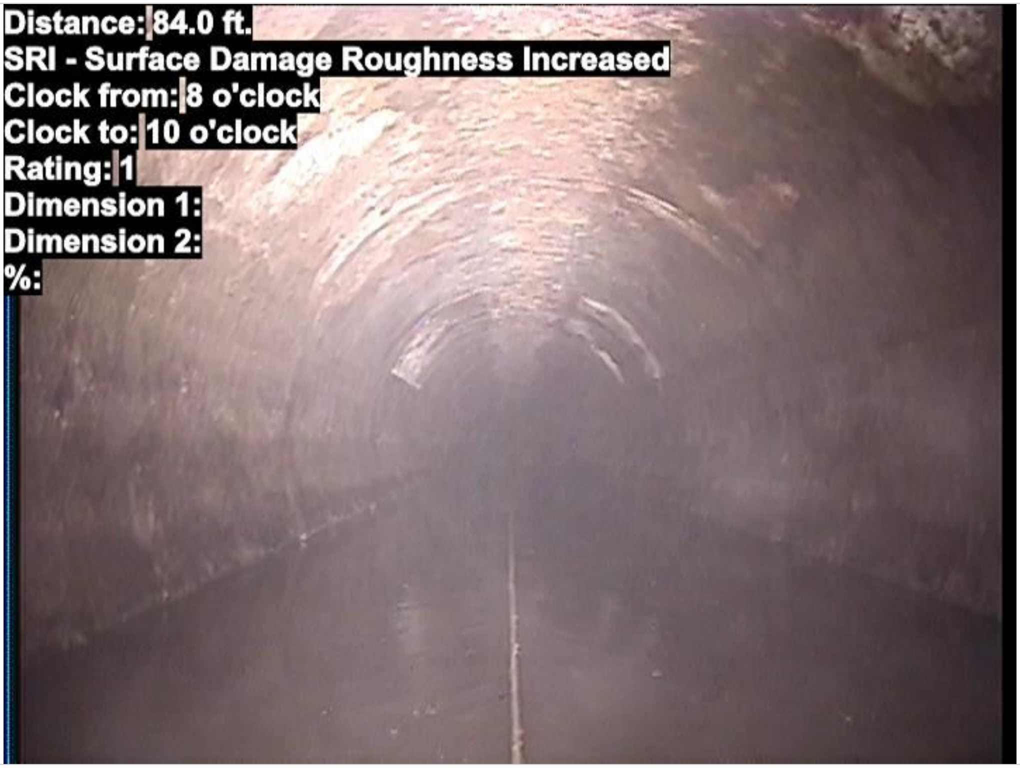
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
36.9 ft.	U		10 / 2	SAV		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
84.0 ft.	U		9 / 3	SSC		1	

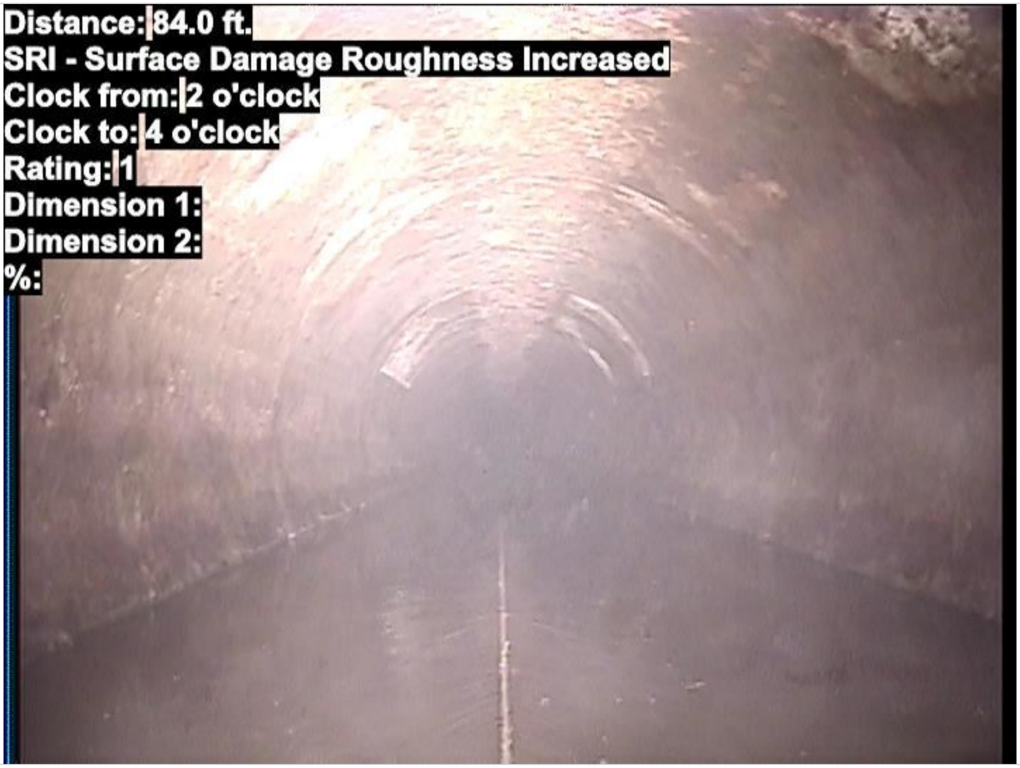
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
84.0 ft.	U		10 / 2	SAV		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
84.0 ft.	U		8 / 10	SRI		1	



Observations

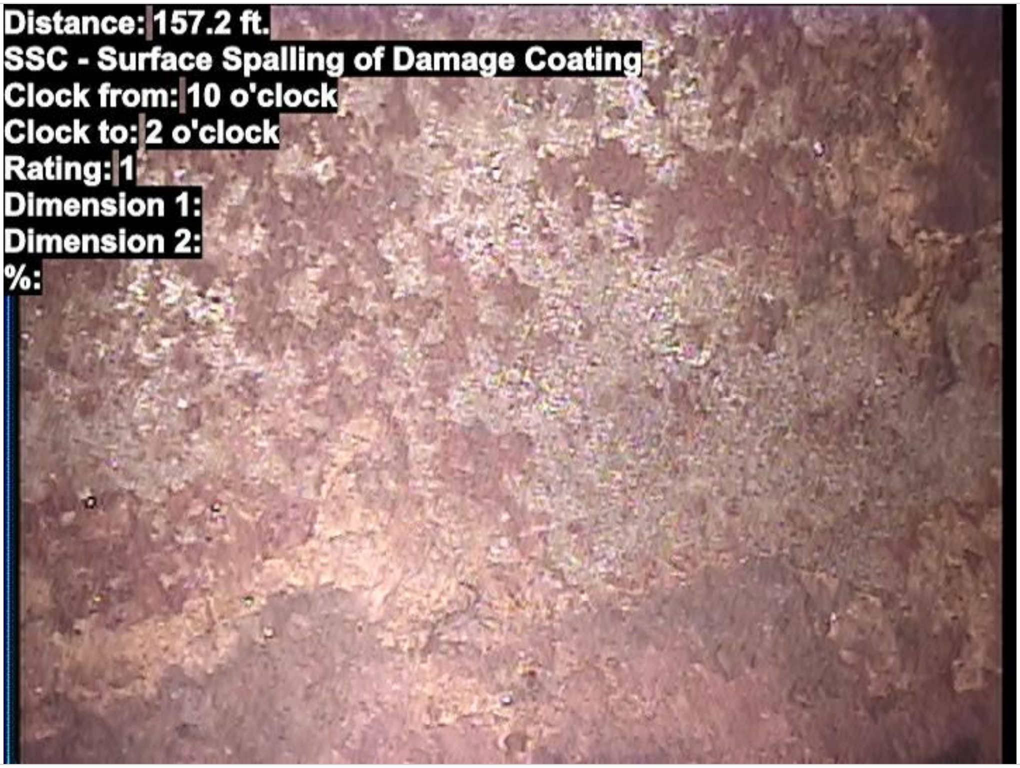
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
84.0 ft.	U		2 / 4	SRI		1	



Observations

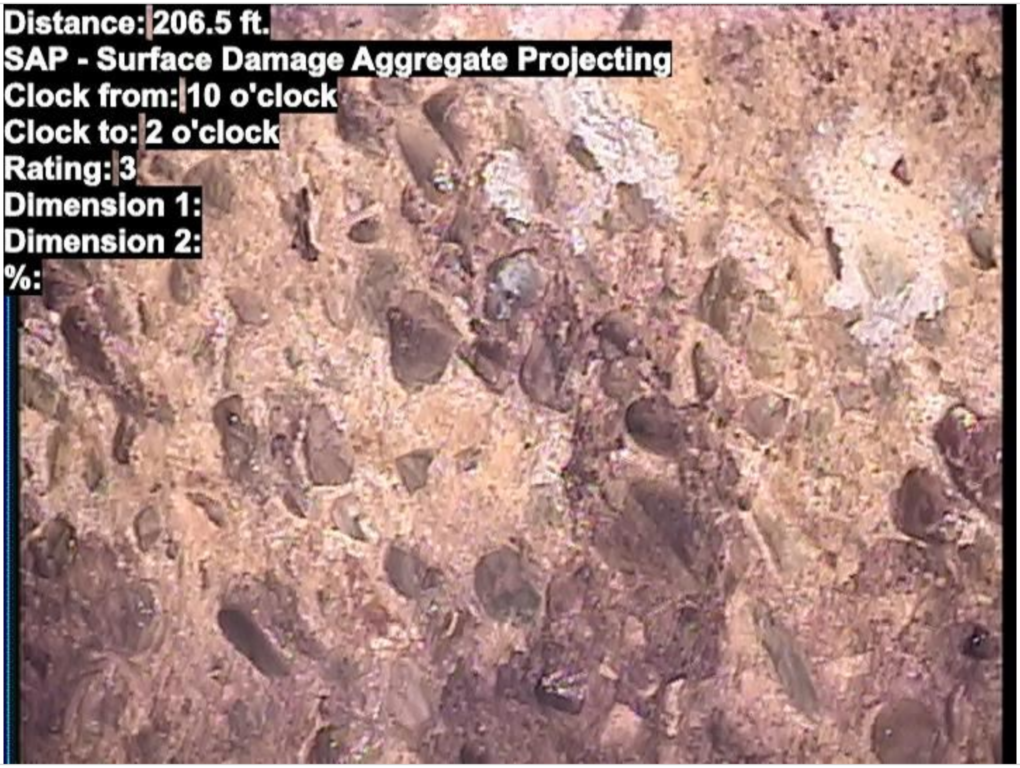
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
84.0 ft.	U		3 / 4	CM		3	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
157.2 ft.	**U**		**10 / 2**	**SSC**		**1**	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
206.5 ft.	U		10 / 2	SAV		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
206.5 ft.	U		10 / 2	SAP		3	

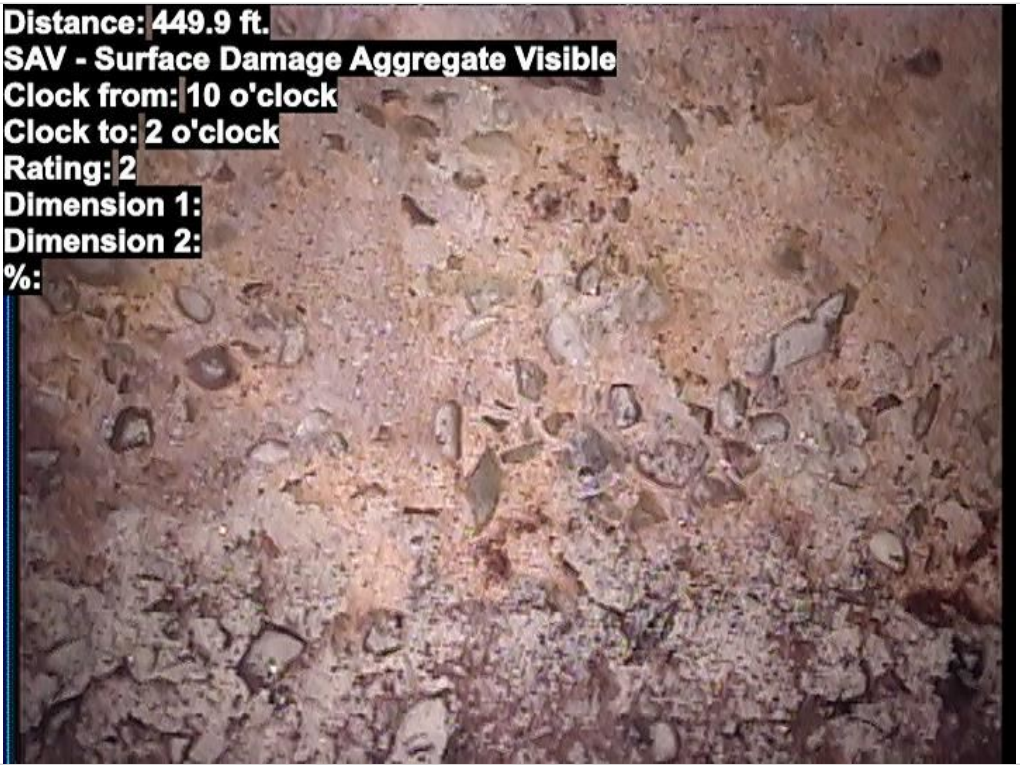


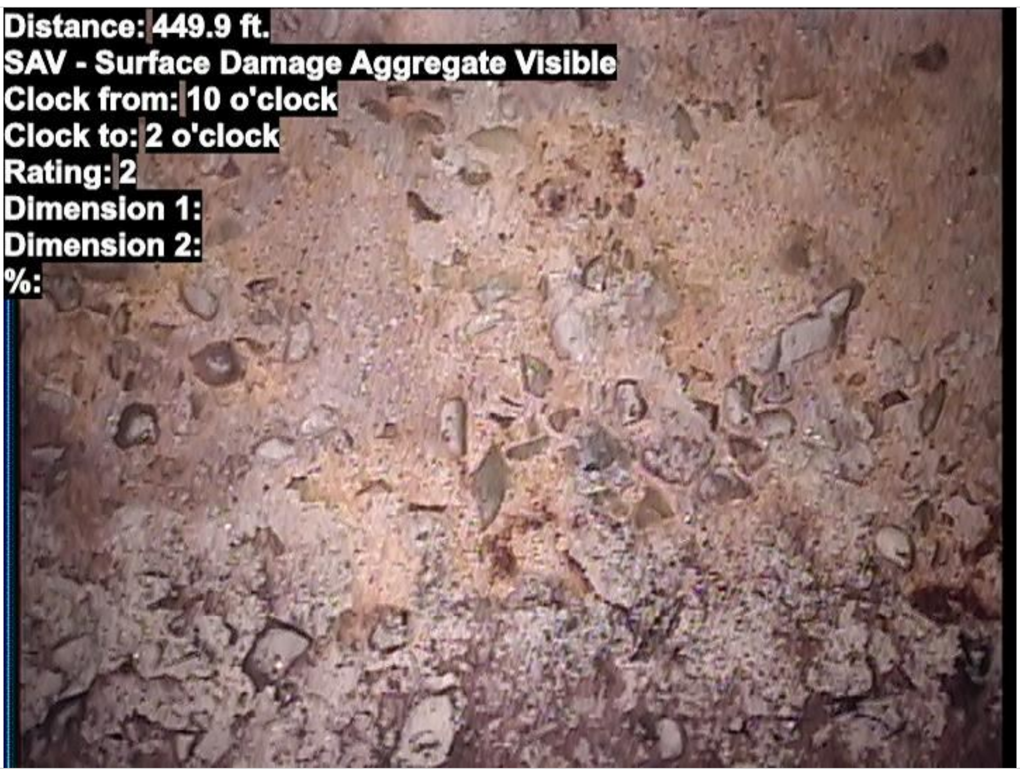
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
349.7 ft.	U		10 / 2	SAP		3	

Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
349.7 ft.	U		10 / 2	SAV		2	

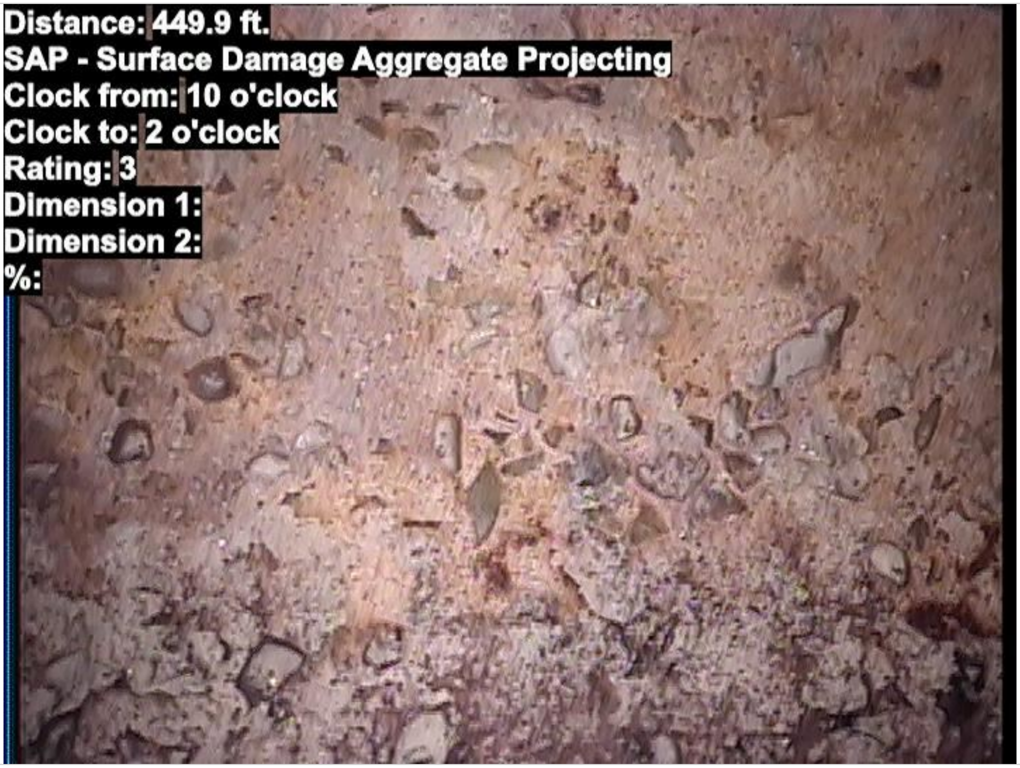
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
449.9 ft.	U		10 / 2	SAV		2	



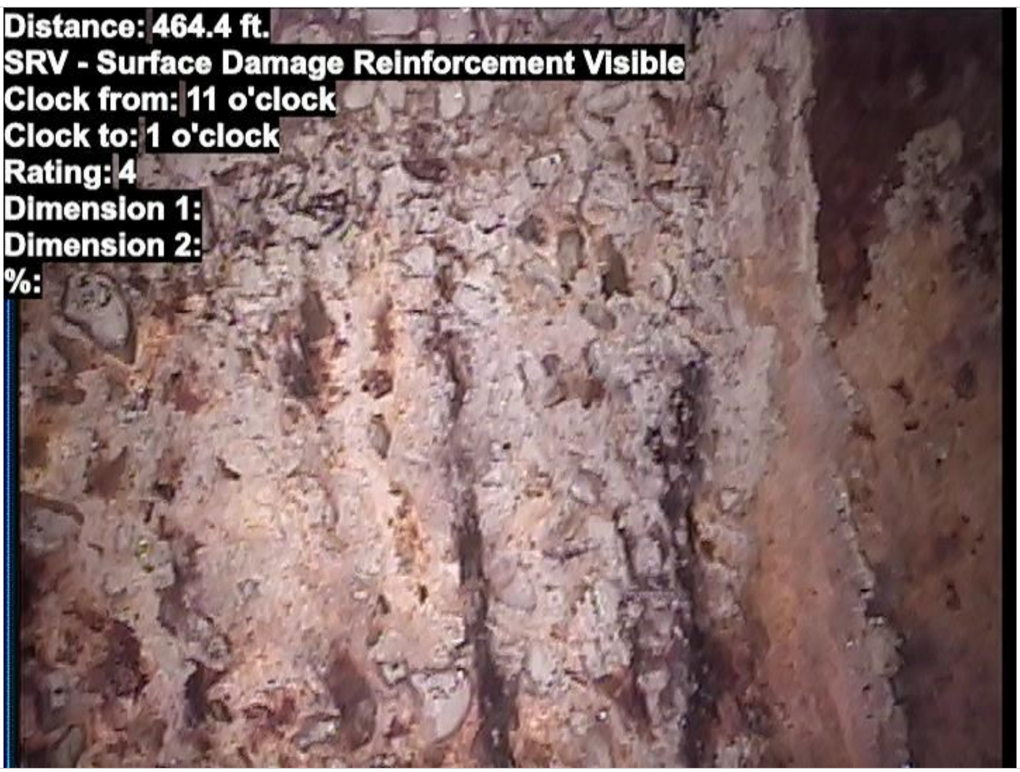


Observations

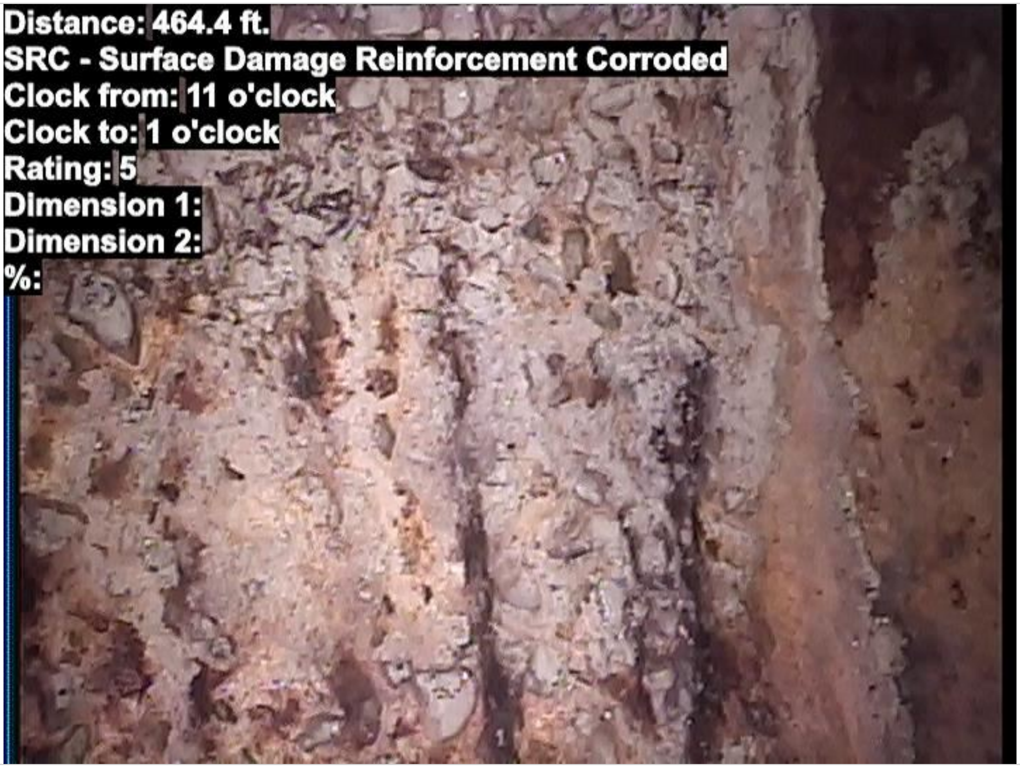
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
449.9 ft.	U		10 / 2	SAP		3	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
464.4 ft.	U		11 / 1	SRV		4	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
464.4 ft.	**U**		**11 / 1**	**SRC**		**5**	



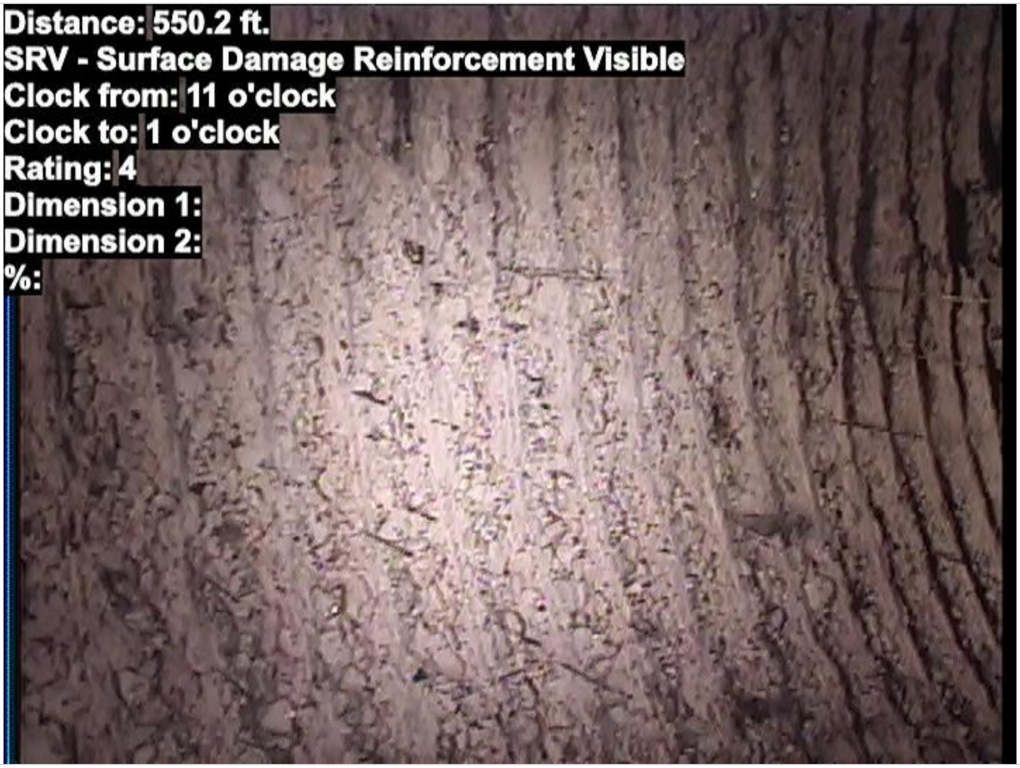
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
475.0 ft.	U		11 / 1	SRV		4	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
475.0 ft.	U		11 / 1	SRC		5	

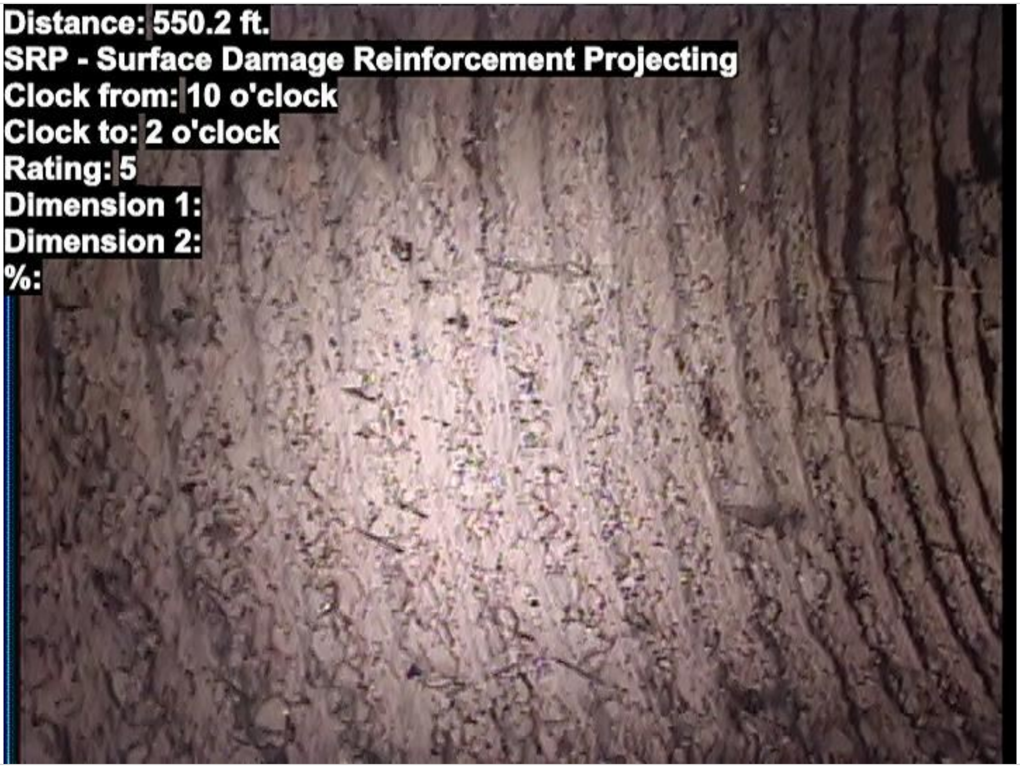
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
550.2 ft.	U		11 / 1	SRV		4	

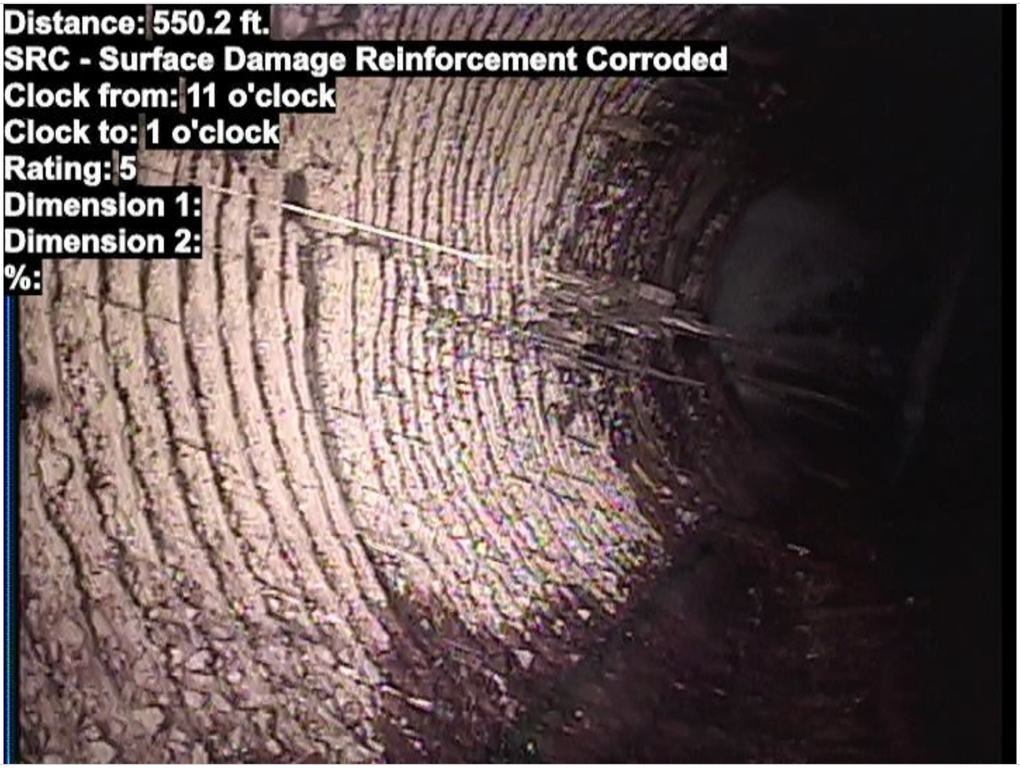


Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
550.2 ft.	U		10 / 2	SRP		5	



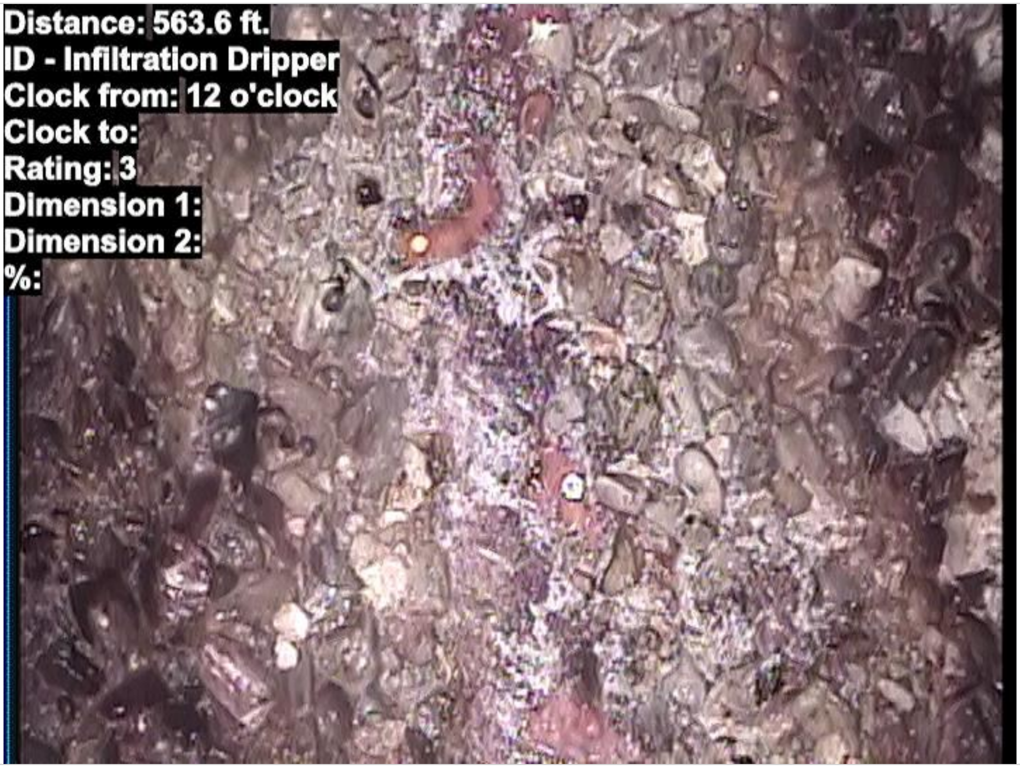
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
550.2 ft.	U		11 / 1	SRC		5	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
550.2 ft.	U		10 / 2	SRC		5	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
554.3 ft.	U		12 /	SAM		4	

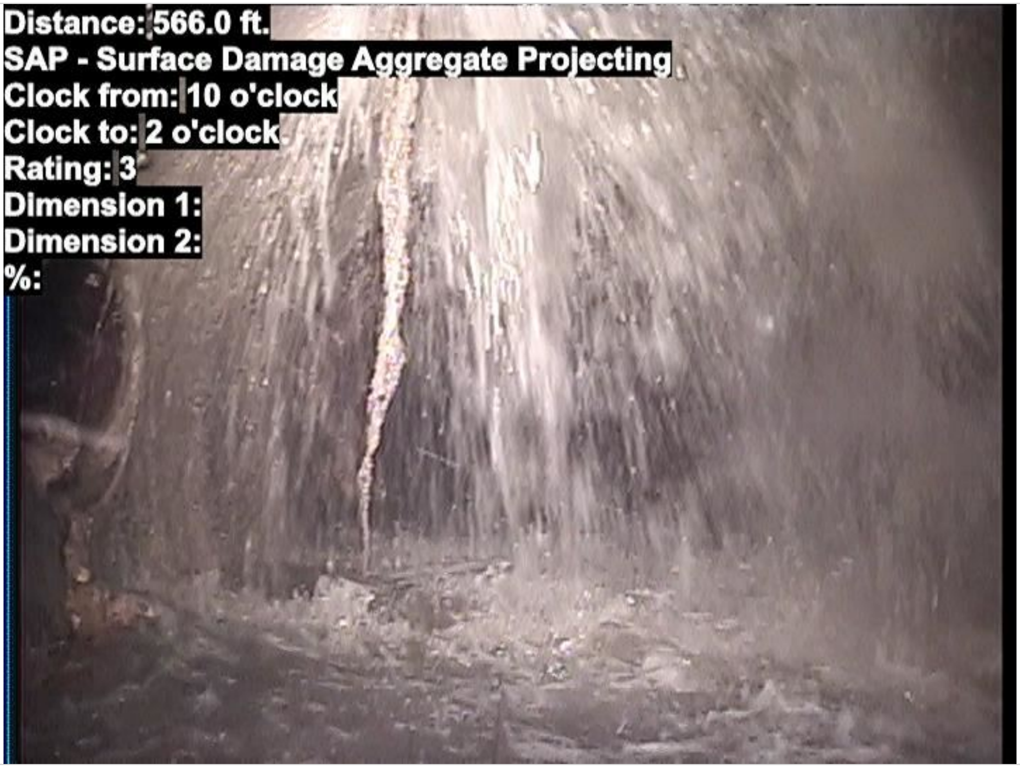
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
563.6 ft.	U		12 /	ID		3	



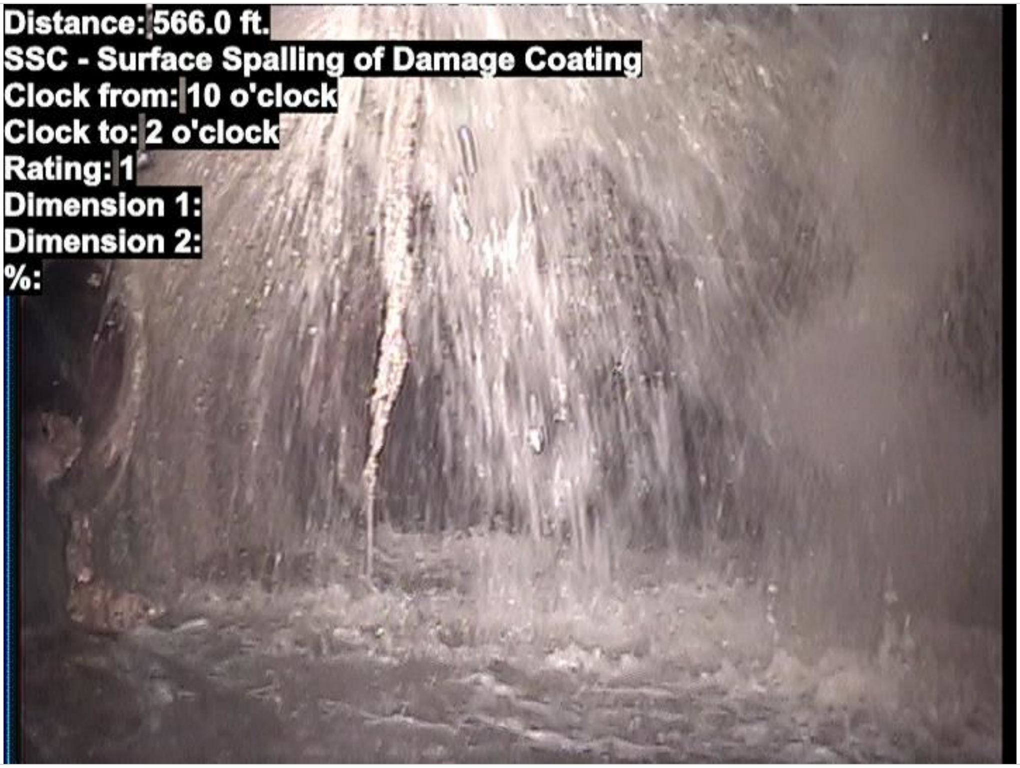
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
563.6 ft.	U		10 / 2	SRP		5	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
563.6 ft.	U		10 / 2	SRC		5	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
566.0 ft.	U		10 / 2	SAP		3	

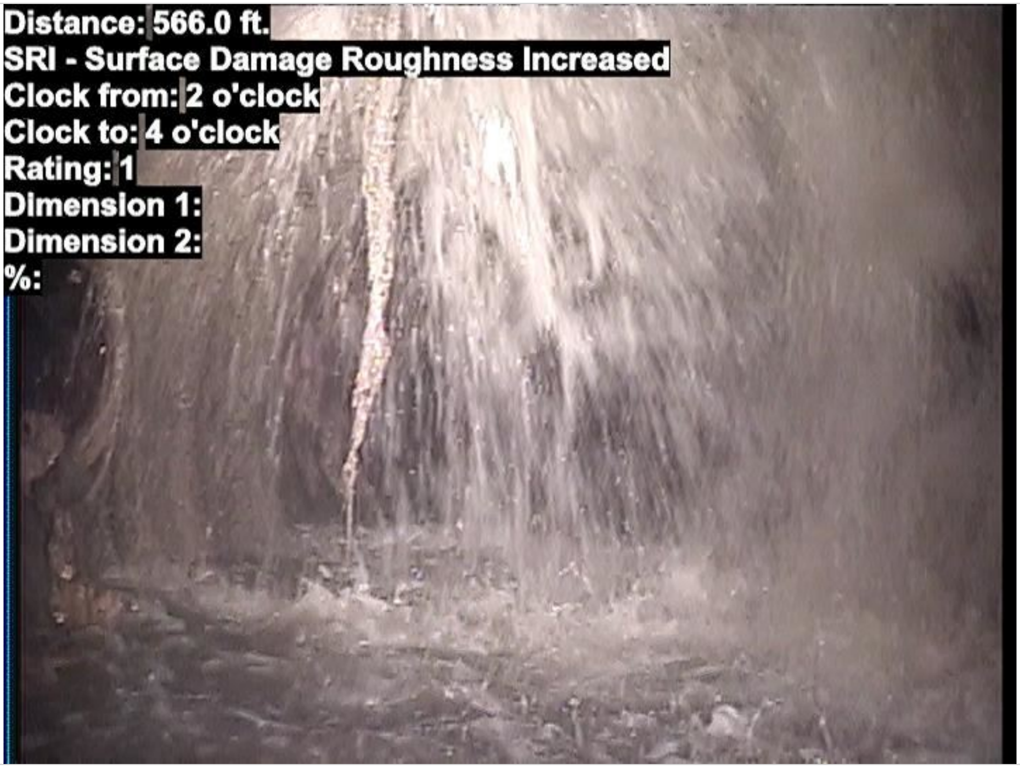


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
566.0 ft.	U		10 / 2	SSC		1	



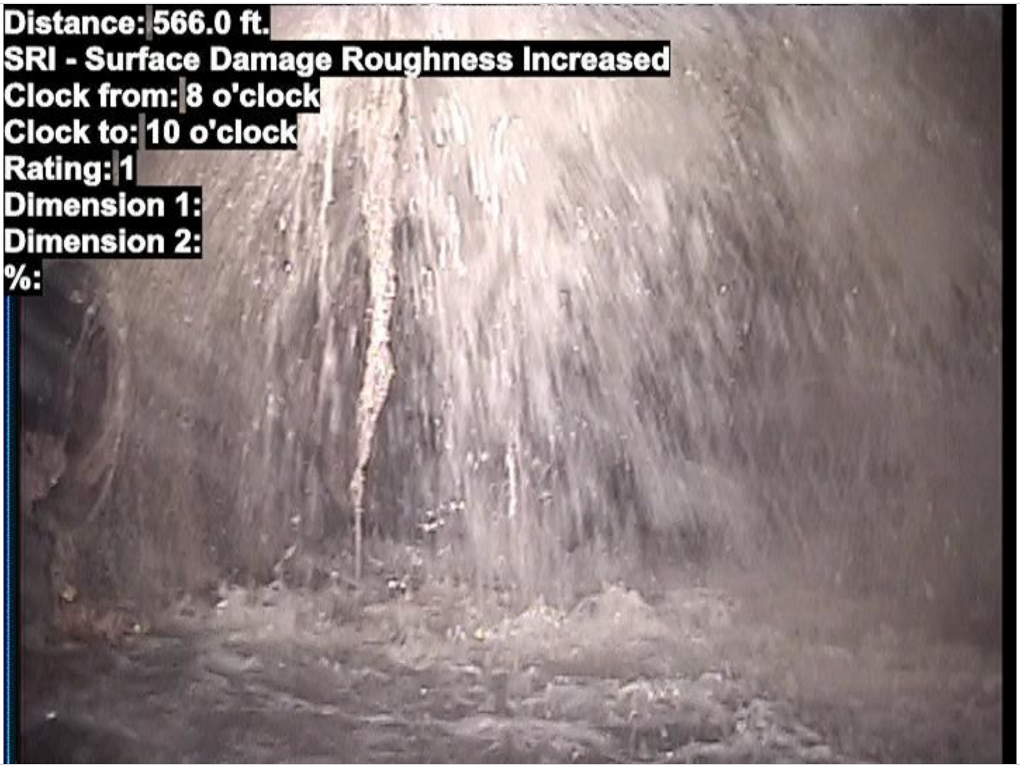
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
566.0 ft.	U		2 / 4	SRI		1	



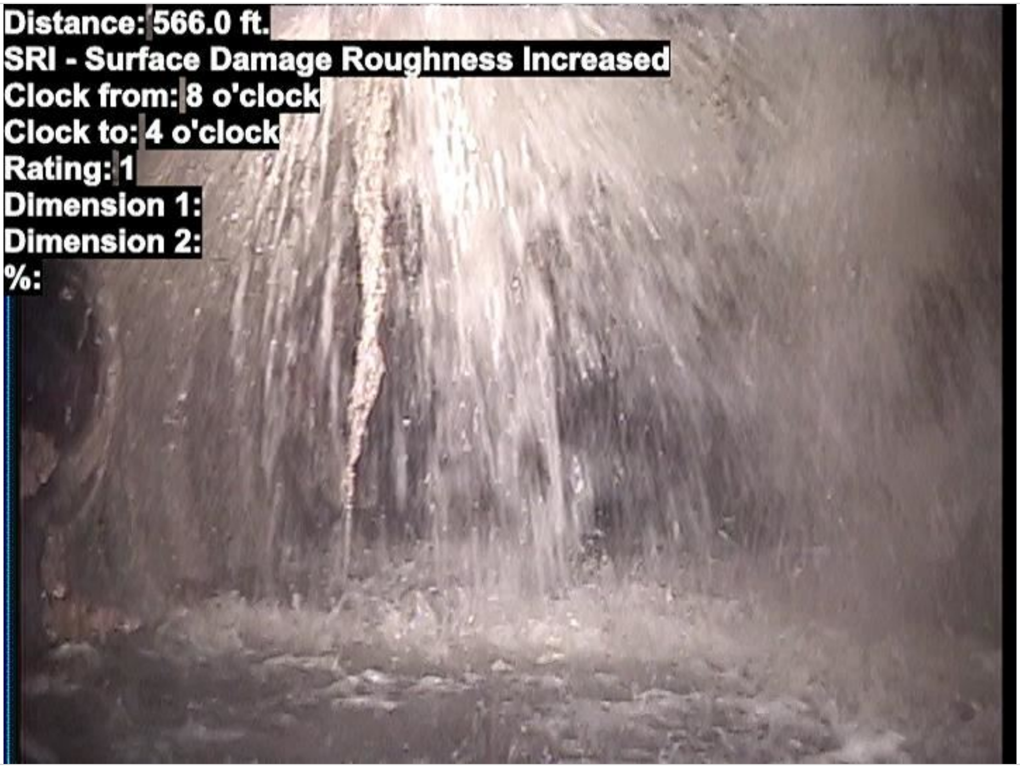
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
566.0 ft.	U		8 / 10	SRI		1	



Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
566.0 ft.	U		8 / 4	SRI		1	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
566.0 ft.	**U**		**12 /**	**SAM**		**4**	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
566.0 ft.	U		/	AMH			S15

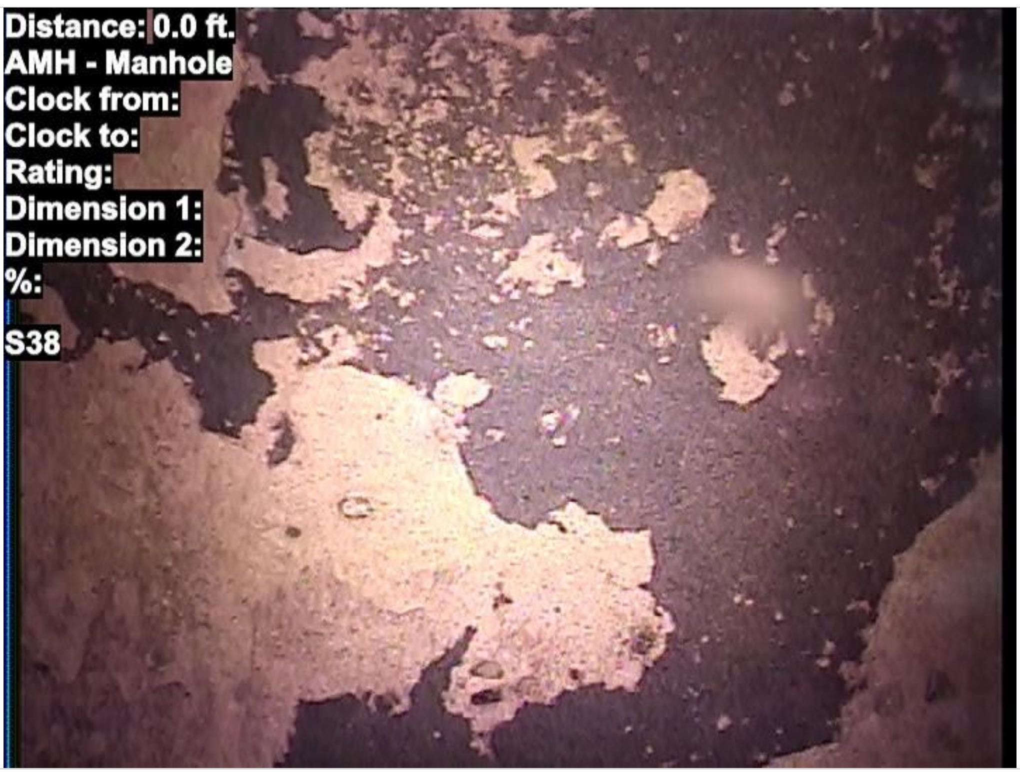
Inspection's photos

Main Inspections Large Photos

Mainline ID:	City:	Street:	Project name:
S38S391	**OAKLAND**	**EMBARCADERO/S. OF 9TH AVE**	**EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022**
Start date/time:	Total length:	Weather:	Surveyed by:
5/20/2022 11:24 AM	**1,410.100 ft.**	**1**	**F MORENO/NPS**
Upstream MH No:	Depth US:	Downstream MH No:	Depth DS:
S38		**S39**	
Shape:	Material:	Height:	Width:
C	**RCP**	**77 in.**	
Additional info:			

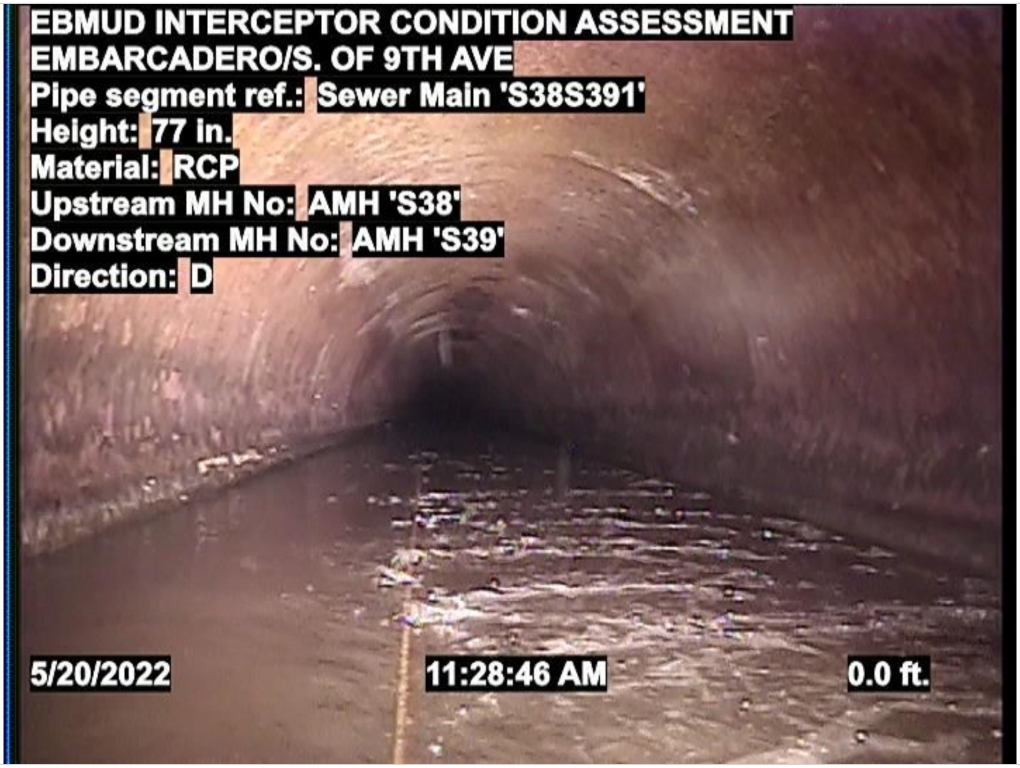
Observations

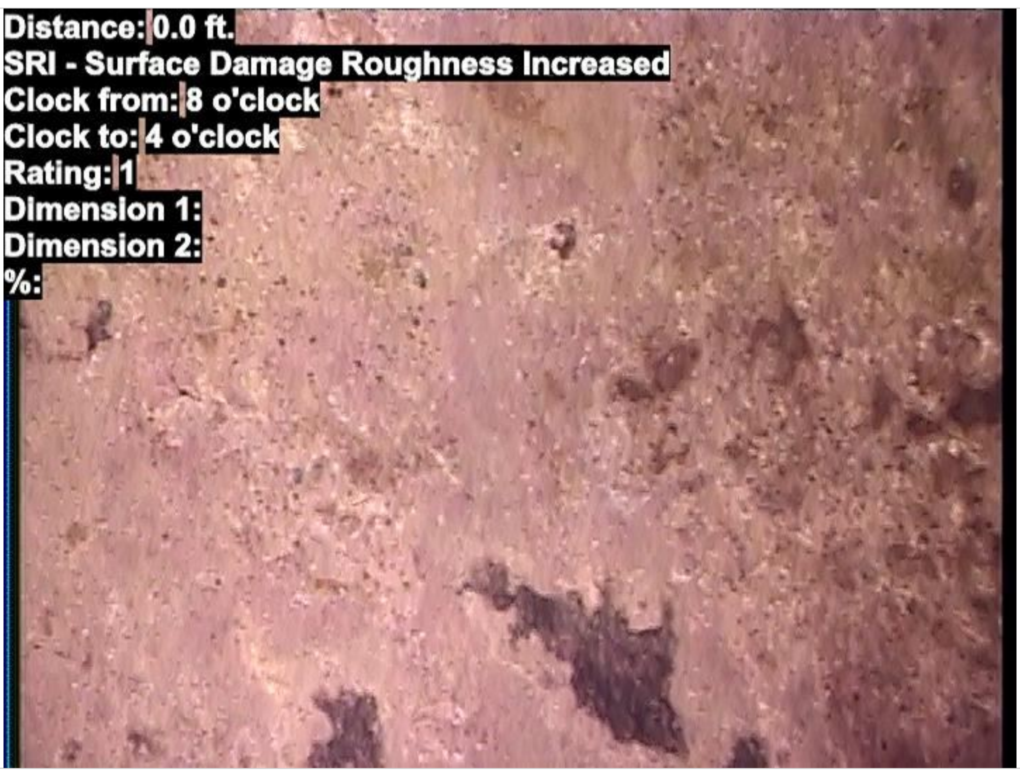
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**/**	**AMH**			**S38**



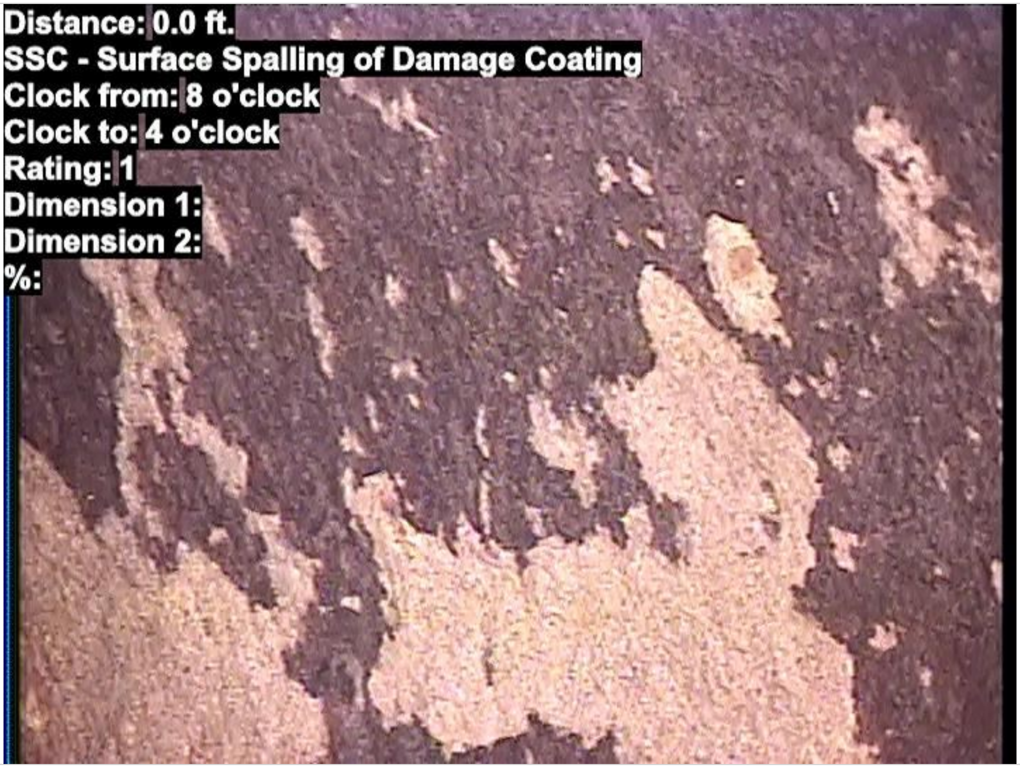
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**/**	**MWL**			

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		8 / 4	SRI		1	





Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		8 / 4	SSC		1	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	**D**		**8 / 4**	**SAV**		**2**	

Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
948.7 ft.	**D**		**10 / 2**	**IWJ**		**2**	

Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
1,410.1 ft.	D		8 / 4	SAV		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
1,410.1 ft.	**D**		**8 / 4**	**SSC**		**1**	

Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
1,410.1 ft.	D		8 / 4	SRI		1	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
1,410.1 ft.	D		/	AMH			S39

Main Inspections Large Photos

Mainline ID:	City:	Street:	Project name:
S47S481	**OAKLAND**	**EMBARCADERO**	**EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022**
Start date/time:	Total length:	Weather:	Surveyed by:
5/18/2022 12:00 PM	**707.800 ft.**	**1**	**F MORENO/NPS**
Upstream MH No:	Depth US:	Downstream MH No:	Depth DS:
S47		**S48**	
Shape:	Material:	Height:	Width:
H	**RCP**	**105 in.**	**105 in.**
Additional info:			

Observations

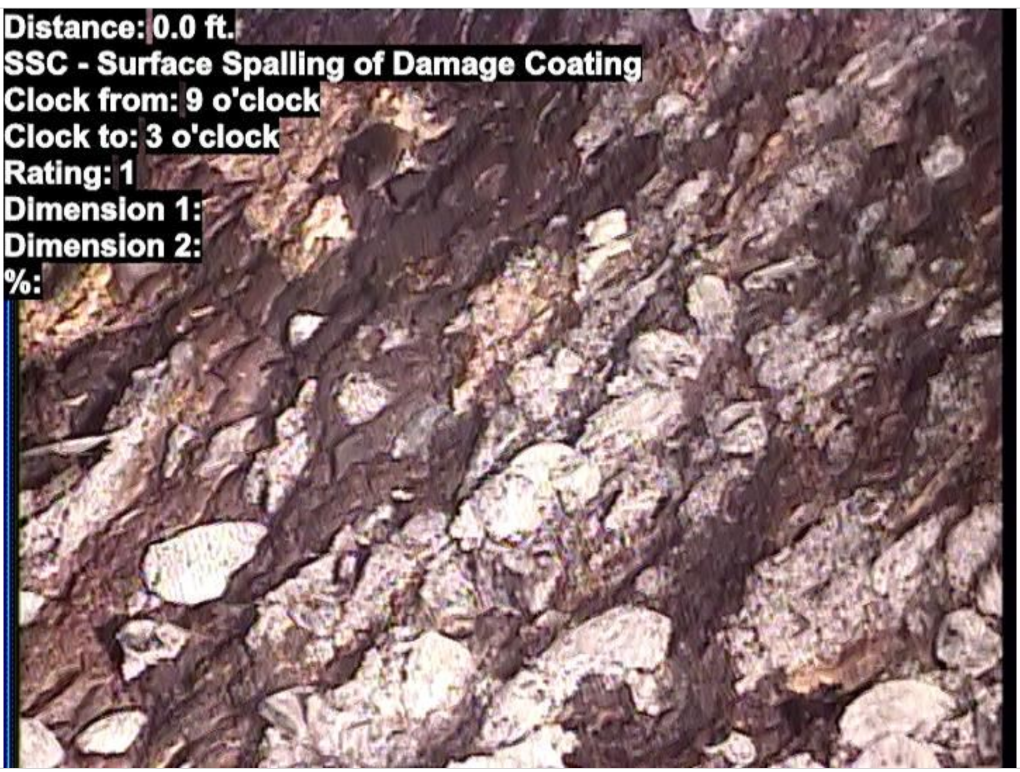
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**/**	**AMH**			**S47**

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**/**	**MWL**			

Observations

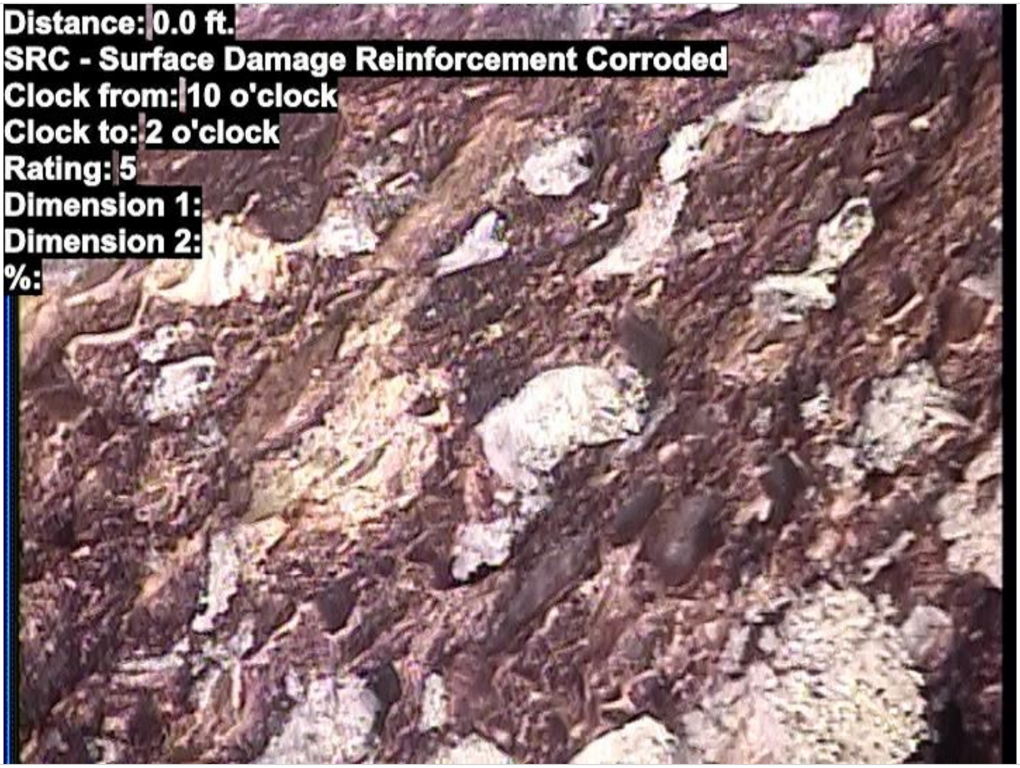
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		9 / 3	SAP		3	

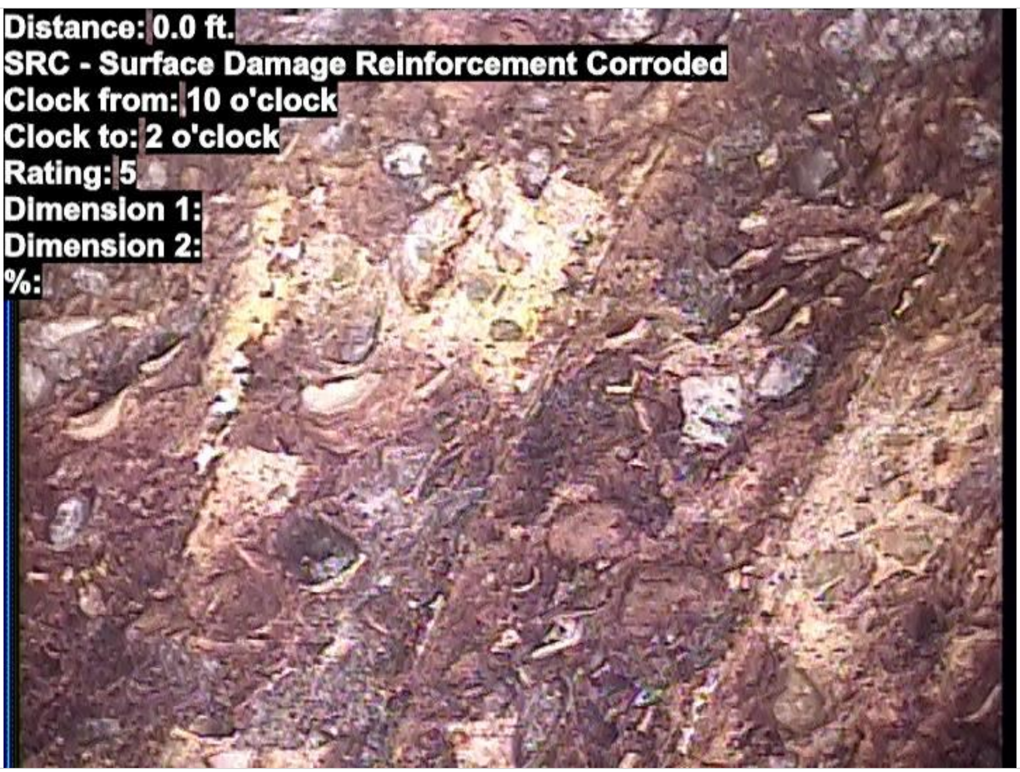
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**9 / 3**	**SSC**		**1**	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		10 / 2	SRV		4	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		10 / 2	SRC		5	



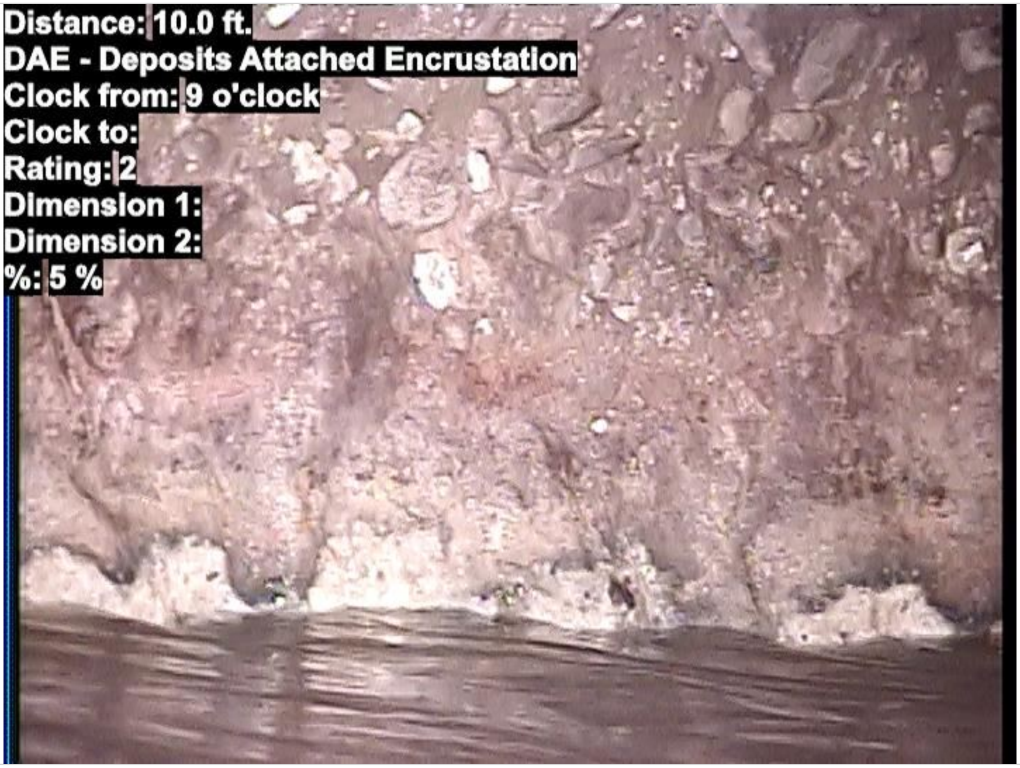


Observations

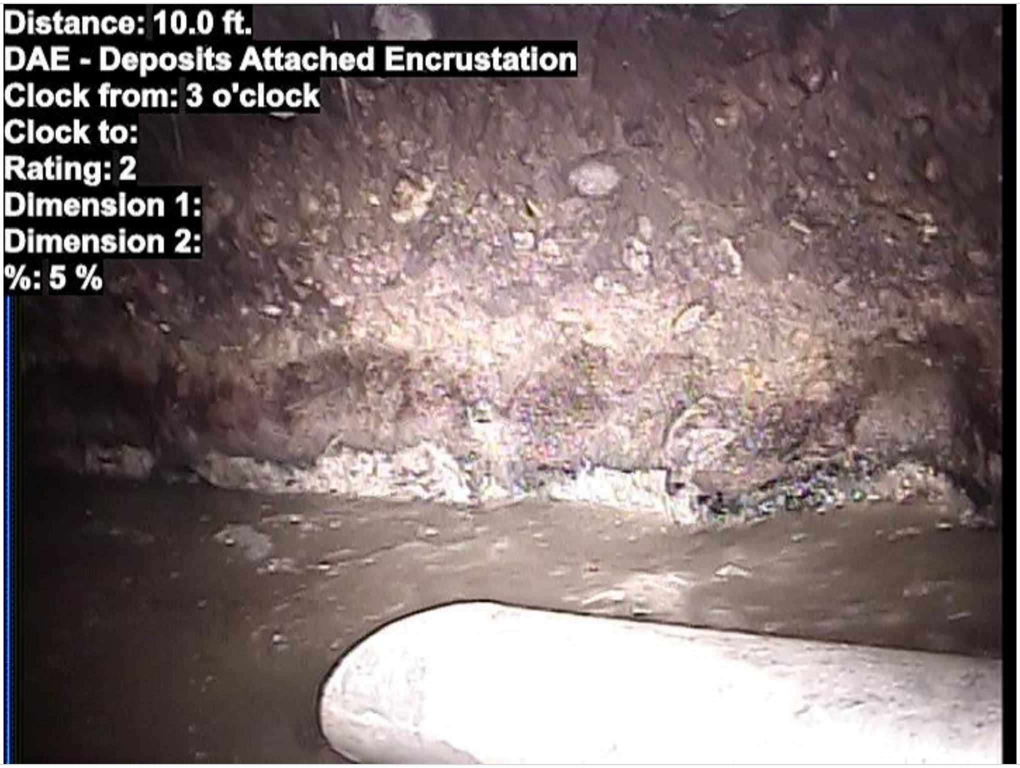
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	**D**		**10 / 2**	**SRC**		**5**	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	D		10 / 2	SRV		4	

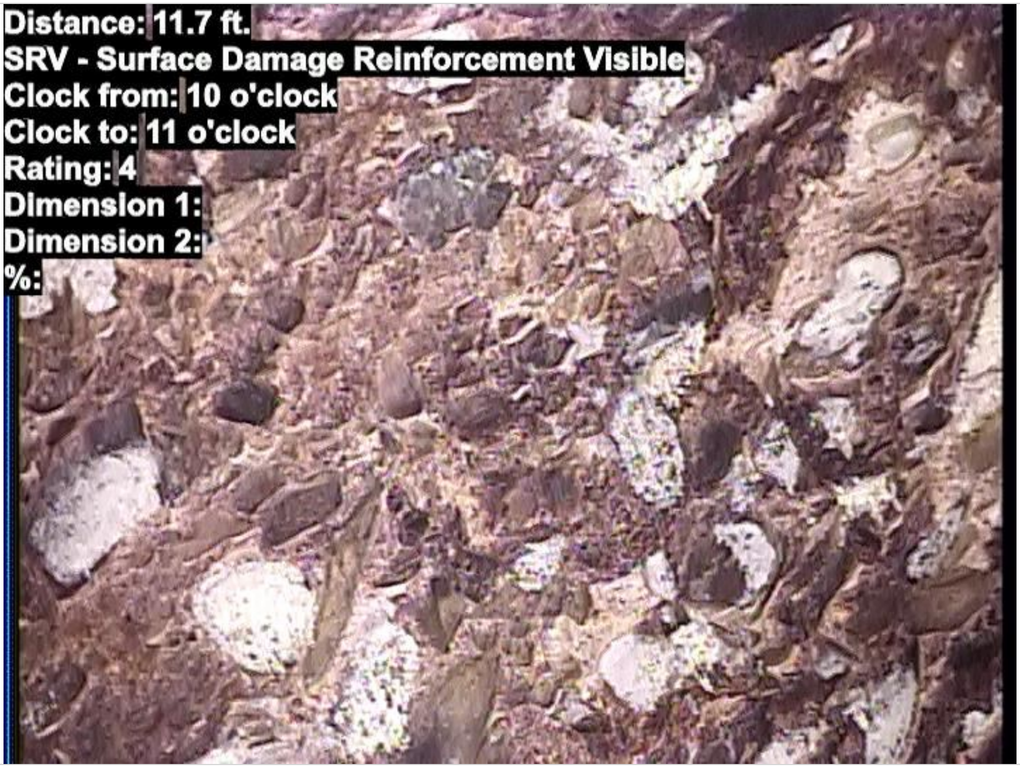
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	D		9 /	DAE		2	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	D		3 /	DAE		2	



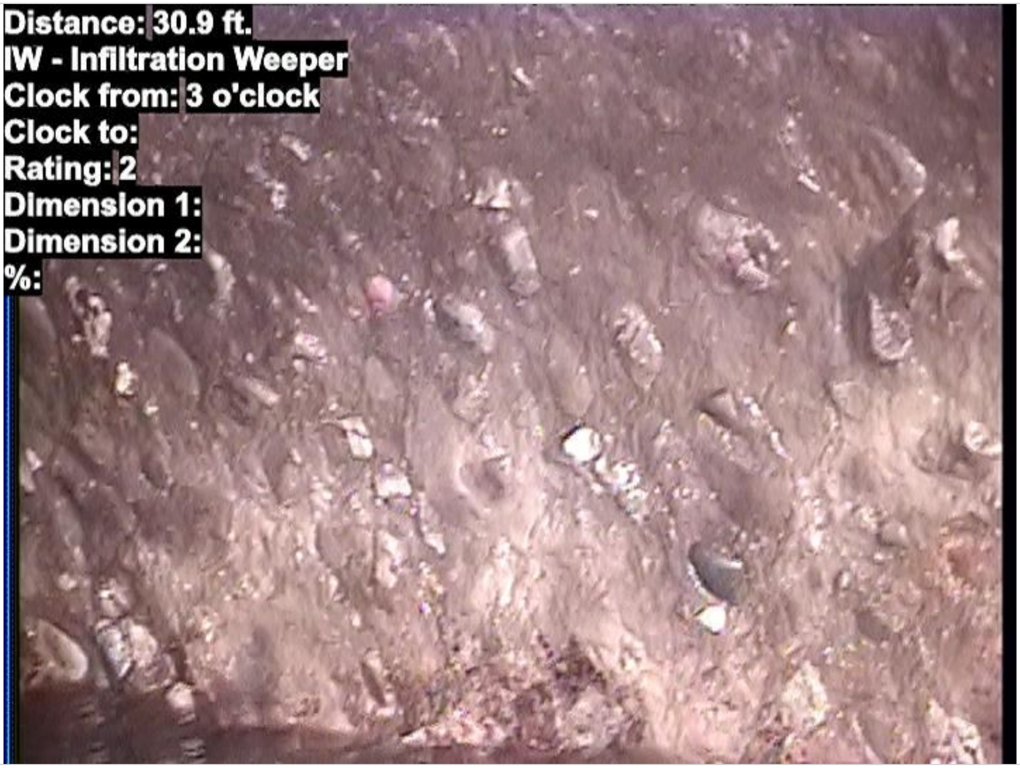
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
11.7 ft.	D		10 / 11	SRV		4	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
11.7 ft.	D		10 / 11	SRC		5	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
30.9 ft.	**D**		**9 /**	**IW**		**2**	

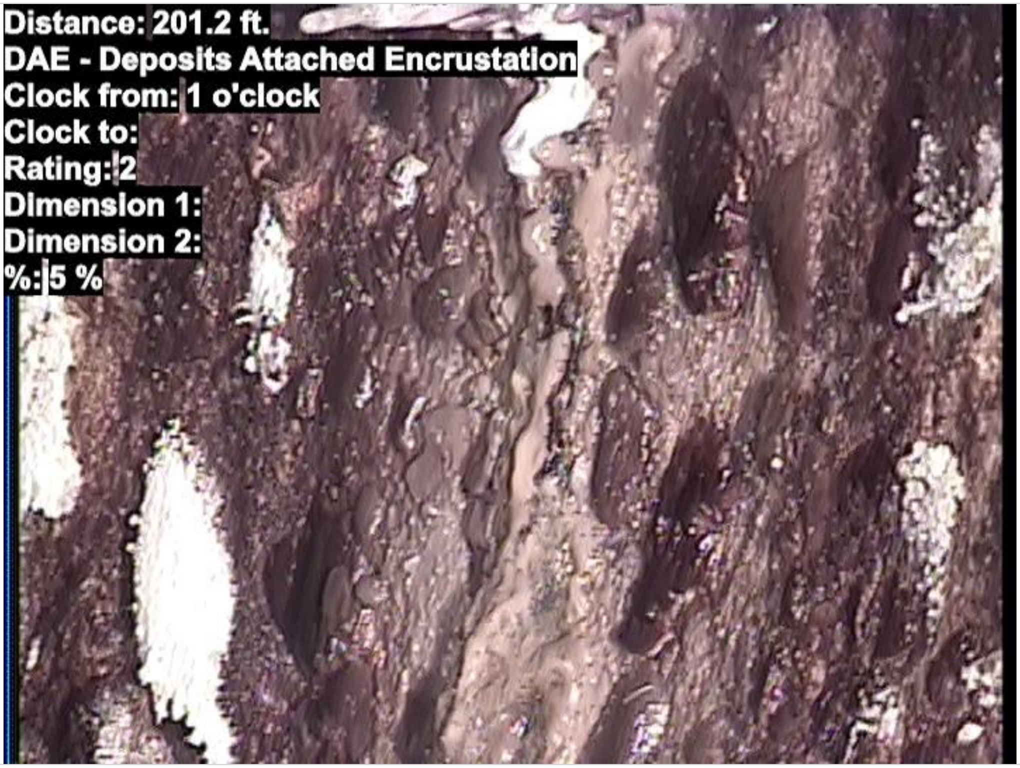
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
30.9 ft.	D		3 /	IW		2	



Observations

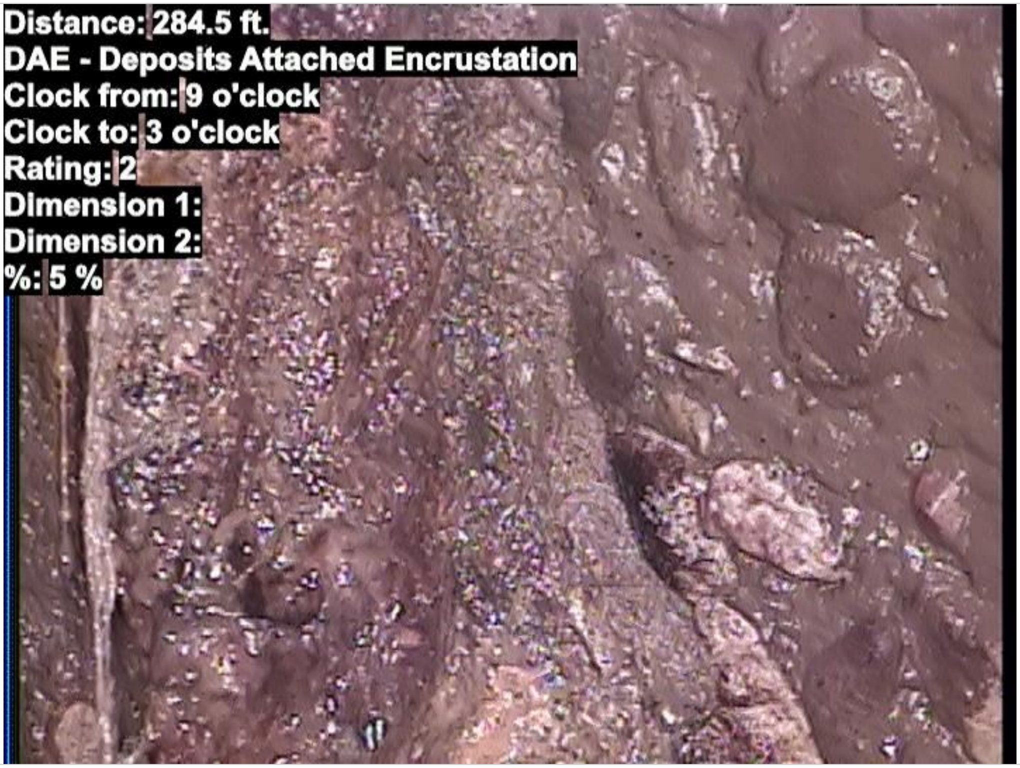
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
201.2 ft.	D		1 /	ID		3	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
201.2 ft.	D		1 /	DAE		2	

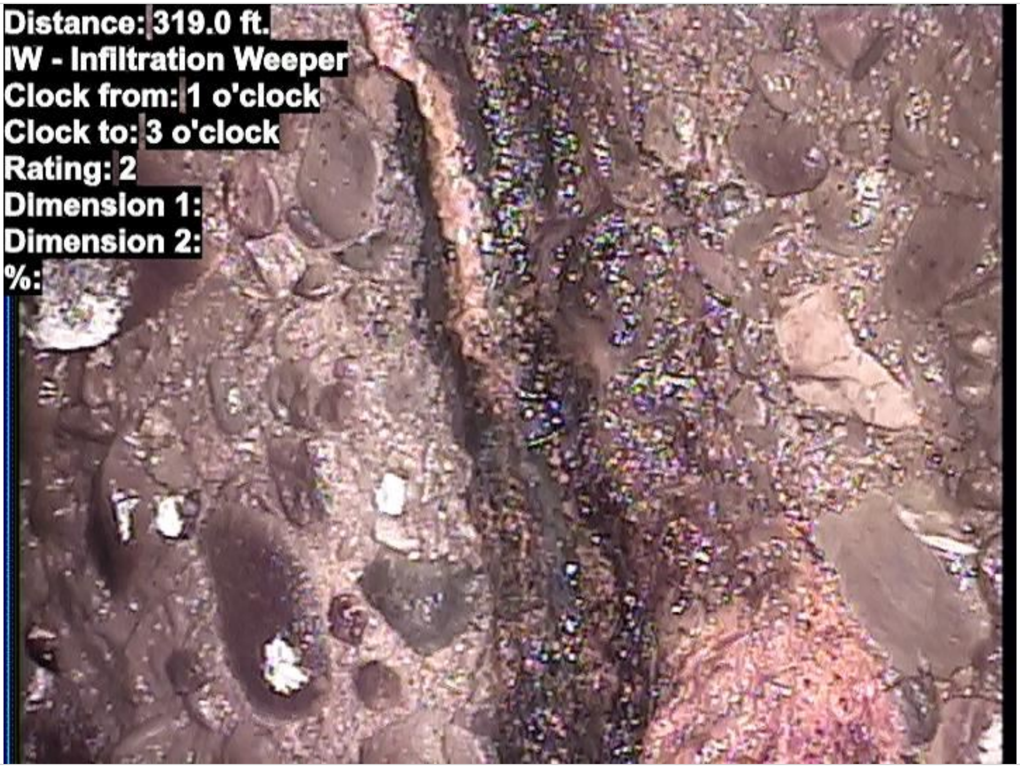


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
284.5 ft.	D		9 / 3	IW		2	

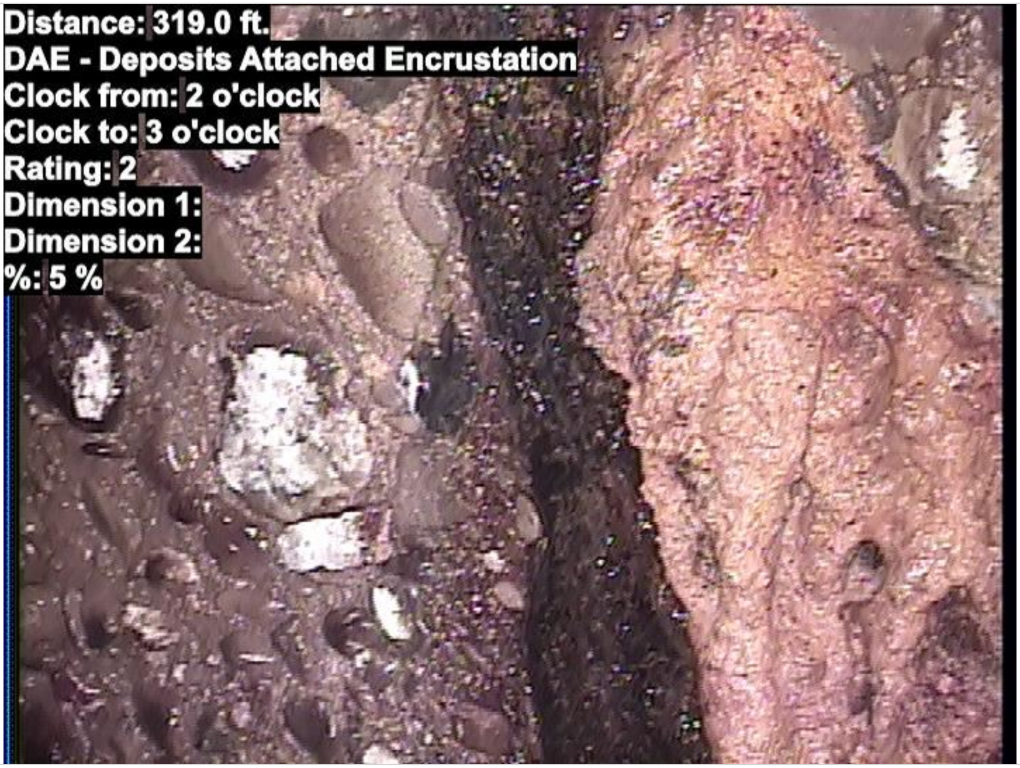
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
284.5 ft.	D		9 / 3	DAE		2	



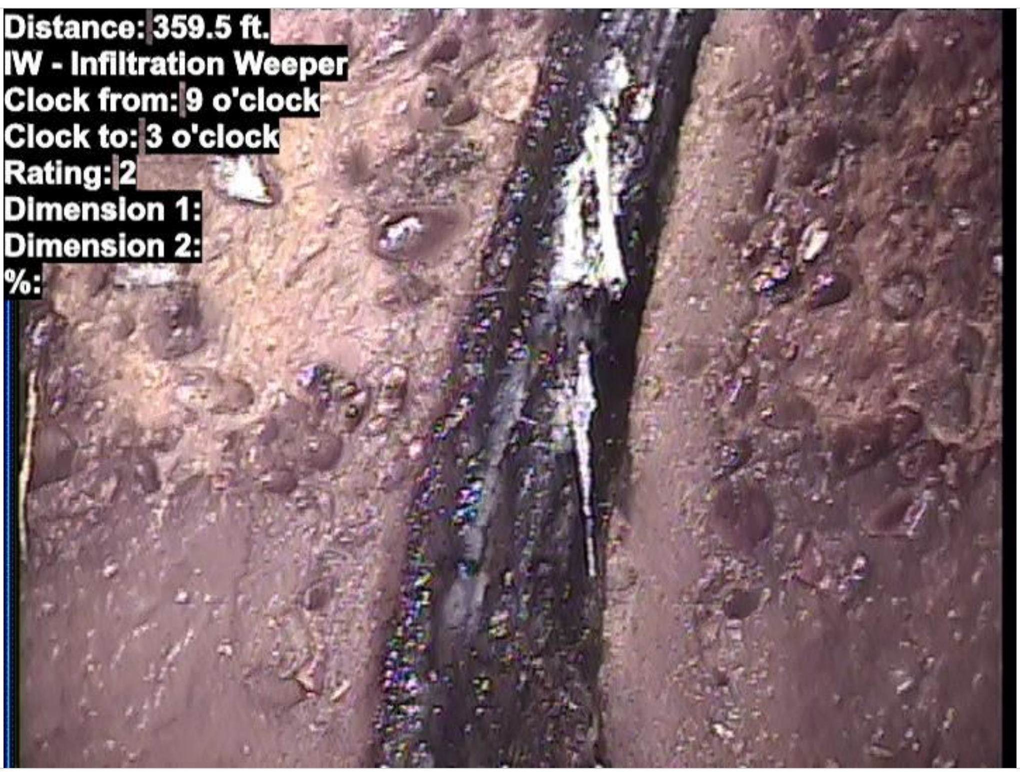
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
319.0 ft.	**D**		**1 / 3**	**IW**		**2**	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
319.0 ft.	D		2 / 3	DAE		2	

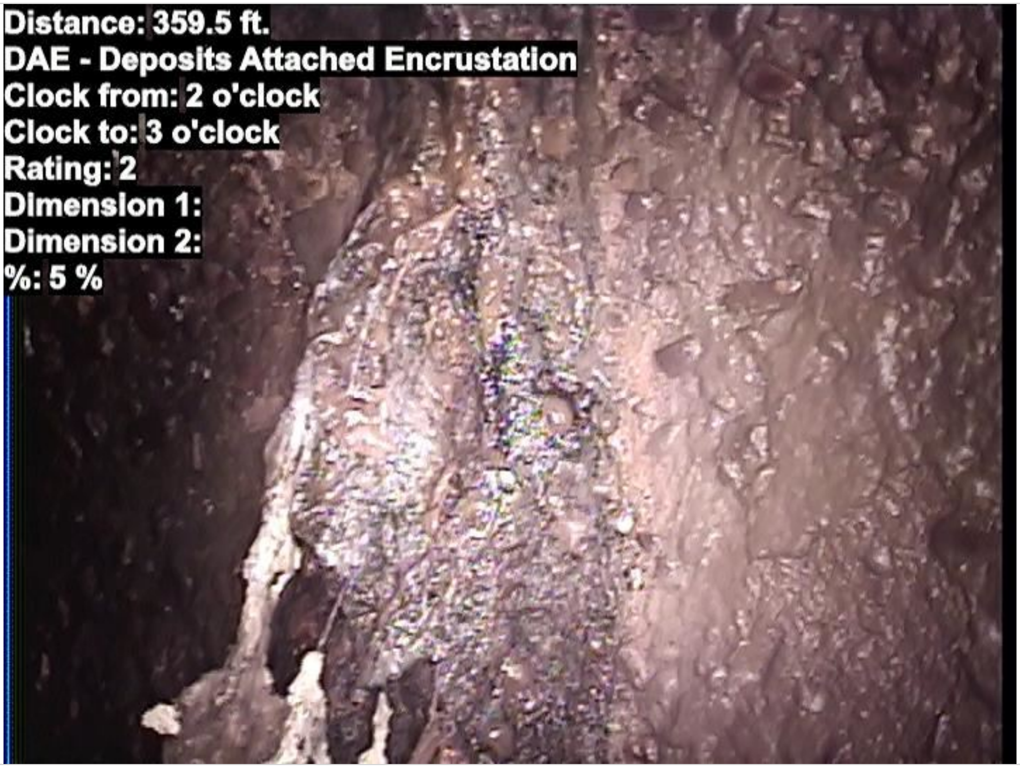


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
359.5 ft.	D		9 / 3	IW		2	

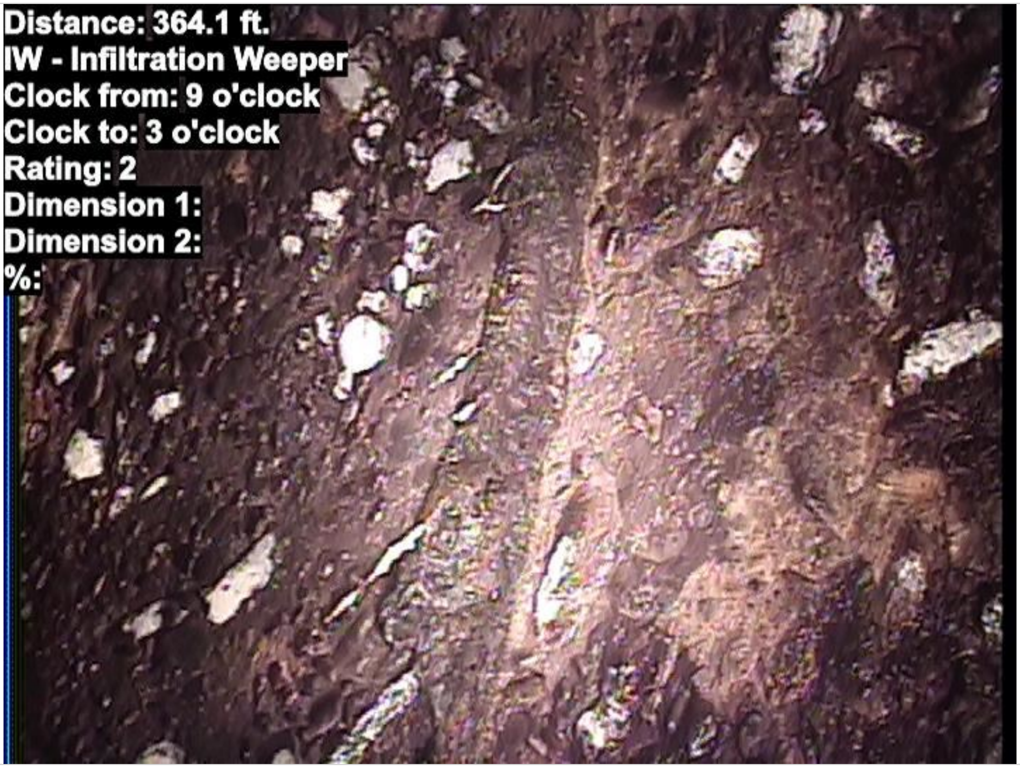


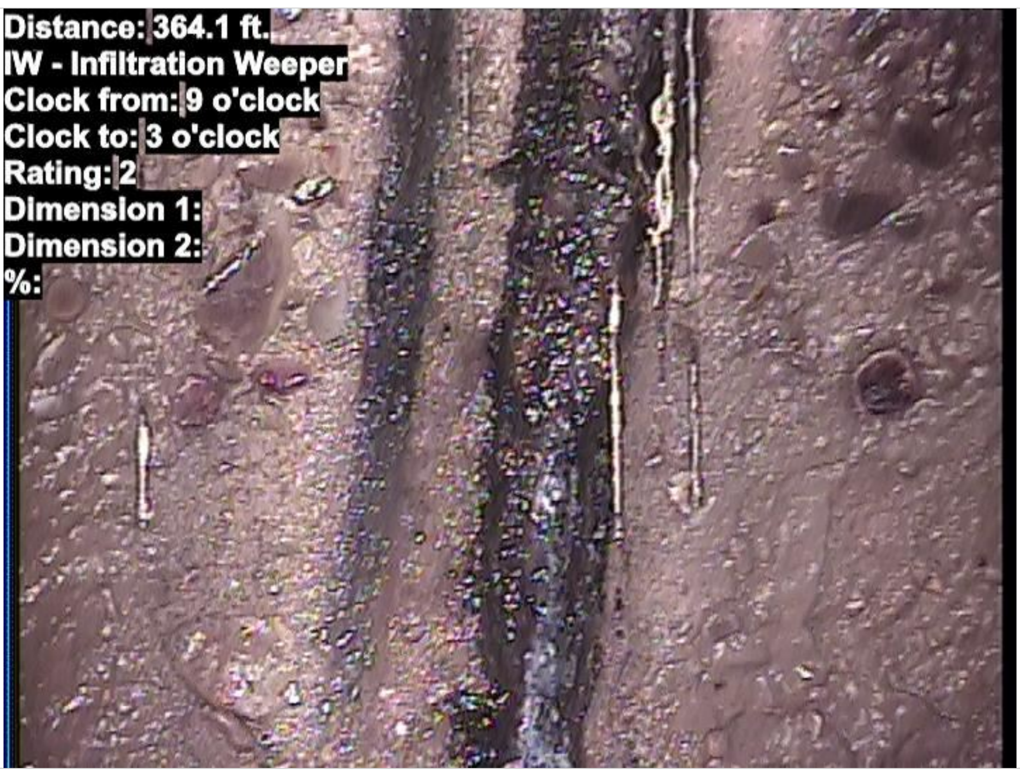
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
359.5 ft.	D		2 / 3	DAE		2	

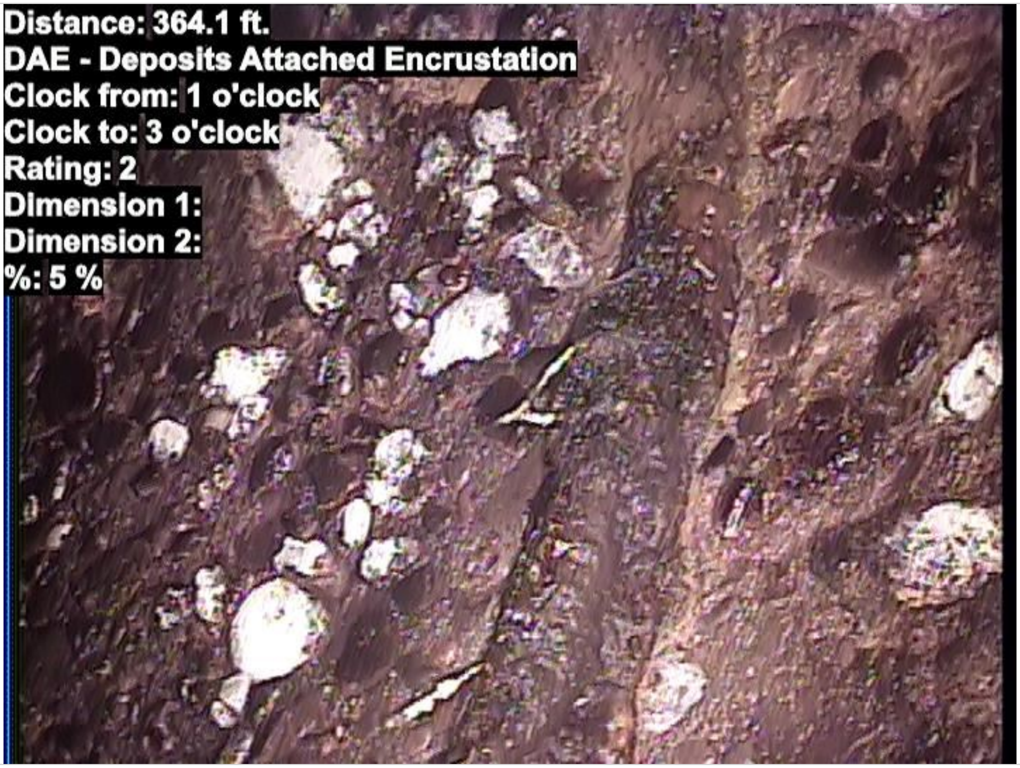


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
364.1 ft.	D		9 / 3	IW		2	



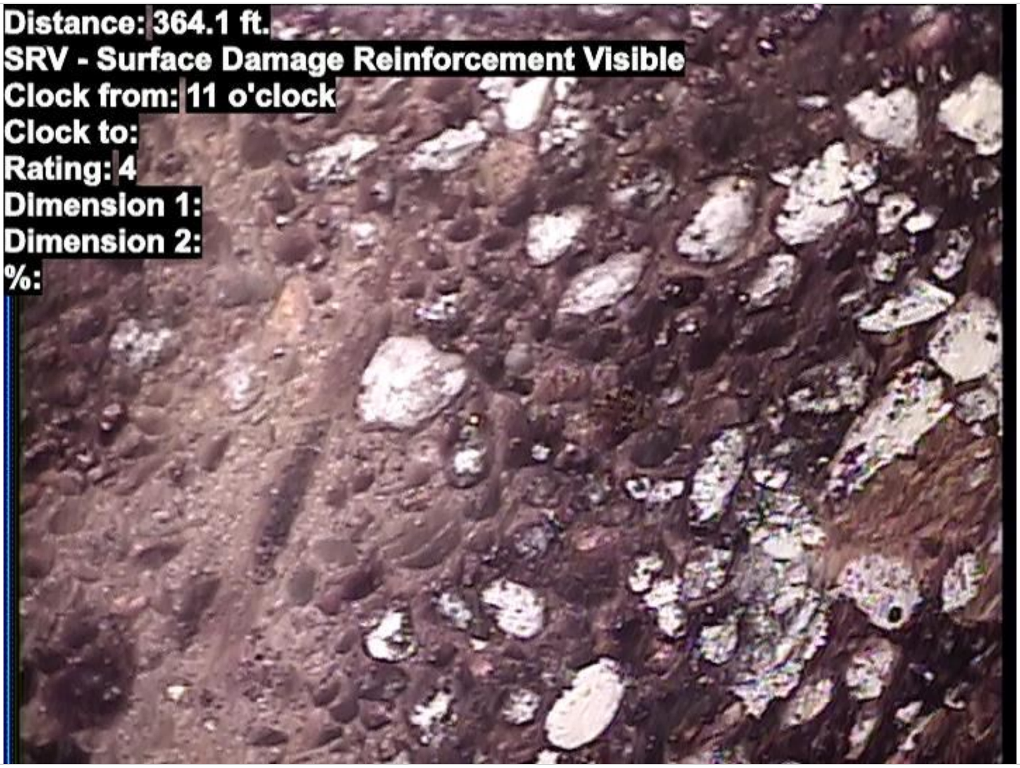


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
364.1 ft.	D		1 / 3	DAE		2	



Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
364.1 ft.	D		11 /	SRV		4	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
364.1 ft.	D		11 /	SRC		5	

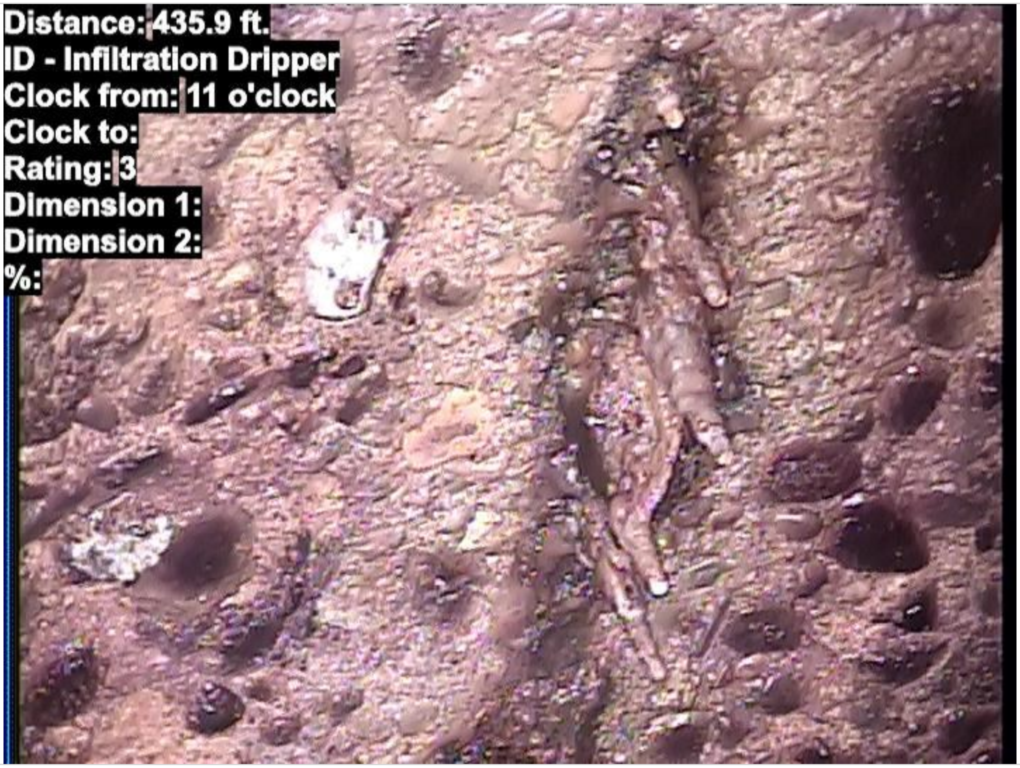
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
401.4 ft.	D		9 / 10	IW		2	

Observations

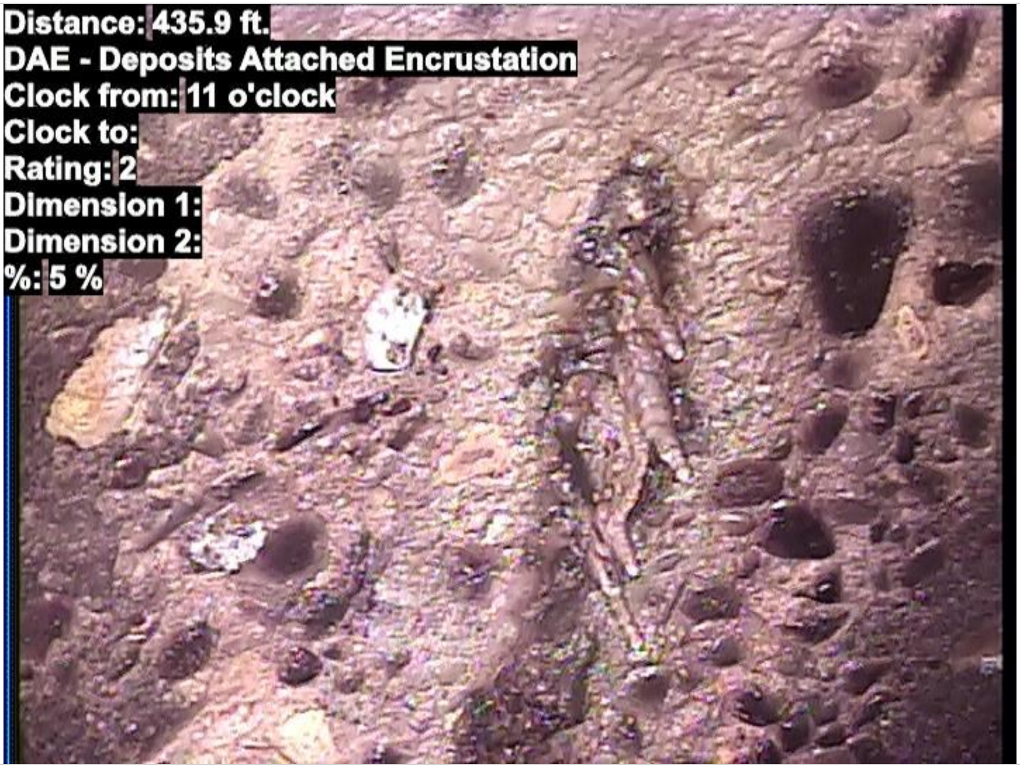
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
401.4 ft.	**D**		**9 / 10**	**DAE**		**2**	

Observations

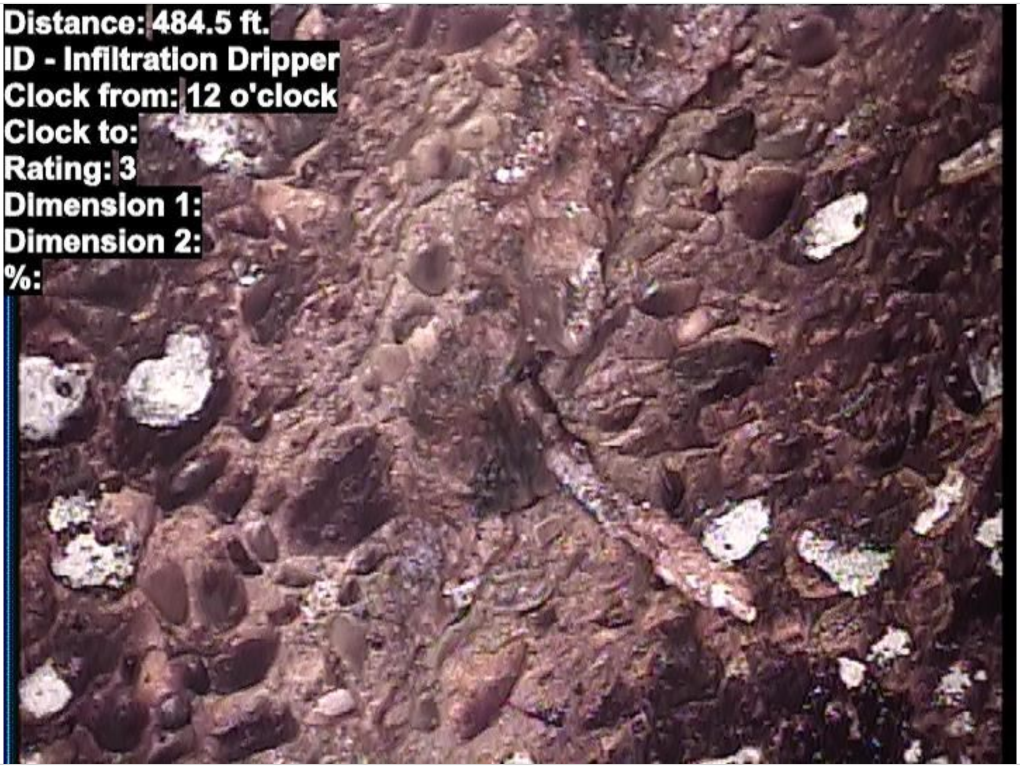
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
435.9 ft.	D		11 /	ID		3	



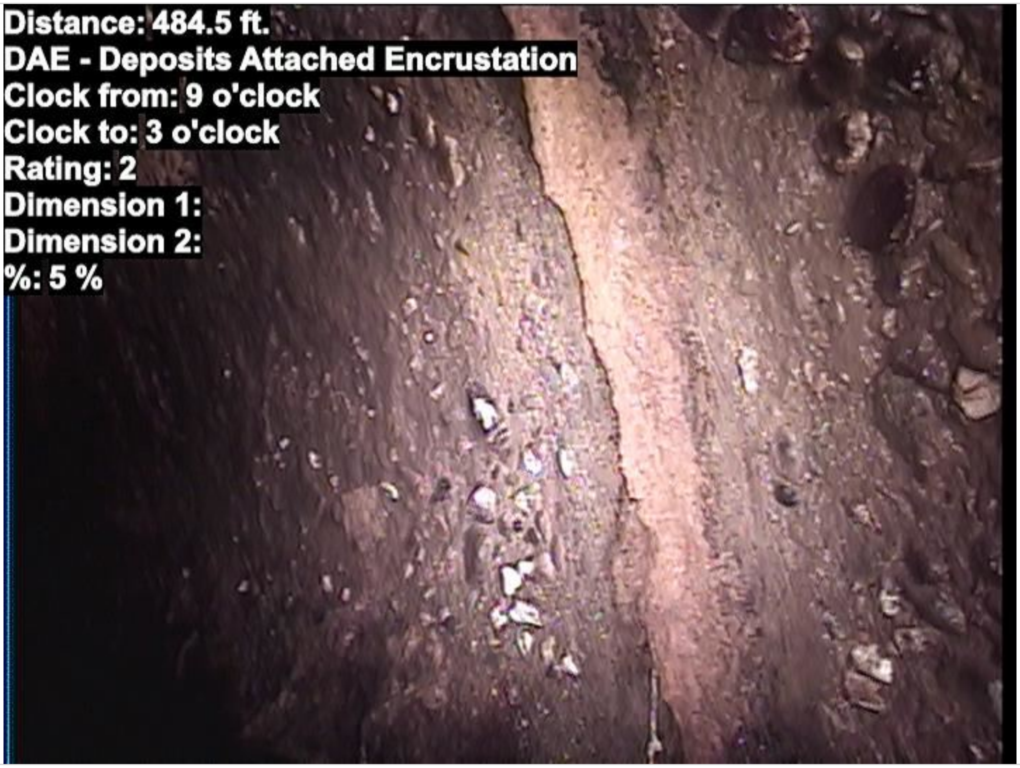
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
435.9 ft.	**D**		**11 /**	**DAE**		**2**	

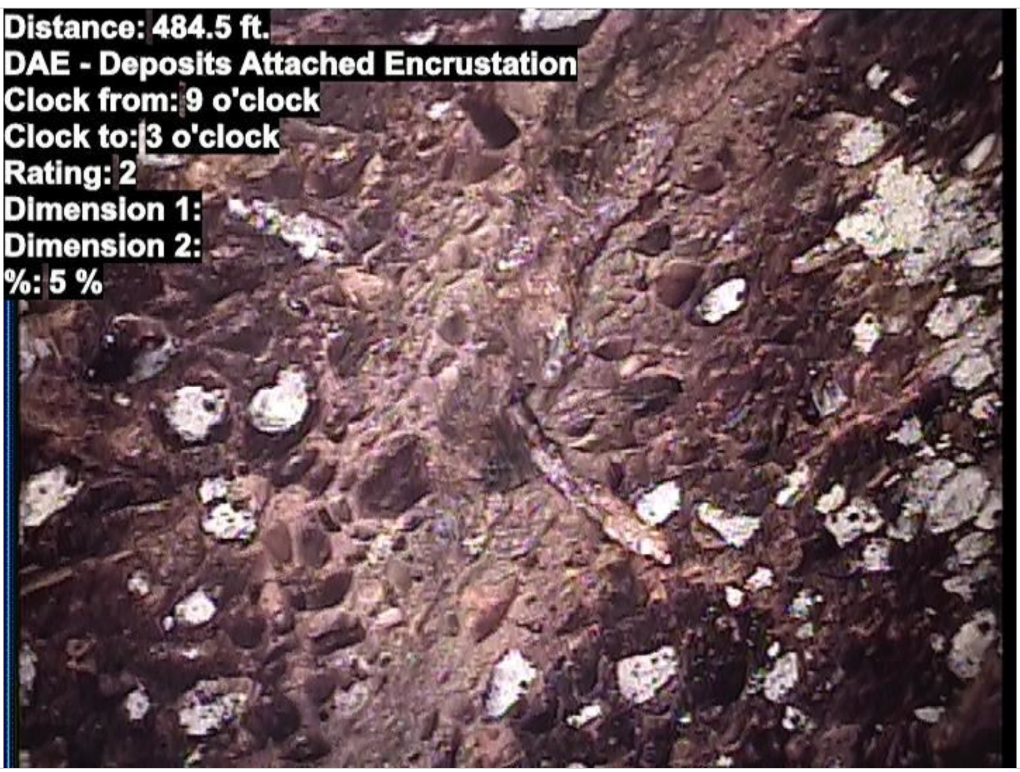


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
484.5 ft.	D		12 /	ID		3	

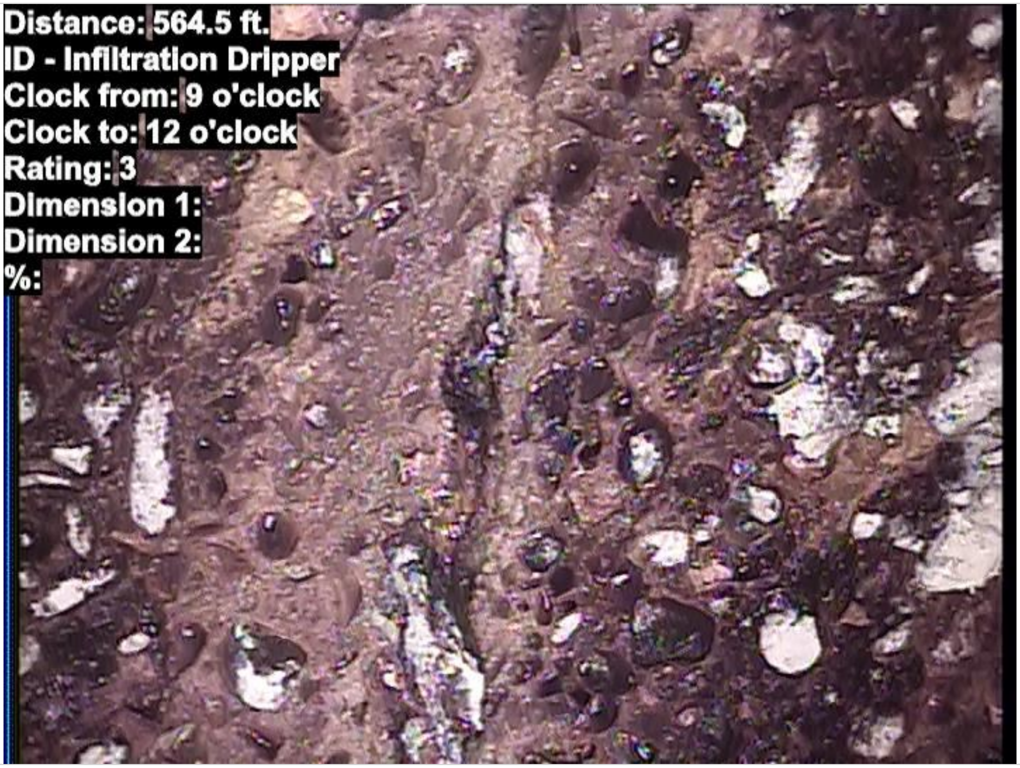


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
484.5 ft.	**D**		**9 / 3**	**DAE**		**2**	





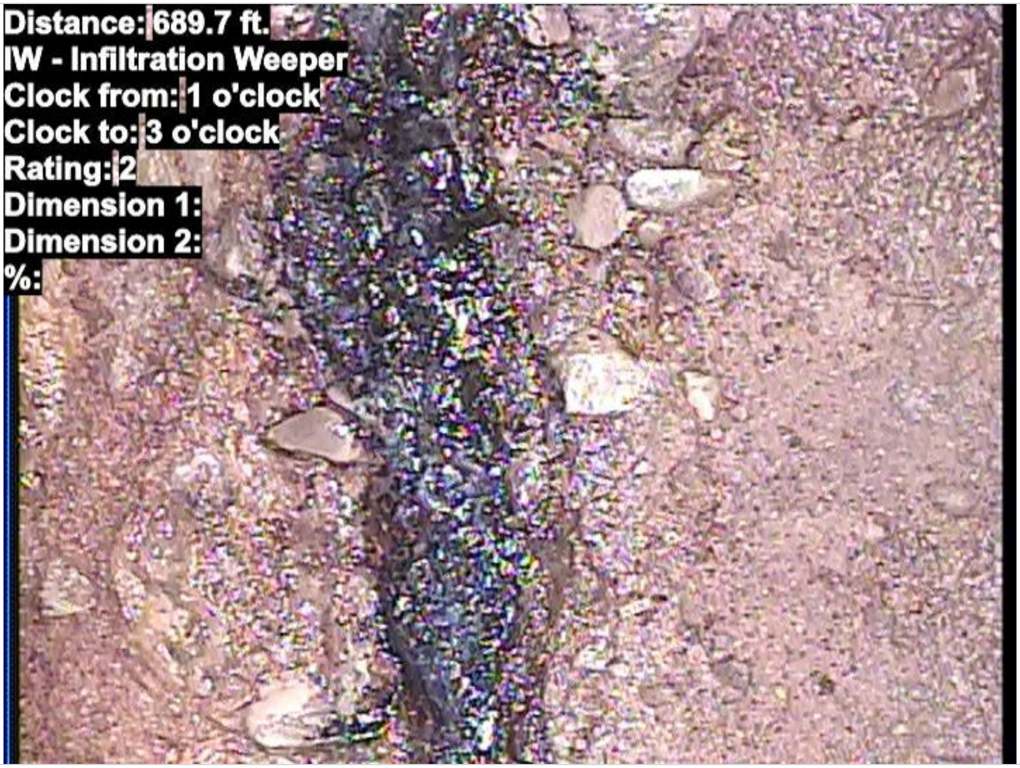
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
564.5 ft.	D		9 / 12	ID		3	

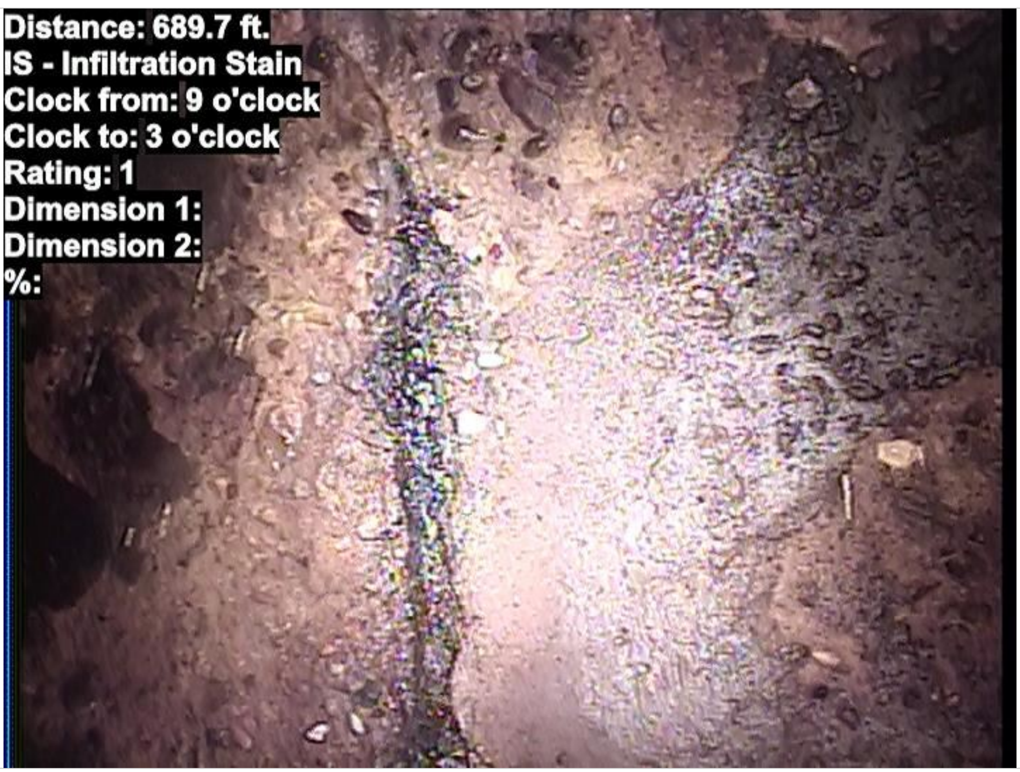


Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
564.5 ft.	**D**		**9 / 3**	**DAE**		**2**	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
689.7 ft.	**D**		**1 / 3**	**IW**		**2**	

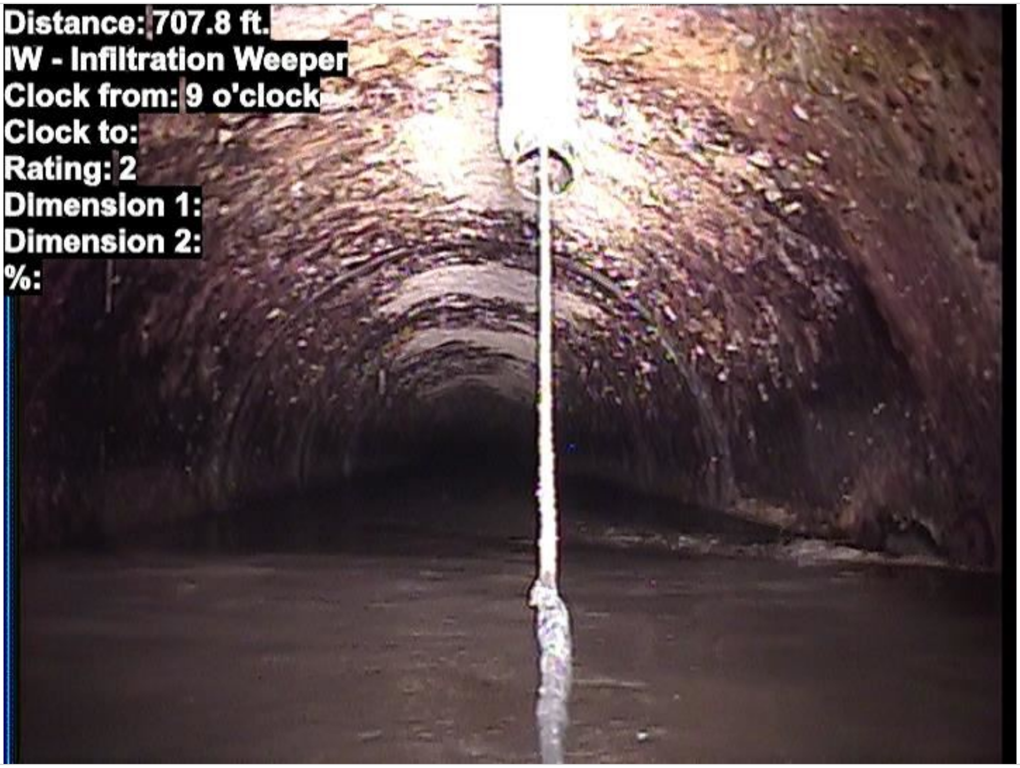




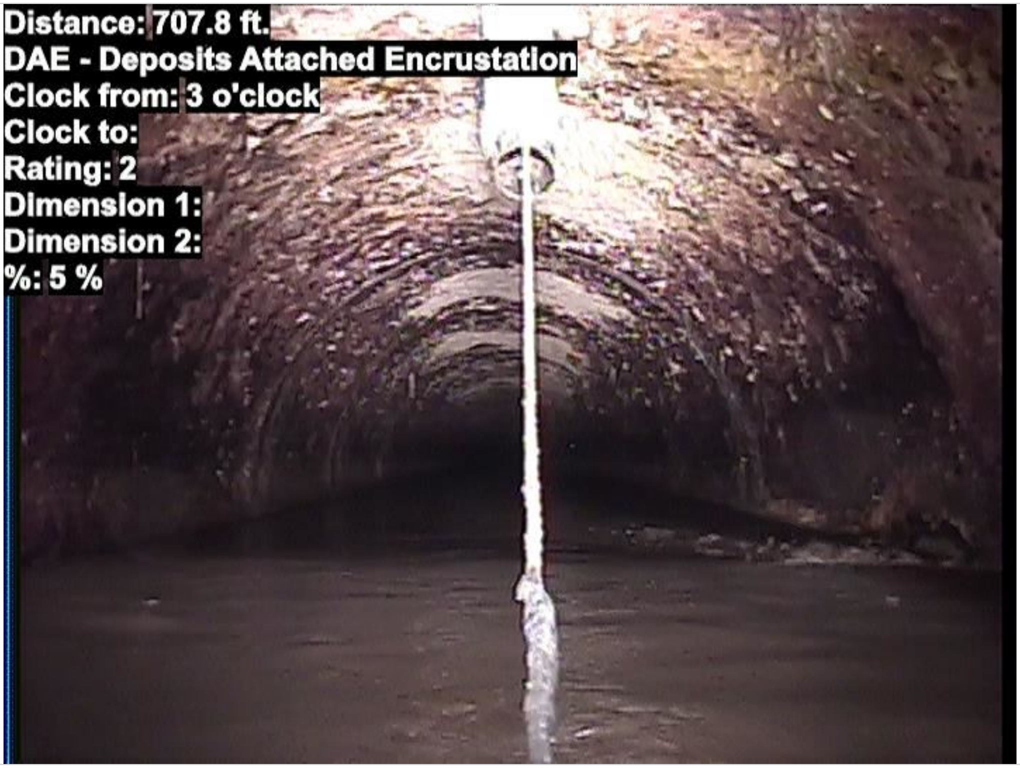
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		3 /	IW		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		9 /	IW		2	



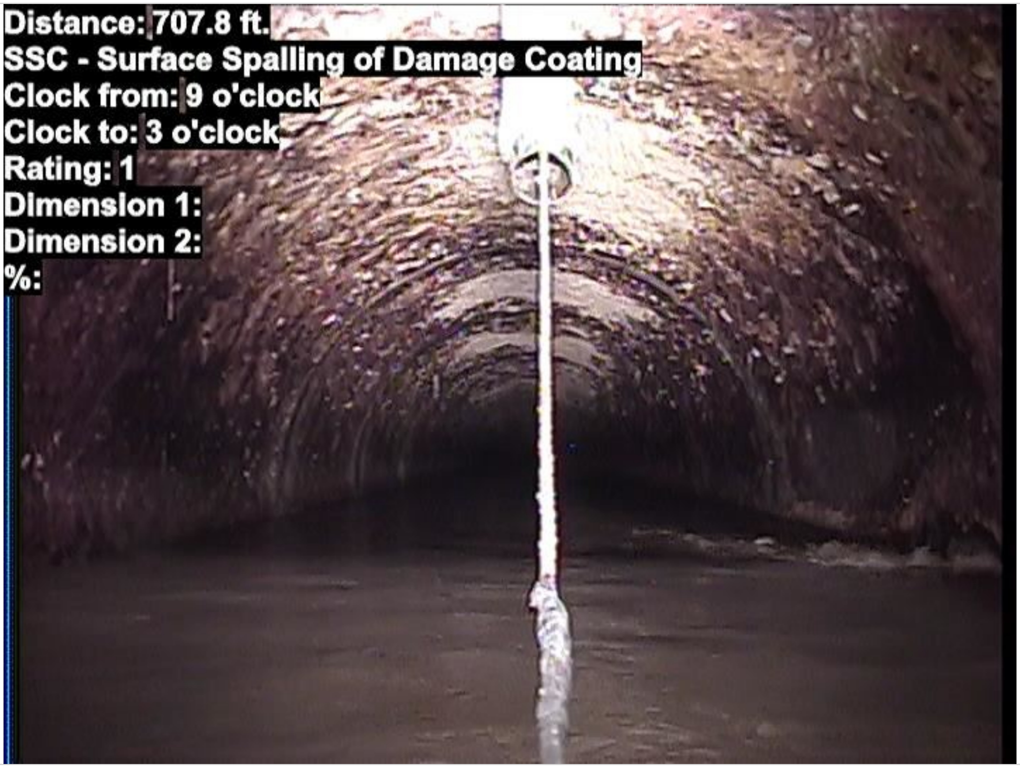
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		3 /	DAE		2	



Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		9 /	DAE		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		9 / 3	SSC		1	



Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		9 / 3	SAP		3	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		/	AMH			S48

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/18/2022		Dry	OBRIEN NPS	U-508-7068	S48-S49
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	Downstream		380.8 '	380.8 '

City:	OAKLAND	Drainage Area:		Upstream MH:	S48
Street:	EMBARCADERO WEST	Media Label:		Up Rim to Invert:	0.0
Location Code:	Local rural streets with light traffic	Flow Control:	Not Controlled	Downstream MH:	S49
Location Details:		Sheet Number:		Down Rim to Invert:	0.0
Pipe shape:	Horseshoe	Sewer Use:	Sanitary Sewage Pipe	Total gallons used:	0.0
Pipe size:	120 x 120 "	Sewer Category:	SEC	Joints passed:	0
Pipe material:	Other	Purpose:		Joints failed:	0
Lining Method:		Owner:			

Additional Info:

1:3327	Distance		Code	Observation	Grade
S48	0.0		AMH	Manhole / S48	
	0.0		MWL	Water Level, 40% of the vertical dimension	
	0.0		MWM	Miscellaneous Water Mark, 70% of the vertical dimension	
	0.0	S04	SAV	Surface Damage Aggregate Visible from 7 o'clock to 5 o'clock, within 8 inch, Start	
	0.0	S05	SAP	Surface Damage Aggregate Projecting from 11 o'clock to 1 o'clock, within 8 inch, Start	
	380.0	F04	SAV	Surface Damage Aggregate Visible from 7 o'clock to 5 o'clock, within 8 inch, Finish	S2
	380.1	F05	SAP	Surface Damage Aggregate Projecting from 11 o'clock to 1 o'clock, within 8 inch, Finish	S3
S49	380.8		AMH	Manhole / S49	


AMH - 0.00 ft


MWL - 0.00 ft


SAV - 0.00 ft


SAP - 0.00 ft

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/18/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**S48-S49**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	Not Known	**Downstream**		**380.8 '**	**380.8 '**

SAV - 380.00 ft

SAP - 380.10 ft

AMH - 380.85 ft

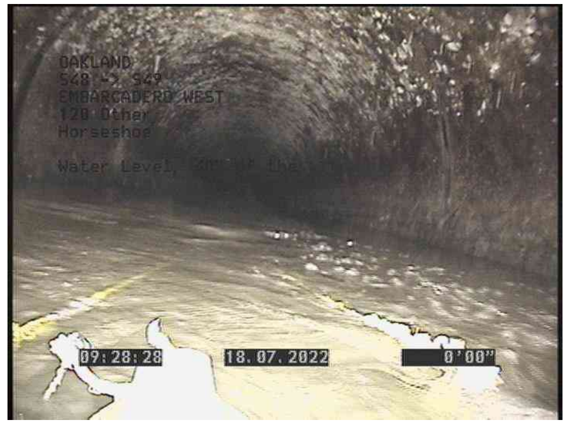
QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
3N2N	0000	3N2N	380.0	0.0	380.0	2.5	0.0	2.5

WinCan

Section Pictures - 7/18/2022 - S48-S49

City	Street	Date	Pipe Segment Reference	Section No.
OAKLAND	**EMBARCADERO WEST**	**7/18/2022**	**S48-S49**	**11**

1, 00:00:00, 0.00ft
Manhole / S48



2, 00:00:01, 0.00ft
Water Level, 40% of the vertical dimension

3, 00:00:09, 0.00ft
Surface Damage Aggregate Visible from 7 o'clock to 5 o'clock, within 8 inch, Start

4, 00:01:09, 0.00ft
Surface Damage Aggregate Projecting from 11 o'clock to 1 o'clock, within 8 inch, Start

5, 00:07:37, 380.00ft
Surface Damage Aggregate Visible from 7 o'clock to 5 o'clock, within 8 inch, Finish

6, 00:07:33, 380.10ft
Surface Damage Aggregate Projecting from 11 o'clock to 1 o'clock, within 8 inch, Finish

Section Pictures - 7/18/2022 - S48-S49

City	Street	Date	Pipe Segment Reference	Section No.
OAKLAND	**EMBARCADERO WEST**	**7/18/2022**	**S48-S49**	**11**

7, 00:08:00, 380.85ft
Manhole / S49

WinCan

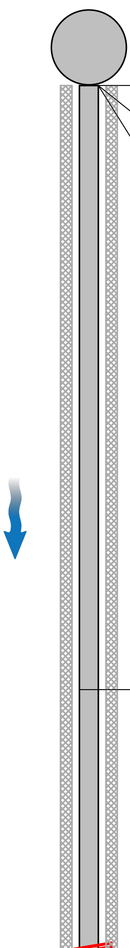
Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/18/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**S49-S50**
Year laid:	Pre-cleaning: **No Pre-Cleaning**	Direction: **Downstream**	Pipe Joint Length:	Total Length: **376.0 '**	Length Surveyed: **376.0 '**

City:	**OAKLAND**	Drainage Area:		Upstream MH:	**S49**
Street:	**EMBARCADERO WEST**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	Local rural streets with light traffic	Flow Control:	**Not Controlled**	Downstream MH:	**S50**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Horseshoe**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**120 x 120 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Other**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			
Additional Info:					

1:3285

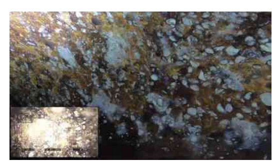
S49



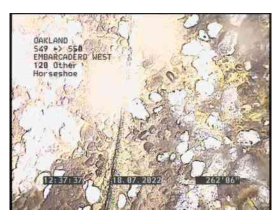
Distance		Code	Observation	Grade
0.0		AMH	Manhole / S49	
0.0		MWL	Water Level, 40% of the vertical dimension	
0.0	S01	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Start	
262.5		ID	Infiltration Dripper at 12 o'clock, within 8 inch	M3
376.0	F01	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Finish	S2
376.0		MSA	Miscellaneous Survey Abandoned / PARACHUTE GOT STUCK AT BEND. CAMERA WILL NOT TRAVEL ANY FARTHER	

AMH - 0.00 ft

MWL - 0.00 ft



SAV - 0.00 ft



ID - 262.52 ft

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Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/18/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**S49-S50**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**		**376.0 '**	**376.0 '**

SAV - 376.04 ft

MSA - 376.04 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
2N00	3100	312N	150.0	3.0	153.0	2.0	3.0	2.0

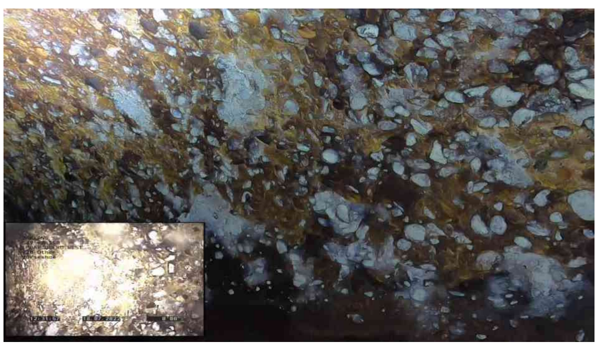
WinCan

Section Pictures - 7/18/2022 - S49-S50

City	Street	Date	Pipe Segment Reference	Section No.
OAKLAND	**EMBARCADERO WEST**	**7/18/2022**	**S49-S50**	**9**

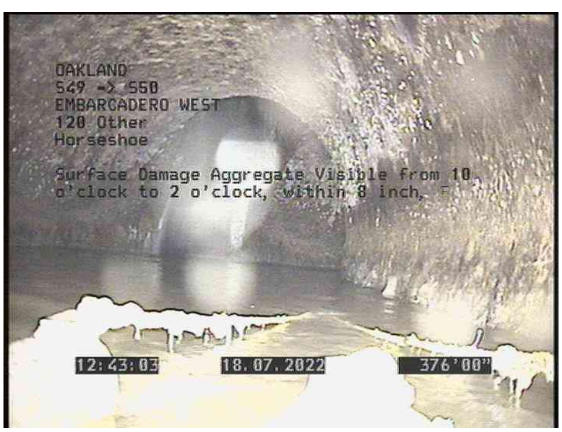
1, 00:00:00, 0.00ft
Manhole / S49

2, 00:00:00, 0.00ft
Water Level, 40% of the vertical dimension



3, 00:00:00, 0.00ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Start

4, 00:07:13, 262.52ft
Infiltration Dripper at 12 o'clock, within 8 inch



5, 00:12:37, 376.04ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, within 8 inch, Finish

6, 00:13:24, 376.04ft
Miscellaneous Survey Abandoned / PARACHUTE GOT STUCK AT BEND. CAMERA WILL NOT TRAVEL ANY

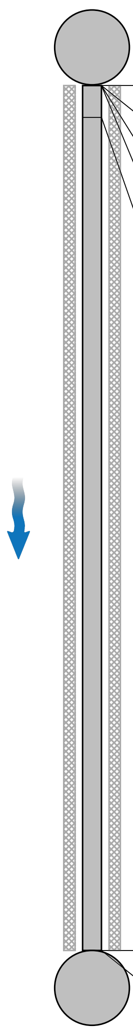
WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/18/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**S50-S51**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**		**319.7 '**	**319.7 '**

City:	**OAKLAND**	Drainage Area:		Upstream MH:	**S50**
Street:	**BROADWAY**	Media Label:		Up Rim to Invert:	**0.0**
Location Code:	**Local rural streets with light traffic**	Flow Control:	**Not Controlled**	Downstream MH:	**S51**
Location Details:		Sheet Number:		Down Rim to Invert:	**0.0**
Pipe shape:	**Horseshoe**	Sewer Use:	**Sanitary Sewage Pipe**	Total gallons used:	**0.0**
Pipe size:	**120 x 120 "**	Sewer Category:	**SEC**	Joints passed:	**0**
Pipe material:	**Other**	Purpose:		Joints failed:	**0**
Lining Method:		Owner:			

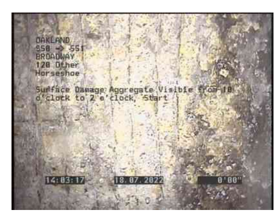
Additional Info:



1:2793	Distance		Code	Observation	Grade
S50	0.0		AMH	Manhole / S50	
	0.0		MWL	Water Level, 40% of the vertical dimension	
	0.0	S01	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, Start	
	0.0		SRV	Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, within 8 inch	S4
	11.9		ID	Infiltration Dripper at 12 o'clock	M3
	319.7	F01	SAV	Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, Finish	S2
S51	319.7		AMH	Manhole / S51	

AMH - 0.00 ft

MWL - 0.00 ft



SAV - 0.00 ft

SRV - 0.00 ft

WinCan

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
7/18/2022		**Dry**	**OBRIEN NPS**	**U-508-7068**	**S50-S51**
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	**Downstream**		**319.7 '**	**319.7 '**

ID - 11.92 ft

SAV - 319.73 ft

AMH - 319.73 ft

QSR	QMR	QOR	SPR	MPR	OPR	SPRI	MPRI	OPRI
412K	3100	4131	132.0	3.0	135.0	2.0	3.0	2.0

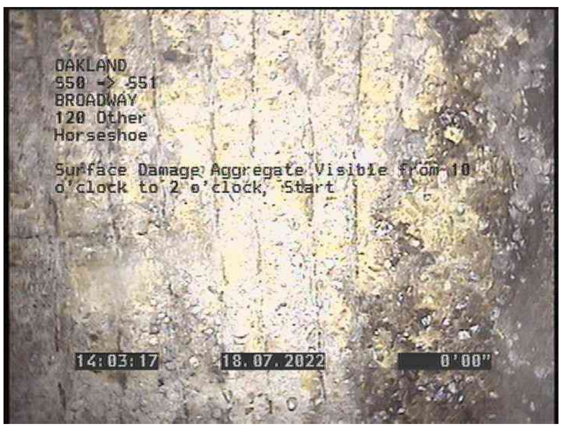
WinCan

Section Pictures - 7/18/2022 - S50-S51

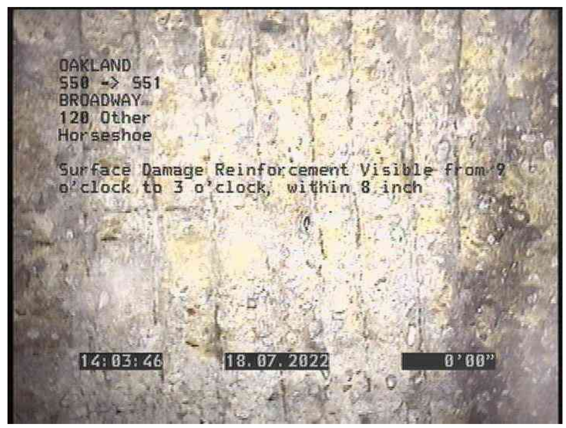
City	Street	Date	Pipe Segment Reference	Section No.
OAKLAND	**BROADWAY**	**7/18/2022**	**S50-S51**	**10**

1, 00:00:30, 0.00ft
Manhole / S50

2, 00:00:00, 0.00ft
Water Level, 40% of the vertical dimension



3, 00:00:00, 0.00ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, Start



4, 00:02:13, 0.00ft
Surface Damage Reinforcement Visible from 9 o'clock to 3 o'clock, within 8 inch

5, 00:02:52, 11.92ft
Infiltration Dripper at 12 o'clock

6, 00:33:13, 319.73ft
Surface Damage Aggregate Visible from 10 o'clock to 2 o'clock, Finish

Section Pictures - 7/18/2022 - S50-S51

City	Street	Date	Pipe Segment Reference	Section No.
OAKLAND	**BROADWAY**	**7/18/2022**	**S50-S51**	**10**

7, 00:33:25, 319.73ft
Manhole / S51

CUES, Inc.
3600 Rio Vista Avenue
Orlando, FL 32805
Phone: 407-849-0190
Fax: 407-425-1569

Main Inspections Large Photos

Mainline ID:	City:	Street:	Project name:
S53S541	**OAKLAND**	**2ND ST/MLK**	**EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022**
Start date/time:	Total length:	Weather:	Surveyed by:
5/17/2022 12:05 PM	**973.700 ft.**	**1**	**F MORENO/NPS**
Upstream MH No:	Depth US:	Downstream MH No:	Depth DS:
S53		**S54**	
Shape:	Material:	Height:	Width:
H	**RCP**	**105 in.**	**105 in.**
Additional info:			

Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**/**	**AMH**			**S53**

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		/	MWL			

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	D		8 / 4	SAP		3	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	D		9 / 3	SSC		1	

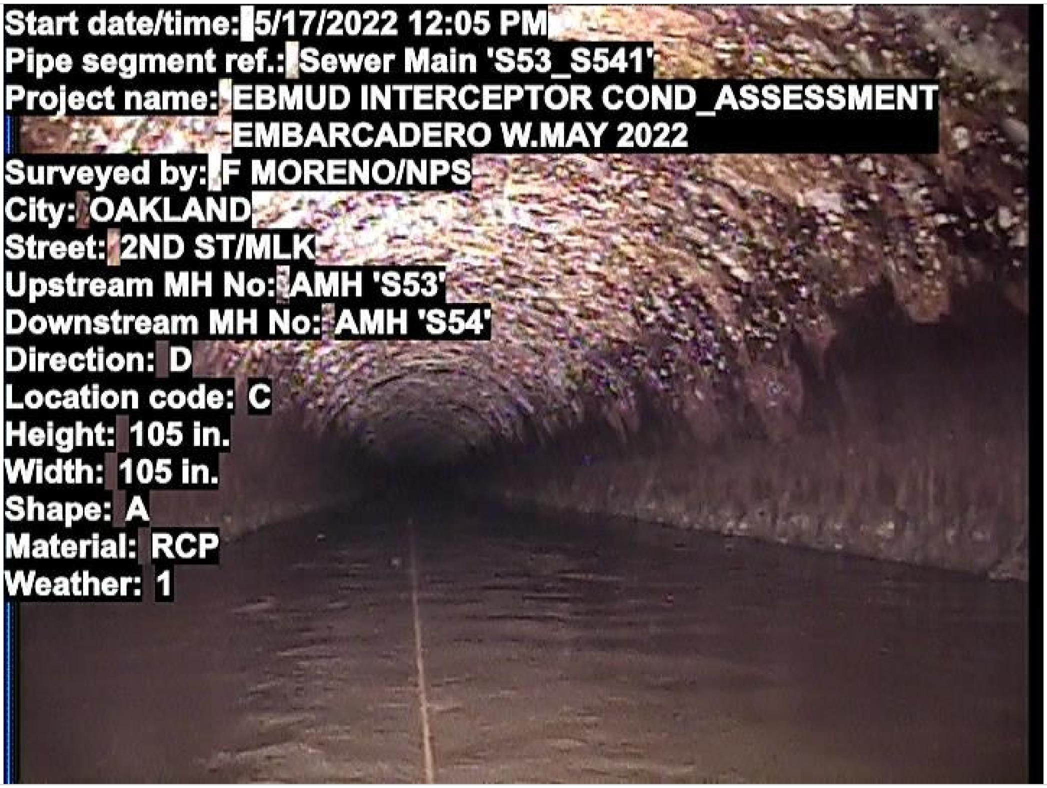
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
314.0 ft.	D		3 /	TBA			
945.0 ft.	D		8 / 1	SRC		5	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
973.7 ft.	D		9 / 3	SSC		1	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
973.7 ft.	D		8 / 4	SAP		3	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
973.7 ft.	D		/	AMH			S54

Inspection's photos



Main Inspections Large Photos

Mainline ID:	City:	Street:	Project name:
S54S551	**OAKLAND**	**MARKET ST/S. OF 3RD ST**	**EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022**
Start date/time:	Total length:	Weather:	Surveyed by:
5/17/2022 1:04 PM	**282.000 ft.**	**1**	**F MORENO/NPS**
Upstream MH No:	Depth US:	Downstream MH No:	Depth DS:
S54		**S55**	
Shape:	Material:	Height:	Width:
H	**RCP**	**105 in.**	**105 in.**

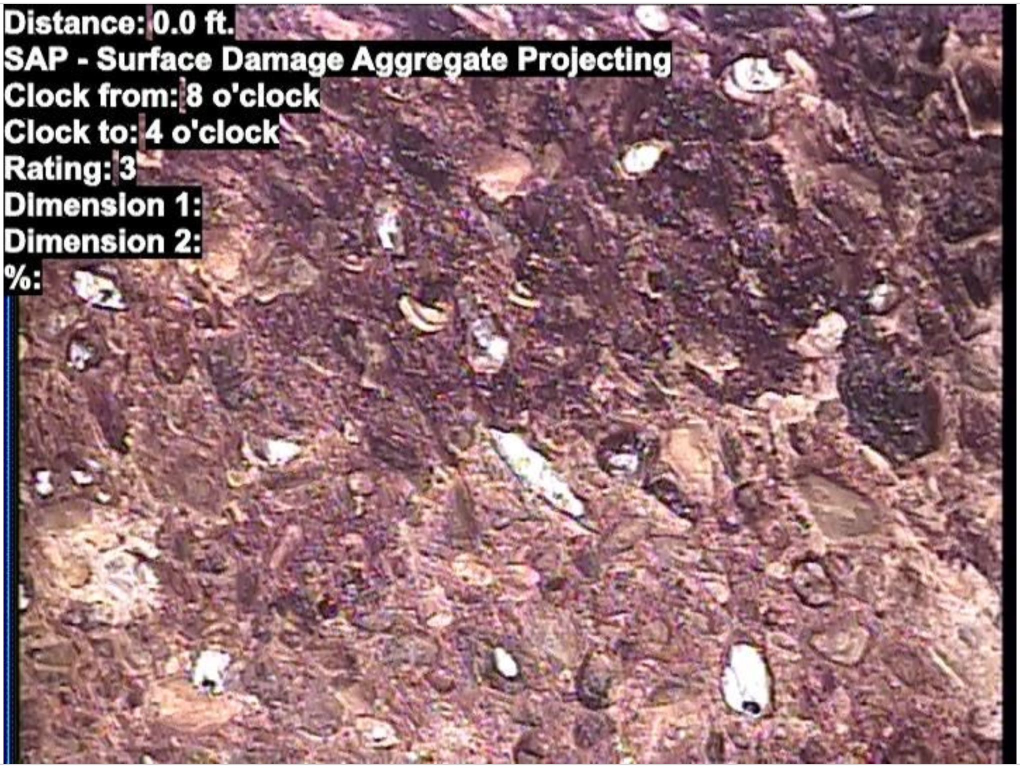
Additional info:

Observations

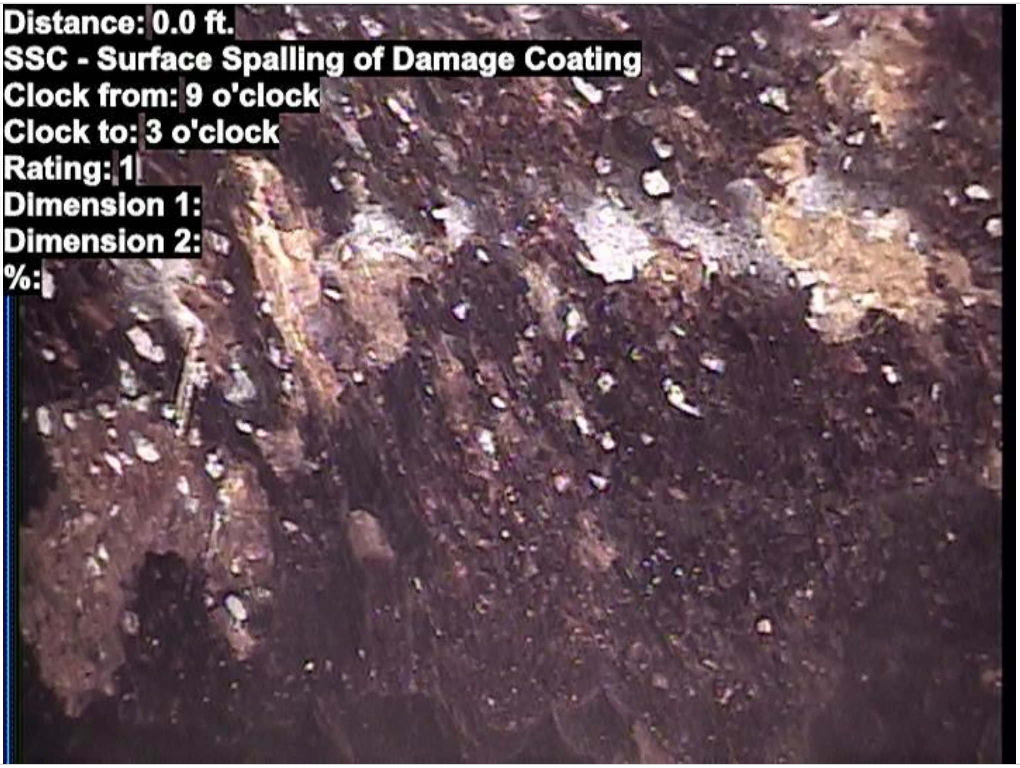
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**/**	**AMH**			**S54**

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		/	MWL			

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		8 / 4	SAP		3	

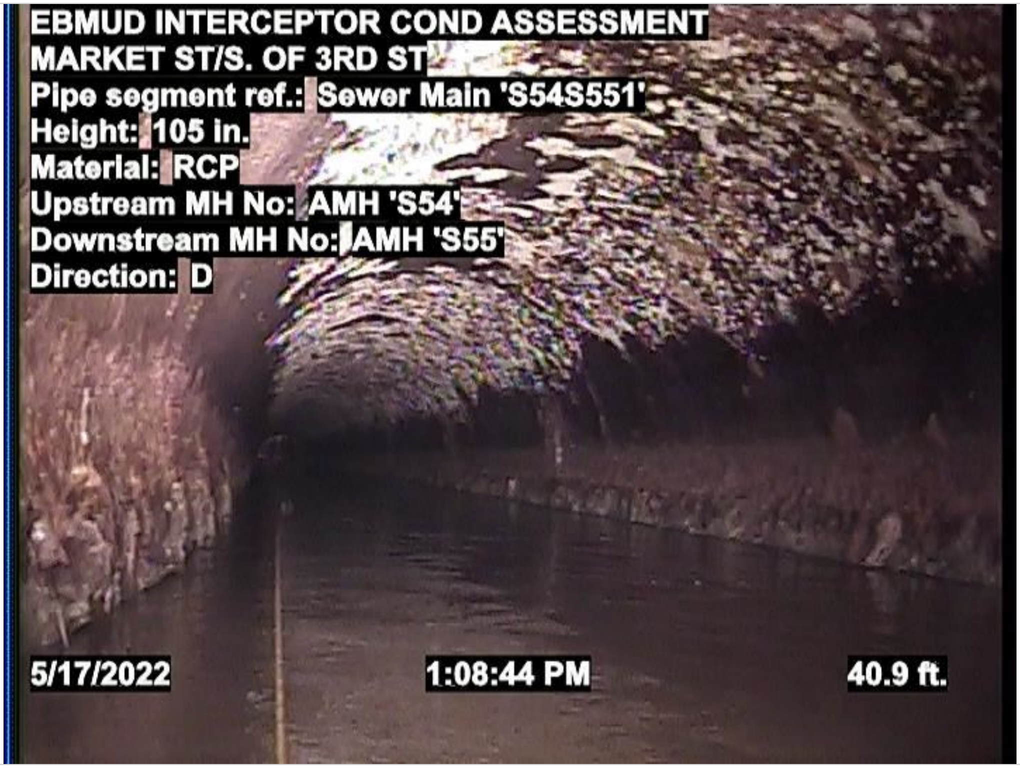


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		9 / 3	SSC		1	



Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
36.9 ft.	D		/	LL		1	

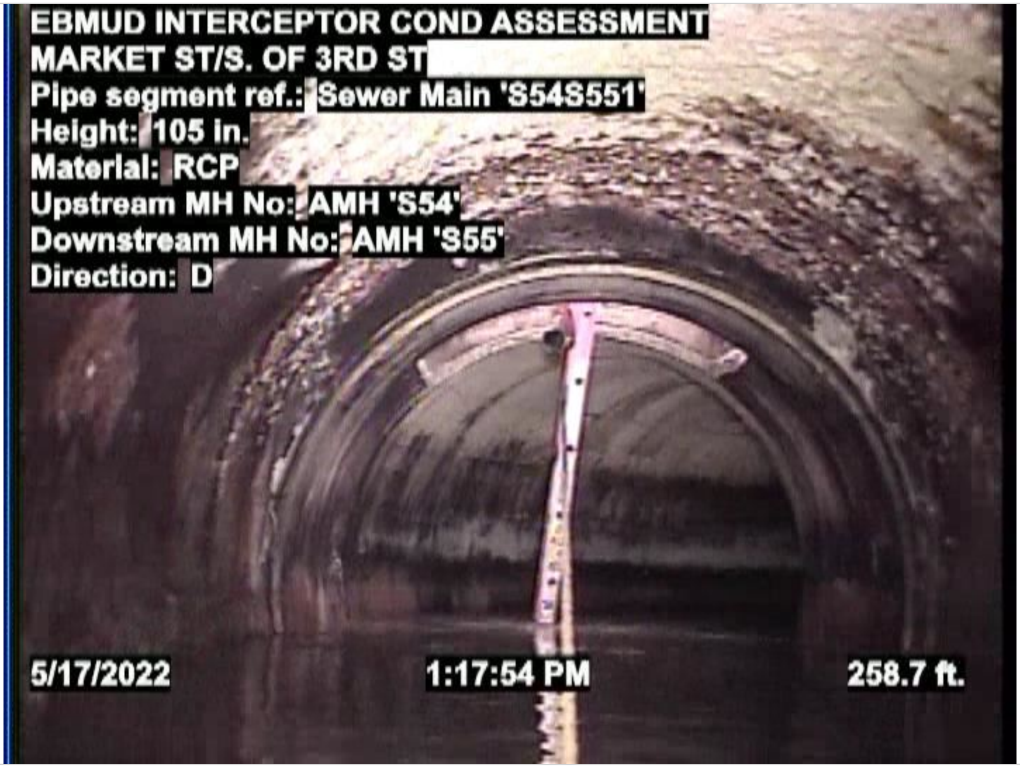


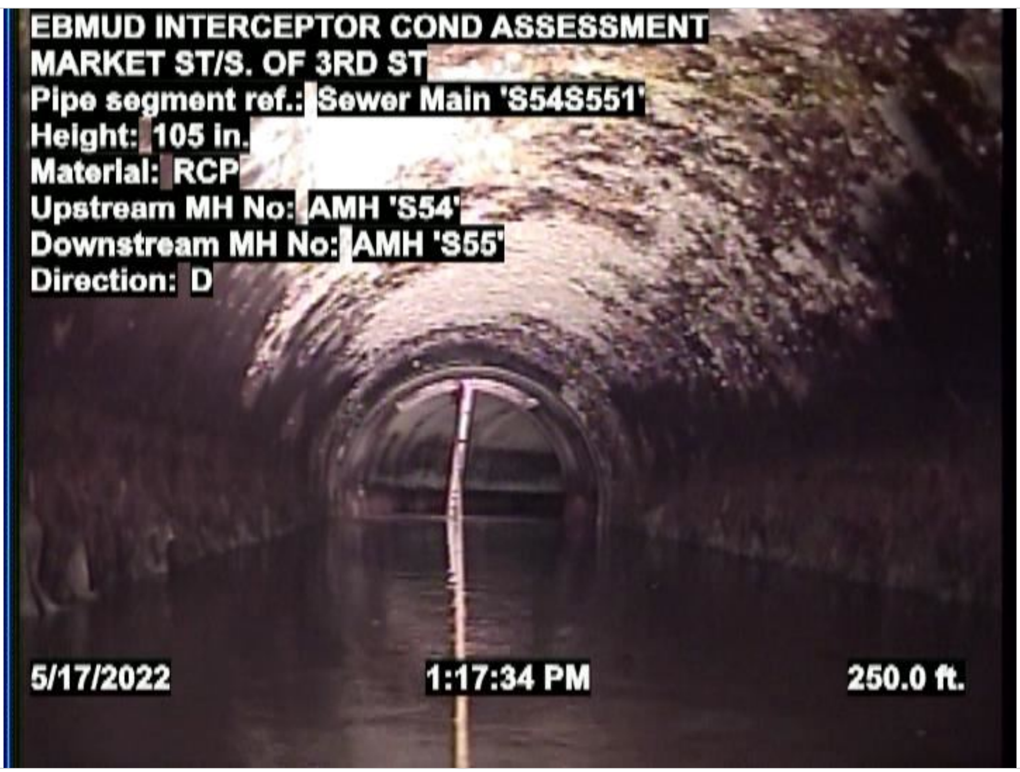
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
58.8 ft.	D		/	LL		1	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
95.1 ft.	**D**		**/**	**MGO**			**Possibly Hole**

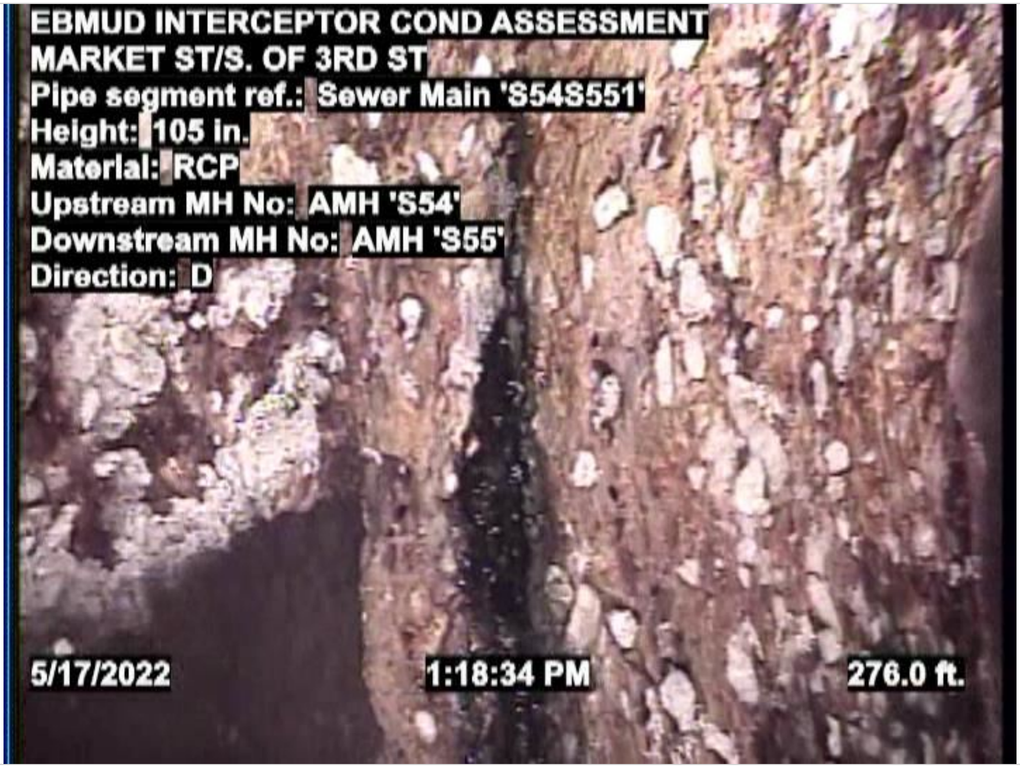
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
258.0 ft.	**D**		**/**	**MGO**			**Possibly Holes**





Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
276.0 ft.	D		9 /	ID		3	

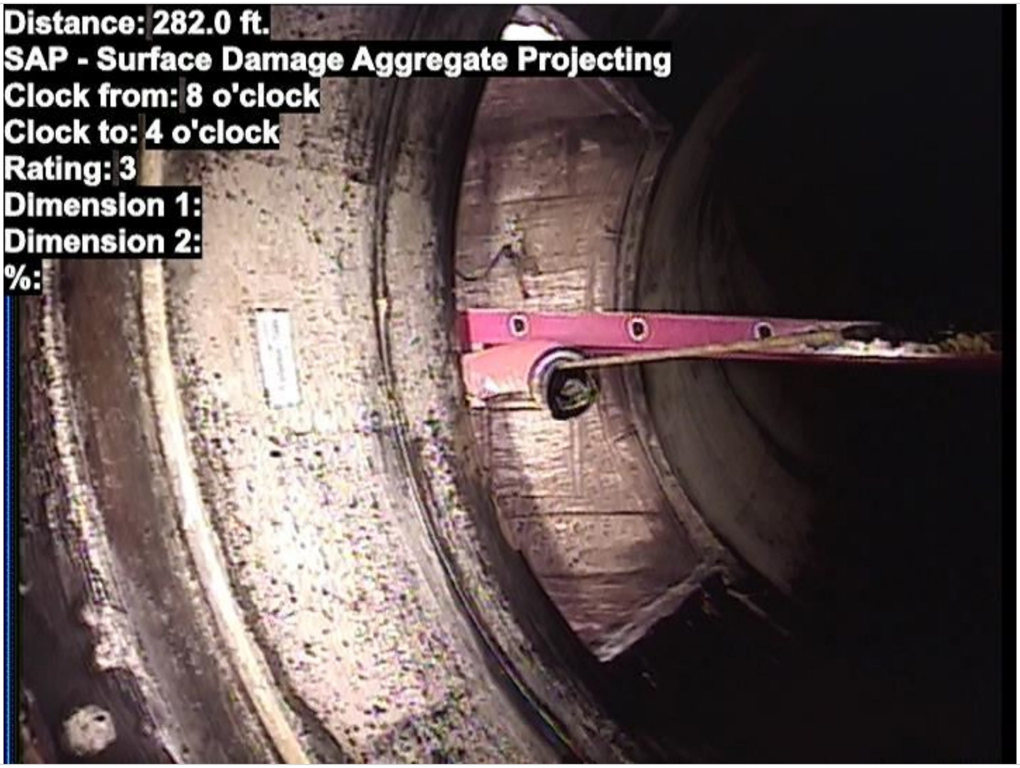


Observations

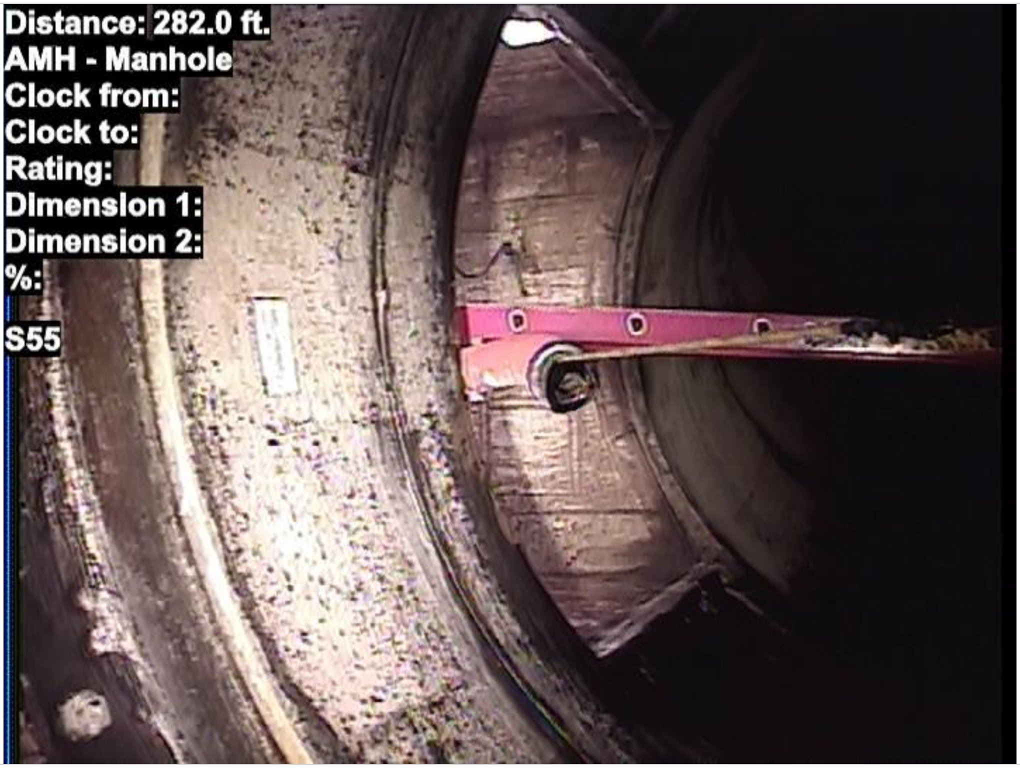
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
282.0 ft.	D		9 / 3	SSC		1	

Observations

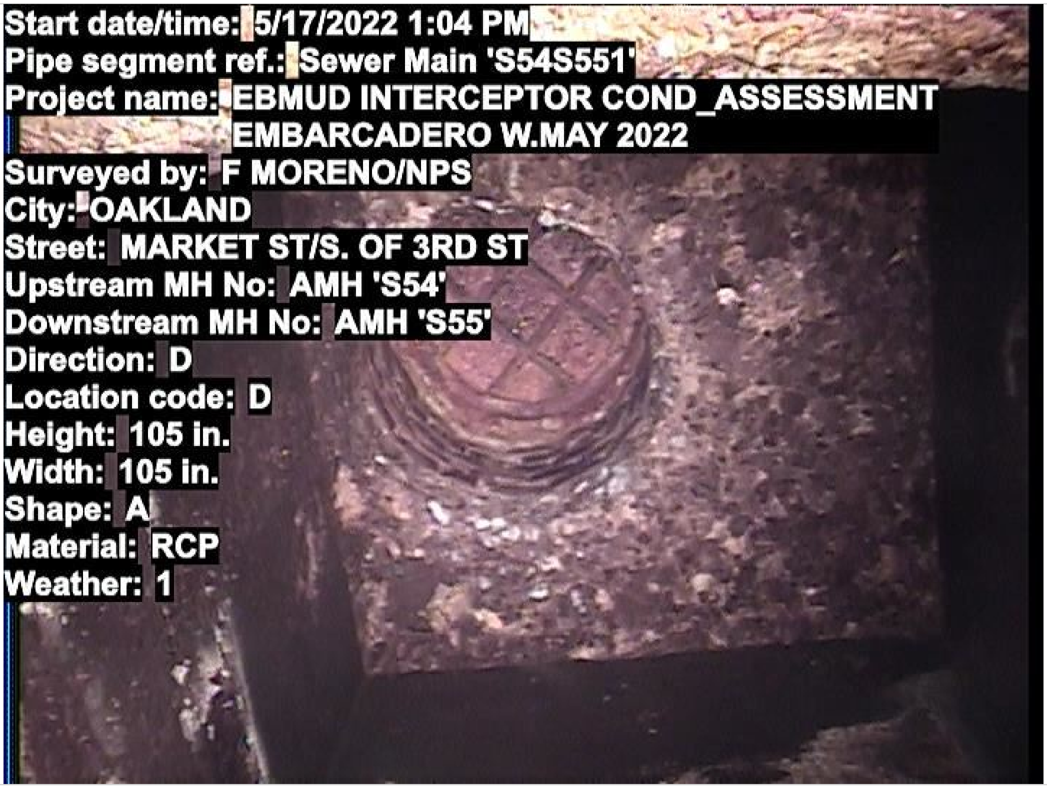
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
282.0 ft.	D		8 / 4	SAP		3	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
282.0 ft.	D		/	AMH			S55



Inspection's photos



Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		9 / 3	SAP		3	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		/	AMH			S48

Main Inspections Large Photos

Mainline ID:	City:	Street:	Project name:
S47S481	**OAKLAND**	**EMBARCADERO**	**EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022**
Start date/time:	Total length:	Weather:	Surveyed by:
5/18/2022 12:00 PM	**707.800 ft.**	**1**	**F MORENO/NPS**
Upstream MH No:	Depth US:	Downstream MH No:	Depth DS:
S47		**S48**	
Shape:	Material:	Height:	Width:
H	**RCP**	**105 in.**	**105 in.**
Additional info:			

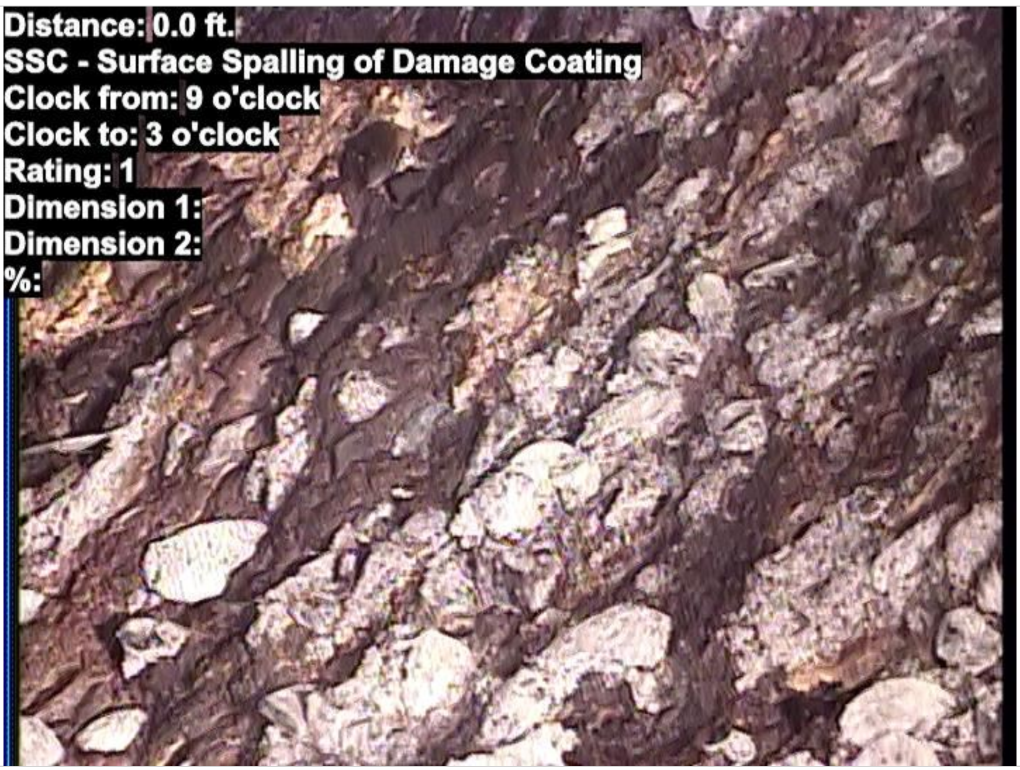
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**/**	**AMH**			**S47**

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	**D**		**/**	**MWL**			

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		9 / 3	SAP		3	

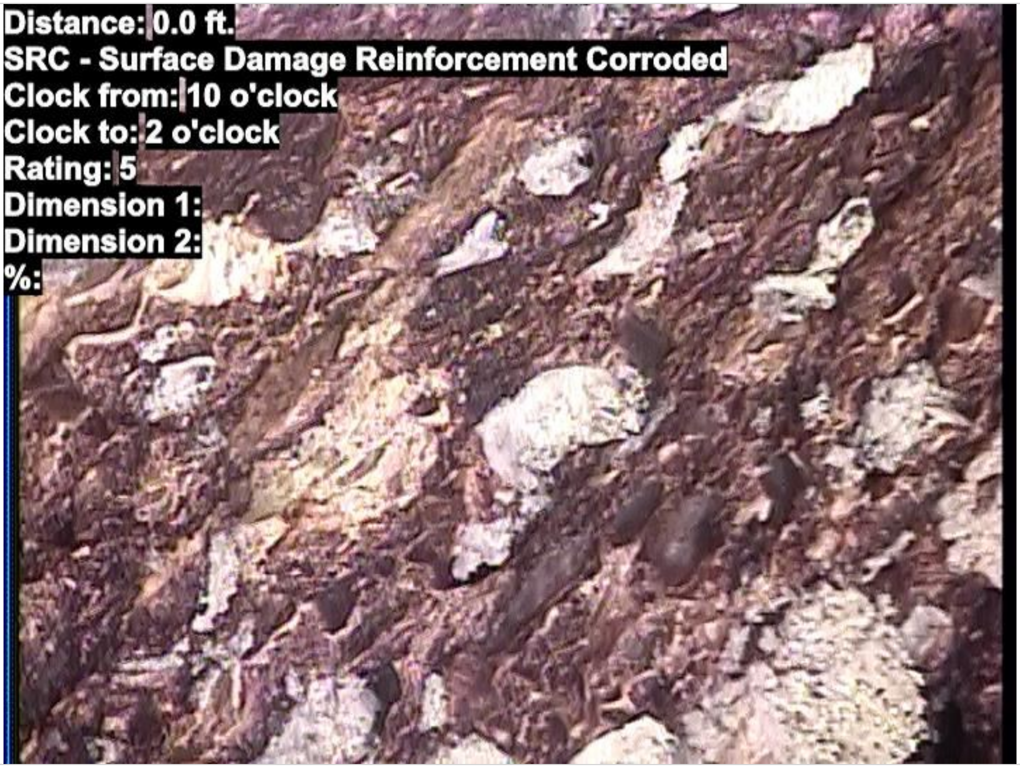
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		9 / 3	SSC		1	

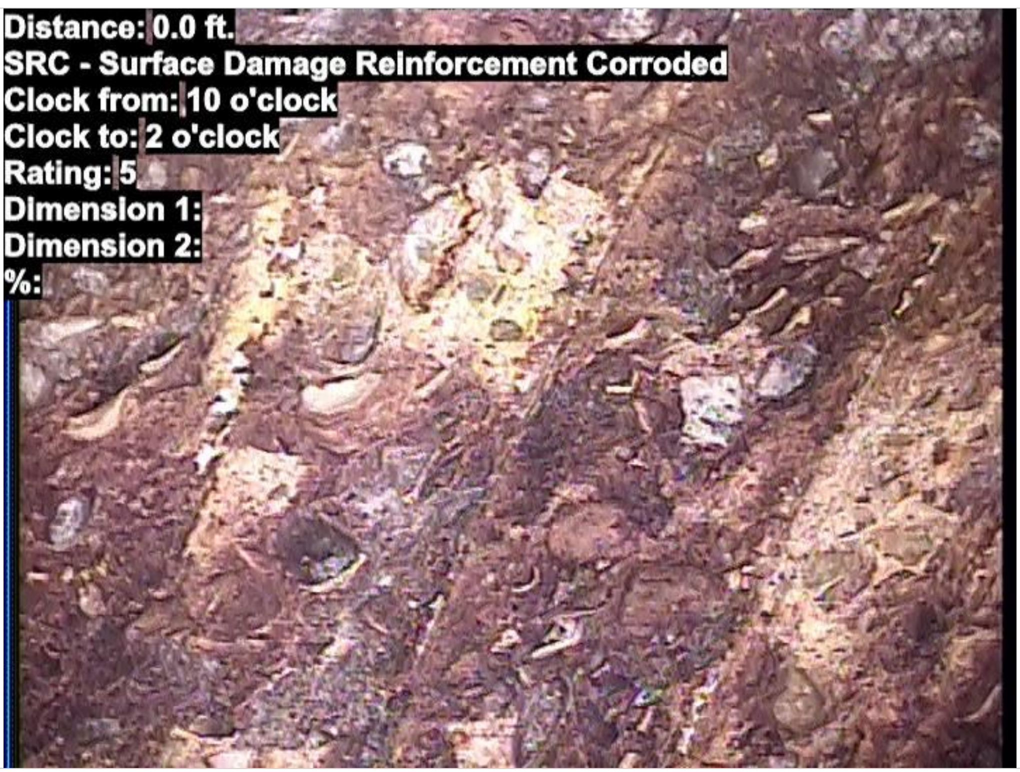


Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		10 / 2	SRV		4	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
0.0 ft.	D		10 / 2	SRC		5	



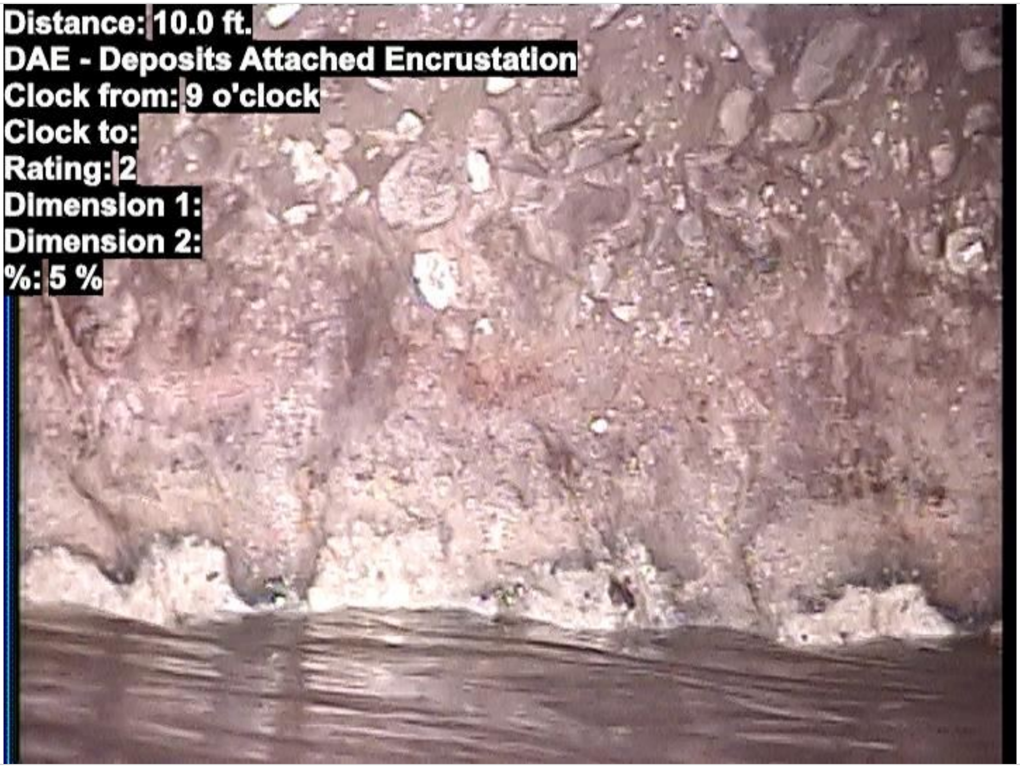


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	D		10 / 2	SRC		5	

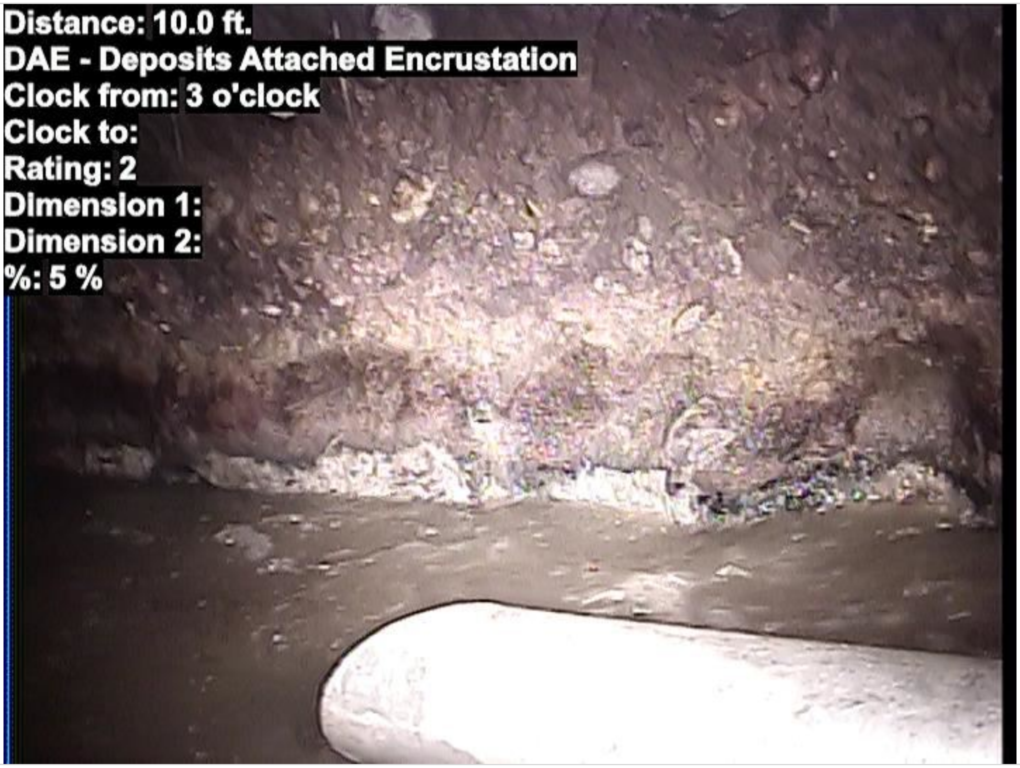
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	D		10 / 2	SRV		4	

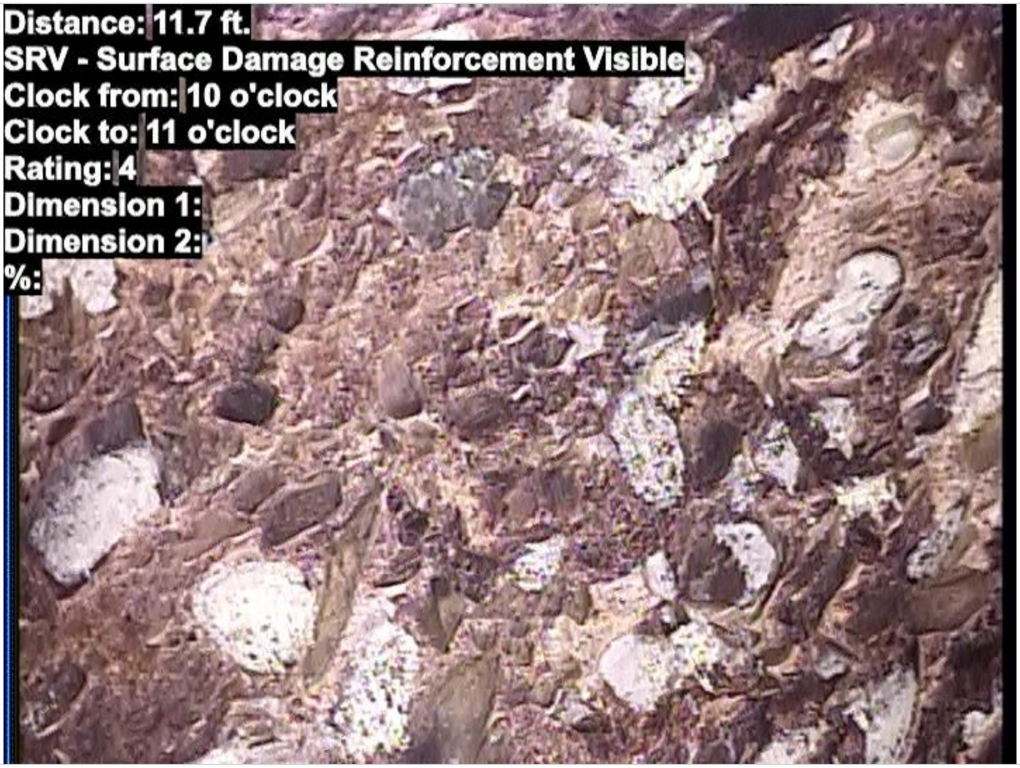
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	D		9 /	DAE		2	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
10.0 ft.	**D**		**3 /**	**DAE**		**2**	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
11.7 ft.	D		10 / 11	SRV		4	

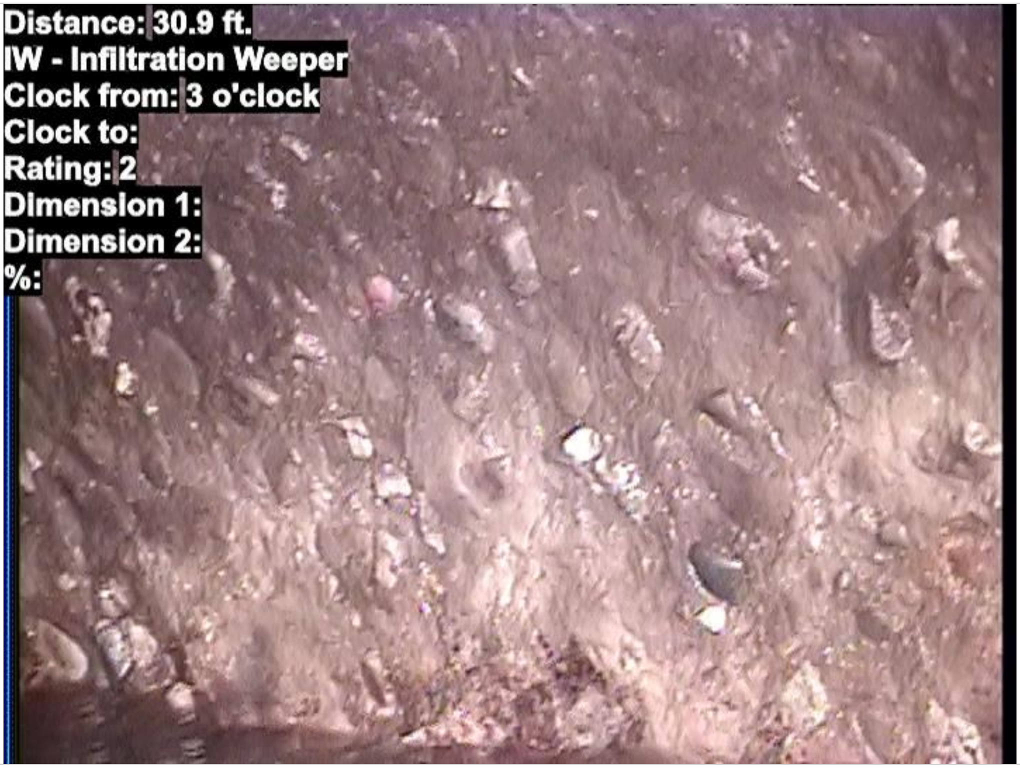


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
11.7 ft.	D		10 / 11	SRC		5	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
30.9 ft.	**D**		**9 /**	**IW**		**2**	

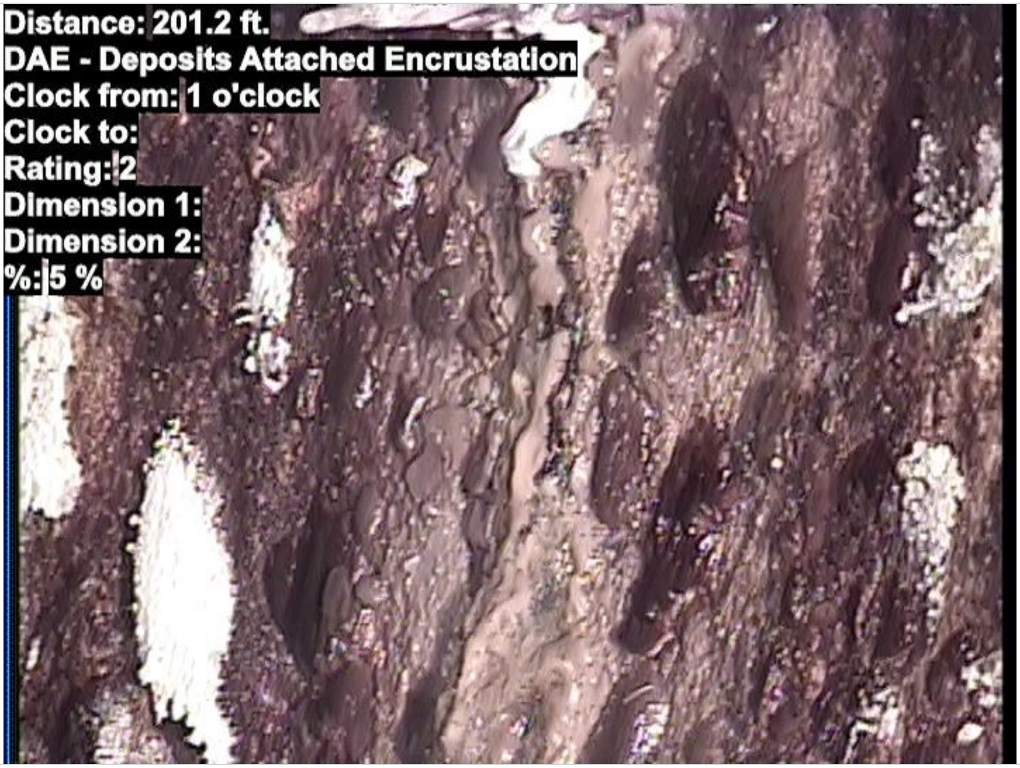
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
30.9 ft.	D		3 /	IW		2	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
201.2 ft.	D		1 /	ID		3	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
201.2 ft.	D		1 /	DAE		2	

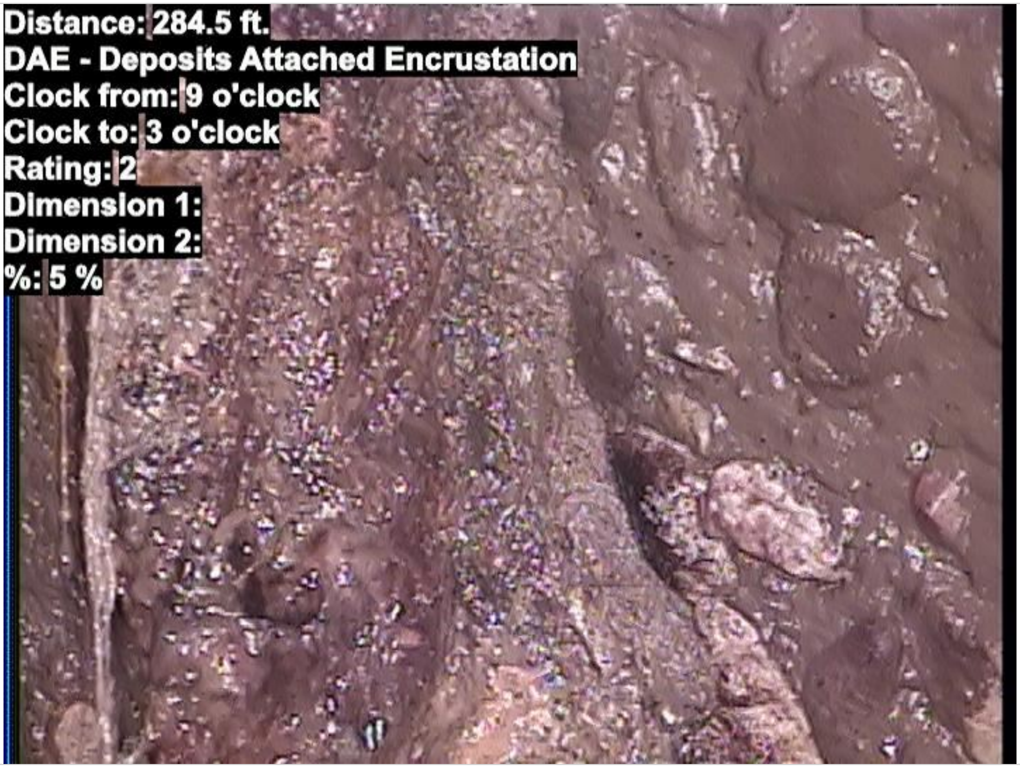


Observations

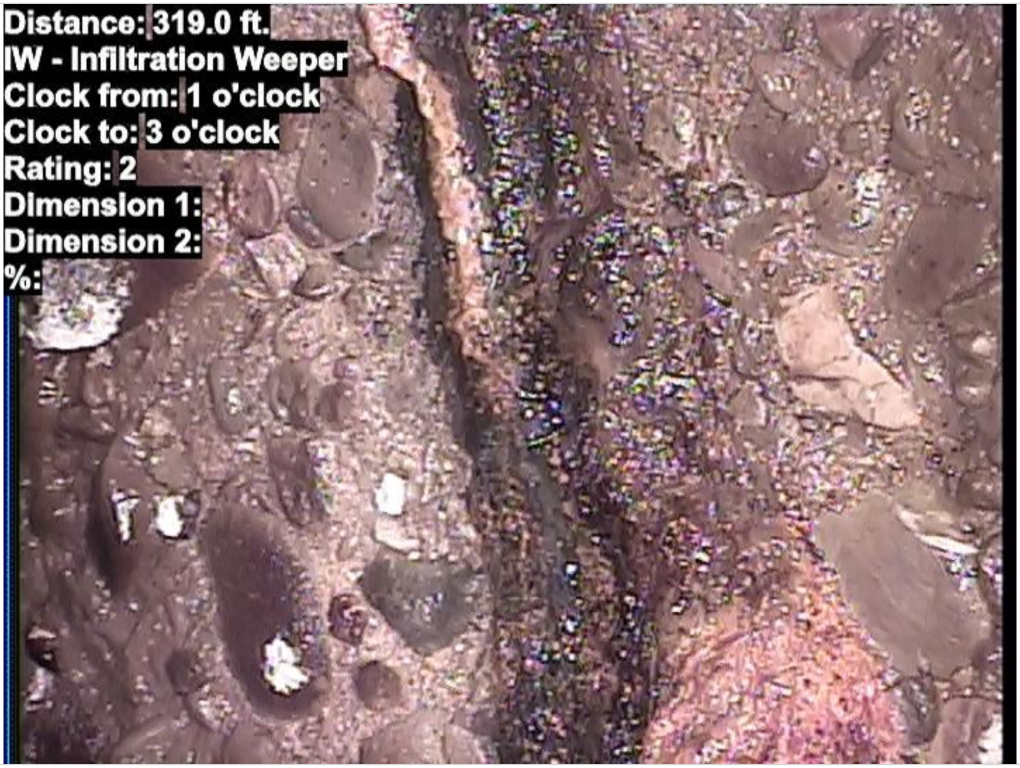
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
284.5 ft.	D		9 / 3	IW		2	

Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
284.5 ft.	D		9 / 3	DAE		2	

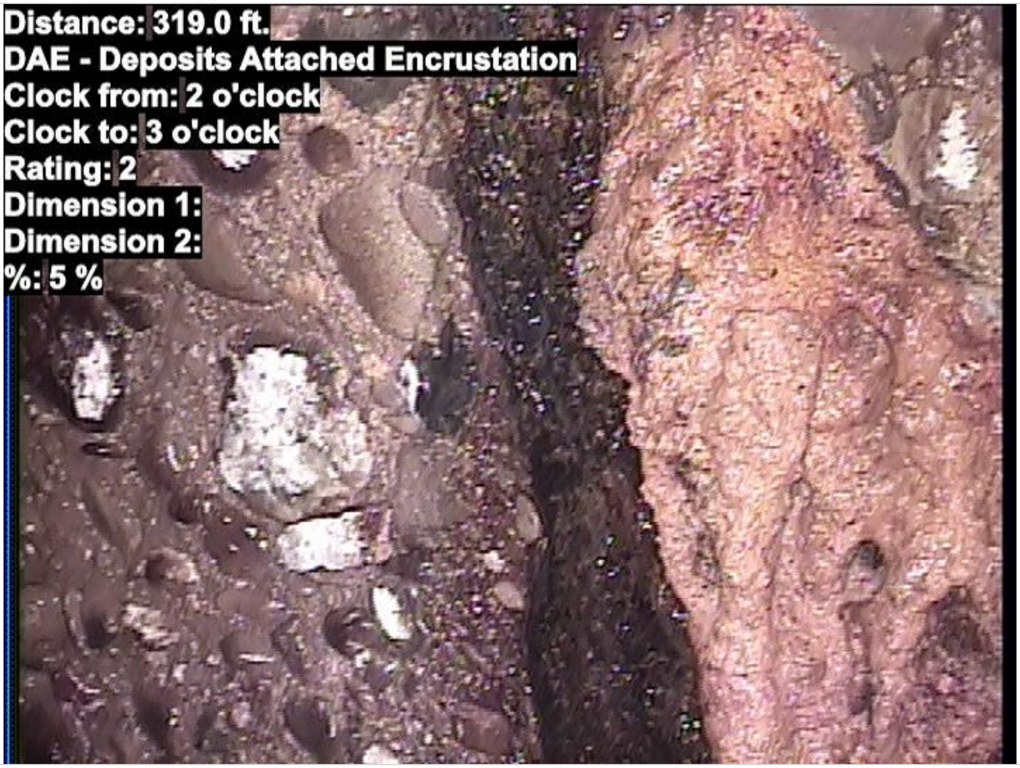


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
319.0 ft.	D		1 / 3	IW		2	

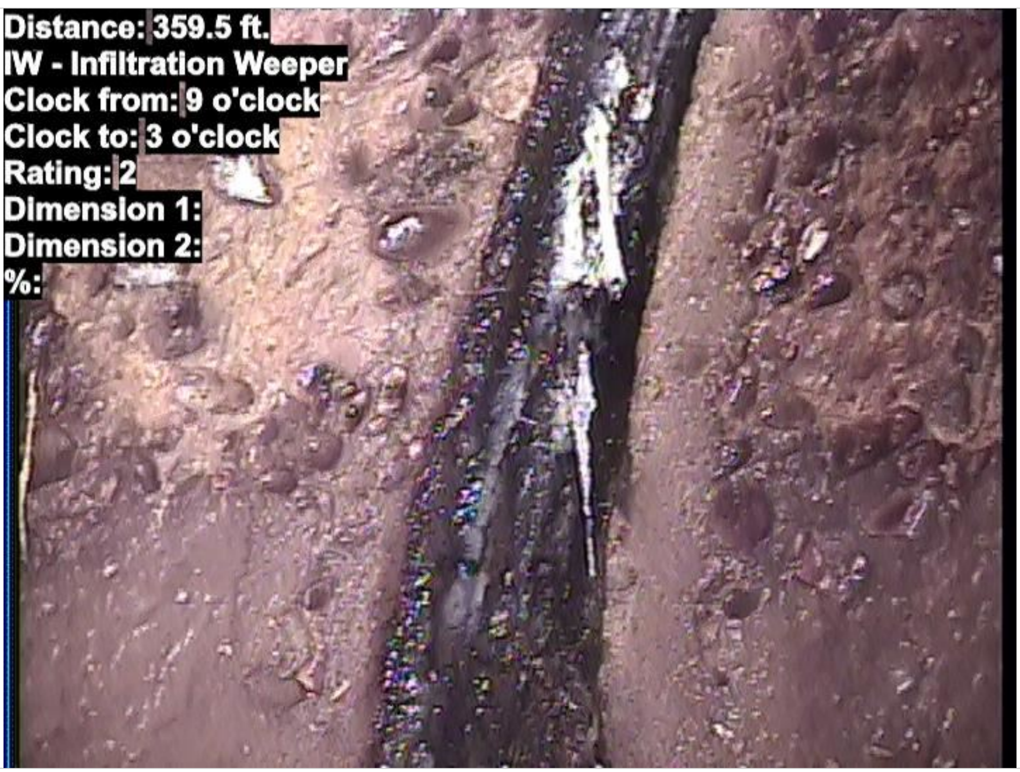


Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
319.0 ft.	D		2 / 3	DAE		2	

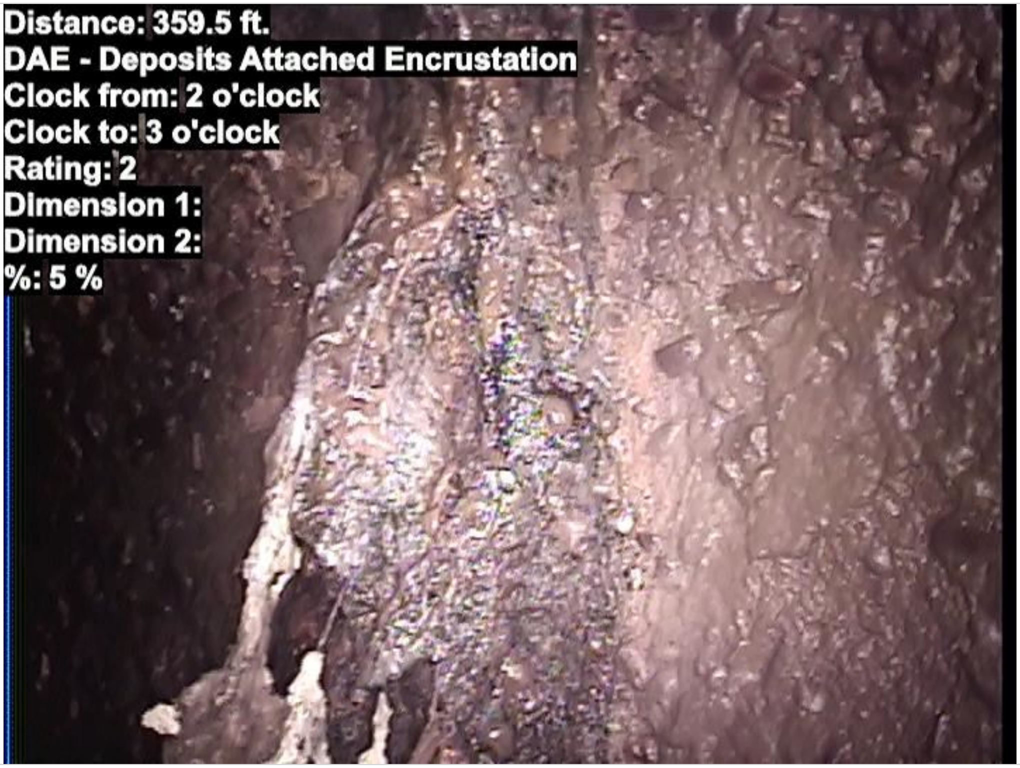


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
359.5 ft.	D		9 / 3	IW		2	

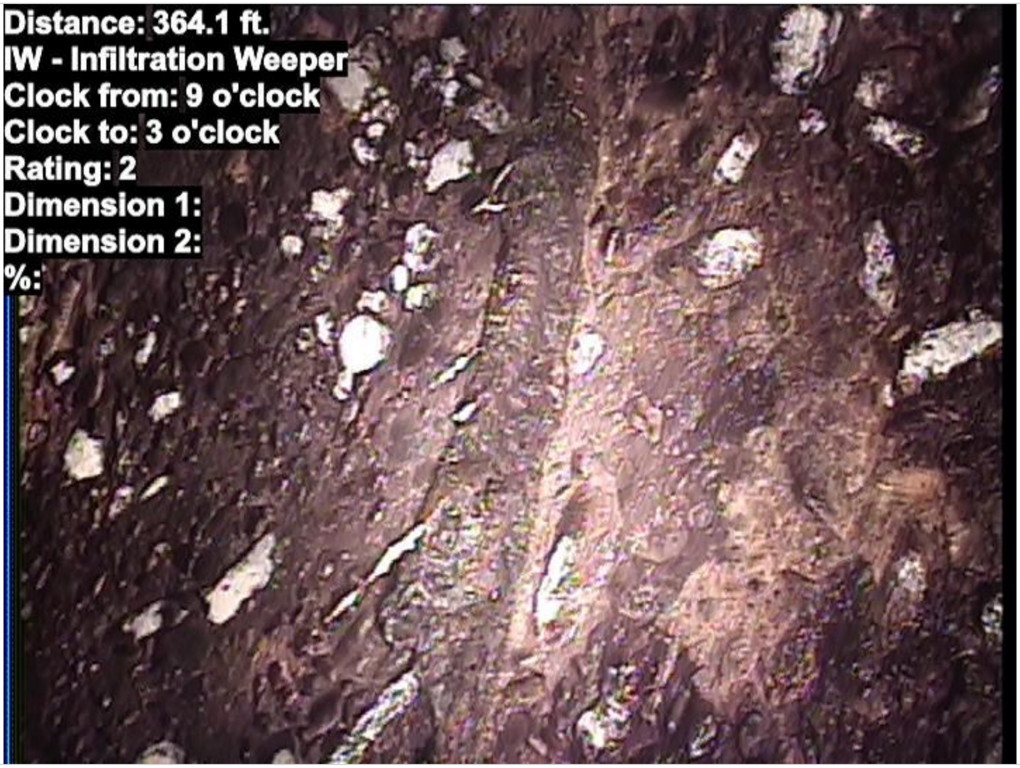


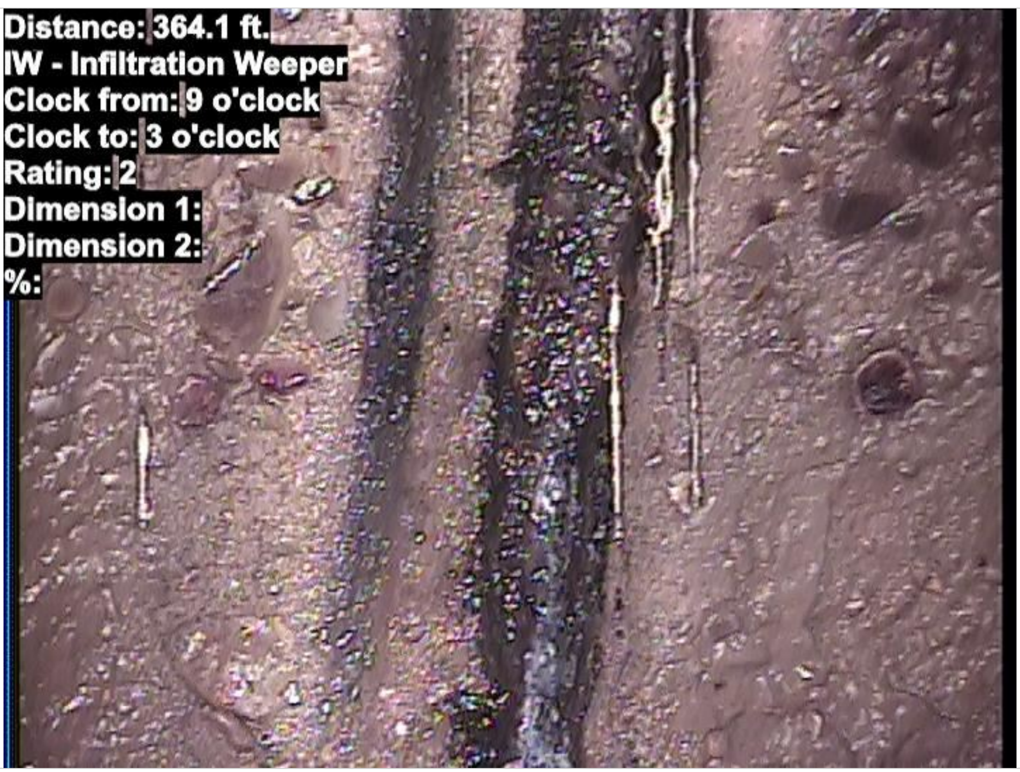
Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
359.5 ft.	D		2 / 3	DAE		2	

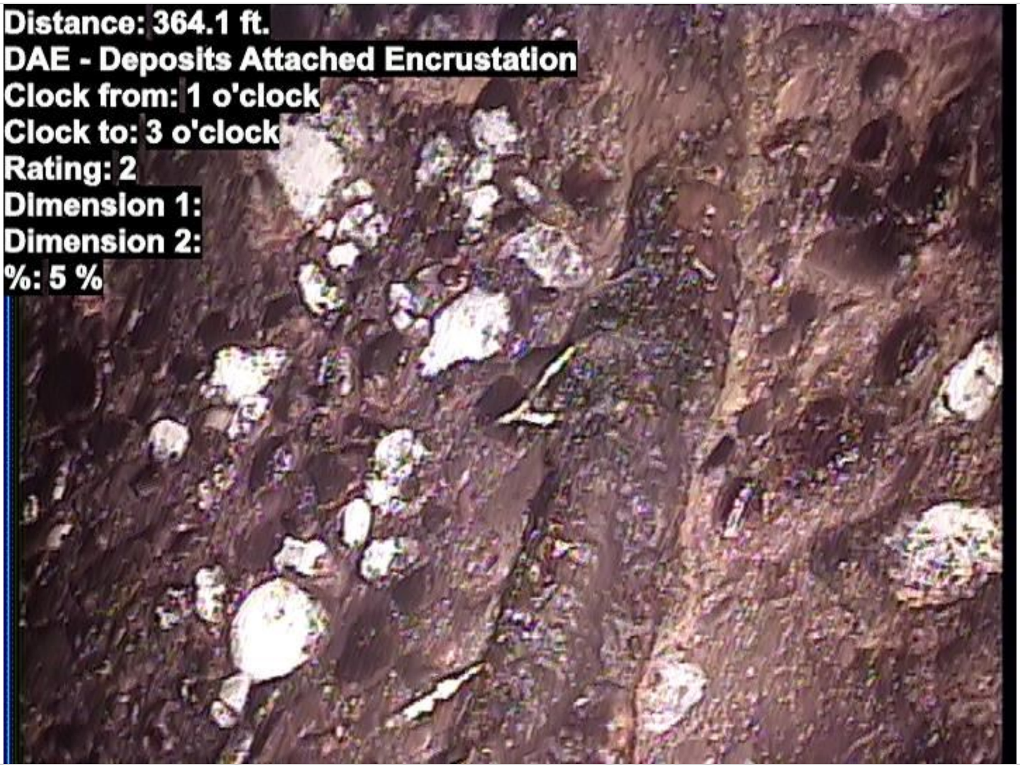


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
364.1 ft.	D		9 / 3	IW		2	



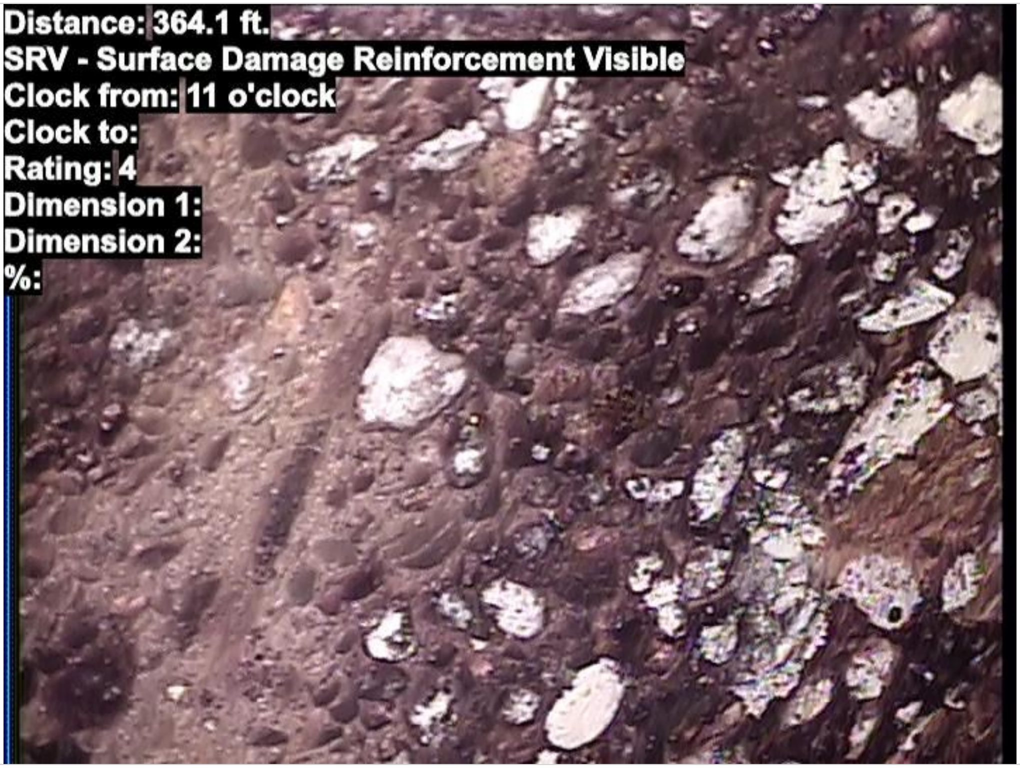


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
364.1 ft.	D		1 / 3	DAE		2	



Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
364.1 ft.	D		11 /	SRV		4	



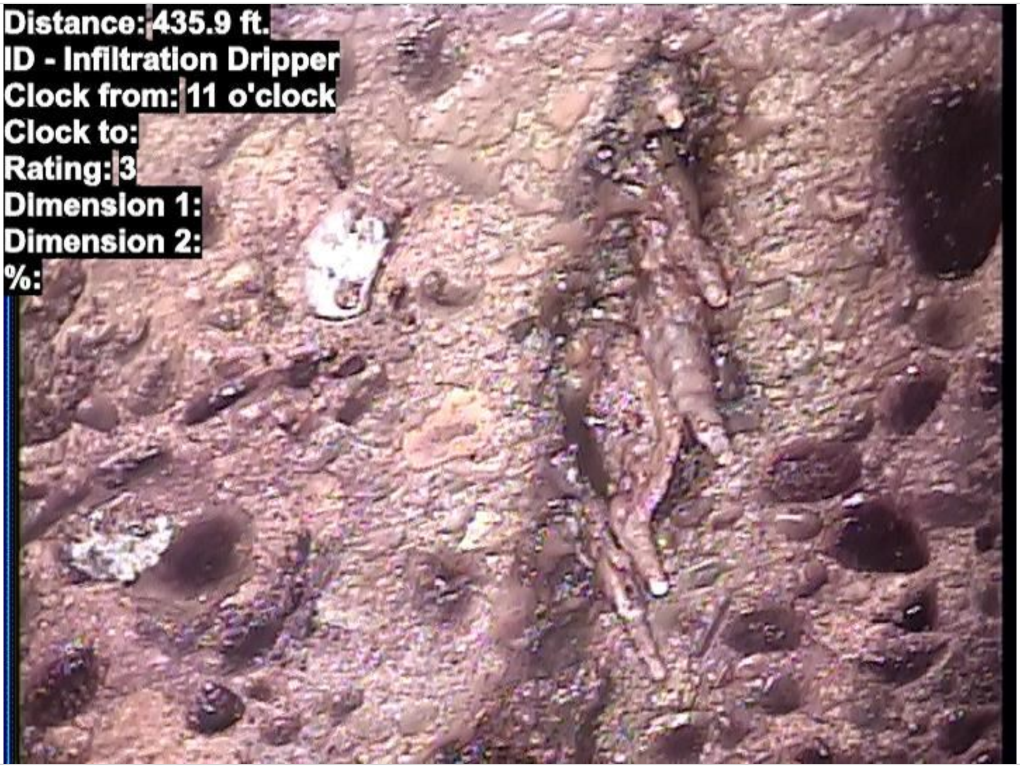
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
364.1 ft.	D		11 /	SRC		5	

Observations

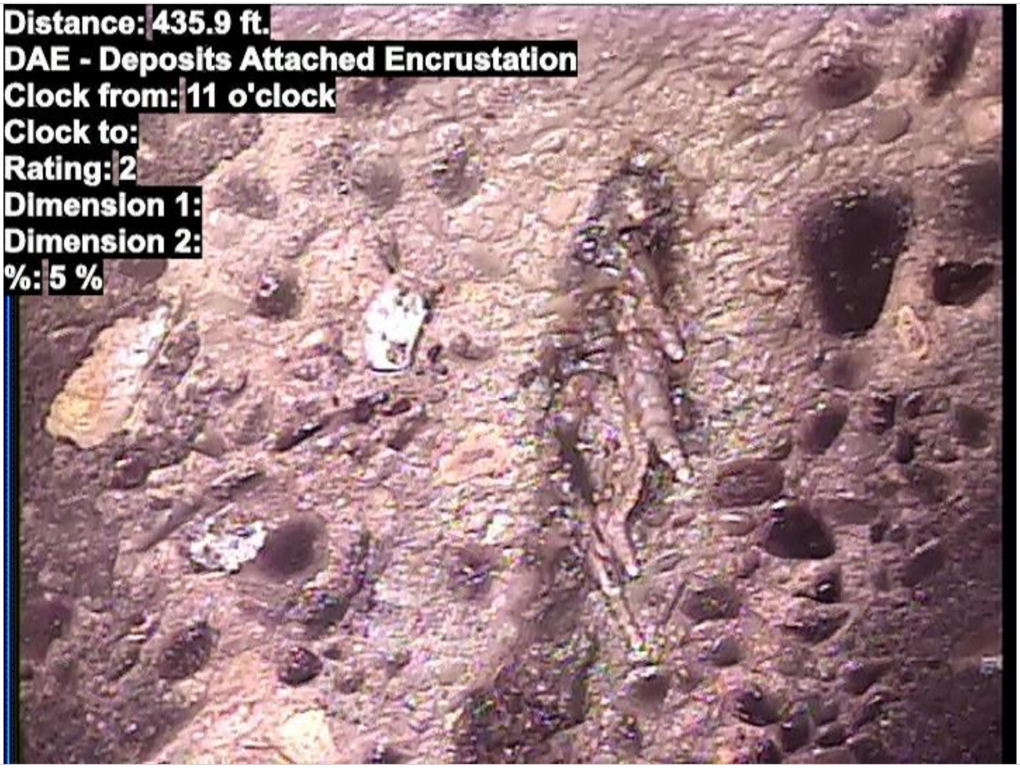
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
401.4 ft.	D		9 / 10	IW		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
401.4 ft.	D		9 / 10	DAE		2	

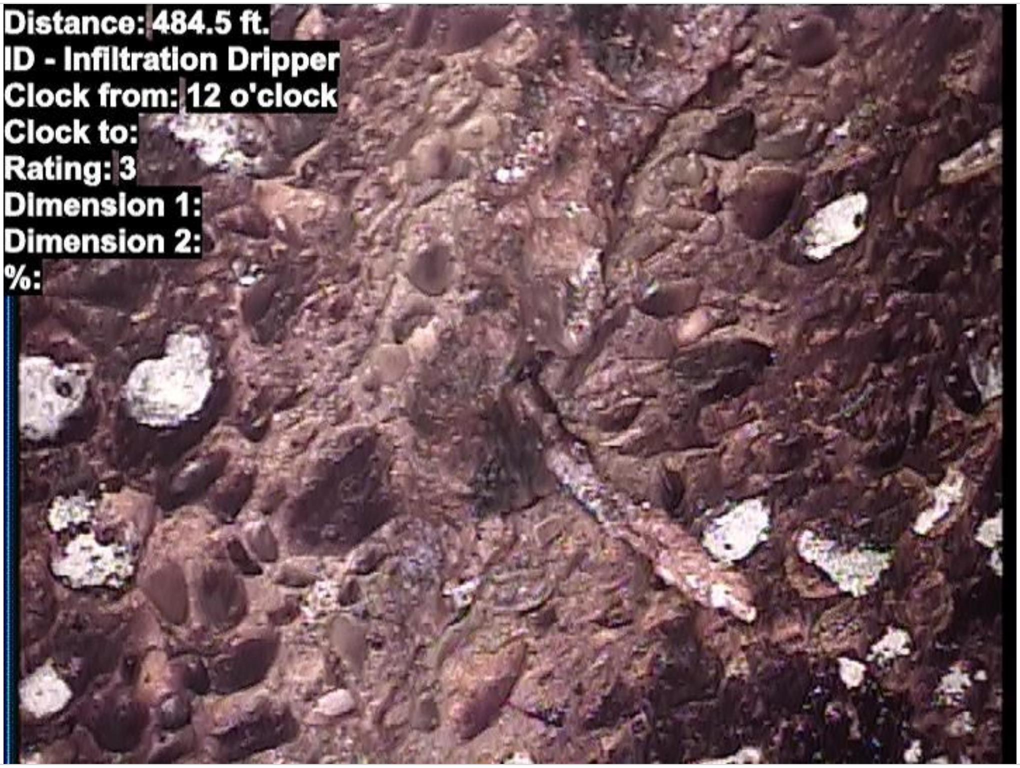
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
435.9 ft.	D		11 /	ID		3	



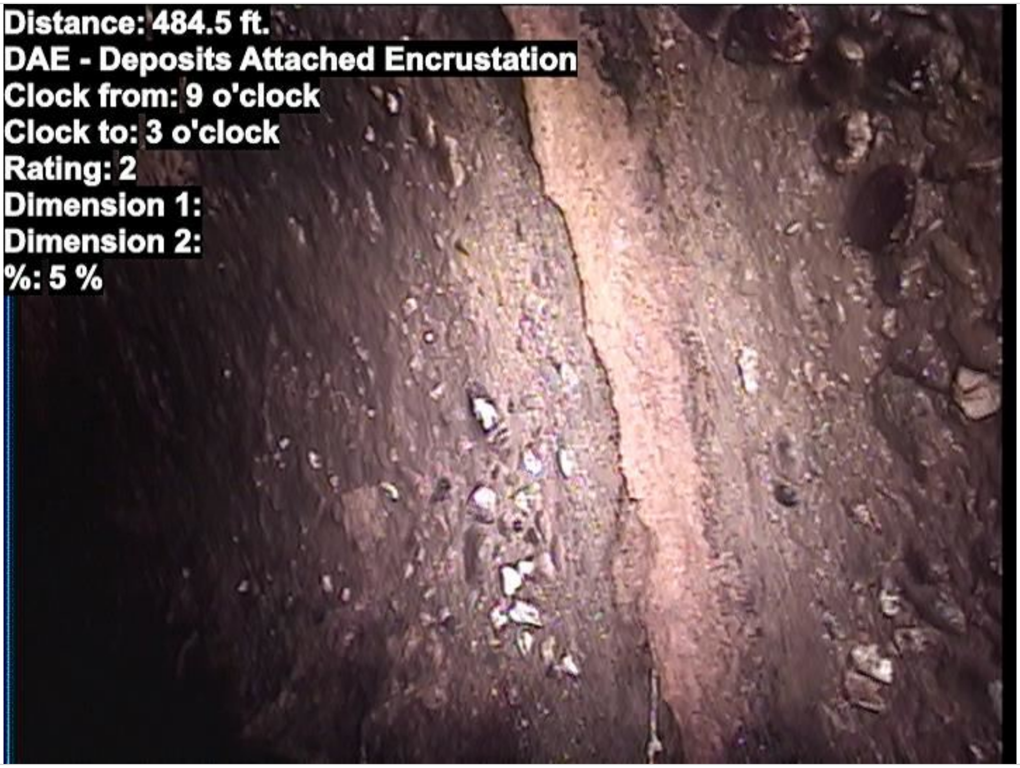
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
435.9 ft.	D		11 /	DAE		2	

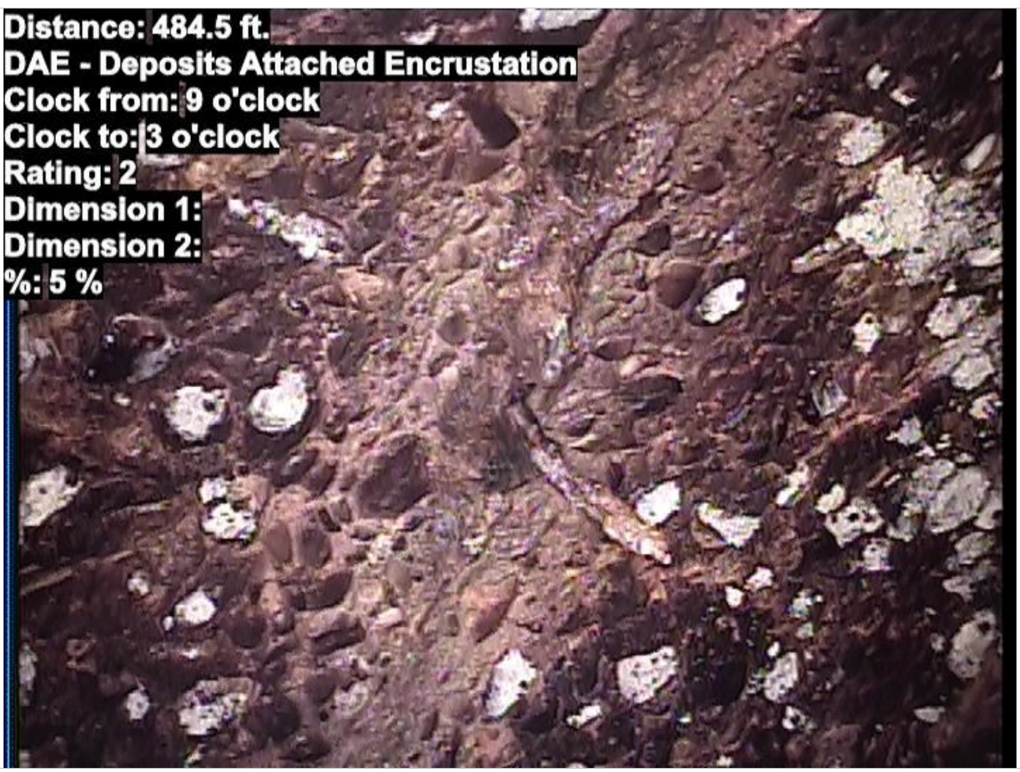


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
484.5 ft.	D		12 /	ID		3	

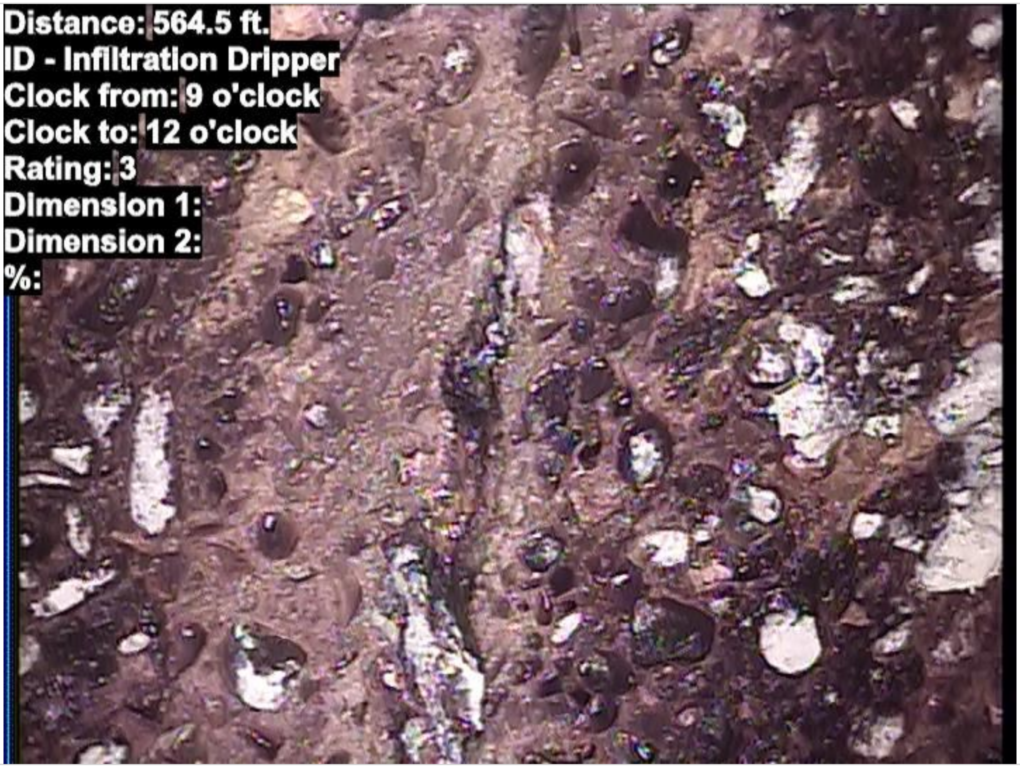


Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
484.5 ft.	D		9 / 3	DAE		2	



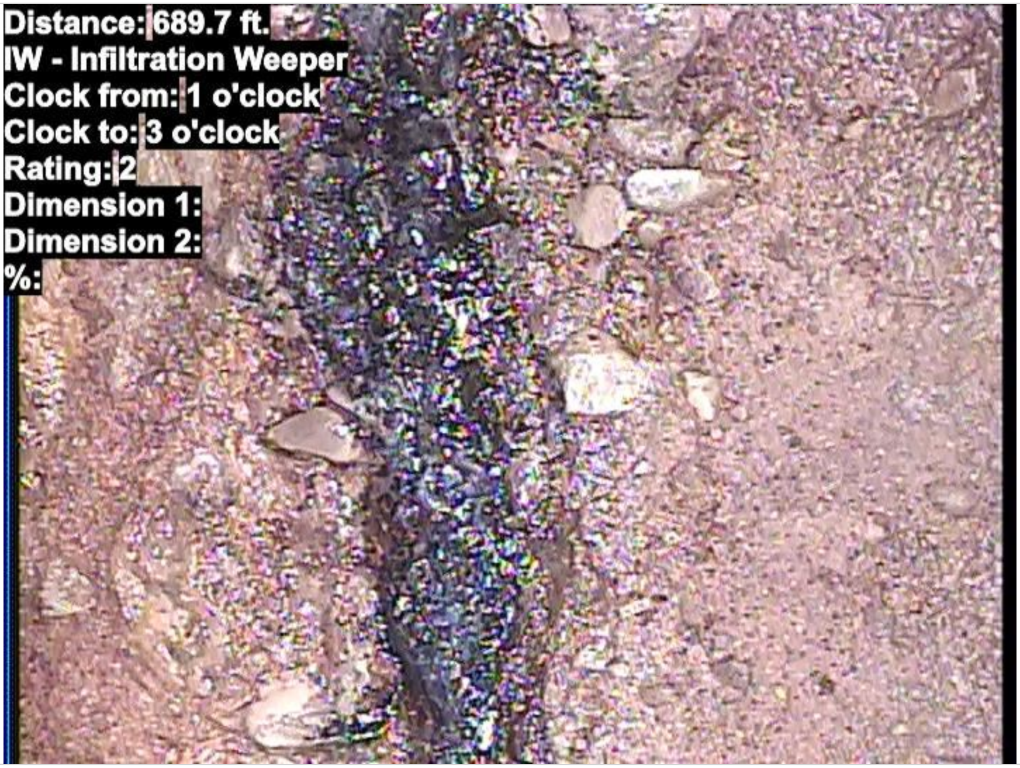


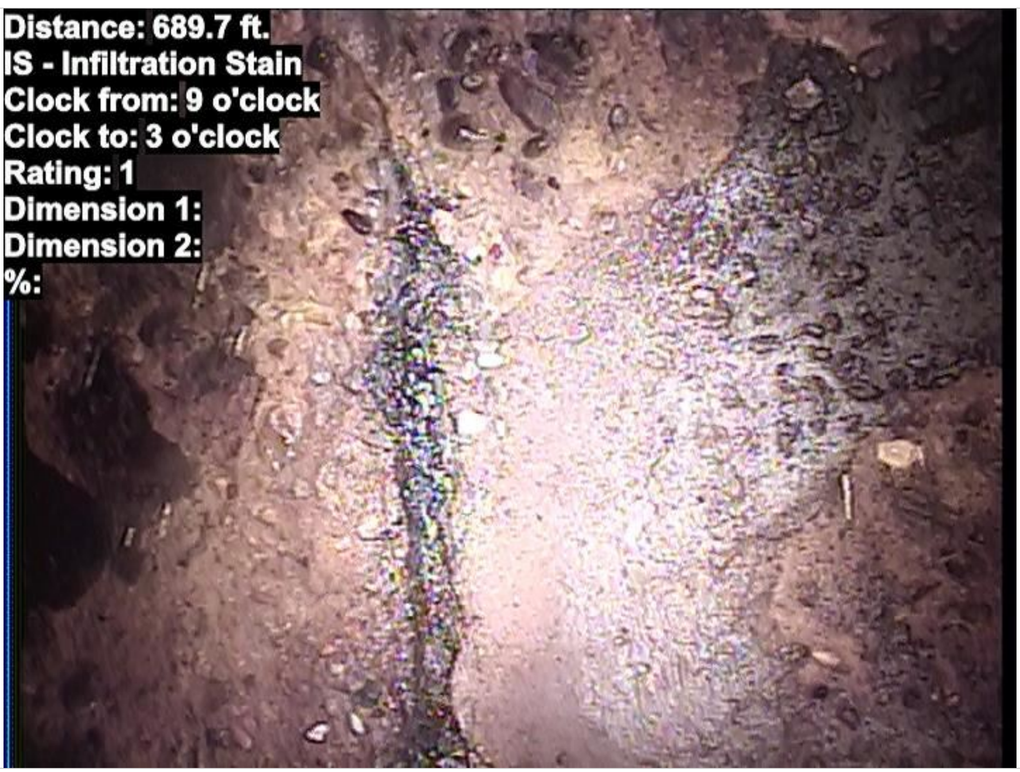
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
564.5 ft.	D		9 / 12	ID		3	



Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
564.5 ft.	D		9 / 3	DAE		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
689.7 ft.	**D**		**1 / 3**	**IW**		**2**	

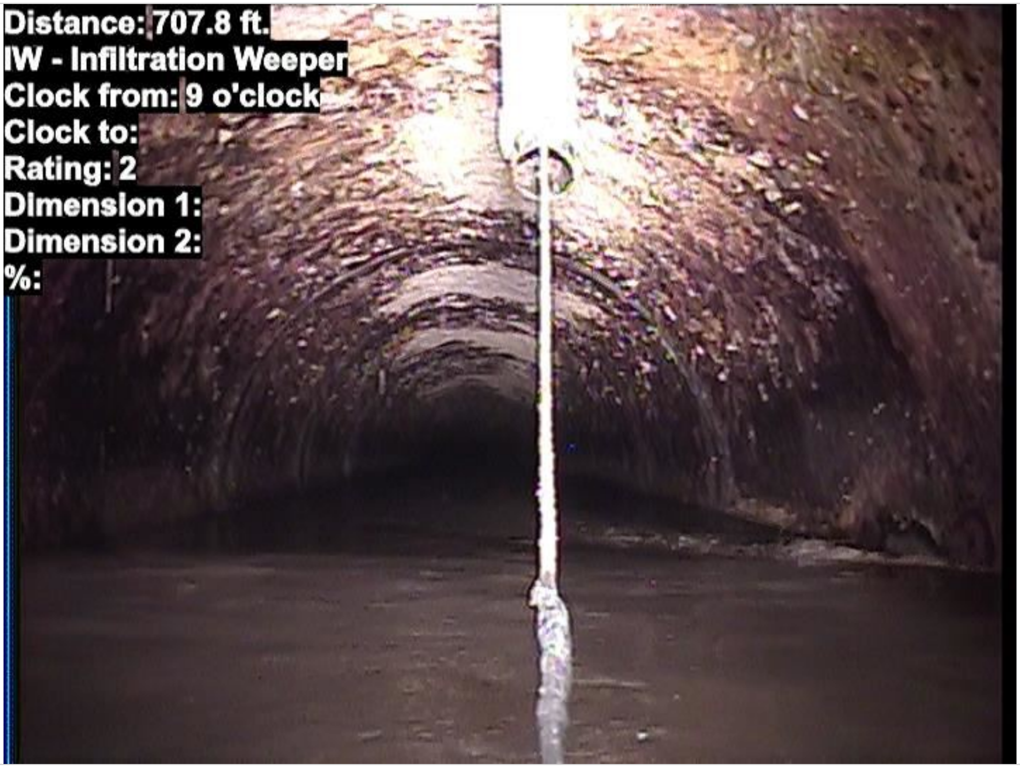




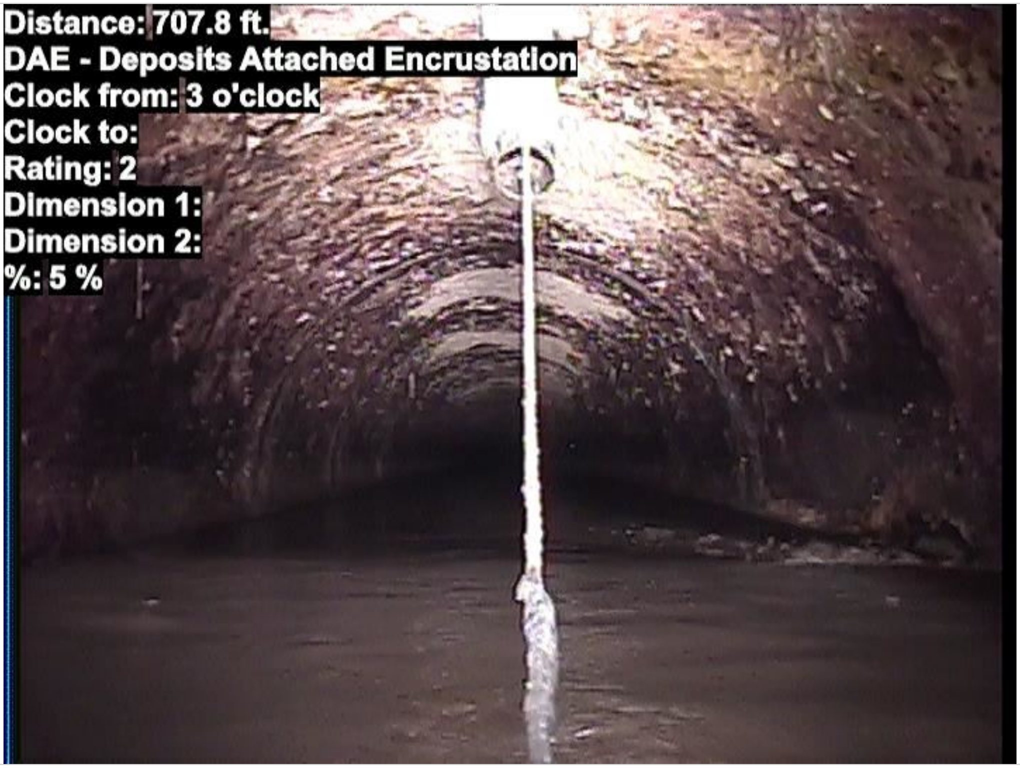
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		3 /	IW		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		9 /	IW		2	



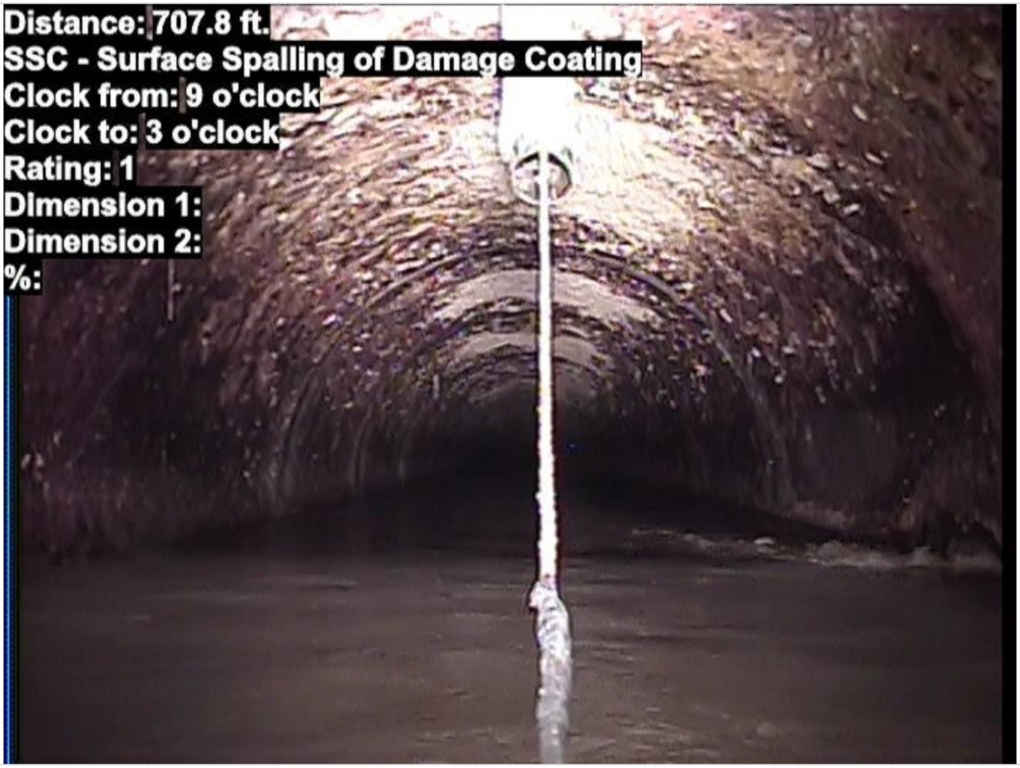
Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		3 /	DAE		2	



Observations

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		9 /	DAE		2	

Distance	Dir.	ForDista	From/To	Code	Modifier	Rating	Remarks
707.8 ft.	D		9 / 3	SSC		1	



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Appendix B
MSI Assessment Report

TECHNICAL MEMORANDUM

EAST BAY MUNICIPAL UTILITY DISTRICT
Multi-Sensor Inspection Project

PREPARED FOR: East Bay Municipal Utility District

PREPARED BY: Michelle Beason, PE, National Plant Services, Inc.

DATE: June 7, 2022

Introduction

Thank you for allowing us to demonstrate our Multi-Sensor Inspection (MSI) technology to the East Bay Municipal Utility District (EBMUD)!

This memorandum provides a summary of the inspection and condition assessment evaluations performed for EBMUD by National Plant Services, Inc. (NPS) the week of May 16, 2022.

The purpose of this project was to perform a condition assessment and determine the extent of concrete corrosion in RCP interceptors from 63” circular to 105” horseshoe pipelines.

This technical memorandum provides EBMUD with the results and assessment of 6 sewer segments. Work products are included in the Appendices as follows:

Appendix A – PACP and MSI Data Export (Delivered via Dropbox)

https://www.dropbox.com/scl/fo/e3bkvjaq4nqjye3ovzden/h?dl=0&rlkey=13phofdk91ey8z3s3vlfi5duf

Appendix B – Excel Spreadsheet of PACP, Laser, and Sonar Results

Appendix C – Line Segment MSI Summary Reports

Executive Summary

The project scope of work was as follows:

- Inspect a various RCP sewers with Multi-sensor Inspection technology (CCTV, 3D LiDAR, and sonar)
- Provide all final PACP, sonar, and 3D Laser Data
- Provide a Condition Assessment Summary Memorandum

Pipe Inspection Methodology

CCTV

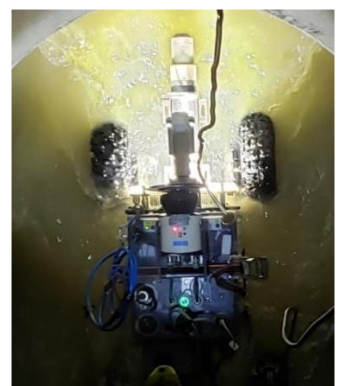
CCTV is the standard acceptable method for visually inspecting pipelines to identify defects and construction features. The digital CCTV inspection provides a visual view of the pipeline interior. The pan/tilt/zoom features of CCTV cameras coupled with a high-resolution picture provides detailed views of the current pipe condition above the water surface.

PACP (Pipeline Assessment Certification Program) coding is a national standard for identifying structural defects and operational concerns in sewer and storm water pipelines. PACP is owned and maintained by NASSCO (National Association of Sewer Service Companies). CCTV operators take a PACP certification course that is valid for three years before a renewal course is required. PACP is made up of Configuration Codes (taps, manholes, etc), Structural defect codes, and Operation and Maintenance defect codes. Pages 4-6 include the list of PACP codes.

PACP is a beneficial coding system for pipe inspection as it takes all individual defects for each pipe segment and coverts them into overall defect scores, which then helps a system owner prioritize necessary Capital Improvements. It also allows us to track changes to the pipe condition over time to help predict rate of failure, and when repairs may be needed.

During the inspections, the CCTV technician identified defects, appurtenances, general pipe conditions, flow levels, and other important project details while maintaining a running distance log in the video. Using NASSCO PACP-certified software and database, the trained technician identified and coded pipe defects by type and severity.

3D Laser and Sonar



Multi-sensor inspections (MSI) are typically known to include a combination of the following sensors: CCTV, 3D Laser/LiDAR, and sonar. All sensors are deployed in a single robotic platform, so all sensors are collected in one inspection pass, minimizing impacts to the public.

Our Carylon MSI system can be mounted on either a tracked or a floating platform. Due to suspected debris levels, the floating pontoon was used for this inspection.

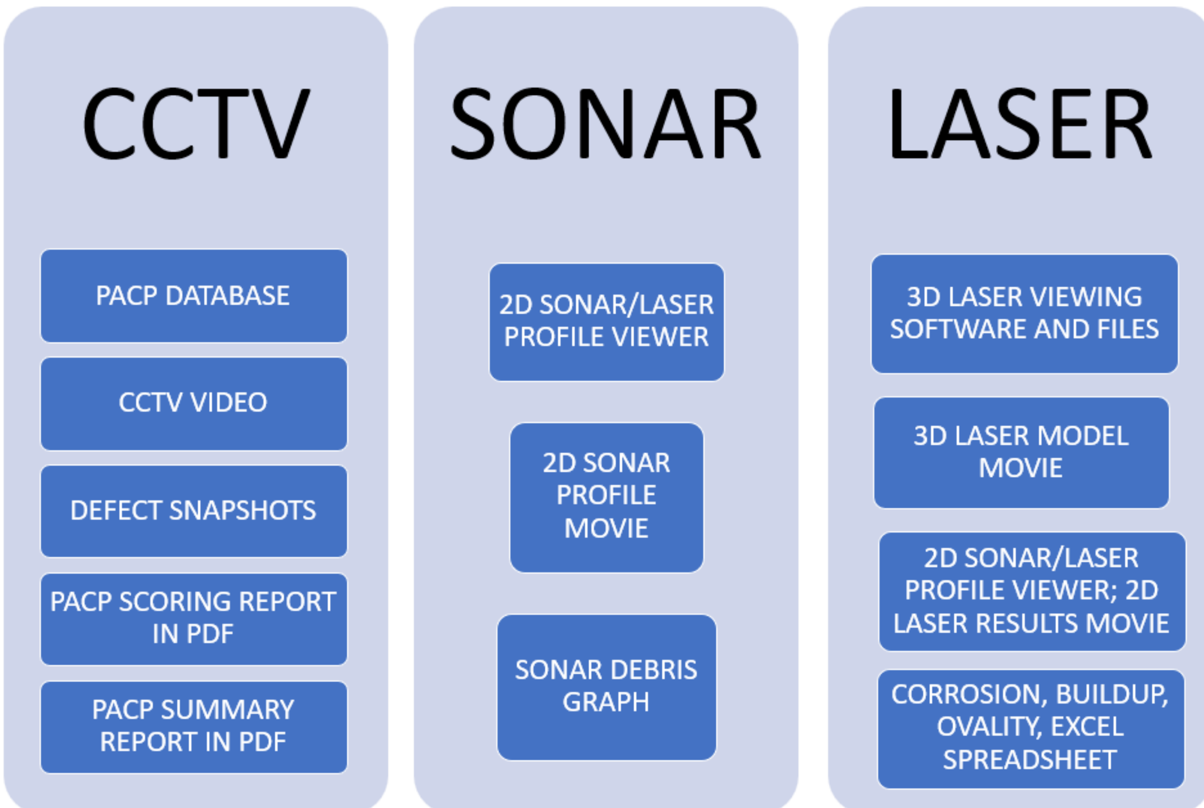
The laser and sonar sensors simultaneously collect data as the operators are completing their normal PACP-coded CCTV inspection. The laser measures inside the pipe to determine the exact quantity of buildup or loss of pipe wall, plus ovality changes. The laser reporting for every inspection is very detailed, as the laser collects hundreds of thousands of measurements.

Our powerful 3D viewing software allows a system owner to virtually walk through a 3D laser scan of their pipeline, which shows precise measurements of corrosion, buildup, and ovality changes.

Sonar collected data under the water line to determine debris levels, and to determine if there are large defects to the pipe walls, as long as those defects aren't obscured by debris.

DELIVERABLES

NATIONAL PLANT SERVICES, INC.
CCTV/3D LASER/SONAR DELIVERABLES



ALL CAPTURED MSI DATA IS SUMMARIZED AND ANALYZED FOR OUR CLIENTS INTO:

1. **Final Project Summary Report (This document)**
2. **Summary Spreadsheet of PACP, sonar, and MSI Results (Appendix B)**
3. **MSI Line Segment Summary Reports (Appendix C)**
   All CCTV, Sonar, and 2D and 3D LiDar data is summarized in individual line segment reports, which pulls together the PACP inspection data, laser measurements, and laser viewer results for each segment inspected.

***Go Pro Videos were also gathered on two of the 105" pipelines to provide higher definition video as an added benefit to EBMUD.**

Appendix B - Color Coded Chart

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP)®

Section 2 — Header Form Fields

14 Weather 2-5
- 1 = Dry
- 2 = Heavy Rain
- 3 = Light Rain
- 4 = Snow
- 5 = Dry Weather/Wet Ground

15 Pre-Cleaning 2-5
- H = Heavy Cleaning
- L = Light Cleaning (Jetting)
- N = No Pre-Cleaning
- X = Not Known
- Z = Other

17 Flow Control 2-6
- B = Bypassed
- D = Dewatered Using Jetter
- L = Lift Station
- N = Not Controlled
- P = Plugged

18 Purpose 2-7
- A = Maintenance
- B = Infiltration/Inflow Invest.
- C = Post-Rehabilitation
- D = Pre-Rehabilitation
- E = Pre-Acceptance
- F = Routine Assessment

18 Purpose 2-7
- G = Capital Improvement Program Assessment
- H = Resurvey
- I = SSES
- R = Pre-Existing Video
- X = Not Known

19 Direction 2-7
- D = Downstream
- U = Upstream

20 Inspection Technology 2-8
- CC = CCTV
- LA = Laser
- SO = Sonar
- SS = Sidewall Scanning
- **ZM** = Zoom
- ZZ = Other

21 Inspection Status 2-8
- BM = Buried & Marked
- CI = Complete Inspection
- NA = No Access
- NE = Does Not Exist

21 Inspection Status 2-8
- NF = Not Found
- NI = Traffic
- NO = Not Opened
- SD = Surcharged/Debris

28 Location Code 2-11
- A = Primary Major Arterial Road
- B = Secondary Road
- C = Local/Rural Street
- D = Easement/Right-of-Way
- E = Woods

28 Location Code 2-11
- F = Sidewalk
- G = Parking Lot
- H = Alley
- I = Ditch
- J = Building
- K = Creek (or any waterway)

28 Location Code 2-11
- L = Railway
- M = Airport
- N = Levee/Floodwall
- O = Dam
- P = Levee Pump Station
- Y = Yard
- Z = Other

30 Pipe Use 2-12
- CB = Combined Pipe
- DP = Dam Pipe
- FM = Force Main
- LG = Levee Gravity Pipe
- LP = Levee Pressure Pipe

30 Pipe Use 2-12
- PR = Process Pipe
- SS = Sanitary Sewage Pipe
- SW = Stormwater Pipe
- XX = Not Known
- ZZ = Other

33 Shape 2-13 E-1
- A = Arched
- B = Barrel
- C = Circular
- E = Egg-Shaped
- H = Horseshoe
- O = Oval (elliptical)

33 Shape 2-13 E-1
- R = Rectangular
- S = Square
- T = Trapezoidal
- U = U-Shaped with Flat Top
- Z = Other

34 Material 2-14 E-4
- ABS = Acrylonitrile Butadiene Styrene
- AC = Asbestos Cement
- BR = Brick
- CAS = Cast Iron
- CLC = Clay-Lined Concrete
- CMP = Corrugated Metal Pipe

34 Material 2-14 E-4
- CP = Concrete Pipe
- CSB = Conc. Segments Bolted
- CSU = Conc. Segments Unbolted
- CT = Clay Tile
- DIP = Ductile Iron Pipe

34 Material 2-14 E-4
- FRP = Fiberglass Reinforced Pipe
- OB = Orangeburg/Pitch Fiber
- PCCP = Pre-Stressed Concrete Cylinder Pipe
- PCP = Polymer Concrete Pipe
- PE = Polyethylene

34 Material 2-14 E-4
- PP = Polypropylene
- PSC = Plastic/Steel Composite
- PVC = Polyvinyl Chloride
- RCP = Reinf. Concrete Pipe
- RPM = Reinf. Plastic Pipe
- **SB** = Segmented Block

34 Material 2-14 E-4
- SP = Steel Pipe
- VCP = Vitrified Clay Pipe
- WD = Wood
- XXX = Not Known
- ZZZ = Other

35 Lining Method 2-15 E-17
- CIP = Cured-In-Place Pipe
- FF = Fold and Form
- FP = Formed-In-Place Liner
- GP = Grout-In-Place Liner
- GRC = Glass Reinf. Cement
- N = None
- SC = Continuous Slip Liner

35 Lining Method 2-15 E-17
- SE = Sectional Slip Liner
- SL = Spray Liner
- SN = Segmented Panel
- SP = Segmented Pipe
- SW = Spiral Wound
- XX = Not Known
- ZZ = Other

36 Coating Method 2-16 E-23
- CT = Coal Tar
- CM = Cement Mortar
- EP = Epoxy
- PE = Polyethylene

36 Coating Method 2-16 E-23
- PO = Polyurethane
- PU = Polyurea
- PVC = Polyvinyl Chloride
- XX = Not Known
- ZZ = Other

58 GPS Accuracy 2-27
- L = Survey Level
- M = Sub-Meter
- N = Nearest Meter

Appendix B - Color Coded Chart

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP®)

Section 4 — Structural Defect Coding

C CRACK 4-3
CL Longitudinal
CC Circumferential
CM Multiple
CS Spiral
CH Hinge (2, 3, 4)

F FRACTURE 4-9
FL Longitudinal
FC Circumferential
FM Multiple
FS Spiral
FH Hinge (2, 3, 4)

B BROKEN 4-17
BSV Soil Visible
BVV Void Visible

H HOLE 4-21
HSV Soil Visible
HVV Void Visible

D DEFORMED (Rigid) 4-25
DR Deformed Rigid
No modifiers used.

D DEFORMED (Flexible) 4-25
DFBR Bulging Round
DFBI Bulging Inv.Curv.
DFC Creasing
DFE Elliptical

D DEFORMED (Brick) 4-25
DTBR Bulging Round
DTBI Bulging Inv.Curv.

X COLLAPSE 4-37
X Collapse
No descriptors and no modifiers used.

J JOINT 4-43
JOS Offset Small
JOM Offset Medium
JOL Offset Large

J JOINT 4-43
JOSD Offset Small Defect
JOMD Offset Medium Defect
JOLD Offset Large Defect

J JOINT 4-43
JSS Separation Small
JSM Separation Med.
JSL Separation Large

J JOINT 4-43
JAS Angular Small
JAM Angular Medium
JAL Angular Large

S SURFACE DAMAGE 4-51
SRI Roughness Increased
SAV Aggregate Visible
SAP Aggregate Projecting
SAM Aggregate Missing

S SURFACE DAMAGE 4-51
SRV Reinforcement Visible
SRP Reinforcemt.Projecting
SRC Reinforcemt.Corroded
SMW Missing Wall

S SURFACE DAMAGE 4-51
SSS Surface Spalling
SSC Surface Spalling Coating
SCP Surface Damage Corrosion
SZ Other

LF LINING FEATURES 4-67
LFAC Abdn'd Connection
LFAS Annular Space
LFB Blistered Lining
LFCS Service Cut Shifted

LF LINING FEATURES 4-67
LFD Detached
LFDC Discoloration
LFDE Defective End
LFDL Delamination

LF LINING FEATURES 4-67
LFOC Overcut Service
LFRS Resin Slug
LFUC Undercut Service
LFW Wrinkled
LFZ Other

WF WELD FAILURE 4-85
WFC Circumferential
WFL Longitudinal
WFM Multiple
WFS Spiral
WFZ Other

RP POINT REPAIR 4-89
RPL Liner
RPLD Liner Defective
RPP Patch
RPPD Patch Defective

RP POINT REPAIR 4-89
RPR Replacement
RPRD Replmt. Defective
RPZ Other
RPZD Other Defective

BRICKWORK 4-97
DB Displaced
MB Missing
DI Dropped Invert

BRICKWORK 4-97
MMS Mortar Missing Small
MMM Mortar Missing Med.
MML Mortar Missing Large

Pipeline Assessment Certification Program
Version 7.0.3 January 2018

B-1

Appendix B - Color Coded Chart

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP)®

Section 5 — Operation and Maintenance

D DEPOSITS (Attached) 5-3
- DAE Encrustation
- DAGS Grease
- DAR Ragging
- DAZ Other

D DEPOSITS (Settled) 5-4
- DSF Fine
- DSGV Gravel
- DSC Hard/Compact
- DSZ Other

D DEPOSITS (Ingress) 5-4
- DNF Fine (silt/sand)
- DNGV Gravel
- DNZ Other

R ROOTS (Fine) 5-11
- RFB Barrel
- RFL Lateral
- RFC Connection
- RFJ Joint

R ROOTS (Medium) 5-11
- RMB Barrel
- RML Lateral
- RMC Connection
- RMJ Joint

R ROOTS (Ball) 5-11
- RBB Barrel
- RBL Lateral
- RBC Connection
- RBJ Joint

R ROOTS (Tap) 5-11
- RTB Barrel
- RTL Lateral
- RTC Connection
- RTJ Joint

I INFILTRATION 5-19
- IS Stain
- ISB Barrel
- ISC Connection
- ISJ Joint
- ISL Lateral

I INFILTRATION 5-19
- IW Weeper
- IWB Barrel
- IWC Connection
- IWJ Joint
- IWL Lateral

I INFILTRATION 5-19
- ID Dripper
- IDB Barrel
- IDC Connection
- IDJ Joint
- IDL Lateral

I INFILTRATION 5-19
- IR Runner
- IRB Barrel
- IRC Connection
- IRJ Joint
- IRL Lateral

I INFILTRATION 5-19
- IG Gusher
- IGB Barrel
- IGC Connection
- IGJ Joint
- IGL Lateral

OB OBSTACLES 5-31 OBSTRUCTIONS
- OBB Brick or Masonry
- OBC Object Through Connection
- OBI Object Intruding Through Wall

OB OBSTACLES 5-31 OBSTRUCTIONS
- OBJ Object in Joint
- OBM Pipe Material in Invert
- OBN Construction Debris
- OBP External Pipe Cable

OB OBSTACLES 5-31 OBSTRUCTIONS
- OBR Rocks
- OBS Built In Structure
- OBZ Other

V VERMIN 5-45
- VR Rat
- VC Cockroach
- VZ Other

G GROUT TEST & SEAL 5-49
- GTP Grout Test Passed
- GTPJ Joint
- GTPL Lateral
- GTF Grout Test Failed
- GTFJ Joint
- GTFL Lateral

G GROUT TEST & SEAL 5-49
- GTU Grout Test Unable
- GTUJ Joint
- GTUL Lateral
- GRT Grout Test Location

Section 6 — Construction Features

T TAP 6-3
- TB Break-In/Hammer
- TBI Intruding
- TBD Defective
- TBC Capped
- TBA Activity
- TBB Abandoned

T TAP 6-3
- TF Factory Made
- TFI Intruding
- TFD Defective
- TFC Capped
- TFA Activity
- TFB Abandoned

T TAP 6-3
- TR Rehabilitated
- TRI Intruding
- TRD Defective
- TRC Capped
- TRA Activity
- TRB Abandoned

T TAP 6-3
- TS Saddle
- TSI Intruding
- TSD Defective
- TSC Capped
- TSA Activity
- TSB Abandoned

IS INTRUDING SEALING MATERIAL 6-15
- ISSR Sealing Ring
- ISSRB Broken
- ISSRH Hanging
- ISSRL Loose
- ISGT Grout
- ISZ Other

L LINE (of sewer) 6-21
- LD Down
- LL Left
- LLD Left Down
- LLU Left Up

L LINE (of sewer) 6-21
- LR Right
- LRD Right Down
- LRU Right Up
- LU Up

A ACCESS POINT 6-25
- ACB Catch Basin
- ACO Cleanout
- ACOM Mainline
- ACOP Property
- ACOH House

A ACCESS POINT 6-25
- ADP Discharge Point
- AEP End of Pipe
- AJB Junction Box
- AM Meter
- AMH Manhole

A ACCESS POINT 6-25
- AOC Other Structure
- ATC Tee Connection
- AWA Wastewater Access
- AWW Wetwell
- AZ Other

Section 7 — Miscellaneous Features

M MISCELLANEOUS FEATURES 7-1
- MCU Camera Underwater
- MGO General Observation
- MGP General Photograph
- MJL Joint Length

M MISCELLANEOUS FEATURES 7-1
- MLC Lining Change
- MMC Material Change
- MSC Shape/Size Change
- MSA Survey Abandoned
- MWL Water Level

M MISCELLANEOUS FEATURES 7-1
- MWLS Water Level Sag
- MWM Water Mark
- MY Dye Test
- MYV Dye Visible
- MYN Not Visible

Pipeline Assessment Certification Program
Version 7.0.3 January 2018

B-2

Understanding PACP Structural and O&M Inspection Coding

Field inspections identified the following types of defects:

Operational & Maintenance Defects: deposits of silt and gravel, infiltration, roots, and water level sags.

Structural Defects: fractures, cracks, holes and broken pipe, and degraded surface.

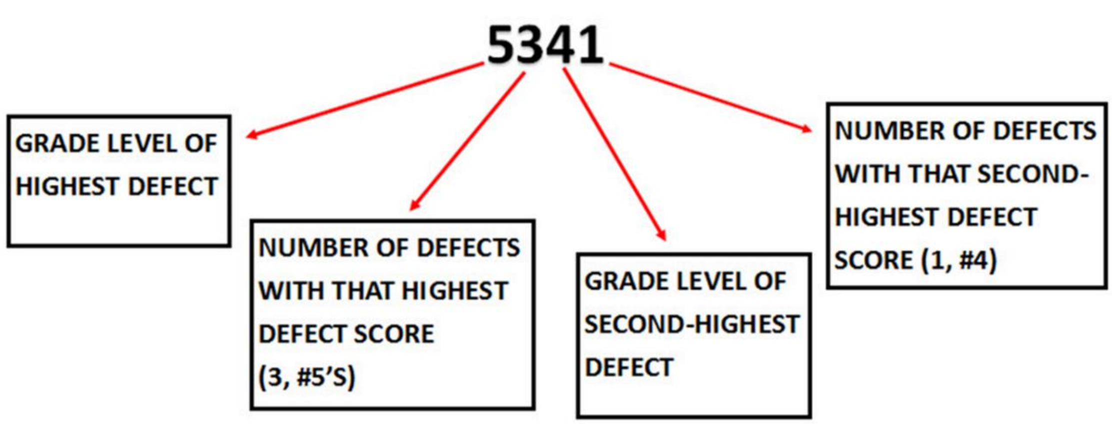
Both Operational and Maintenance and Structural pipeline deficiencies can lead to reduced pipe performance, surcharging, increased wet weather response and overall deterioration of the pipe.

Structural defects should be addressed, if needed, to prevent future pipe degradation. Recurring inspections are recommended to track changes over time.

Appendix B includes the PACP, sonar, and 3D Laser results for this inspection. The PACP defect codes are shown in the table in columns labeled “Code 1” through “Code 14”. The numbering of the defects only indicated the order in which the defects appear in the inspection (“Code 1” is the first defect that was coded, “Code 2” the second, etc). Continuous defect codes are noted by a © after the defect code. Continuous codes are defects that extend over 3 feet in length, or through sequential joints.

A defect with a “(Code) x 2”, etc., indicates the number of incidences of a particular defect in a line segment, including those indicating a continuous defect. This reporting method provides more detailed information on the types of defects that were encountered in each inspection.

Quick Scores indicate the number of defects with the highest score observed within each line segment (5 is a severe defect, 1 is a minor defect). When the number of defects, including continuous codes increases, the defect number switches to letters. In this example: 5941 means that there is nine grade 5 defects and one grade four defect. If there were to be more grade 5 scores, that quick score would become 5A41, then 5B41, 5C41, etc.



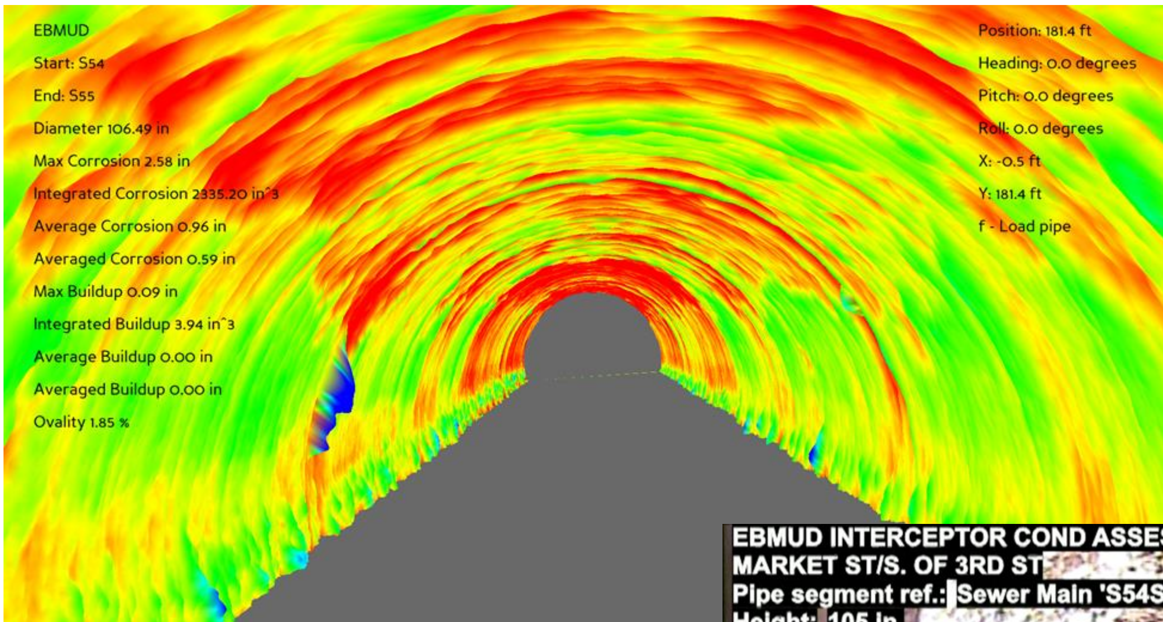
Understanding 3D Laser Inspection Results

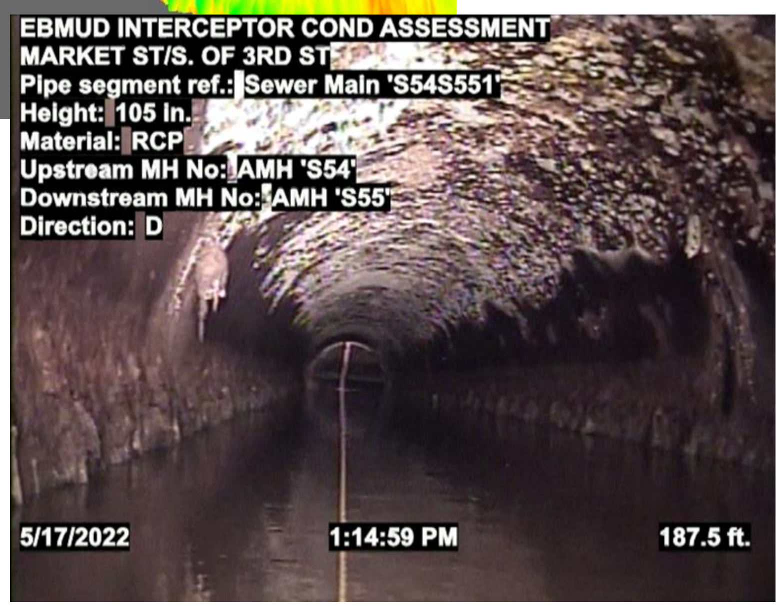
While PACP Coded CCTV inspections are a valuable tool to assess condition of sewers, CCTV technology does not measure the pipe interior, so we are unable to determine the amount of concrete corrosion that has occurred. 3D Laser/LiDar is the tool to provide this data.

3D laser collects hundreds of thousands of measurements throughout the pipe inspection. The data is then averaged using our powerful software to provide a virtual model of the interior of the pipelines, allowing the user to 'walk' through a 3D color-coded dimensional model of their pipelines. **The color coding compares the laser results against the known (or suspected) as-built pipe dimensions to determine amount of buildup or corrosion. Laser only measures the interior dimensions, and does not take into account the presence of soft concrete.**

The color ramp graduates automatically depending on the range of corrosion.

- **Green indicates as-built pipe size/condition, or pipe in better condition than the rest.**
- **Yellow indicates minor corrosion**
- **Red indicates more major corrosion, or where pipe is outside as-built measurements. The darker the red color, the more corrosion is present.**
- **Blue indicates buildup, or where pipe is inside as-built measurements.**





Each processed 3D Laser inspection produces an Excel data file with corrosion, buildup, and ovality measurements for every 1-foot slice of the pipe. Those measurements and their definitions are as follows:

MAXIMUM CORROSION: MAXIMUM DEPTH OF CORROSION IN THE ONE FOOT SECTION OF PIPE. THESE MEASUREMENTS CAN SOMETIMES BE DEEP JOINTS OR TAPS.

AVERAGE CORROSION: THE AVERAGE CORROSION FOR EACH ONE FOOT SECTION OF PIPE.

INTEGRATED CORROSION: CORROSION OVER A 1-FOOT-WIDE SECTION OF PIPE IN CUBIC INCHES.

AVERAGED CORROSION: INTEGRATED CORROSION DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE THIS NUMBER TO COMPARE THE EXTENT OF CORROSION IN EACH ONE FOOT SECTION OF PIPE.

MAXIMUM BUILDUP: MAXIMUM BUILDUP IN THE ONE FOOT SECTION OF PIPE.

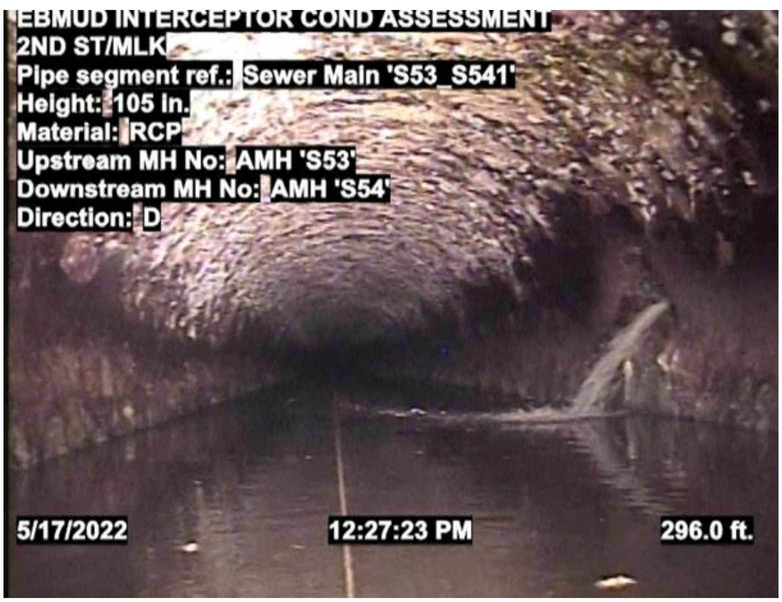
AVERAGE BUILDUP: THE AVERAGE BUILDUP FOR EACH ONE FOOT SECTION.

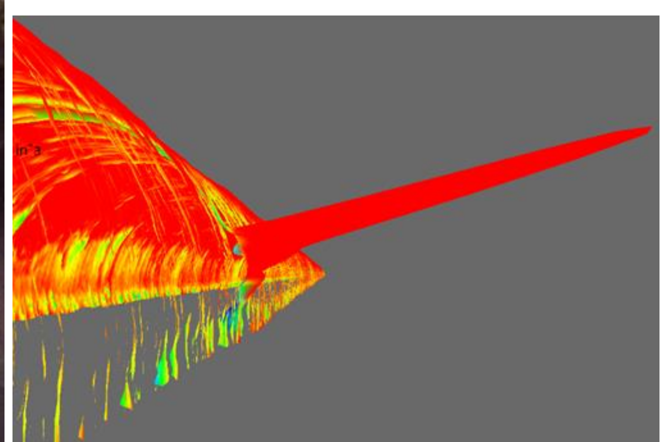
INTEGRATED BUILDUP: BUILDUP OVER A 1-FOOT-WIDE SECTION OF PIPE IN CUBIC INCHES.

AVERAGED BULDUP: INTEGRATED BUILDUP DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE THIS NUMBER TO COMPARE THE EXTENT OF BUILDUP IN EACH ONE FOOT SECTION OF PIPE.

OVALITY: CHANGE IN CIRCULARITY; THE AMOUNT OF OUT-OF-ROUNDNESS.

Keep in mind that measurements reflect "Corrosion **OR** Outside Reference Circle", "Buildup **OR** Inside Reference Circle", or near "As-Built Condition". The outside reference circle measurement does not always indicate corrosion; it could be recording a deeper joint, a hole, or a tap. In S53 to S54, a tap is located at 314 feet, which is clearly visible if we look from the exterior of the pipe scan.

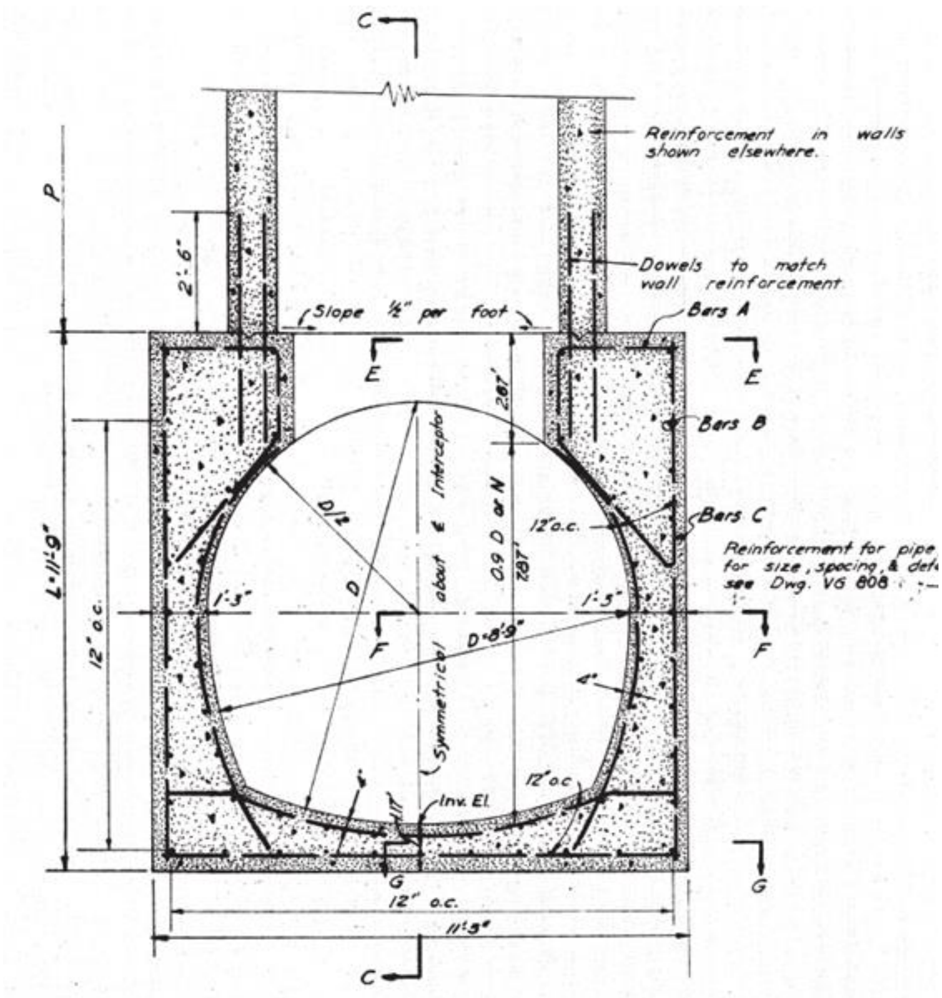




When reviewing data, it is best to review the "Average Corrosion" to determine the average corrosion level throughout the pipe scans, with emphasis on larger continuous corrosion levels that indicate consistent high corrosion levels over long lengths of pipe. The "Integrated Corrosion" shows the amount of corrosion in cubic inches over a 1-foot slice of pipe. These values can be used to compare and find the location in the pipelines with the highest overall corrosion.

DETERMINING WALL LOSS IN THE 105" MONOLITHIC PIPE

The 3D laser software and viewer compares the laser data measured in the pipe against the as-built dimensions of the pipe. For circular pipes, this is simple. For horseshoe-shaped monolithic pipe like the three 105" segments completed as part of this inspection phase, we relied on the as-built drawings provided by EBMUD to try and configure the as-built dimensions. The monolithic pipe measurement details were limited, so we digitized the cross section to reflect the dimensional information that was shown in the drawings to get the correct as-built pipe geometry. A special software program had to be written to compare these digitized measurements with the laser measurements to produce the 3D model.

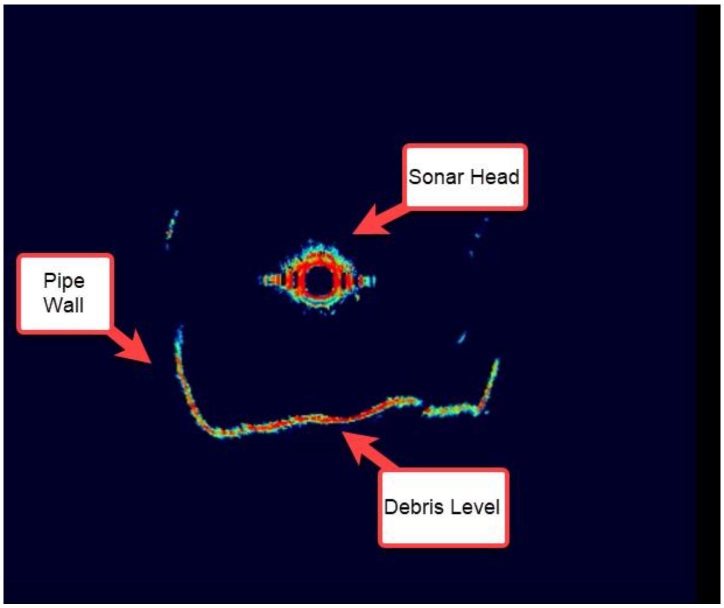


SECTION B-B
MONOLITHIC PIPE

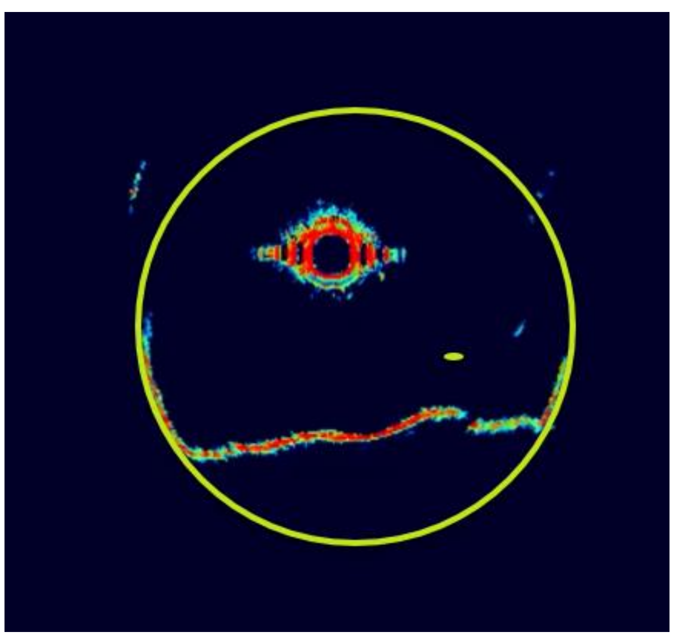
EBMUD DRAWING
VG 839

UNDERSTANDING SONAR RESULTS

The Marine Electronics Profiling Sonar was utilized to profile the pipe under the water line. The sonar unit is an acoustical device 2D profiling device that takes between 1-3 profile scans per foot. The number of scans per foot depends on the rate of travel of the platform.



We can then compute the depth of debris in each scan. Our software computes that volume of debris assumed over the 1 foot of pipe length. Of course, the sonar only scans the material it hits and provides the depths, but we have to no way to know if that debris is solid matter like gravel, or light fines or rags that will consolidate once removed from the pipes.

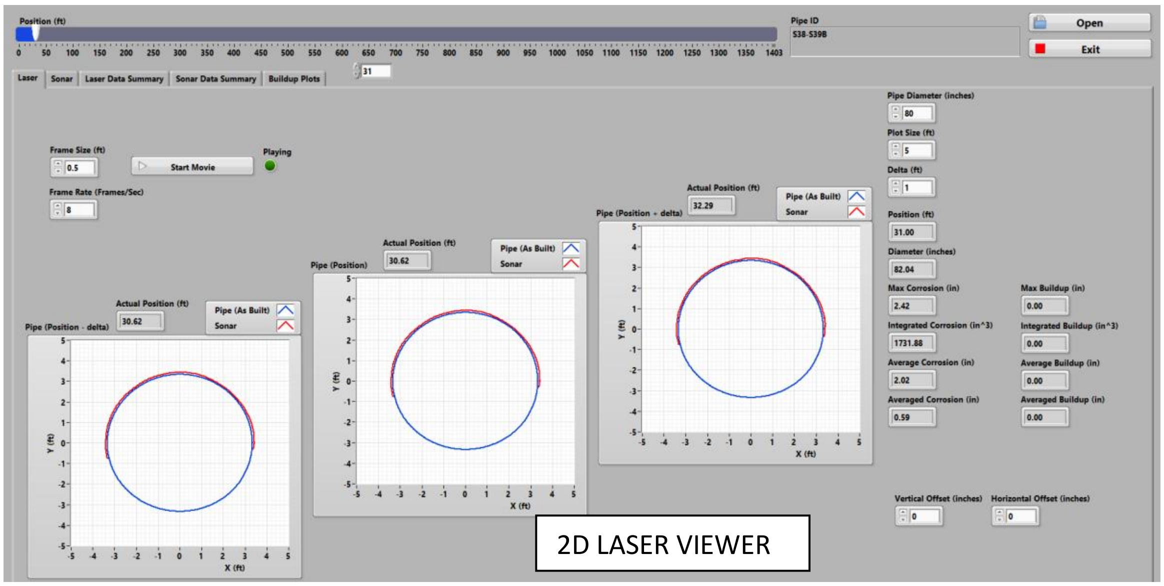


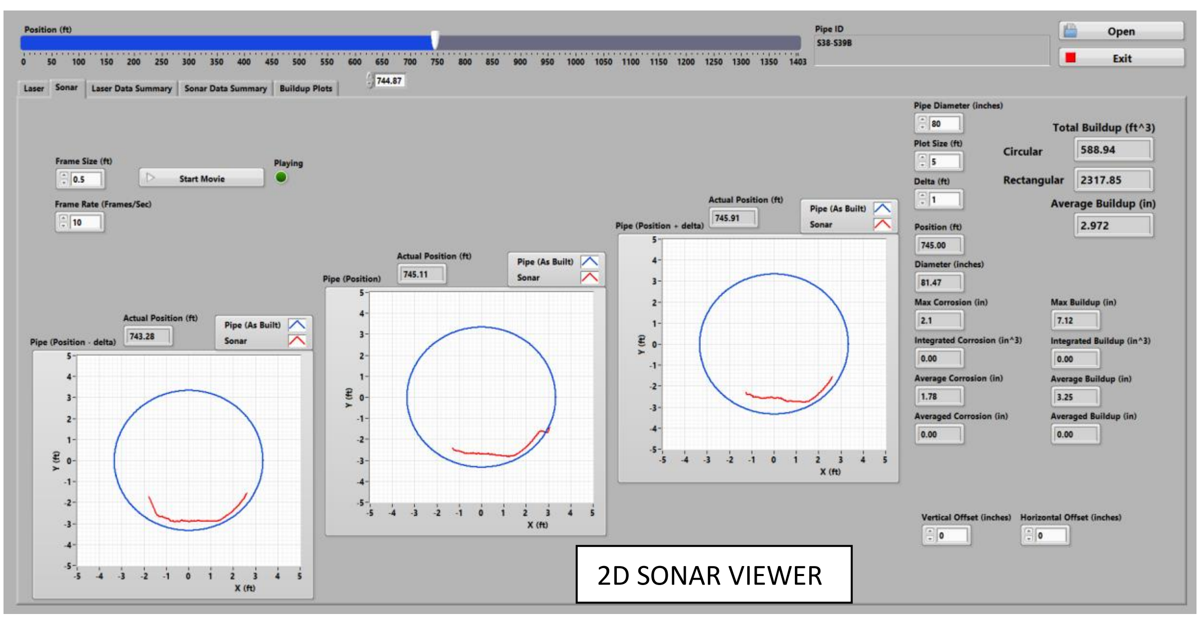
2D LASER AND SONAR VIEWER

The 2D sonar and laser viewer is a separate viewing tool to view the profile scans of the sonar and laser results as compared to the cross sections of pipe. Downloading and viewing Instructions are found in the Dropbox link, but we have created movies of the 2D Sonar and 2D laser scans for ease of viewing and uploading to EBMUD's asset management system.

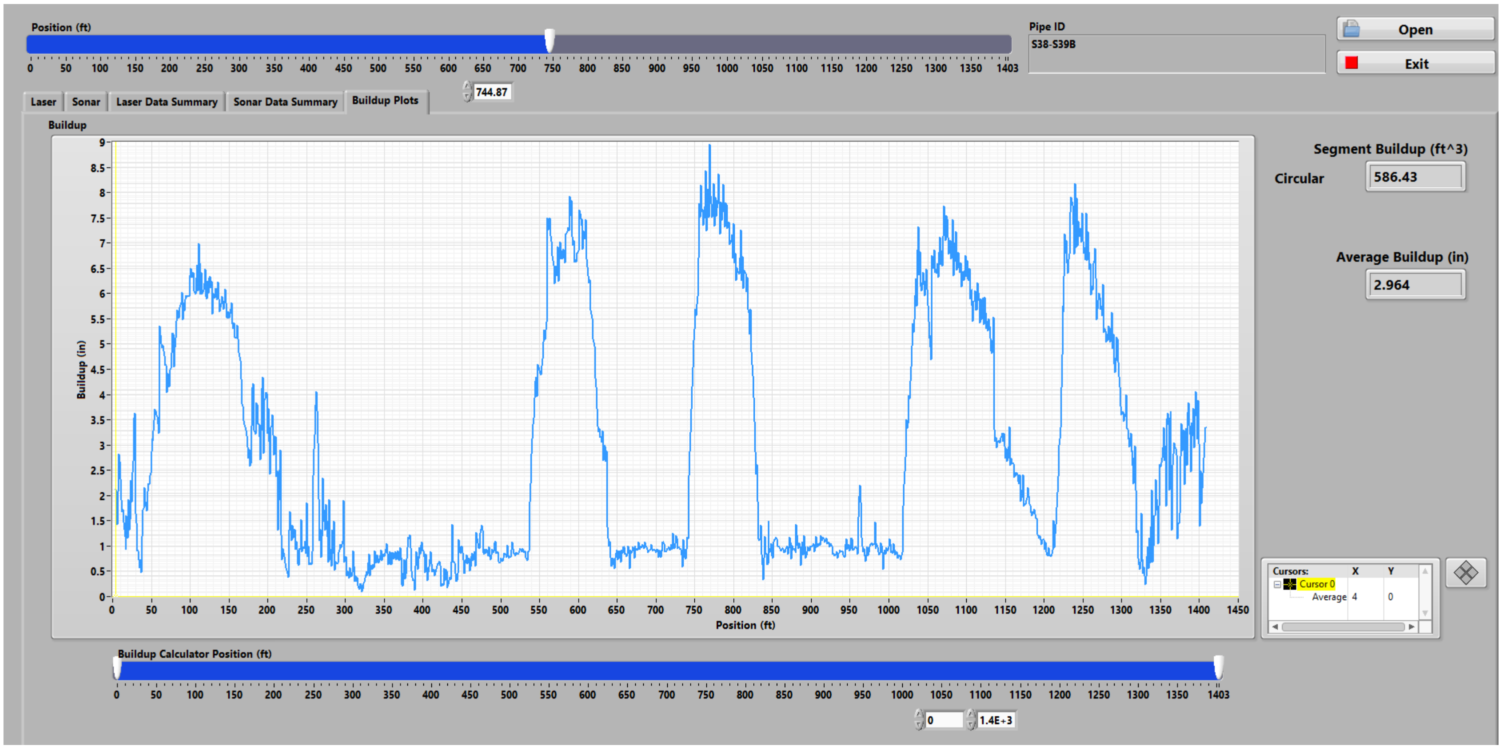
<u>For segment S38 to S39, the as-builts say the pipe is 78 inches, however, the walls appear in relatively good condition. Therefore, we ran the 2D and 3D modeling software to reference 80-inch for the as-built dimension as that looked more realistic.</u>

Sample images from the 2D viewer for sonar and laser are shown below:





The 2D viewer also provides a debris graph over the entire pipe length, and shows average buildup in inches, and the total buildup in the entire segment in cubic feet.



INSPECTION SUMMARY

In each inspection, corrosion varies over the pipe surface, and can exhibit deep to no corrosion all within a one-foot scan. This is why our continuous 3D laser profiling is critical as it provides a full dimensional model for every inch of pipe wall to know where the corrosion levels can pose a risk of failure. The summary table of 3D Laser results from this inspection (from Appendix B) follows:

Upstream MH	Downstream MH	DATE	TIME	INSPECTION DIRECTION	AS-BUILT PIPE SIZE	ACTUAL MATERIAL	FOOTAGE INSPECTED	MAXIMUM CORROSION IN A 1FT SCAN (INCH)	MAXIMUM AVERAGE CORROSION IN 1FT SCAN (INCH)	AVERAGE CORROSION OVER ENTIRE PIPE (INCH)	AVERAGE PIPE DIAMETER (INCH)	DEBRIS/ SONAR RESULTS (CF)
S53	S54	5/17/2022	12:-05 PM	D	105	RCP	973.70	5.18	2.72	1.76	107.35	6534
S54	S55	5/17/2022	1:04 PM	D	105	RCP	282.00	4.34	2.24	1.03	106.52	2953
S47	S48	5/18/2022	12:00 PM	D	105	RCP	707.80	5.85	3.43	1.34	106.75	N/A
S14	S15	5/19/2022	10:48 AM	D	63	RCP	847.60	4.33	2.29	1.2	65.39	420
S15	S16	5/19/2022	2:50 PM	U	63	RCP	566.00	4.84	2.98	1.13	65.26	164
S38	S39	5/20/2022	11:24 AM	D	78 *	RCP	1410.10	1.86	1.4	0.66	81.3	586
						TOTAL	4,787.20					10,657

* AS-BUILT DIMENSION OF 78" IS IN QUESTION

MAXIMUM CORROSION: MAXIMUM DEPTH OF CORROSION IN A 1 FOOT SECTION OF PIPE

AVERAGE CORROSION: THE AVERAGE CORROSION OVER THE ENTIRE LENGTH OF PIPE

MAXIMUM AVERAGE CORROSION: THE ONE FOOT SECTION OF PIPE WITH THE HIGHEST AVERAGE CORROSION

The following PACP summary table indicates the Structural and O&M Quick scores, and the overall PACP score. The particular defects coded are listed in Appendix B, with their occurrences summarized as described on page 7. The following surface damage codes were observed: SRI, SAV, SAP, SSC, SRV, SRC, and SAM. Infiltration areas were also coded (ID, IW, and IR).

Upstream MH	Downstream MH	AS-BUILT PIPE SIZE	ACTUAL MATERIAL	FOOTAGE INSPECTED	PACP STRUCTURAL QUICK SCORE	PACP O&M QUICK SCORE	OVERALL PACP SCORE
S53	S54	105	RCP	973.70	513Z	0000	2
S54	S55	105	RCP	282.00	3J1J	3114	2
S47	S48	105	RCP	707.80	5444	342Z	2
S14	S15	63	RCP	847.60	5545	4137	1.5
S15	S16	63	RCP	566.00	5C4B	3100	1.5
S38	S39	78 *	RCP	1410.10	2Z1Z	2100	1.3
			TOTAL	4,787.20			

TECHNICAL MEMORANDUM

NOTE ABOUT MSI INSPECTIONS

It is up to each utility owner to determine the time for rehabilitation and repair, and the extent and method of repair, based on their risk tolerance, the criticality of the asset, and available budget.

Multi-sensor inspections are best completed at regular intervals to determine rate of corrosion, ovality, or other defects as it is difficult to predict remaining useful life with only one data set. Good asset management practices track changes in pipe material over time to determine if corrosion/defects are increasing in severity and number, or staying constant. The results of any first inspections performed by National Plant Services should be considered a baseline, and compared against future years to track changes in pipe deterioration, which will help determine proper maintenance frequencies, and remaining useful life of EBMUD's assets.

Sincerely,

Michelle Beason, PE
Regional Manager/Principal Engineer
National Plant Services, Inc., 2159 National Avenue, Hayward, CA 94545

APPENDIX A

CCTV Videos

Delivered via Dropbox

https://www.dropbox.com/scl/fo/e3bkvjaq4nqjye3ovzden/h?dl=0&rlkey=13phofdk91ey8z3s3vlfi5duf

APPENDIX B

CCTV Inspection Results/PACP Score Summary

MSI Corrosion Summary

Sonar Debris Volumes

Appendix B includes the PACP Structural and O&M Defect scores that were observed in each inspection. The PACP codes are shown in the table in columns labeled "Code 1" through "Code 14".

Continuous defect codes are listed with a © after the defect code.

A defect with a "(Code) x 2", etc., indicates the number of incidences of a particular defect in a line segment, including when indicating multiple instances of a continuous code.

Upstream MH	Downstream MH	DATE	TIME	INSPECTION DIRECTION	AS-BUILT PIPE SIZE	ACTUAL MATERIAL	FOOTAGE INSPECTED	MAXIMUM CORROSION IN A 1FT SCAN (INCH)	MAXIMUM AVERAGE CORROSION IN 1FT SCAN (INCH)	AVERAGE CORROSION OVER ENTIRE PIPE (INCH)	AVERAGE PIPE DIAMETER (INCH)	DEBRIS/ SONAR RESULTS (CF)	Debris per foot of pipe (CF)	AVERAGE DEPTH OF DEBRIS (INCHES)	PACP STRUCTURAL QUICK SCORE	PACP O&M QUICK SCORE	OVERALL PACP SCORE
S53	S54	5/17/2022	12:-05 PM	D	105	RCP	973.70	5.18	2.72	1.76	107.35	6534	6.7	9.2	513Z	0000	2
S54	S55	5/17/2022	1:04 PM	D	105	RCP	282.00	4.34	2.24	1.03	106.52	2953	10.5	14.3	3J1J	3114	2
S47	S48	5/18/2022	12:00 PM	D	105	RCP	707.80	5.85	3.43	1.34	106.75	N/A	N/A	N/A	5444	342Z	2
S14	S15	5/19/2022	10:48 AM	D	63	RCP	847.60	4.33	2.29	1.2	65.39	420	0.5	3.63	5545	4137	1.5
S15	S16	5/19/2022	2:50 PM	U	63	RCP	566.00	4.84	2.98	1.13	65.26	164	0.3	2.52	5C4B	3100	1.5
S38	S39	5/20/2022	11:24 AM	D	78 *	RCP	1410.10	1.86	1.4	0.66	81.3	586	0.4	2.96	2Z1Z	2100	1.3
						TOTAL	4,787.20					10,657					

Upstream MH	PACP SCORE 1	PACP SCORE 2	PACP SCORE 3	PACP SCORE 4	PACP SCORE 5	PACP SCORE 6	PACP SCORE 7	PACP SCORE 8	PACP SCORE 9	PACP SCORE 10	PACP SCORE 11	PACP SCORE 12	PACP SCORE 13	PACP SCORE 14
S53	MWL 40%	SAP©	SSC©	TBA	SRC									
S54	MWL 40%	SAP©	SSC©	LL©	MGO - POSSIBLE HOLES OR SAM X 2	ID								
S47	MWL 40%	SAP©	SSC©	SRV©	SRC©	DAE© X 2	SRV X 2	SRC X 2	IW© X 2	ID X 4	DAE X 9	IW X 6		
S14	MWL 35%	IW X 4	SRI©	DAE© X 2	SSC©		DAE X 3	IS X 2	IS©	ID X 7	SAP©	SRV©	SRC©	IR
S15	MWL 35%	SRI© X 3	SSC© X 2	MGO - LIGHT STEAM	SAV	SAV© X 2	SAP© X 2	SRV	SRC	SRV©	SRC© X 2	SRP©	SAM X 2	ID
S38	MWL 35%	SRI©	SSC©	SAV©	IWJ									

* AS-BUILT DIMENSION OF 78" IS IN QUESTION
3D MODEL WAS RUN AT 80 INCHES

MAXIMUM CORROSION: MAXIMUM DEPTH OF CORROSION IN A 1 FOOT SECTION OF PIPE
AVERAGE CORROSION: THE AVERAGE CORROSION OVER THE ENTIRE LENGTH OF PIPE
MAXIMUM AVERAGE CORROSION: THE ONE FOOT SECTION OF PIPE WITH THE HIGHEST AVERAGE CORROSION

APPENDIX C

Line Segment MSI Summary Reports With Laser/Sonar Videos and Excel Data Files

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

MULTI-SENSOR INSPECTION SUMMARY REPORT FOR: S14 TO S15, 63" RCP, 847.6 LF INSPECTED LENGTH

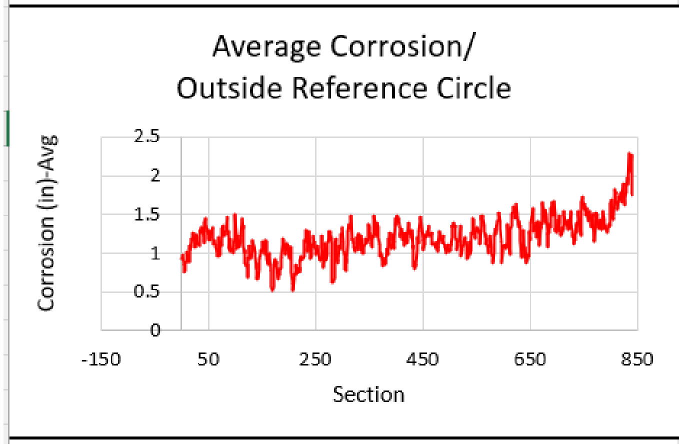
INSPECTION PROCEEDED DOWNSTREAM. THE FLOATING PONTOON WAS USED FOR THIS INSPECTION. WATER LEVEL WAS AT 35%.

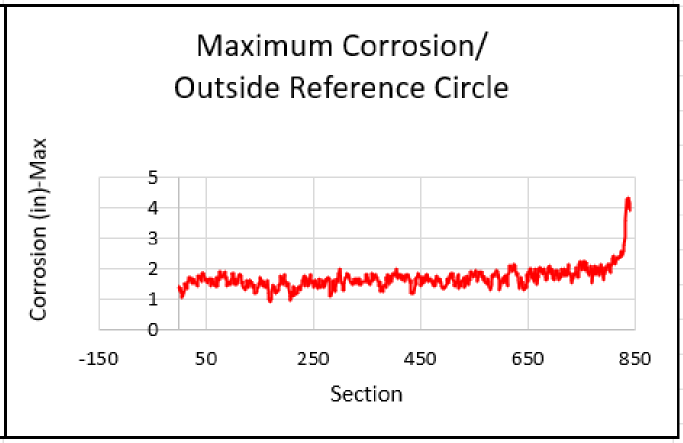
THE DOWNSTREAM MANHOLE HAS A TIE-IN WITH A SIGNIFICANT AMOUNT OF WATER FLOWING INTO THE PIPE AT THIS LOCATION. CONSEQUENTLY, THE HIGHEST CORROSION READINGS ARE NEAR THIS DOWNSTREAM MANHOLE. HIGHEST CORROSION LEVELS ARE FROM 832-844 FEET. MAXIMUM CORROSION IS 4.33 INCHES AT 841 FEET. SURFACE DAMAGE PRESENT INCLUDING REINFORCEMENT VISIBLE/CORRODED AT END OF PIPE SEGMENT.

AVERAGE CORROSION OVER ENTIRE LENGTH OF PIPE IS 1.2 INCHES.

THE TOTAL DEBRIS AS MEASURED BY THE SONAR IS 420 CF (15.6 CY).

Measurement	*Measurement From Pipe Center (Inches)*
Average Corrosion/Outside Reference Circle	1.20
Maximum Average Corrosion/Outside Reference Circle	2.29
Maximum Corrosion/Outside Reference Circle	4.33





Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

PACP SCORING REPORT

PACP v7.0 Inspections and Scoring

General Information:

Surveyed by:	Certificate number:	Reviewed by:	Reviewer certificate no.	Owner:	Customer:
F MORENO/NPS	U-913-19012				

P/O number:	Work order no.:	Media label:	Project name:	Start date/time:
			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022	20220519 10:48

Sheet number:	Weather:	Pre-cleaning:	Date cleaned:	Flow control:	Purpose:
	1	N		N	F

Direction:	Technology used:	Inspection status:	Consequence of failure:	Pressure value:
D		CI		

Location:

Drainage area:	Pipe segment ref.:	Street:
	S14S151	COLISEUM WY/N. OF KEVIN CT

City:	Location code:	Location details:
OAKLAND	B	

Pipe:

Pipe use:	Height:	Width:	Shape:	Material:	Lining method:
SS	63 in.		C	RCP	

Coating method:	Pipe joint length:	Total length:	Length surveyed:	Year constructed:	Year renewed:
		847.600 ft.	847.600 ft.		

Measurements:

	MH No:	Rim to invert:	Rim to grade:	Grade to invert:	Northing:	Easting:	Elevation:
Upstream	S14						
Downstream	S15						

MH coordinate system:	MH vertical datum:	GPS accuracy:

Pipe Ratings

Grade	Structural: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	O&M: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	Overall: Pipe Rating	Pipe Rating Index	LoF	Risk
1	338	338	401	5545	1.1	162	162	881	4137	1.7	1,282	1.5	5.5	
2	0	0				347	694							
3	6	18				7	21							
4	5	20				1	4							
5	5	25				0	0							

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
0.0 ft.		AMH					☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 0.0 ft_3.JPG	S14
0.0 ft.		MWL				35	☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---MWL at 0.0 ft_2.JPG	
0.0 ft.	00:01:34	IW					☐	12 /		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IW at 0.0 ft.JPG	
0.0 ft.	00:01:59	SRI	S01				☐	8 /	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 0.0 ft.JPG	
0.0 ft.	00:02:34	DAE	S02			5	☐	4 /		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---DAE at 0.0 ft_1.JPG	

Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	Value Inches (mm) 2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
0.0 ft.	00:03:01	DAE	S03			5	☐	8 /		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---DAE at 0.0 ft_2.JPG	
10.0 ft.	00:04:26	SSC	S04				☐	8 /	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 10.0 ft_1.JPG	
19.8 ft.	00:06:36	IW					☑	9 /	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IW at 19.8 ft_1.JPG	
19.8 ft.	00:07:15	DAE				5	☑	8 /	10	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---DAE at 19.8 ft.JPG	
30.1 ft.	00:09:08	IS					☑	8 /	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IS at 30.1 ft_1.JPG	
36.0 ft.	00:10:27	IS					☑	8 /	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IS at 36.0 ft_1.JPG	
45.4 ft.	00:11:34	IS	S05				☑	8 /	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IS at 45.4 ft.JPG	

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	Value Inches (mm) 2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
269.4 ft.	00:22:27	ID					☑	12 /		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---ID at 269.4 ft_1.JPG	
439.0 ft.	00:30:16	ID					☑	11 /	1	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---ID at 439.0 ft_1.JPG	
494.6 ft.	00:33:14	ID					☑	10 /	12	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---ID at 494.6 ft.JPG	
494.6 ft.	00:33:30	DAE				5	☑	10 /	12	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---DAE at 494.6 ft_1.JPG	
506.3 ft.	00:34:51	IW					☑	9 /	12	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IW at 506.3 ft.JPG	
688.9 ft.	00:44:48	IW					☑	9 /	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IW at 688.9 ft.JPG	
752.6 ft.	00:48:14	ID					☑	12 /		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---ID at 752.6 ft_1.JPG	

Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	Value Inches (mm) 2nd	%	Joint	Circumferential Location At/From	Circumferential Location To	Rating	Image Ref.	Remarks
784.9 ft.	00:49:56	ID					☑	10	12	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---ID at 784.9 ft_1.JPG	
793.6 ft.	00:51:22	ID					☑	9	12	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---ID at 793.6 ft.JPG	
793.6 ft.	00:51:40	DAE				5	☑	9	12	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---DAE at 793.6 ft_1.JPG	
801.7 ft.	00:52:32	ID					☑	12		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---ID at 801.7 ft_1.JPG	
818.7 ft.	00:54:01	SAP	S06				☑	9	3	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 818.7 ft_1.JPG	
824.7 ft.	00:56:04	SRV	S07				☑	10	2	4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRV at 824.7 ft_1.JPG	
824.7 ft.	00:56:35	SRC	S08				☑	10	2	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRC at 824.7 ft_1.JPG	

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	Value Inches (mm) 2nd	%	Joint	Circumferential Location At/From	Circumferential Location To	Rating	Image Ref.	Remarks
844.8 ft.	00:59:27	IR					☐	12		4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IR at 844.8 ft_1.JPG	
847.5 ft.	01:00:47	SRC	F08				☑	10	2	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRC at 847.5 ft.JPG	
847.5 ft.	01:00:52	SRV	F07				☑	10	2	4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRV at 847.5 ft.JPG	
847.5 ft.	01:01:00	SAP	F06				☑	9	3	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 847.5 ft.JPG	
847.5 ft.	01:01:05	IS	F05				☑	8	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IS at 847.5 ft.JPG	
847.5 ft.	01:01:10	SSC	F04				☐	8	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 847.5 ft.JPG	
847.5 ft.	01:01:17	DAE	F03			5	☐	8		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---DAE at 847.5 ft.JPG	

Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

Observations

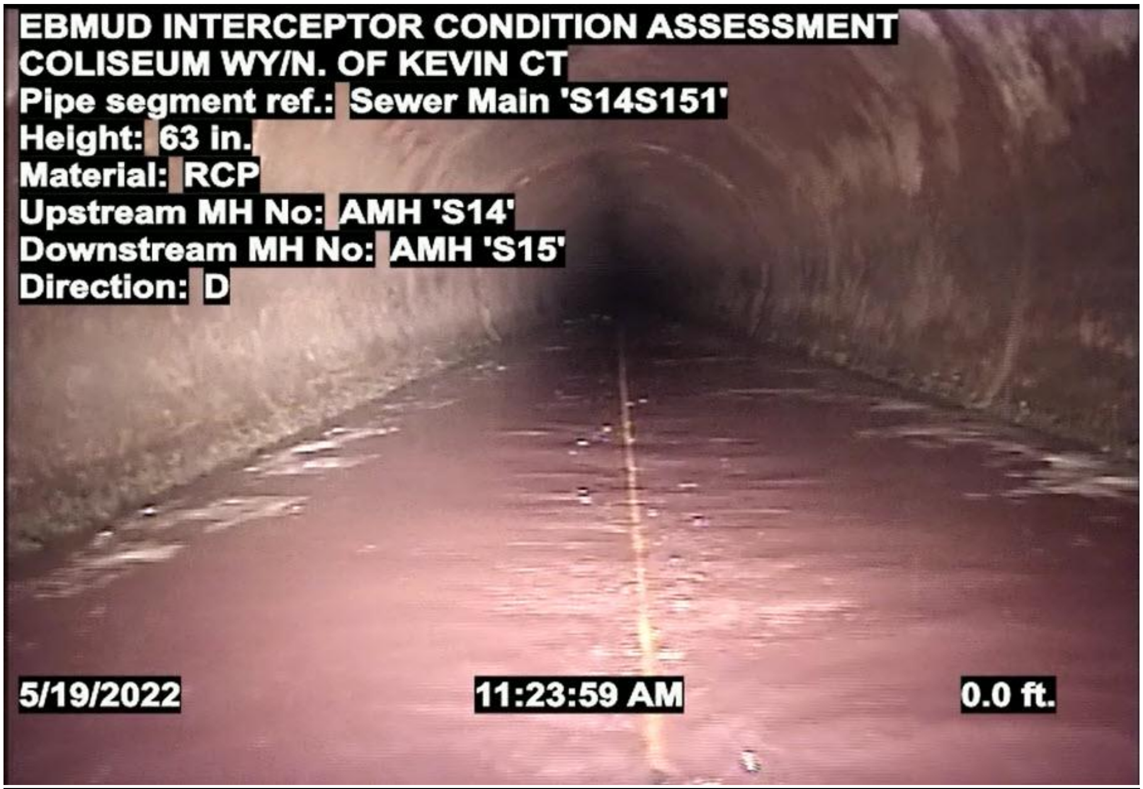
Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	Value Inches (mm) 2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
847.5 ft.	01:01:22	DAE	F02			5	☐	4 /		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---DAE at 847.5 ft_1.JPG	
847.5 ft.	01:01:26	SRI	F01				☐	8 /	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 847.5 ft.JPG	
847.5 ft.	01:01:30	AMH					☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 847.5 ft.JPG	S15

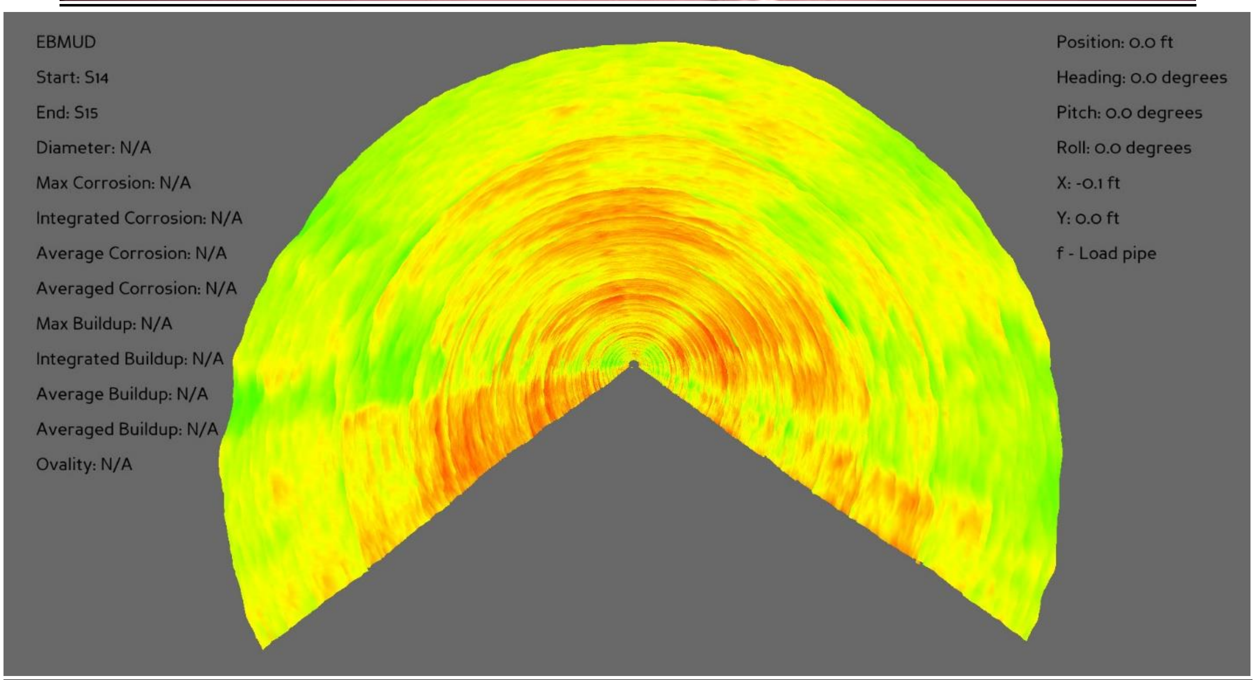
Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

IMAGE REPORT :

GENERAL INTERIOR VIEW, 0 FEET

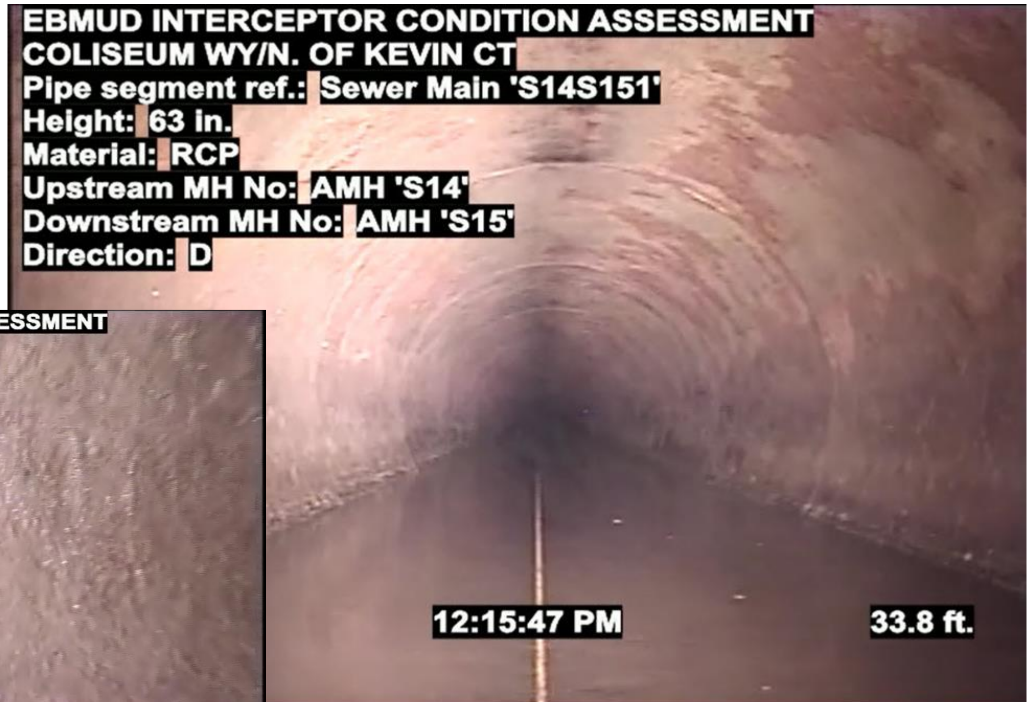


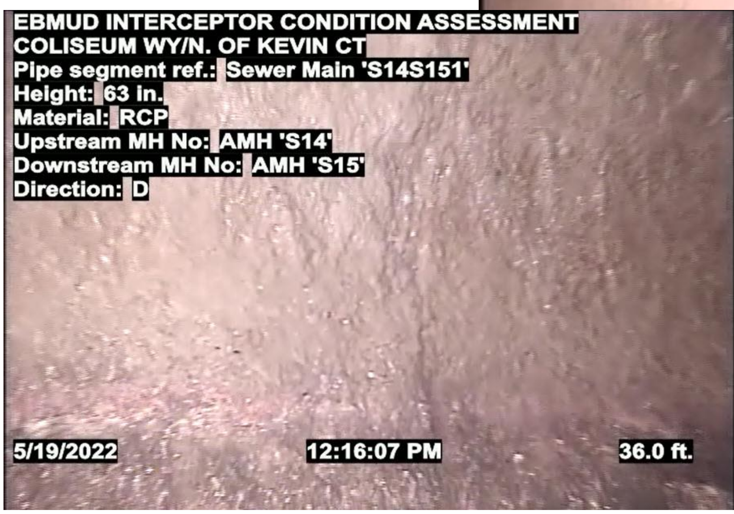


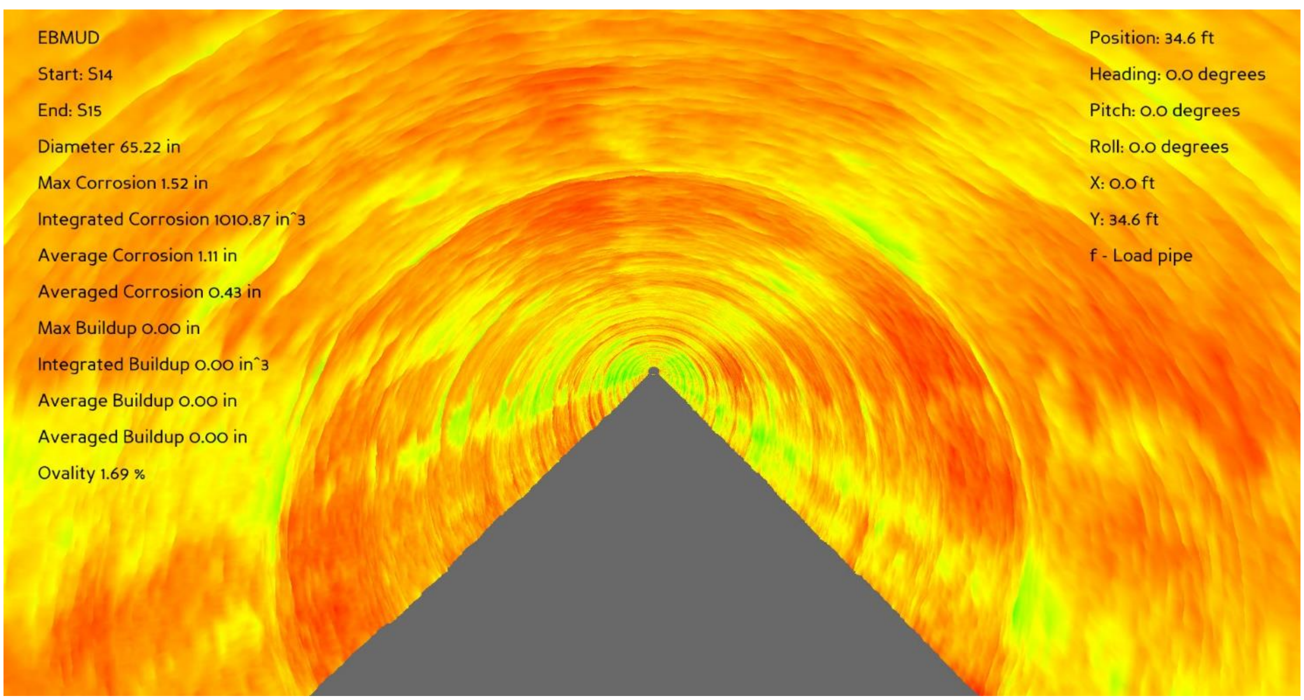
Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

GENERAL INTERIOR VIEW, 33 FEET



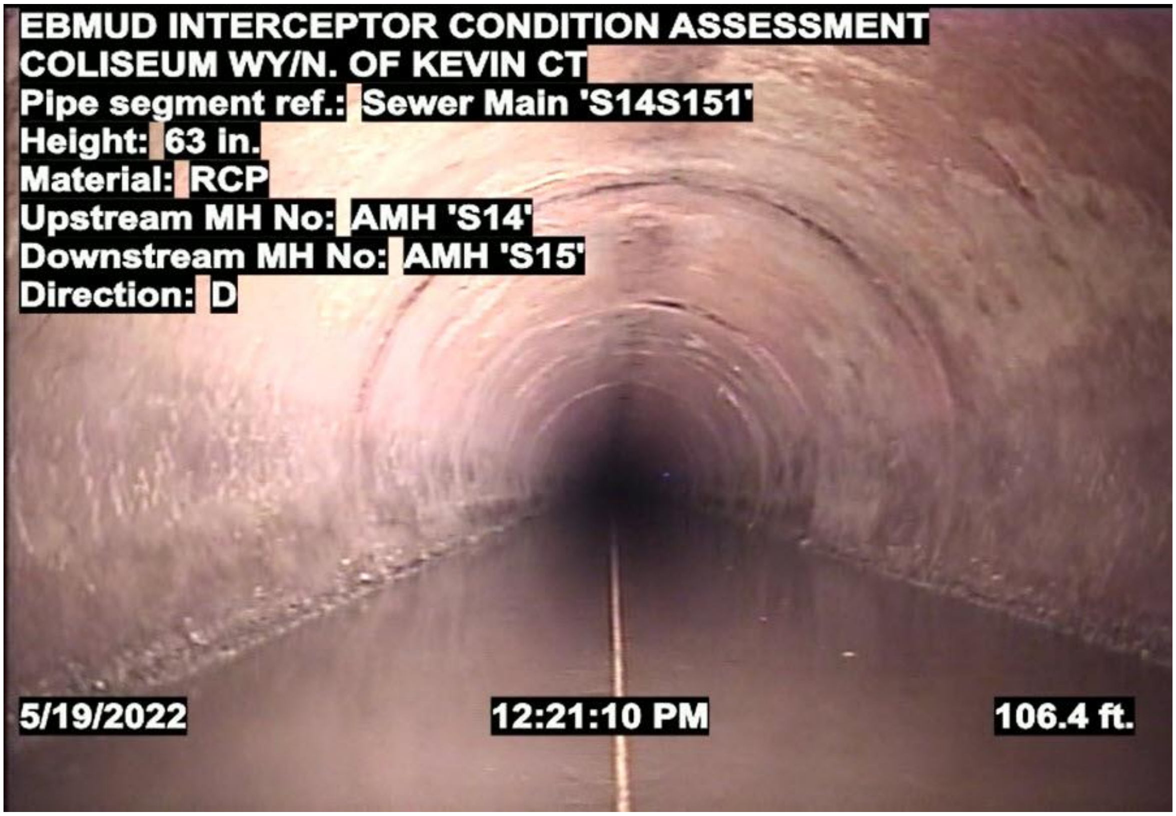


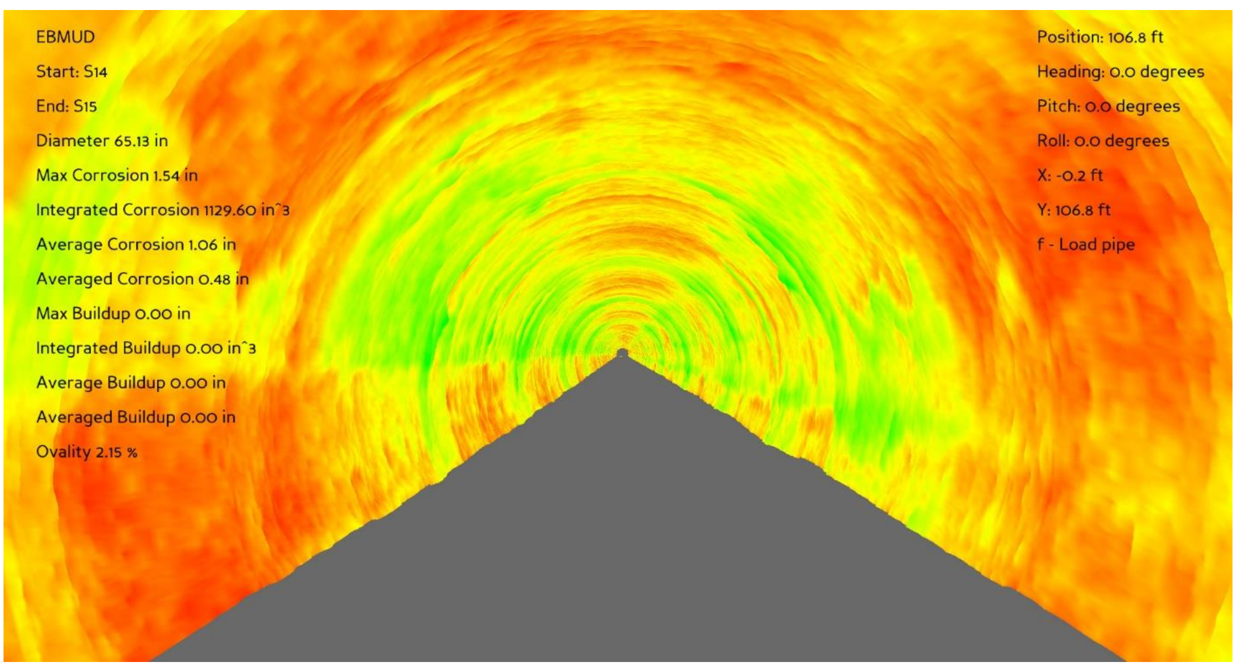


Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

GENERAL INTERIOR VIEW, 106 FEET

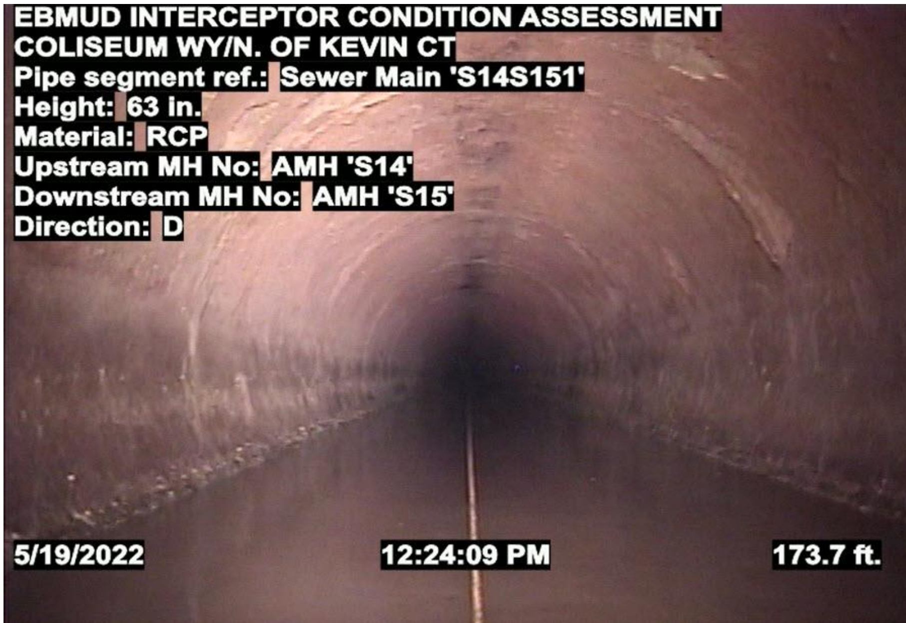


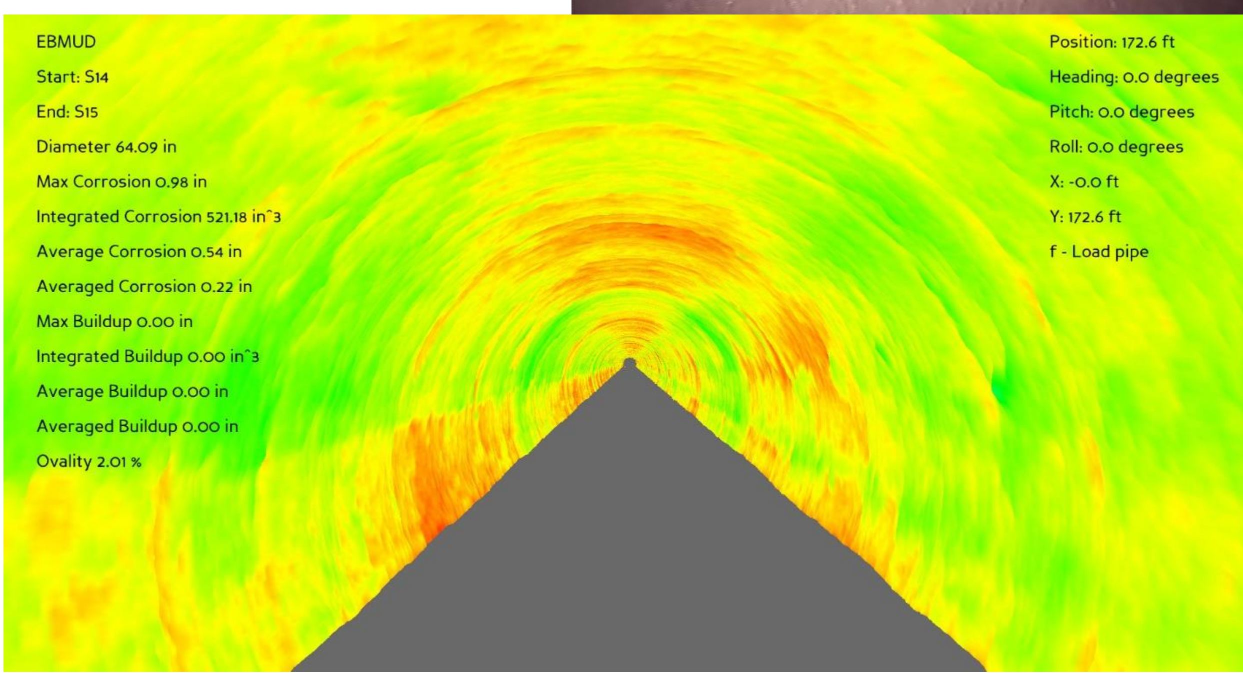


Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

GENERAL INTERIOR VIEW, 173 FEET

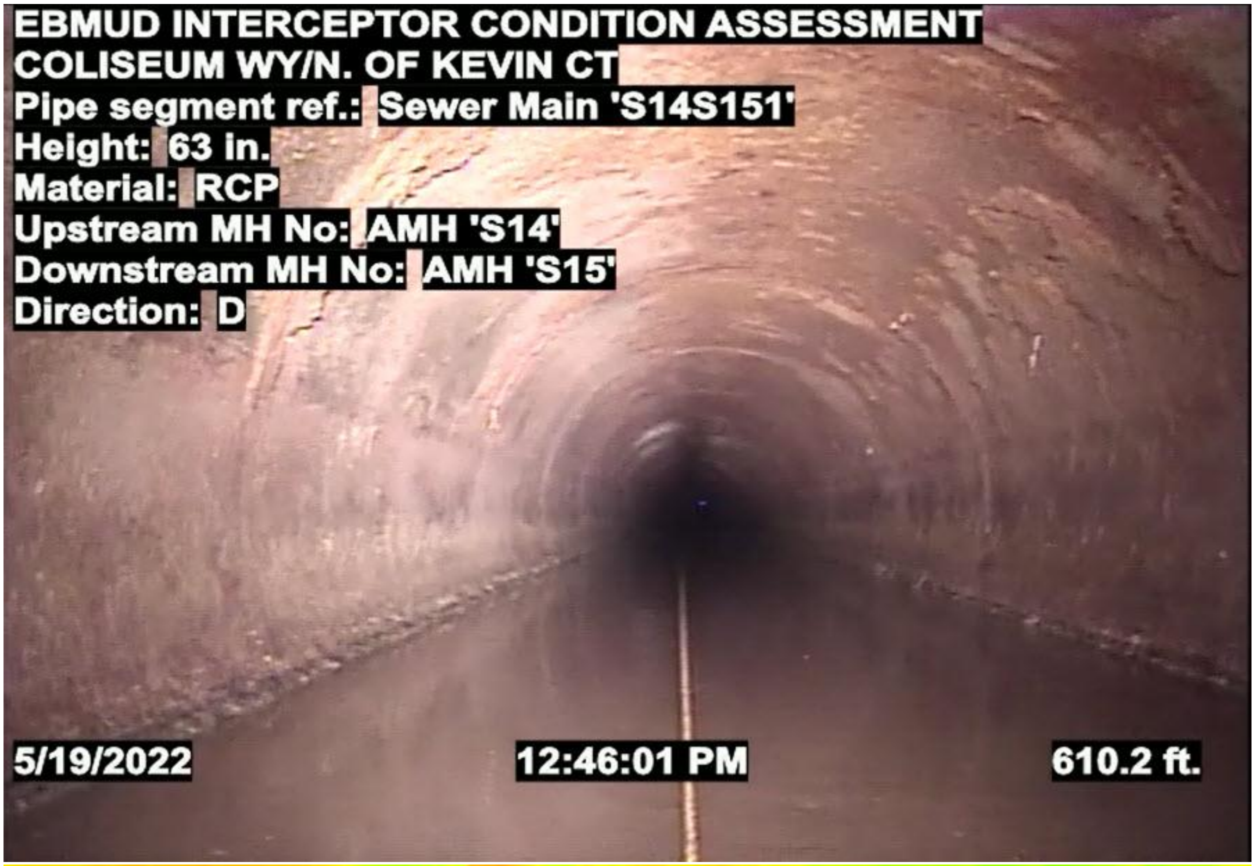


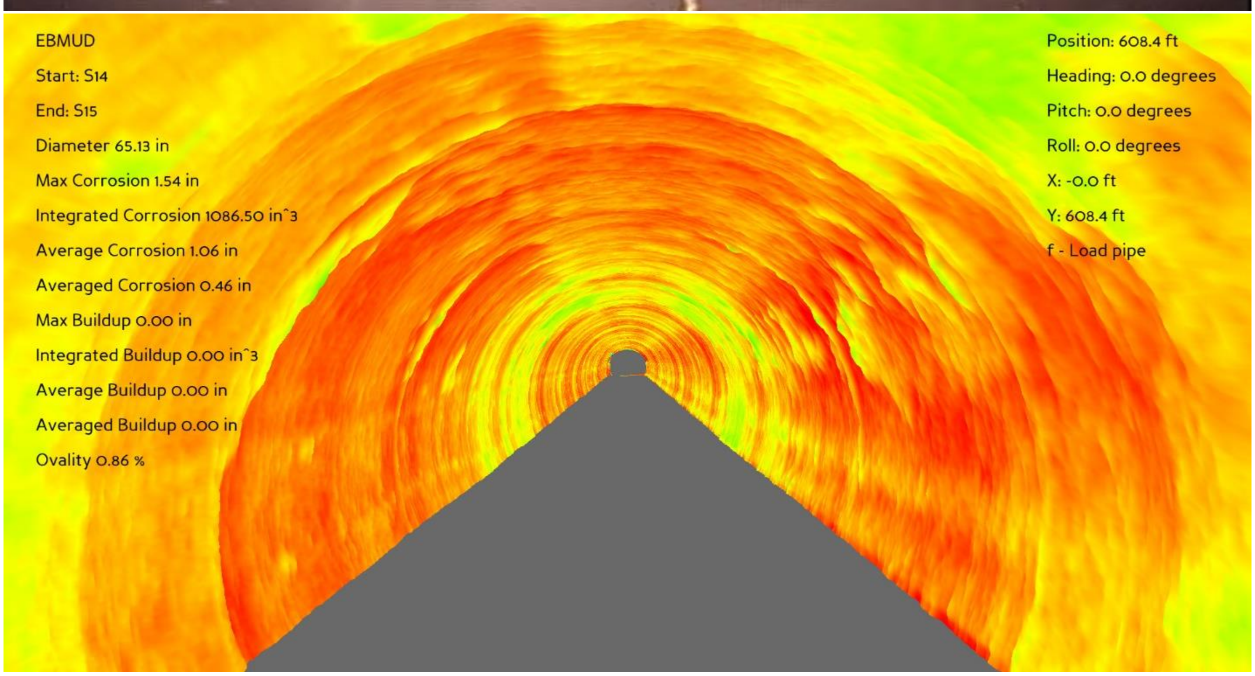


Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

GENERAL INTERIOR VIEW, 608 FEET

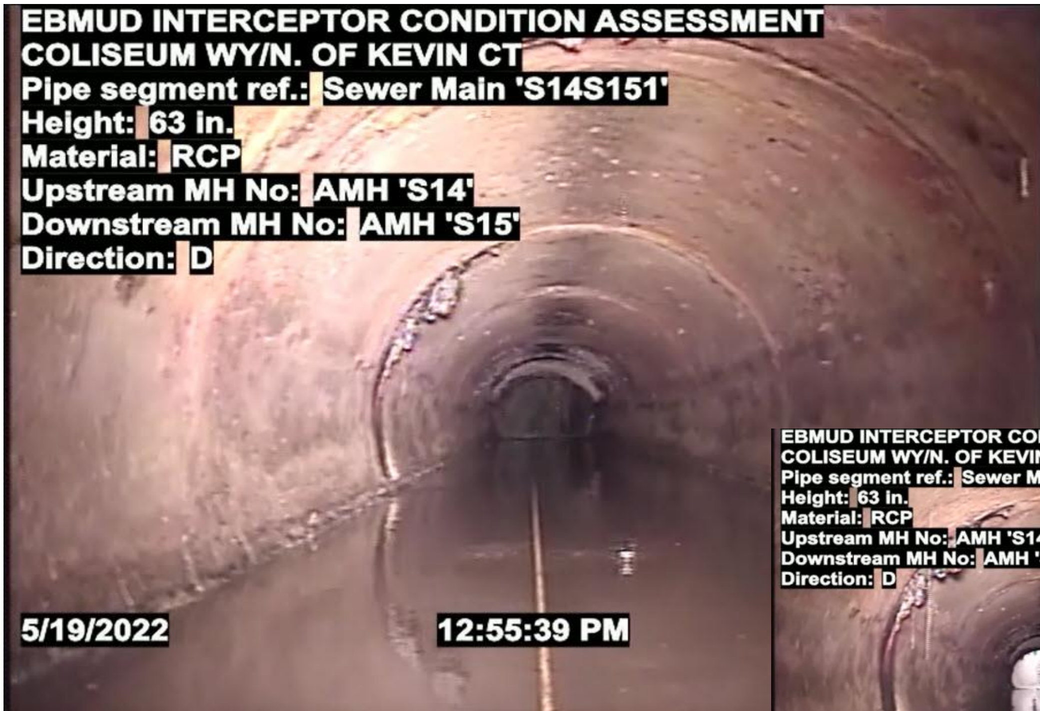


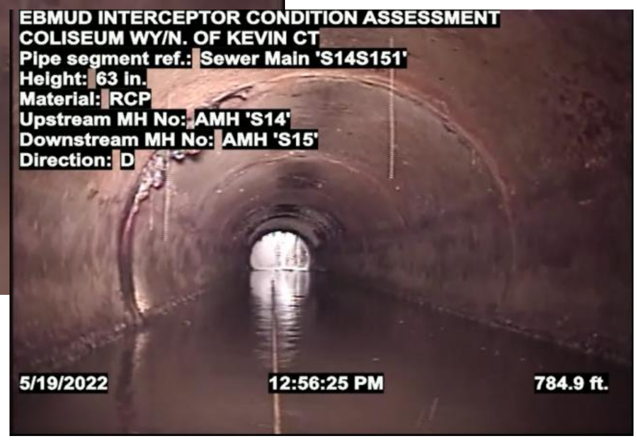


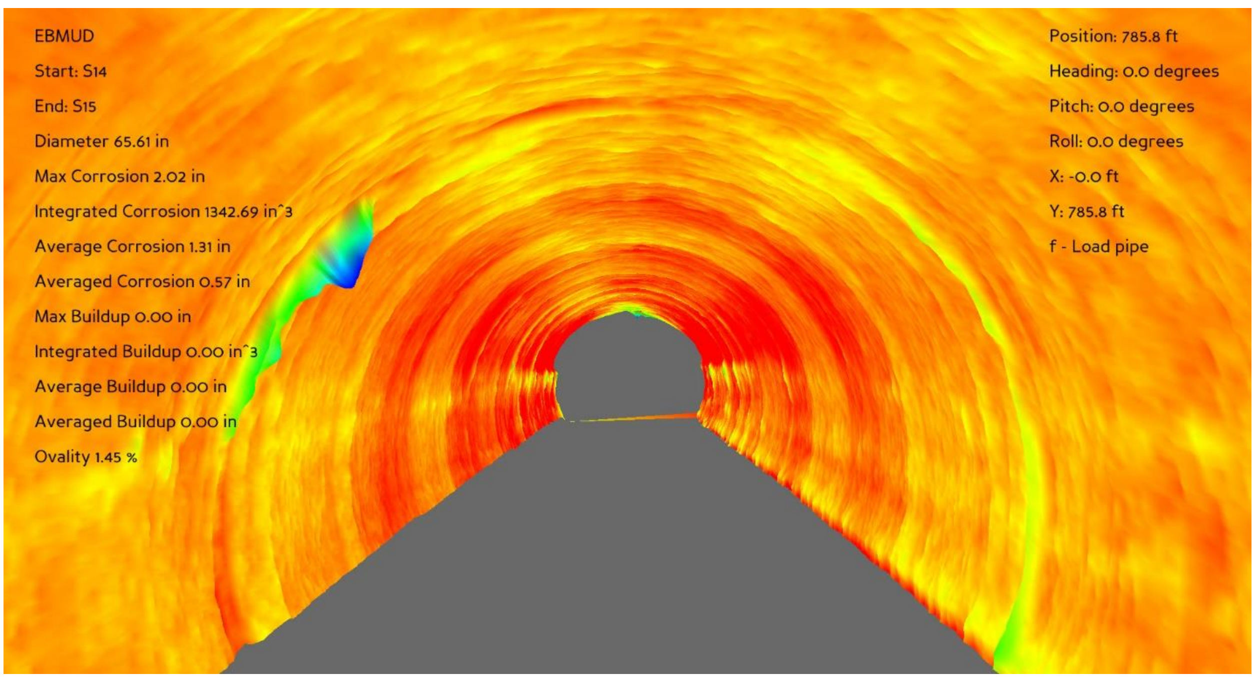
Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

GENERAL INTERIOR VIEW 785 FEET





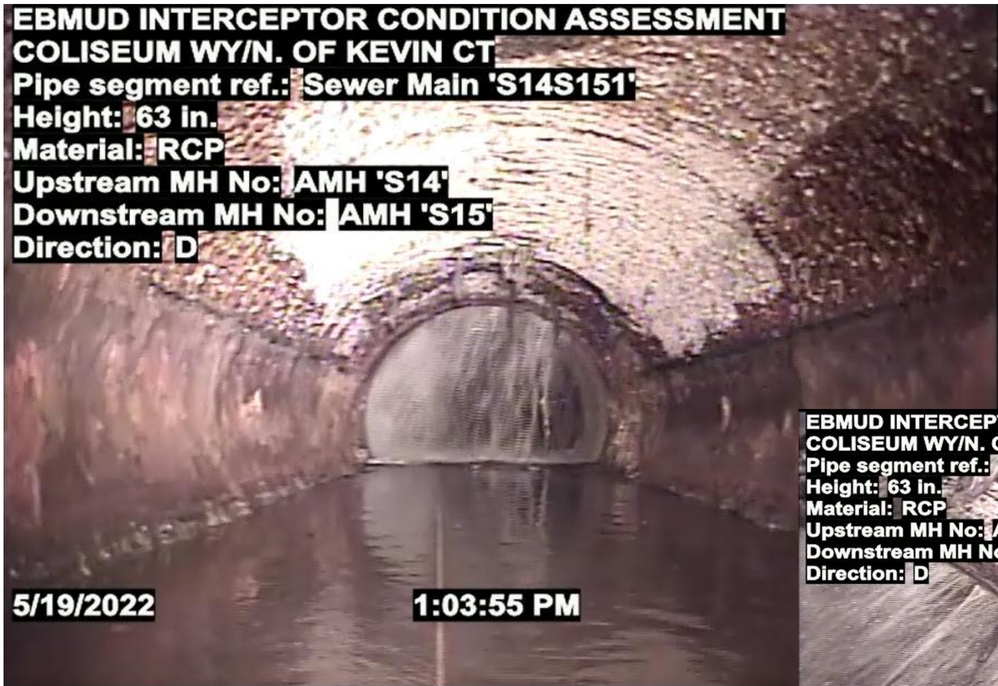


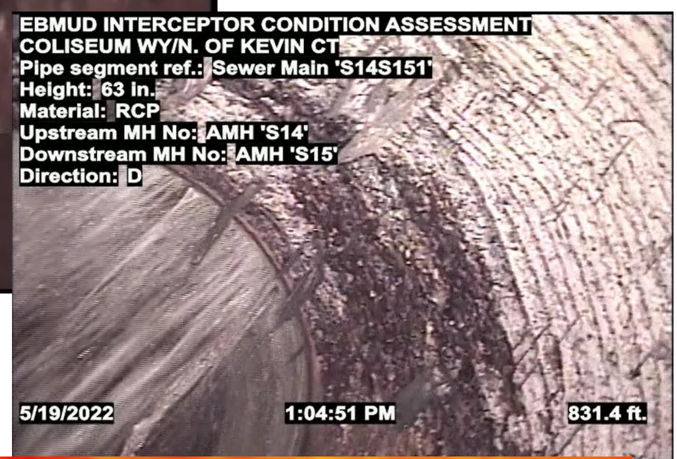
Segment S14S151

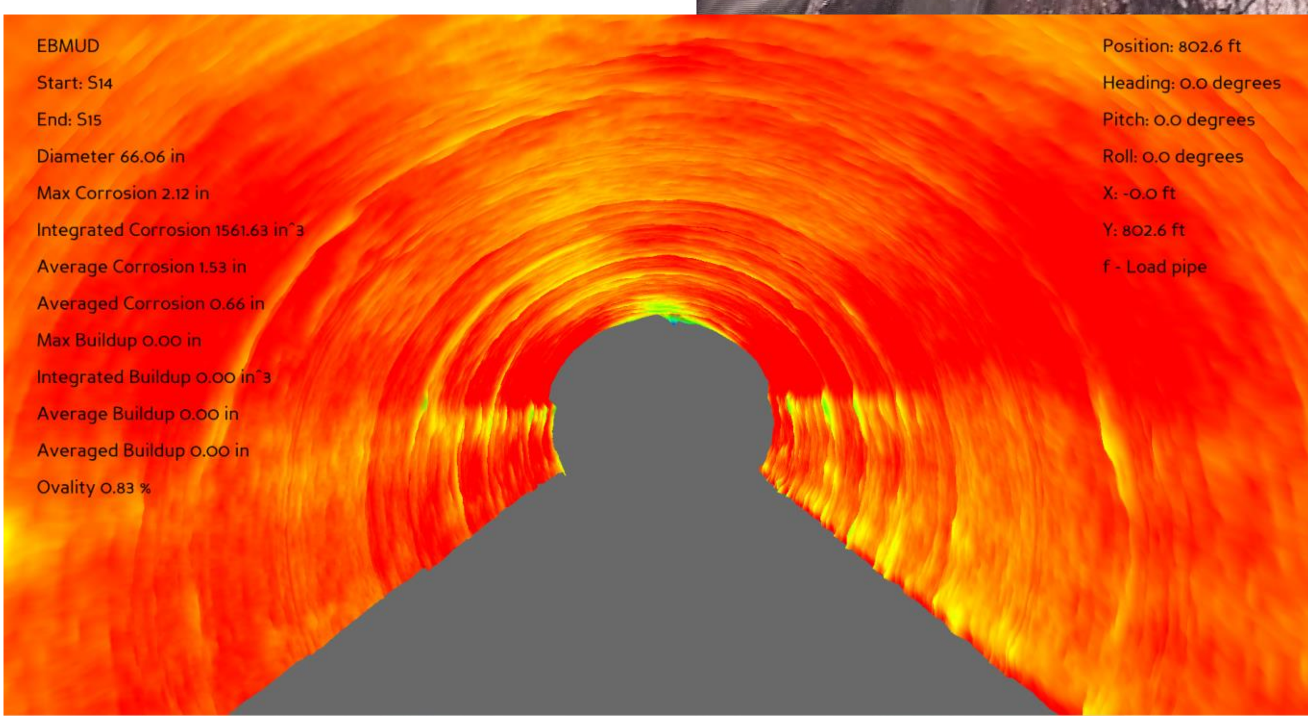
EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

AREA OF MOST SEVERE CORROSION STARTING AT 832 FEET.

MAXIMUM CORROSION OF 4.33 INCHES AT 841 FEET.



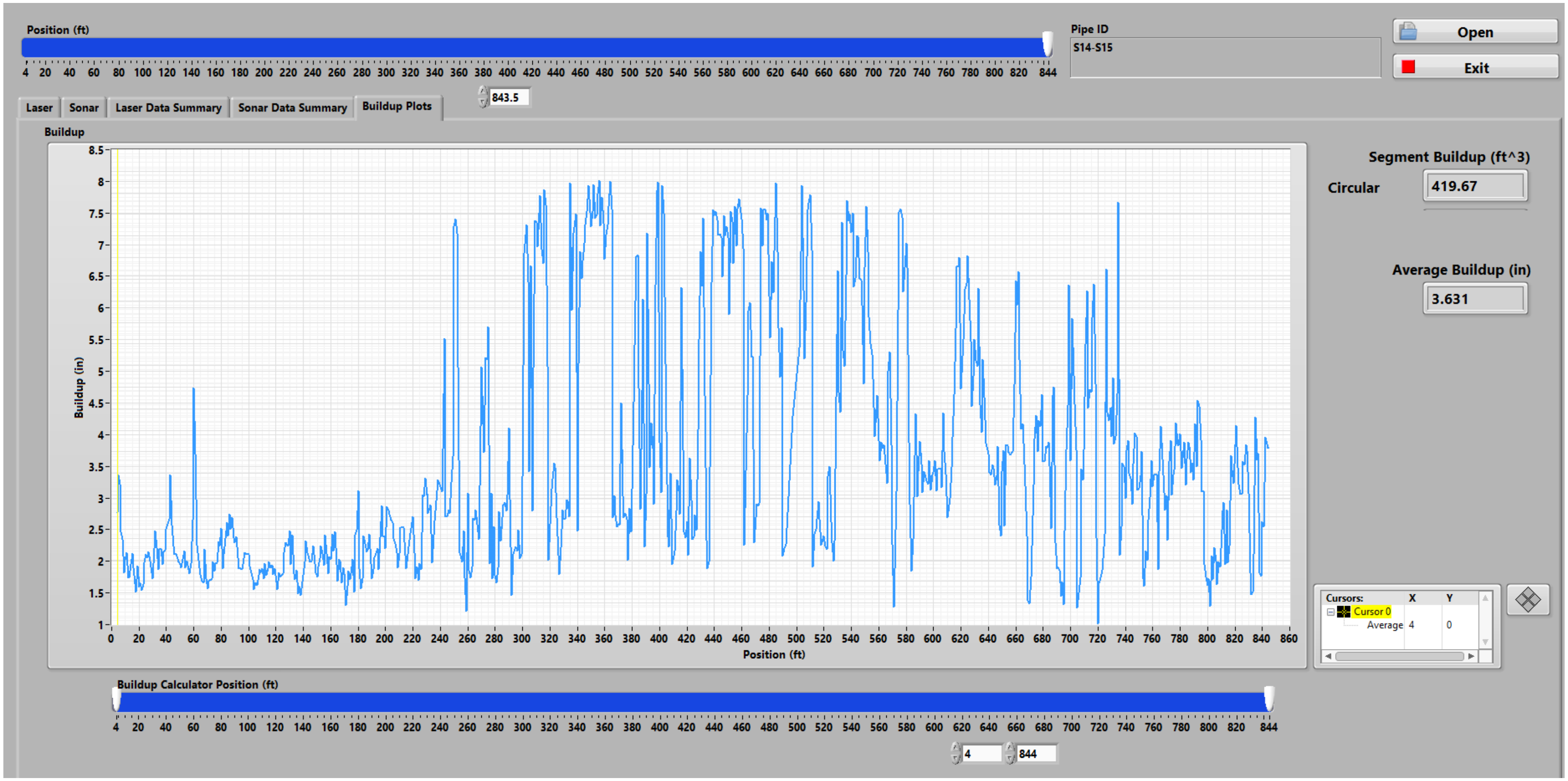




Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

SONAR RESULTS: 420 CF (15.6 CY)



Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

LASER RESULTS BY 1 FOOT SCAN

Segment S14S151

Title 1	Title 2	Title 3	Minimum Position (ft)	Maximum Position (ft)	Surface Area(in2)/ft
EBMUD	Start: S14	End: S15	10	849	2375.044046

Position (ft)	Circular Radius (in)	Circular Normalized Residual Range	Maximum Corrosion (in)	Average Corrosion (in)	Integrated Corrosion (in3)	Averaged Corrosion (in)	Maximum Buildup (in)	Average Buildup (in)	Integrated Buildup (in3)	Averaged Buildup (in)	Ovality (%)
4	29.25739	0.189213	1.46808	0.920384	132.198043	0.055661	0	3.24915	8.302243	0.003496	1.693703
5	32.439074	0.159347	1.26342	0.938143	1143.014364	0.48126	0	0	0	0	0.261961
6	32.487857	0.162207	1.385304	0.98708	1050.210997	0.442186	0	0	0	0	0.216647
7	32.354132	0.167144	1.22472	0.852341	988.800823	0.416329	0	0	0	0	0.871475
8	32.349715	0.168699	1.241568	0.846581	917.074016	0.386129	0	0	0	0	0.854402
9	32.256077	0.169315	1.080948	0.753257	862.118333	0.36299	0	0	0	0	1.141034
10	32.274777	0.168549	1.146396	0.772409	907.488253	0.382093	0	0	0	0	1.20205
11	32.305707	0.169313	1.2096	0.803582	830.496778	0.349676	0	0	0	0	1.069413
12	32.363373	0.167349	1.224372	0.861724	1066.919808	0.449221	0	0	0	0	0.93984
13	32.402112	0.161088	1.300284	0.899326	1025.039241	0.431587	0	0	0	0	1.319491
14	32.413917	0.178059	1.531788	0.910849	995.669558	0.419222	0	0	0	0	2.503316
15	32.514212	0.172941	1.520436	1.010761	1148.960662	0.483764	0	0	0	0	1.986855
16	32.44659	0.176942	1.481544	0.943156	968.448457	0.40776	0	0	0	0	2.079683
17	32.392908	0.176483	1.39956	0.889098	835.420992	0.35175	0	0	0	0	2.616293
18	32.389446	0.180298	1.359564	0.887327	1002.572044	0.422128	0	0.003704	0.041342	0.000017	2.280971
19	32.595338	0.182961	1.603956	1.092494	1164.088257	0.490133	0	0	0	0	2.279136
20	32.537606	0.185807	1.576104	1.036308	1153.304813	0.485593	0	0	0	0	1.897133
21	32.651405	0.186403	1.58916	1.149446	1231.4237	0.518485	0	0	0	0	1.642148
22	32.670148	0.189807	1.682016	1.16686	1341.752769	0.564938	0	0	0	0	0.99064
23	32.694172	0.185404	1.722768	1.191565	1291.037048	0.543584	0	0	0	0	1.555955
24	32.689475	0.18692	1.643376	1.186889	1384.295813	0.582851	0	0	0	0	1.454728
25	32.764573	0.202612	1.734732	1.261576	1186.811945	0.499701	0	0	0	0	1.700235
26	32.659886	0.202434	1.61892	1.156425	1348.287	0.567689	0	0	0	0	1.362119
27	32.666403	0.204361	1.654002	1.162983	1135.522764	0.478106	0	0	0	0	1.414509
28	32.569594	0.195946	1.531128	1.065894	887.180755	0.373543	0	0	0	0	1.597374
29	32.640176	0.191033	1.558524	1.13624	1340.351752	0.564348	0	0	0	0	1.505025
30	32.581971	0.199978	1.690885	1.077993	1076.407959	0.453216	0	0	0	0	1.484905
31	32.747637	0.211321	1.67509	1.246171	1420.559641	0.598119	0	0	0	0	1.160325
32	32.702738	0.216257	1.571904	1.200711	1067.844088	0.44961	0	0	0	0	1.018466
33	32.64532	0.213483	1.569084	1.143094	1282.268686	0.539893	0	0	0	0	1.635782
34	32.609496	0.209859	1.522824	1.106227	1010.873925	0.425623	0	0	0	0	1.692144
35	32.62644	0.207775	1.53882	1.122969	1179.831064	0.496762	0	0	0	0	1.451517
36	32.611146	0.207791	1.505784	1.108989	1151.187539	0.484702	0	0	0	0	0.732273
37	32.59644	0.206337	1.431144	1.094942	1237.211485	0.520921	0	0	0	0	0.565115
38	32.598144	0.207711	1.552503	1.095017	1055.981537	0.444616	0	0	0	0	1.531962
39	32.810432	0.21834	1.795038	1.305444	1347.56143	0.567384	0	0	0	0	1.232722
40	32.771456	0.225138	1.729692	1.267533	1298.104041	0.54656	0	0	0	0	1.037353
41	32.795227	0.231891	1.702068	1.292848	1317.949854	0.554916	0	0	0	0	0.987634
42	32.834925	0.232711	1.765134	1.332595	1421.730616	0.598612	0	0	0	0	0.841055
43	32.826526	0.238115	1.72269	1.323549	1313.80753	0.553172	0	0	0	0	1.187764
44	32.78064	0.225669	1.703784	1.278891	1295.146053	0.545315	0	0	0	0	0.652809
45	32.728798	0.217481	1.61388	1.227341	1111.252353	0.467887	0	0	0	0	0.171929
46	32.635248	0.214376	1.61226	1.133034	1077.681793	0.453752	0	0	0	0	0.601427
47	32.902396	0.22231	1.89282	1.401864	1465.904106	0.617211	0	0	0	0	0.498364
48	32.945008	0.220006	1.854276	1.443996	1331.067526	0.560439	0	0	0	0	0.8351
49	32.957122	0.214627	1.81464	1.456358	1438.476868	0.605663	0	0	0	0	0.74442
50	32.878147	0.212362	1.861812	1.375922	1442.973108	0.607556	0	0	0	0	0.831697
51	32.783033	0.191738	1.669344	1.282716	1339.484044	0.563983	0	0	0	0	0.521286
52	32.769266	0.193221	1.69746	1.269252	1274.648016	0.536684	0	0	0	0	0.5893
53	32.747263	0.189542	1.611336	1.246685	1394.215017	0.587027	0	0	0	0	0.365927
54	32.677659	0.202262	1.599288	1.176508	1295.249591	0.545358	0	0	0	0	1.036221
55	32.804086	0.20719	1.696992	1.301494	1258.895595	0.530051	0	0	0	0	0.929987
56	32.748091	0.199257	1.596492	1.246579	1202.280652	0.506214	0	0	0	0	0.280696
57	32.665768	0.198751	1.528608	1.16249	1182.634377	0.497942	0	0	0	0	0.637793
58	32.707396	0.208378	1.639392	1.205436	1275.157769	0.536899	0	0	0	0	0.743462
59	32.780671	0.210142	1.666272	1.27855	1374.75496	0.578833	0	0	0	0	0.824778
60	32.786721	0.211514	1.66662	1.285443	1040.514456	0.438103	0	0	0	0	0.521304
61	32.845402	0.210348	1.695612	1.34338	1381.694804	0.581755	0	0	0	0	0.707116
62	32.739525	0.207359	1.6689	1.238351	1283.135846	0.540258	0	0	0	0	0.729033
63	32.620831	0.200341	1.452372	1.118328	1041.586278	0.438555	0	0	0	0	0.710217
64	32.633676	0.198376	1.62648	1.131351	1110.303694	0.467488	0	0	0	0	0.594193
65	32.677847	0.201672	1.679117	1.175152	1231.143763	0.518367	0	0	0	0	0.878166
66	32.640508	0.201585	1.631184	1.13749	1064.757025	0.44831	0	0	0	0	0.905931
67	32.622475	0.196109	1.583952	1.120519	1133.892842	0.47742	0	0	0	0	0.91226
68	32.623905	0.198499	1.534116	1.121739	1070.00294	0.450519	0	0	0	0	1.169561
69	32.577266	0.19365	1.500948	1.075238	1203.540138	0.506744	0	0	0	0	0.896626
70	32.530317	0.180163	1.488924	1.027754	973.037034	0.409692	0	0	0	0	1.057368
71	32.468232	0.187442	1.459704	0.964044	997.918405	0.420168	0	0	0	0	2.468329
72	32.526543	0.184808	1.449672	1.022715	926.194765	0.38997	0	0	0	0	1.433973
73	32.704562	0.196361	1.719636	1.200705	1411.407212	0.594266	0	0	0	0	1.661022
74	32.471545	0.19944	1.472784	0.968179	1034.668951	0.435642	0	0	0	0	1.746222
75	32.49	0.198263	1.461732	0.985986	890.103246	0.374773	0	0	0	0	1.763871
76	32.543335	0.189862	1.553652	1.038929	1027.142113	0.432473	0	0	0	0	1.627269
77	32.644141	0.194115	1.736352	1.142281	1214.060716	0.511174	0	0	0	0	1.405529
78	32.606445	0.199761	1.621368	1.103128	1128.793675	0.475273	0	0	0	0	1.501248
79	32.81367	0.197006	1.914888	1.312128	1012.937728	0.426492	0	0	0	0	0.791599
80	32.864059	0.196113	1.908084	1.362262	1471.72072	0.61966	0	0	0	0	0.767719
81	32.802802	0.196403	1.917888	1.300379	1365.820018	0.575071	0	0	0	0	1.056725

Segment S14S151

82	32.73441	0.198618	1.74282	1.23112	1367.983335	0.575982	0	0	0	0	0.867147
83	32.752311	0.200267	1.754988	1.249557	1046.127117	0.440466	0	0	0	0	0.931913
84	32.729534	0.199765	1.782324	1.226297	1272.477812	0.53577	0	0	0	0	1.200526
85	32.759796	0.19995	1.790328	1.256243	1322.302452	0.556749	0	0	0	0	1.106012
86	32.808855	0.202962	1.761732	1.306341	1468.089757	0.618132	0	0	0	0	1.492711
87	32.842281	0.20625	1.83072	1.339509	1141.663657	0.480692	0	0	0	0	1.381568
88	32.976869	0.197755	1.909356	1.474997	1531.621219	0.644881	0	0	0	0	0.908961
89	32.798962	0.195815	1.865808	1.29603	1326.183758	0.558383	0	0	0	0	1.010082
90	32.737538	0.193888	1.694928	1.234639	1367.910685	0.575952	0	0	0	0	1.27952
91	32.791042	0.194116	1.73034	1.288886	1309.119432	0.551198	0	0	0	0	1.341472
92	32.68608	0.193943	1.654512	1.183989	1031.874739	0.434466	0	0	0	0	0.963335
93	32.565003	0.200002	1.454892	1.062706	1128.215803	0.475029	0	0	0	0	0.997992
94	32.682494	0.196527	1.582092	1.181477	1267.507504	0.533677	0	0	0	0	0.384332
95	32.51795	0.202264	1.506852	1.017096	1025.187778	0.43165	0	0	0	0	1.197719
96	32.538144	0.203133	1.51152	1.037739	923.228083	0.38872	0	0	0	0	1.255035
97	32.546567	0.216033	1.588368	1.044111	1181.618683	0.497514	0	0	0	0	1.522855
98	32.565082	0.220921	1.504152	1.062263	974.760962	0.410418	0	0	0	0	1.497157
99	32.554061	0.220949	1.522824	1.05073	944.521413	0.397686	0	0	0	0	1.732468
100	32.509159	0.216199	1.495944	1.005833	1007.54502	0.424222	0	0	0	0	1.591197
101	32.605711	0.213696	1.605713	1.101662	1170.042006	0.49264	0	0	0	0	1.948067
102	32.704877	0.207128	1.715124	1.199486	1237.859255	0.521194	0	0	0	0	2.016043
103	32.746107	0.208175	1.873392	1.239123	1106.211527	0.465765	0	0	0	0	2.621545
104	33.012218	0.200606	1.848492	1.510205	1717.184186	0.723012	0	0	0	0	1.085383
105	32.744861	0.197769	1.892244	1.241349	1386.626416	0.583832	0	0	0	0	1.738044
106	32.564259	0.201522	1.537668	1.060081	1129.598346	0.475612	0	0	0	0	2.151496
107	32.570592	0.198825	1.508508	1.068822	951.194795	0.400496	0	0	0	0	1.992376
108	32.722884	0.195513	1.700268	1.219767	1100.578678	0.463393	0	0	0	0	2.074709
109	32.692311	0.194956	1.64352	1.190309	1325.780826	0.558213	0	0	0	0	1.223504
110	32.654923	0.192588	1.58976	1.152125	1252.279206	0.527266	0	0	0	0	1.416472
111	32.58486	0.189754	1.583136	1.082112	1077.866111	0.45383	0	0	0	0	2.274881
112	32.59509	0.181398	1.514196	1.092114	974.314379	0.41023	0	0	0	0	0.765441
113	32.651748	0.194662	1.674384	1.148969	1250.285976	0.526426	0	0	0	0	1.19527
114	32.727239	0.202716	1.749108	1.224073	1166.258086	0.491047	0	0	0	0	1.304878
115	32.94042	0.201782	1.835412	1.437194	1271.654877	0.535424	0	0	0	0	0.900658
116	32.938743	0.199271	1.804152	1.434894	1446.887523	0.609205	0	0	0	0	1.01753
117	32.942563	0.197032	1.818768	1.439754	1525.864493	0.642457	0	0	0	0	0.491059
118	32.827819	0.203625	1.803792	1.325939	1386.527391	0.58379	0	0	0	0	1.488861
119	32.862368	0.200631	1.7607	1.363218	1454.30276	0.612327	0	0	0	0	1.03954
120	32.603751	0.196177	1.540848	1.103103	970.407694	0.408585	0	0	0	0	1.41971
121	32.510358	0.195193	1.542972	1.006737	1046.503671	0.440625	0	0	0	0	2.198591
122	32.536055	0.187798	1.584624	1.032562	1154.979538	0.486298	0	0	0	0	1.932532
123	32.37573	0.176459	1.466952	0.871004	891.293187	0.375274	0	0	0	0	2.114872
124	32.356104	0.170476	1.346952	0.850695	830.125918	0.34952	0	0	0	0	2.061819
125	32.336248	0.171052	1.373904	0.830525	910.170978	0.383223	0	0	0	0	2.195317
126	32.351416	0.172188	1.410792	0.846551	970.514767	0.40863	0	0	0	0	2.283264
127	32.184741	0.16656	1.318032	0.682937	795.084992	0.334766	0	0.01194	0.23738	0.0001	3.16521
128	32.450993	0.159533	1.444104	0.95045	1039.857368	0.437827	0	0.020453	0.184018	0.000077	1.640681
129	32.422788	0.159407	1.43034	0.921339	1038.294681	0.437169	0	0.014529	0.119155	0.00005	2.861976
130	32.602848	0.184375	1.637862	1.097355	1083.320412	0.456126	0	0	0	0	2.323529
131	32.509269	0.189807	1.604616	1.004167	1034.520263	0.435579	0	0	0	0	1.703123
132	32.468076	0.193372	1.418844	0.96401	981.498927	0.413255	0	0	0	0	1.605951
133	32.429441	0.204119	1.38192	0.924254	871.517462	0.366948	0	0	0	0	2.034412
134	32.545476	0.212445	1.62672	1.040412	1085.525391	0.457055	0	0	0	0	2.143263
135	32.53974	0.211277	1.59486	1.038495	1092.329773	0.45992	0	0.027111	0.973161	0.00041	2.940376
136	32.675626	0.199861	1.6194	1.171632	1113.300784	0.46875	0	0	0	0	2.329532
137	32.590169	0.193674	1.545048	1.08662	1129.553497	0.475593	0	0	0	0	2.225588
138	32.552223	0.191678	1.535004	1.04787	1157.850209	0.487507	0	0	0	0	2.293478
139	32.584492	0.178472	1.571808	1.080576	1168.634185	0.492047	0	0	0	0	2.655557
140	32.515248	0.175511	1.455252	1.010766	1006.339381	0.423714	0	0	0	0	2.298087
141	32.461831	0.167557	1.395288	0.956758	992.27847	0.417794	0	0	0	0	2.166103
142	32.30524	0.166162	1.455084	0.800952	925.51761	0.389684	0	0	0	0	2.520454
143	32.370403	0.159024	1.484136	0.868454	921.584116	0.388028	0	0	0	0	2.406638
144	32.15868	0.160094	1.23372	0.662066	649.945949	0.273656	0	0.01475	0.593985	0.00025	3.386795
145	32.255623	0.157587	1.233744	0.752623	897.223847	0.377771	0	0	0	0	1.203214
146	32.169888	0.163522	1.224366	0.666779	801.128924	0.337311	0	0.00062	0.025971	0.000011	2.109001
147	32.166956	0.169905	1.190928	0.662423	820.827676	0.345605	0	0	0	0	2.301007
148	32.299442	0.173682	1.259076	0.795235	744.178141	0.313332	0	0	0	0	2.275038
149	32.331773	0.174414	1.307664	0.828531	877.521629	0.369476	0	0	0	0	2.218295
150	32.434977	0.183447	1.382832	0.933688	1080.430668	0.45491	0	0	0	0	1.524897
151	32.507811	0.16815	1.407336	1.007361	1173.192882	0.493967	0	0	0	0	1.161747
152	32.54031	0.167253	1.545696	1.035573	836.421944	0.352171	0	0	0	0	2.94502
153	32.523511	0.162256	1.504104	1.018187	1200.654847	0.50553	0	0	0	0	2.381605
154	32.534508	0.173119	1.68144	1.029366	1154.023943	0.485896	0	0	0	0	2.649884
155	32.651516	0.167854	1.752744	1.146085	1271.090439	0.535186	0	0	0	0	2.312638
156	32.632982	0.168232	1.658736	1.127753	1065.38827	0.448576	0	0	0	0	2.433212
157	32.630674	0.160703	1.536984	1.126382	1407.494898	0.592618	0	0	0	0	1.857259
158	32.633734	0.16055	1.630476	1.128877	1313.935954	0.553226	0	0	0	0	1.677643
159	32.484208	0.159072	1.437204	0.979884	1155.756884	0.486625	0	0	0	0	1.921766
160	32.679914	0.149128	1.597548	1.175766	1397.915674	0.588585	0	0	0	0	2.13334
161	32.656605	0.146148	1.61196	1.152876	1370.880476	0.577202	0	0	0	0	2.305867
162	32.491789	0.154477	1.581448	0.986093	1175.884478	0.4951	0	0	0	0	3.343244
163	32.436946	0.156916	1.4427	0.930985	1113.31623	0.468756	0	0	0	0	3.498571
164	32.362614	0.153709	1.378944	0.858732	962.070214	0.405075	0	0	0	0	3.103871

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165	32.399019	0.1498	1.378728	0.894555	1024.943485	0.431547	0	0	0	0	2.460582
166	32.446695	0.157263	1.483812	0.941678	1090.063936	0.458966	0	0	0	0	2.721841
167	32.500583	0.160657	1.486092	0.995763	1101.94702	0.463969	0	0	0	0	2.808313
168	32.476626	0.162547	1.624308	0.970538	1098.678576	0.462593	0	0	0	0	2.646139
169	32.286946	0.157803	1.190796	0.781867	732.949388	0.308605	0	0	0	0	1.89214
170	32.243216	0.17348	1.16772	0.738989	872.956458	0.367554	0	0	0	0	1.138846
171	32.065849	0.175714	1.022844	0.562551	617.240214	0.259886	0	0.009462	0.058852	0.000025	1.446086
172	32.042764	0.17184	0.980688	0.538174	521.179667	0.21944	0	0.000292	0.000739	0	2.014588
173	32.02782	0.168981	0.932748	0.523104	564.817658	0.237814	0	0	0	0	2.252018
174	32.02358	0.17014	1.027212	0.520776	600.069322	0.252656	0	0.005732	0.019911	0.000008	1.951416
175	32.068812	0.166168	1.040988	0.566024	586.581089	0.246977	0	0	0	0	1.61556
176	32.272845	0.164169	1.259508	0.767784	854.091779	0.359611	0	0	0	0	2.478755
177	32.361188	0.163043	1.280472	0.85653	932.043704	0.392432	0	0	0	0	2.129835
178	32.433399	0.165412	1.485128	0.928145	1174.928895	0.494698	0	0	0	0	2.516475
179	32.331505	0.162158	1.432008	0.827904	856.545131	0.360644	0	0	0	0	2.542605
180	32.38387	0.158523	1.304496	0.880113	999.258374	0.420733	0	0	0	0	2.29973
181	32.365905	0.155108	1.329432	0.860945	941.96275	0.396609	0	0	0	0	2.50308
182	32.334717	0.165485	1.428564	0.829683	1024.599878	0.431402	0	0	0	0	2.489623
183	32.159011	0.167371	1.220052	0.658431	677.188566	0.285127	0	0.060151	0.745825	0.000314	2.845903
184	32.292168	0.16408	1.266456	0.788578	908.420207	0.382486	0	0	0	0	2.814318
185	32.241823	0.151731	1.215552	0.737926	731.651398	0.308058	0	0	0	0	2.317458
186	32.231315	0.16302	1.286276	0.726505	830.41321	0.349641	0	0	0	0	2.652479
187	32.300749	0.16289	1.25064	0.796321	908.347926	0.382455	0	0	0	0	2.721527
188	32.321544	0.158323	1.328592	0.817766	1005.531784	0.423374	0	0	0	0	2.465393
189	32.456462	0.149766	1.410972	0.952188	1028.335863	0.432975	0	0	0	0	2.61476
190	32.443831	0.152697	1.494288	0.939114	1075.032355	0.452637	0	0	0	0	2.264472
191	32.61707	0.159159	1.51962	1.113206	1265.971359	0.533031	0	0	0	0	1.826866
192	32.626149	0.155375	1.66038	1.119999	1224.323529	0.515495	0	0	0	0	2.905541
193	32.691981	0.152997	1.768752	1.185945	1278.159816	0.538163	0	0	0	0	2.465125
194	32.66641	0.1631	1.691256	1.161124	1293.498641	0.544621	0	0	0	0	2.011042
195	32.627852	0.167999	1.600776	1.123206	1311.671378	0.552272	0	0	0	0	1.648688
196	32.501466	0.163429	1.527468	0.996399	928.537242	0.390956	0	0	0	0	1.918519
197	32.481742	0.162618	1.487304	0.976339	1075.806232	0.452963	0	0	0	0	2.152532
198	32.537888	0.1622	1.610772	1.032135	1096.35857	0.461616	0	0	0	0	2.103767
199	32.633227	0.163336	1.82364	1.129188	1320.558542	0.556014	0	0	0	0	1.221395
200	32.547072	0.160845	1.603608	1.042817	1052.729566	0.443246	0	0	0	0	2.240322
201	32.624021	0.15443	1.577664	1.119429	1158.446332	0.487758	0	0	0	0	2.020616
202	32.606745	0.147573	1.599174	1.10295	1279.378305	0.538676	0	0	0	0	1.849716
203	32.535693	0.143201	1.504332	1.032379	1079.800292	0.454644	0	0	0	0	1.97529
204	32.494805	0.140811	1.469724	0.991001	1120.268901	0.471683	0	0	0	0	2.41054
205	32.436045	0.141673	1.427256	0.931666	1130.026528	0.475792	0	0	0	0	2.578051
206	32.570734	0.143595	1.564152	1.067315	1236.452312	0.520602	0	0	0	0	1.975216
207	32.586764	0.13963	1.54536	1.084378	1198.261553	0.504522	0	0	0	0	1.785628
208	32.487768	0.138441	1.561212	0.985102	1094.836288	0.460975	0	0	0	0	1.999702
209	32.256811	0.144607	1.331736	0.753192	831.314238	0.350021	0	0	0	0	2.11017
210	32.10706	0.145266	1.113252	0.604087	626.63721	0.263842	0	0	0	0	2.465192
211	32.044342	0.140242	0.996216	0.541552	626.103261	0.263618	0	0.007412	0.059092	0.000025	2.712424
212	32.016173	0.136821	1.040616	0.512006	536.26674	0.225792	0	0.002666	0.011947	0.000005	3.183565
213	32.174108	0.141118	1.225632	0.669965	797.892	0.335948	0	0	0	0	2.999965
214	32.249657	0.150158	1.253544	0.745373	727.1122	0.306147	0	0	0	0	2.584321
215	32.229895	0.157844	1.130856	0.725093	784.058701	0.330124	0	0	0	0	2.141903
216	32.30891	0.154763	1.340028	0.80497	864.804087	0.364121	0	0	0	0	2.139847
217	32.346776	0.16405	1.43742	0.843476	971.361422	0.408987	0	0	0	0	1.649082
218	32.246001	0.16106	1.174596	0.742582	834.539873	0.351379	0	0	0	0	1.794687
219	32.319751	0.156645	1.385832	0.815923	861.128624	0.362574	0	0	0	0	2.407097
220	32.246115	0.153506	1.144104	0.743304	699.801624	0.294648	0	0	0	0	1.997573
221	32.298234	0.157695	1.209348	0.79524	903.330269	0.380343	0	0	0	0	2.032972
222	32.280547	0.162331	1.19526	0.77739	876.455985	0.369027	0	0	0	0	2.159135
223	32.318033	0.158922	1.221084	0.814891	805.400995	0.33911	0	0	0	0	2.58068
224	32.264407	0.157719	1.279716	0.761419	958.04888	0.403382	0	0	0	0	2.330032
225	32.415348	0.166176	1.34985	0.911977	1017.320942	0.428338	0	0	0	0	2.311813
226	32.476019	0.165442	1.434864	0.972214	1018.475964	0.428824	0	0	0	0	2.370098
227	32.425982	0.161319	1.3617	0.922418	886.885365	0.373418	0	0	0	0	2.372067
228	32.408007	0.15576	1.370148	0.904354	1040.041715	0.437904	0	0	0	0	2.245543
229	32.431713	0.157032	1.4121	0.928127	1041.031617	0.438321	0	0	0	0	2.164959
230	32.437482	0.154404	1.321224	0.93388	1174.58809	0.494554	0	0	0	0	2.524201
231	32.438141	0.14799	1.428744	0.934279	897.231972	0.377775	0	0	0	0	2.563332
232	32.470579	0.144168	1.497708	0.967221	991.318434	0.417389	0	0	0	0	2.37064
233	32.678212	0.144925	1.615692	1.176764	1351.769623	0.569156	0	0	0	0	1.229999
234	32.65357	0.148444	1.574172	1.151869	1434.031023	0.603791	0	0	0	0	1.289415
235	32.781974	0.147355	1.655628	1.279642	1306.972267	0.550294	0	0	0	0	1.436122
236	32.795561	0.145162	1.730496	1.29299	1355.53141	0.570739	0	0	0	0	1.160432
237	32.783277	0.146907	1.767624	1.281159	1481.787526	0.623899	0	0	0	0	1.23822
238	32.527583	0.147632	1.510716	1.026581	1186.112015	0.499406	0	0	0	0	1.322292
239	32.543261	0.14986	1.448112	1.040762	1121.223656	0.472085	0	0	0	0	1.54019
240	32.643235	0.154436	1.713492	1.141307	1192.321334	0.502021	0	0	0	0	1.584267
241	32.783727	0.16201	1.667304	1.281079	1447.898664	0.60963	0	0	0	0	0.988471
242	32.523174	0.162836	1.620996	1.019977	1151.328173	0.484761	0	0	0	0	2.287978
243	32.511142	0.155981	1.443336	1.007548	1142.356554	0.480983	0	0	0	0	2.54862
244	32.430911	0.151282	1.428702	0.926973	1093.895563	0.460579	0	0	0	0	2.771749
245	32.460364	0.159951	1.515498	0.955823	1101.447362	0.463759	0	0	0	0	2.982099
246	32.514578	0.161578	1.557396	1.010254	992.313821	0.417809	0	0	0	0	2.738755
247	32.580482	0.159513	1.53414	1.077182	1032.066865	0.434546	0	0	0	0	2.065827

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248	32.660876	0.165328	1.80708	1.15507	1310.534417	0.551794	0	0	0	0	2.741648
249	32.720599	0.173398	1.668426	1.217715	1332.792149	0.561165	0	0	0	0	1.25255
250	32.606218	0.174158	1.565688	1.102848	1114.134993	0.469101	0	0	0	0	2.089758
251	32.644488	0.172587	1.608336	1.141013	1054.396606	0.443948	0	0	0	0	1.945223
252	32.585831	0.168697	1.579476	1.081781	1157.66565	0.487429	0	0	0	0	2.350951
253	32.558916	0.168363	1.546332	1.055319	1154.013258	0.485891	0	0	0	0	2.387032
254	32.543084	0.163607	1.475712	1.039342	996.271204	0.419475	0	0	0	0	2.464155
255	32.493862	0.160898	1.39938	0.990872	1070.813567	0.450861	0	0	0	0	1.553708
256	32.516893	0.15661	1.658532	1.012787	1128.844165	0.475294	0	0	0	0	2.469922
257	32.581051	0.163586	1.573932	1.077635	1215.758557	0.511889	0	0.001486	0.010504	0.000004	2.500006
258	32.595869	0.164011	1.622184	1.092369	1173.530588	0.494109	0	0	0	0	2.759453
259	32.481872	0.167777	1.501692	0.979006	1037.821984	0.43697	0	0	0	0	2.40852
260	32.489825	0.178542	1.45788	0.986152	952.151073	0.400898	0	0	0	0	2.414636
261	32.41043	0.186932	1.46565	0.906643	986.17338	0.415223	0	0	0	0	2.027281
262	32.453136	0.182652	1.405464	0.950006	911.029784	0.383584	0	0	0	0	1.966547
263	32.408743	0.18014	1.3653	0.90581	954.693062	0.401969	0	0	0	0	1.920553
264	32.430832	0.177729	1.628352	0.926102	1027.655563	0.432689	0	0	0	0	2.437802
265	32.71996	0.164969	1.689144	1.217204	1360.179918	0.572697	0	0	0	0	1.218613
266	32.576742	0.157272	1.497276	1.073876	1200.447164	0.505442	0	0	0	0	0.937806
267	32.458253	0.154469	1.397112	0.953683	955.967761	0.402505	0	0	0	0	1.777079
268	32.320526	0.159454	1.409124	0.816477	937.611382	0.394776	0	0	0	0	2.413663
269	32.495797	0.16221	1.55052	0.991608	1178.752647	0.496308	0	0	0	0	2.524307
270	32.637276	0.16018	1.605708	1.133102	1149.754214	0.484098	0	0	0	0	2.63633
271	32.642141	0.158992	1.634496	1.139515	1232.437422	0.518911	0	0	0	0	2.113571
272	32.485287	0.164663	1.534032	0.983289	1193.1714	0.502379	0	0	0	0	0.857266
273	32.521142	0.165242	1.507512	1.017503	1004.584468	0.422975	0	0	0	0	1.506572
274	32.408875	0.167029	1.382136	0.903744	935.585713	0.393924	0	0	0	0	2.325866
275	32.488095	0.166361	1.515564	0.98437	1081.8555	0.45551	0	0	0	0	1.960459
276	32.650548	0.172008	1.64646	1.147111	1257.422943	0.529431	0	0	0	0	2.09895
277	32.668089	0.172855	1.68072	1.164828	1154.319252	0.48602	0	0	0	0	2.092874
278	32.778502	0.169313	1.664628	1.275322	1185.835221	0.49929	0	0	0	0	1.965245
279	32.654626	0.162425	1.600644	1.152261	1358.730122	0.572086	0	0	0	0	2.157365
280	32.788093	0.161768	1.72698	1.28692	1425.822552	0.600335	0	0	0	0	1.27682
281	32.752196	0.161938	1.667688	1.249231	1257.20146	0.529338	0	0	0	0	1.902434
282	32.750406	0.165235	1.706784	1.246652	1381.709366	0.581762	0	0	0	0	1.956721
283	32.688707	0.164392	1.673832	1.184727	1314.424296	0.553432	0	0	0	0	2.131907
284	32.431245	0.164587	1.543266	0.926101	1085.266106	0.456946	0	0	0	0	2.424295
285	32.131185	0.161319	1.132896	0.626139	738.406002	0.310902	0	0	0	0	2.891477
286	32.134954	0.161493	1.143984	0.62959	603.805857	0.254229	0	0	0	0	2.434804
287	32.13312	0.1566	1.096416	0.628204	782.531294	0.329481	0	0	0	0	2.371886
288	32.191531	0.162896	1.288872	0.687218	767.332498	0.323081	0	0	0	0	2.212552
289	32.449956	0.162957	1.465824	0.94555	1011.171114	0.425748	0	0.001259	0.00338	0.000001	1.969437
290	32.625434	0.163025	1.581348	1.12191	1277.61458	0.537933	0	0	0	0	0.853215
291	32.682335	0.158507	1.643016	1.180181	1173.709127	0.494184	0	0	0	0	1.245297
292	32.637608	0.176958	1.661976	1.13379	1336.127697	0.56257	0	0	0	0	1.523768
293	32.4786	0.176593	1.421616	0.974668	931.480837	0.392195	0	0	0	0	1.554147
294	32.368674	0.174106	1.274028	0.867147	684.973841	0.288405	0	0	0	0	1.055675
295	32.404593	0.16754	1.308432	0.90306	1002.179256	0.421962	0	0	0	0	1.130421
296	32.602551	0.170005	1.680648	1.102548	1160.095395	0.488452	0	0	0	0	1.32777
297	32.565817	0.169412	1.657668	1.063638	1321.011314	0.556205	0	0	0	0	1.393073
298	32.574732	0.167555	1.575408	1.071439	983.989733	0.414304	0	0	0	0	0.788667
299	32.562912	0.172157	1.603632	1.059489	1086.138288	0.457313	0	0	0	0	1.045692
300	32.695411	0.185446	1.768068	1.19177	1353.622313	0.569936	0	0	0	0	1.747851
301	32.748974	0.179548	1.865496	1.244966	1077.096971	0.453506	0	0	0	0	1.509453
302	32.752478	0.170264	1.891368	1.248754	1323.583435	0.557288	0	0	0	0	1.161139
303	32.750478	0.165278	1.92624	1.246375	1364.899789	0.574684	0	0	0	0	1.185291
304	32.835794	0.165115	1.99956	1.332065	1468.540747	0.618321	0	0	0	0	1.332612
305	32.646506	0.169282	1.547124	1.146298	1082.57118	0.455811	0	0	0	0	0.883056
306	32.538134	0.165483	1.548084	1.035559	1219.816483	0.513597	0	0	0	0	1.31019
307	32.486625	0.169917	1.52136	0.983354	1159.087856	0.488028	0	0	0	0	2.345204
308	32.339585	0.175648	1.432416	0.8352	855.75493	0.360311	0	0	0	0	3.132959
309	32.296291	0.173221	1.305624	0.79055	931.751792	0.392309	0	0	0	0	3.267558
310	32.280411	0.174628	1.308462	0.775922	753.705375	0.317344	0	0	0	0	2.679898
311	32.435922	0.180386	1.426844	0.932543	1007.459511	0.424186	0	0	0	0	2.286593
312	32.379284	0.179327	1.523556	0.875574	974.524597	0.410319	0	0	0	0	2.818732
313	32.609138	0.177221	1.720392	1.106918	1198.696723	0.504705	0	0	0	0	2.076354
314	32.788905	0.174298	1.67844	1.286271	1264.888225	0.532575	0	0	0	0	1.128381
315	32.875158	0.174054	1.817964	1.373566	1451.562664	0.611173	0	0	0	0	1.020604
316	32.88003	0.167136	1.87362	1.377758	1558.138207	0.656046	0	0	0	0	1.31442
317	32.83975	0.162663	1.810476	1.337196	1393.281231	0.586634	0	0	0	0	1.158365
318	32.820238	0.163201	1.734204	1.318555	1495.815071	0.629805	0	0	0	0	1.245983
319	32.902737	0.163284	1.827408	1.401843	1608.818633	0.677385	0	0	0	0	0.906109
320	32.994909	0.161824	1.850868	1.495056	1255.245394	0.528515	0	0	0	0	0.893012
321	32.661399	0.167969	1.670316	1.160643	1316.068936	0.554124	0	0	0	0	0.690389
322	32.692115	0.171913	1.661064	1.19037	1301.946029	0.548178	0	0	0	0	0.960056
323	32.633778	0.169681	1.530384	1.130666	1233.890797	0.519523	0	0	0	0	1.238027
324	32.587258	0.173051	1.55424	1.084493	1145.957351	0.482499	0	0	0	0	1.404226
325	32.569805	0.182199	1.5516	1.066754	1147.994504	0.483357	0	0	0	0	2.078982
326	32.51668	0.181601	1.506048	1.013972	1118.860664	0.47109	0	0	0	0	2.046496
327	32.54214	0.177085	1.53036	1.040107	1143.08552	0.48129	0	0	0	0	1.641557
328	32.557693	0.174866	1.549512	1.054357	1106.070917	0.465705	0	0	0	0	1.810094
329	32.596234	0.176434	1.662732	1.092001	1223.079256	0.514971	0	0	0	0	2.62424
330	32.714381	0.171047	1.678944	1.210471	1157.775599	0.487475	0	0	0	0	2.142388

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331	32.650198	0.168285	1.557468	1.146962	1184.813441	0.49886	0	0	0	0	2.095357
332	32.539109	0.172041	1.54476	1.035553	1178.6095	0.496247	0	0	0	0	1.97688
333	32.753021	0.172804	1.703076	1.249565	1203.57592	0.506759	0	0	0	0	1.754141
334	32.738681	0.169999	1.631508	1.23559	1301.186897	0.547858	0	0	0	0	1.434022
335	32.671736	0.168322	1.665336	1.167388	1105.321438	0.46539	0	0	0	0	2.042466
336	32.684198	0.167772	1.674024	1.181215	1380.773544	0.581368	0	0	0	0	1.111045
337	32.546119	0.169892	1.515648	1.042845	1073.254356	0.451888	0	0	0	0	1.64175
338	32.639832	0.170112	1.622076	1.134979	1173.684312	0.494174	0	0	0	0	2.407802
339	32.727431	0.172447	1.67918	1.224576	1220.135254	0.513732	0	0	0	0	2.2618
340	32.6095	0.177168	1.671264	1.107566	1179.910575	0.496795	0	0	0	0	2.072963
341	32.494562	0.170632	1.508736	0.99131	1101.549403	0.463802	0	0	0	0	2.341022
342	32.498357	0.160187	1.502928	0.996478	1064.77389	0.448318	0	0	0	0	2.400987
343	32.54761	0.157263	1.537116	1.044978	1077.908898	0.453848	0	0	0	0	2.10883
344	32.59998	0.154237	1.602048	1.098029	1243.844326	0.523714	0	0	0	0	1.679355
345	32.617231	0.161054	1.587708	1.116046	1228.221831	0.517136	0	0	0	0	1.988441
346	32.664171	0.160912	1.588212	1.162779	1291.829019	0.543918	0	0	0	0	0.84261
347	32.681274	0.171048	1.613856	1.178649	1317.143248	0.554576	0	0	0	0	1.351923
348	32.65815	0.171625	1.611036	1.155732	1207.20062	0.508286	0	0	0	0	1.404266
349	32.633398	0.167421	1.580832	1.13081	1178.651432	0.496265	0	0	0	0	1.692457
350	32.709568	0.16233	1.605552	1.20586	1180.725678	0.497138	0	0	0	0	1.515112
351	32.787691	0.166073	1.748766	1.284804	1414.758644	0.595677	0	0	0	0	1.241044
352	32.874123	0.169411	1.848888	1.372652	1311.036579	0.552005	0	0	0	0	0.732911
353	32.843885	0.167838	1.849332	1.343244	1247.078205	0.525076	0	0	0	0	1.177527
354	32.729098	0.167947	1.658136	1.228068	1371.441673	0.577438	0	0	0	0	1.260572
355	32.760837	0.166688	1.71936	1.258613	1390.438201	0.585437	0	0	0	0	1.321077
356	32.6397	0.164581	1.555248	1.137948	1264.408628	0.532373	0	0	0	0	1.504346
357	32.623279	0.163953	1.568256	1.120034	1192.848622	0.502243	0	0	0	0	1.588011
358	32.6028	0.168814	1.550028	1.099008	1201.192298	0.505756	0	0	0	0	1.525547
359	32.581615	0.173247	1.513836	1.079444	1222.877197	0.514886	0	0	0	0	1.168532
360	32.729524	0.174911	1.579212	1.228192	1288.913529	0.54269	0	0	0	0	1.044844
361	32.707157	0.173121	1.62138	1.205184	1156.348072	0.486874	0	0	0	0	1.381609
362	32.709472	0.176924	1.600938	1.209259	1381.884151	0.581835	0	0	0	0	0.384961
363	32.978876	0.172182	1.865316	1.478782	1528.470037	0.643554	0	0	0	0	0.262066
364	32.882136	0.16594	1.784688	1.381702	1421.243639	0.598407	0	0	0	0	0.639438
365	32.824457	0.163983	1.675164	1.324524	1529.374766	0.643935	0	0	0	0	0.661605
366	32.73837	0.1711	1.642278	1.238198	1408.157008	0.592897	0	0	0	0	0.527288
367	32.726898	0.170788	1.67484	1.226849	1265.863699	0.532985	0	0	0	0	0.316338
368	32.894652	0.171628	1.7847	1.39444	1515.868005	0.638248	0	0	0	0	0.265645
369	32.841334	0.168098	1.832328	1.341057	1426.698989	0.600704	0	0	0	0	1.06935
370	32.718747	0.174525	1.79292	1.216899	1389.337881	0.584974	0	0	0	0	1.801845
371	32.699889	0.169752	1.755516	1.198407	1311.33304	0.55213	0	0	0	0	2.004049
372	32.61745	0.165461	1.732824	1.116454	1143.328098	0.481392	0	0	0	0	1.623339
373	32.558335	0.181567	1.715184	1.055747	1239.157036	0.521741	0	0	0	0	2.406963
374	32.473603	0.184135	1.633992	0.971731	1036.353274	0.436351	0	0	0	0	2.330975
375	32.509522	0.186015	1.570224	1.006635	1070.107747	0.450563	0	0	0	0	2.660893
376	32.495275	0.182158	1.453068	0.992539	910.868036	0.383516	0	0	0	0	1.930491
377	32.407666	0.18413	1.588404	0.905604	1106.616224	0.465935	0	0	0	0	2.280858
378	32.331567	0.180013	1.24824	0.830513	881.668276	0.371222	0	0.000474	0.001204	0.000001	1.489992
379	32.444128	0.175754	1.3071	0.94182	925.760693	0.389787	0	0	0	0	1.442597
380	32.390716	0.175477	1.286676	0.888826	915.555605	0.38549	0	0	0	0	1.315617
381	32.381038	0.179523	1.426728	0.878764	1026.141951	0.432052	0	0	0	0	1.354095
382	32.372352	0.177749	1.289004	0.87031	927.091057	0.390347	0	0	0	0	1.572095
383	32.369753	0.17207	1.273236	0.86785	948.915367	0.399536	0	0	0	0	1.525013
384	32.410515	0.169932	1.320696	0.908882	981.09067	0.413083	0	0	0	0	1.188691
385	32.361106	0.18072	1.44504	0.859202	806.463789	0.339557	0	0	0	0	1.397574
386	32.554662	0.183848	1.496712	1.053831	1143.685407	0.481543	0	0	0	0	1.245919
387	32.540798	0.175881	1.515084	1.039348	1090.405201	0.459109	0	0	0	0	1.795448
388	32.488123	0.174914	1.421148	0.986132	1087.73025	0.457983	0	0	0	0	1.669376
389	32.637214	0.178752	1.728972	1.134932	1226.410035	0.516374	0	0	0	0	1.818431
390	32.691694	0.177758	1.659432	1.188298	1149.591049	0.484029	0	0	0	0	2.208137
391	32.677757	0.176412	1.659744	1.174879	1397.922425	0.588588	0	0	0	0	2.024566
392	32.757749	0.177502	1.810032	1.255498	1060.011897	0.446313	0	0	0	0	1.57383
393	32.608837	0.181094	1.626402	1.106269	1216.073013	0.512021	0	0	0	0	1.855373
394	32.575812	0.178854	1.562052	1.073776	1268.799445	0.534221	0	0	0	0	1.854006
395	32.552777	0.182896	1.496412	1.049566	939.048033	0.395381	0	0	0	0	2.328851
396	32.655702	0.183221	1.778184	1.153073	1246.720267	0.524925	0	0	0	0	2.322792
397	32.745479	0.181296	1.73184	1.242548	1335.846974	0.562451	0	0	0	0	2.035294
398	32.63272	0.176187	1.617204	1.129086	1188.236643	0.500301	0	0	0	0	2.392345
399	32.554971	0.171845	1.603272	1.051351	1136.631246	0.478573	0	0	0	0	2.380308
400	32.580727	0.16799	1.5999	1.080417	1143.483275	0.481458	0	0	0	0	0.467573
401	32.645508	0.177599	1.675644	1.144259	1208.55971	0.508858	0	0	0	0	1.162733
402	32.945805	0.17264	1.853268	1.444973	1673.503308	0.70462	0	0	0	0	0.5849
403	32.858163	0.172629	1.821876	1.356773	1336.450493	0.562706	0	0	0	0	0.881144
404	32.985169	0.183002	1.85412	1.484204	1584.159759	0.667002	0	0	0	0	0.750362
405	32.907119	0.186025	1.764216	1.406581	1566.133788	0.659413	0	0	0	0	0.692275
406	32.950396	0.187388	1.77642	1.450394	1433.198481	0.603441	0	0	0	0	1.002578
407	32.922093	0.185715	1.836996	1.422601	1571.123197	0.661513	0	0	0	0	0.84916
408	32.92242	0.189013	1.796316	1.422233	1510.748975	0.636093	0	0	0	0	0.821085
409	32.951281	0.197663	2.037072	1.451135	1613.153633	0.67921	0	0	0	0	0.582727
410	32.833822	0.19833	1.699056	1.331974	1211.464612	0.510081	0	0	0	0	0.386233
411	32.712955	0.207784	1.725384	1.211264	1269.183782	0.534383	0	0	0	0	0.923468
412	32.746835	0.209402	1.811724	1.244963	1277.624526	0.537937	0	0	0	0	1.416407
413	32.795697	0.196496	1.815492	1.294575	1420.202804	0.597969	0	0	0	0	1.185659

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414	32.821466	0.186483	1.785984	1.319426	1289.380232	0.542887	0	0	0	0	1.277368
415	32.74953	0.174358	1.779528	1.247706	1259.12387	0.530148	0	0	0	0	1.335637
416	32.669751	0.163718	1.691556	1.167853	1305.417741	0.549639	0	0	0	0	1.337354
417	32.741684	0.14927	1.8438	1.239526	1242.699775	0.523232	0	0	0	0	1.417479
418	32.742408	0.151264	1.681728	1.2411	1353.305245	0.569802	0	0	0	0	0.633264
419	32.655344	0.154347	1.63476	1.152207	1332.284705	0.560952	0	0	0	0	0.618697
420	32.595391	0.164569	1.67796	1.091059	1283.840569	0.540554	0	0	0	0	0.896768
421	32.769108	0.167324	1.794648	1.265016	1361.023825	0.573052	0	0	0	0	1.203052
422	32.746906	0.166233	1.72356	1.243162	1316.995607	0.554514	0	0	0	0	1.325546
423	32.639223	0.164906	1.74258	1.13753	1268.906427	0.534266	0	0	0	0	0.403992
424	32.665606	0.160633	1.59558	1.163832	1323.316254	0.557175	0	0	0	0	0.682906
425	32.674997	0.164782	1.697316	1.173979	1311.860448	0.552352	0	0	0	0	0.325245
426	32.893635	0.160989	1.779168	1.392266	1392.684881	0.586383	0	0	0	0	1.027533
427	32.895179	0.160874	1.826004	1.393861	1688.288907	0.710845	0	0	0	0	1.01009
428	32.765757	0.160085	1.716108	1.264065	1503.572993	0.633072	0	0	0	0	1.216708
429	32.780172	0.155591	1.785672	1.278288	1394.354851	0.587086	0	0	0	0	0.383352
430	32.810432	0.153483	1.842072	1.30858	1416.022517	0.596209	0	0	0	0	0.348235
431	32.696019	0.161268	1.701594	1.193994	1411.51433	0.594311	0	0	0	0	0.567155
432	32.781128	0.160962	1.678572	1.279548	1449.178016	0.610169	0	0	0	0	0.447767
433	32.796466	0.159814	1.65324	1.295059	1376.675705	0.579642	0	0	0	0	0.658553
434	32.565587	0.16048	1.527084	1.064669	1171.873277	0.493411	0	0	0	0	0.666417
435	32.594331	0.157021	1.62828	1.091376	1162.676515	0.489539	0	0	0	0	0.482251
436	32.341663	0.147938	1.225536	0.838285	943.113596	0.397093	0	0	0	0	1.248349
437	32.346986	0.146509	1.200792	0.842968	866.081139	0.364659	0	0	0	0	1.262351
438	32.386894	0.157638	1.27512	0.883853	1015.616992	0.42762	0	0	0	0	1.245614
439	32.295562	0.163849	1.213236	0.793168	875.672407	0.368697	0	0	0	0	0.706974
440	32.332699	0.162121	1.209492	0.831626	884.534915	0.372429	0	0	0	0	0.892541
441	32.355806	0.163339	1.207632	0.855663	932.548613	0.392645	0	0	0	0	0.60677
442	32.545885	0.165424	1.514964	1.044863	1151.822453	0.484969	0	0	0	0	1.059781
443	32.654632	0.159605	1.582044	1.152986	1259.137267	0.530153	0	0	0	0	1.132409
444	32.715442	0.155067	1.685496	1.214218	1478.351475	0.622452	0	0	0	0	0.948621
445	32.640125	0.156507	1.514148	1.139592	1147.274894	0.483054	0	0	0	0	1.315994
446	32.781335	0.15599	1.72074	1.280064	1446.516179	0.609048	0	0	0	0	1.313471
447	32.782651	0.155706	1.681872	1.281646	1437.885633	0.605414	0	0	0	0	0.911806
448	32.90595	0.154255	1.839516	1.405881	1570.678584	0.661326	0	0	0	0	0.761251
449	32.967497	0.162656	1.8558	1.464318	1627.293621	0.685164	0	0	0	0	1.221356
450	32.830892	0.162489	1.776204	1.328767	1541.473878	0.64903	0	0	0	0	1.273239
451	32.828923	0.157558	1.761216	1.327603	1568.321849	0.660334	0	0	0	0	0.791966
452	32.844123	0.154222	1.727604	1.343921	1400.358328	0.589614	0	0	0	0	0.524111
453	32.669573	0.155011	1.733172	1.168823	1305.891551	0.549839	0	0	0	0	1.073623
454	32.544264	0.153932	1.439676	1.042606	1219.049406	0.513274	0	0	0	0	1.088383
455	32.576969	0.152998	1.50048	1.076585	943.092643	0.397084	0	0	0	0	0.81205
456	32.618311	0.153674	1.535916	1.118128	1288.571675	0.542546	0	0	0	0	0.490137
457	32.728896	0.163989	1.717692	1.229479	1279.280161	0.538634	0	0	0	0	0.846361
458	32.742063	0.164388	1.712724	1.240505	1360.321043	0.572756	0	0	0	0	0.985003
459	32.723456	0.160375	1.54278	1.223426	1277.702548	0.53797	0	0	0	0	1.23849
460	32.707595	0.161126	1.597848	1.20615	1374.518476	0.578734	0	0	0	0	0.895643
461	32.768074	0.16782	1.709868	1.267578	1410.844667	0.594029	0	0	0	0	1.175044
462	32.786856	0.166938	1.652928	1.286772	1370.936755	0.577226	0	0	0	0	0.8096
463	32.763712	0.164777	1.627836	1.263428	1301.348851	0.547926	0	0	0	0	0.602013
464	32.857989	0.162494	1.822512	1.356774	1511.599284	0.636451	0	0	0	0	0.967916
465	32.747959	0.163104	1.643004	1.246383	1218.909258	0.513215	0	0	0	0	1.257272
466	32.726873	0.159764	1.847604	1.225221	1438.073779	0.605494	0	0	0	0	1.379621
467	32.726501	0.157132	1.619028	1.224787	1276.367957	0.537408	0	0	0	0	1.271585
468	32.724509	0.171249	1.610388	1.223216	1419.281929	0.597581	0	0	0	0	0.913628
469	32.747247	0.16949	1.69368	1.246212	1379.021665	0.58063	0	0	0	0	0.891134
470	32.760864	0.166555	1.693392	1.25993	1353.135181	0.569731	0	0	0	0	1.595235
471	32.619403	0.161541	1.65186	1.117384	1213.724913	0.511033	0	0	0	0	1.491743
472	32.619017	0.163466	1.67556	1.116667	1246.83362	0.524973	0	0	0	0	1.574533
473	32.628442	0.161561	1.612404	1.126781	1247.559567	0.525278	0	0	0	0	1.543745
474	32.637394	0.163607	1.639272	1.135122	1213.655552	0.511003	0	0	0	0	1.591903
475	32.632836	0.169552	1.58346	1.130723	1248.68652	0.525753	0	0	0	0	1.315373
476	32.607294	0.172018	1.562628	1.106137	1211.560632	0.510121	0	0	0	0	1.506487
477	32.5631	0.167312	1.443132	1.062194	1106.864515	0.46604	0	0	0	0	0.699491
478	32.575776	0.162765	1.484964	1.075123	1225.894361	0.516156	0	0	0	0	0.648392
479	32.633139	0.170537	1.576524	1.133288	1263.814751	0.532123	0	0	0	0	0.514304
480	32.647032	0.174255	1.626252	1.147688	1203.460833	0.506711	0	0	0	0	1.062311
481	32.521794	0.173838	1.461564	1.02233	1163.930719	0.490067	0	0	0	0	1.486754
482	32.579548	0.170022	1.58676	1.079013	1070.515809	0.450735	0	0	0	0	0.7497
483	32.73512	0.172704	1.76316	1.235185	1358.196452	0.571862	0	0	0	0	0.343252
484	32.773011	0.166648	1.751832	1.273934	1203.310963	0.506648	0	0	0	0	0.666382
485	32.732602	0.168582	1.664532	1.233188	1426.193854	0.600492	0	0	0	0	0.708792
486	32.699787	0.173017	1.60614	1.200779	1311.565432	0.552228	0	0	0	0	1.096478
487	32.686556	0.176335	1.635564	1.186405	1131.121975	0.476253	0	0	0	0	1.256804
488	32.67555	0.175568	1.59708	1.17653	1252.875773	0.527517	0	0	0	0	0.83235
489	32.629392	0.180519	1.578384	1.130767	1129.150364	0.475423	0	0	0	0	0.728318
490	32.673855	0.199362	1.708051	1.174239	1189.24344	0.500725	0	0	0	0	0.510679
491	32.701756	0.19476	1.543308	1.201877	1233.401182	0.519317	0	0	0	0	0.177897
492	32.728368	0.191898	1.495704	1.228266	758.300423	0.319278	0	0	0	0	0.378835
493	32.664012	0.186082	1.441464	1.163664	855.187541	0.360072	0	0	0	0	0.448844
494	32.5824	0.179749	1.383348	1.082856	1278.19296	0.538177	0	0	0	0	0.352989
495	32.575212	0.175174	1.364472	1.075428	1271.21184	0.535237	0	0	0	0	0.220792
496	32.545512	0.174365	1.401072	1.046328	1254.360384	0.528142	0	0	0	0	0.227539

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497	32.54298	0.172234	1.449912	1.043472	1260.140544	0.530576	0	0	0	0	1.069712
498	32.493816	0.174646	1.36302	0.99288	1201.257216	0.505783	0	0	0	0	1.410515
499	32.611356	0.174038	1.436652	1.109892	1348.892352	0.567944	0	0	0	0	0.851269
500	32.574432	0.170003	1.421304	1.073868	1317.572352	0.554757	0	0	0	0	1.006604
501	32.563836	0.162546	1.412892	1.06356	1299.751488	0.547254	0	0	0	0	0.710028
502	32.510932	0.167445	1.551156	1.010063	1033.892023	0.435315	0	0	0	0	0.765952
503	32.550544	0.183293	1.70334	1.051151	1153.836059	0.485817	0	0	0	0	1.240698
504	32.53787	0.17925	1.567236	1.037887	1138.036588	0.479164	0	0	0	0	1.614356
505	32.615181	0.187159	1.6011	1.11436	1160.114032	0.48846	0	0	0	0	1.446328
506	32.598295	0.185598	1.555608	1.097152	1082.328113	0.455709	0	0	0	0	0.672145
507	32.706306	0.179799	1.7355	1.206056	1180.453006	0.497024	0	0	0	0	1.145986
508	32.848452	0.173412	1.6779	1.350351	1472.287779	0.619899	0	0	0	0	0.929304
509	32.833863	0.165581	1.761816	1.335738	1474.90658	0.621002	0	0	0	0	0.990437
510	32.884636	0.15944	1.866216	1.38522	1511.752594	0.636516	0	0	0	0	1.015746
511	32.853928	0.164935	1.725024	1.354342	1285.45314	0.541233	0	0	0	0	0.871923
512	32.839432	0.166993	1.757664	1.339833	1456.444601	0.613228	0	0	0	0	0.731207
513	32.858683	0.164448	1.874712	1.358162	1456.339132	0.613184	0	0	0	0	0.213362
514	32.714002	0.160001	1.67922	1.213251	1390.972063	0.585662	0	0	0	0	0.470349
515	32.660842	0.160508	1.594848	1.160047	947.177936	0.398804	0	0	0	0	0.681859
516	32.533559	0.153522	1.44459	1.032973	1141.785477	0.480743	0	0	0	0	0.582863
517	32.552012	0.15547	1.513248	1.05157	1172.641927	0.493735	0	0	0	0	0.40431
518	32.604782	0.158074	1.45524	1.103026	1044.232385	0.439669	0	0	0	0	0.630713
519	32.643975	0.162676	1.57074	1.143171	1253.642781	0.52784	0	0	0	0	0.839283
520	32.658607	0.174113	1.582782	1.157871	1266.613381	0.533301	0	0	0	0	0.863724
521	32.667335	0.179956	1.526424	1.167375	1263.224307	0.531874	0	0	0	0	0.520537
522	32.680488	0.182861	1.720656	1.18006	1254.27789	0.528107	0	0	0	0	0.976843
523	32.860846	0.170538	1.831956	1.360059	1492.185512	0.628277	0	0	0	0	0.577026
524	32.612151	0.168933	1.64748	1.11119	1220.086809	0.513711	0	0	0	0	0.709698
525	32.467174	0.169238	1.36212	0.96709	1021.636006	0.430155	0	0	0	0	0.905186
526	32.544494	0.163517	1.600836	1.044348	1087.864965	0.45804	0	0	0	0	0.616898
527	32.579961	0.168176	1.606428	1.080254	1190.390421	0.501208	0	0	0	0	1.151571
528	32.584944	0.167917	1.528818	1.084498	1237.275425	0.520948	0	0	0	0	1.027071
529	32.587156	0.167298	1.469508	1.086728	1003.535309	0.422533	0	0	0	0	0.54907
530	32.65914	0.168615	1.59432	1.158301	1246.701274	0.524917	0	0	0	0	0.823137
531	32.698645	0.181358	1.629888	1.198142	1345.414535	0.56648	0	0	0	0	0.460778
532	32.671663	0.182909	1.57272	1.171627	1261.705737	0.531235	0	0	0	0	0.597847
533	32.669498	0.179489	1.577616	1.170014	1224.422598	0.515537	0	0	0	0	0.842315
534	32.60557	0.175905	1.729704	1.105623	1194.946916	0.503126	0	0	0	0	0.873982
535	32.545636	0.172079	1.64112	1.045789	1026.756508	0.432311	0	0	0	0	1.035192
536	32.433609	0.167907	1.424448	0.933922	1013.440997	0.426704	0	0	0	0	1.029415
537	32.439106	0.164254	1.47894	0.939064	906.934012	0.38186	0	0	0	0	1.335645
538	32.481075	0.166937	1.529304	0.980504	1039.99692	0.437885	0	0	0	0	1.129297
539	32.646929	0.167585	1.764324	1.146591	1368.607705	0.576245	0	0	0	0	1.252432
540	32.56685	0.156267	1.6776	1.066552	1129.946083	0.475758	0	0	0	0	0.709721
541	32.487919	0.149935	1.569816	0.987403	979.674503	0.412487	0	0	0	0	0.617667
542	32.536045	0.164684	1.491348	1.03626	1173.653858	0.494161	0	0	0	0	0.385456
543	32.626143	0.167613	1.617564	1.125496	1225.475502	0.51598	0	0	0	0	0.663892
544	32.765848	0.166549	1.6824	1.26479	1319.415302	0.555533	0	0	0	0	0.711371
545	32.739163	0.166715	1.630188	1.239406	1192.288412	0.502007	0	0	0	0	0.410116
546	32.838347	0.174663	1.844244	1.339197	1559.667373	0.65669	0	0	0	0	1.127645
547	32.959744	0.179349	1.910328	1.458172	1519.602447	0.639821	0	0	0	0	1.0814
548	32.93545	0.180904	1.920096	1.433516	1340.605414	0.564455	0	0	0	0	1.956099
549	32.856843	0.175927	1.94022	1.356838	1436.719916	0.604923	0	0	0	0	0.76541
550	32.683799	0.176212	1.75512	1.18363	1285.858609	0.541404	0	0	0	0	0.946449
551	32.777006	0.174291	1.801092	1.277786	1072.106047	0.451405	0	0	0	0	0.611924
552	32.785633	0.171974	1.78998	1.285697	1417.299328	0.596747	0	0	0	0	0.823371
553	32.794687	0.178131	1.87254	1.294955	1389.47662	0.585032	0	0	0	0	0.779731
554	32.825061	0.176925	1.777128	1.326177	1393.352585	0.586664	0	0	0	0	1.077038
555	32.8425	0.17964	1.759668	1.341607	1213.724425	0.511032	0	0	0	0	1.238711
556	32.76775	0.183038	1.953552	1.267642	1447.980032	0.609664	0	0	0	0	1.291546
557	32.804035	0.190755	1.797732	1.303232	1427.832075	0.601181	0	0	0	0	1.373823
558	32.774958	0.19199	1.732932	1.274442	1299.408822	0.547109	0	0	0	0	0.854065
559	32.613854	0.198335	1.586568	1.111874	984.229961	0.414405	0	0	0	0	0.820473
560	32.621733	0.211221	1.59654	1.119222	1083.956929	0.456394	0	0	0	0	1.026177
561	32.851298	0.213073	1.835916	1.349615	1429.316065	0.601806	0	0	0	0	0.83358
562	32.990626	0.213304	1.91106	1.489318	1281.460777	0.539552	0	0	0	0	1.121436
563	32.926395	0.206147	1.849452	1.426152	1322.814437	0.556964	0	0	0	0	0.845467
564	32.978397	0.202433	1.916166	1.478351	1530.910994	0.644582	0	0	0	0	1.228869
565	32.958314	0.198447	1.820868	1.45804	1358.208592	0.571867	0	0	0	0	1.215496
566	32.857674	0.196953	1.83066	1.357416	1395.45406	0.587549	0	0	0	0	0.560243
567	32.84863	0.197137	1.9091	1.348419	1256.751001	0.529149	0	0	0	0	0.83542
568	32.776029	0.197417	1.730088	1.274352	1322.318256	0.556755	0	0	0	0	1.556777
569	32.716944	0.198046	1.735632	1.21428	1225.820106	0.516125	0	0	0	0	1.449572
570	32.748371	0.192597	1.78692	1.248429	1266.843651	0.533398	0	0	0	0	1.603225
571	32.621568	0.200985	1.631592	1.12044	1116.407301	0.470058	0	0	0	0	1.340823
572	32.688846	0.189097	1.724088	1.187754	1189.754277	0.50094	0	0	0	0	1.582283
573	32.688936	0.185691	1.730496	1.188496	1334.852756	0.562033	0	0	0	0	1.212375
574	32.637909	0.180325	1.577792	1.137619	1156.907926	0.48711	0	0	0	0	0.667907
575	32.493471	0.179724	1.526544	0.993223	1097.560909	0.462122	0	0	0	0	1.100459
576	32.600919	0.177184	1.599516	1.099866	988.315062	0.416125	0	0	0	0	1.229928
577	32.590819	0.182194	1.520256	1.090333	1073.618999	0.452042	0	0	0	0	2.00524
578	32.658812	0.188374	1.69224	1.157974	1224.363667	0.515512	0	0	0	0	1.893302
579	32.720289	0.185525	1.701924	1.219374	929.242122	0.391253	0	0	0	0	0.723825

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580	32.569593	0.182096	1.5759	1.068634	1203.490162	0.506723	0	0	0	0	0.715375
581	32.521361	0.190221	1.41694	1.019689	1122.22671	0.472508	0	0	0	0	0.898801
582	32.5112	0.186078	1.41756	1.008178	983.609106	0.414144	0	0	0	0	1.977575
583	32.472557	0.183736	1.415484	0.97103	983.798342	0.414223	0	0	0	0	1.516595
584	32.36092	0.178012	1.325214	0.860187	805.952822	0.339342	0	0	0	0	0.757029
585	32.513548	0.181448	1.508292	1.012416	1081.464782	0.455345	0	0	0	0	1.758605
586	32.65805	0.180151	1.576644	1.155955	1142.434312	0.481016	0	0	0	0	1.649635
587	32.720831	0.182371	1.776528	1.219499	1286.888321	0.541838	0	0	0	0	1.717044
588	32.821887	0.188308	1.813758	1.321439	1375.565723	0.579175	0	0	0	0	1.53697
589	32.744955	0.194906	1.742376	1.244856	1276.09788	0.537294	0	0	0	0	1.429155
590	32.793262	0.195605	1.732572	1.29378	1261.815803	0.531281	0	0	0	0	1.340191
591	32.890363	0.197968	1.84494	1.389943	1563.016681	0.6581	0	0	0	0	0.747084
592	32.909814	0.201797	1.869024	1.408486	1437.032544	0.605055	0	0	0	0	1.032975
593	32.937088	0.200261	1.936404	1.437562	1492.481858	0.628402	0	0	0	0	0.578811
594	33.031186	0.199911	1.925112	1.530919	1485.689583	0.625542	0	0	0	0	0.449784
595	33.008338	0.211007	1.984872	1.507218	1535.977202	0.646715	0	0	0	0	1.114777
596	32.906851	0.209399	1.912422	1.406895	1434.948577	0.604178	0	0	0	0	0.838869
597	32.858594	0.210072	1.756836	1.359122	1347.059489	0.567172	0	0	0	0	0.346926
598	32.819068	0.207779	1.823364	1.319852	1274.041726	0.536429	0	0	0	0	0.662585
599	32.648955	0.202897	1.665204	1.14983	1177.299589	0.495696	0	0	0	0	0.634217
600	32.574198	0.19996	1.546128	1.075942	1105.964286	0.465661	0	0	0	0	0.577736
601	32.37142	0.198673	1.326912	0.87342	859.578295	0.361921	0	0	0	0	0.907294
602	32.516982	0.203604	1.504872	1.018385	1044.947944	0.43997	0	0	0	0	0.838063
603	32.594109	0.20771	1.610316	1.095887	1032.468028	0.434715	0	0	0	0	1.309404
604	32.585624	0.200535	1.628868	1.086172	1125.783134	0.474005	0	0	0	0	1.024673
605	32.574298	0.201542	1.574724	1.075298	969.812914	0.408335	0	0	0	0	1.346115
606	32.582092	0.189692	1.583652	1.083206	1244.55263	0.524012	0	0	0	0	0.93574
607	32.61581	0.184043	1.740972	1.116872	1037.94404	0.437021	0	0	0	0	0.986479
608	32.563076	0.179982	1.540404	1.064534	1086.495318	0.457463	0	0	0	0	0.858793
609	32.551114	0.178995	1.57584	1.052817	1000.499284	0.421255	0	0	0	0	0.602871
610	32.622962	0.178766	1.613412	1.124549	1238.767378	0.521577	0	0	0	0	0.725317
611	32.863552	0.181014	1.801104	1.365796	1375.098259	0.578978	0	0	0	0	1.223136
612	32.711586	0.185033	1.770396	1.213006	1339.441021	0.563965	0	0	0	0	0.936599
613	32.570027	0.198513	1.71846	1.070222	1108.819214	0.466863	0	0	0	0	0.891147
614	32.603688	0.201021	1.68804	1.103638	1049.020295	0.441685	0	0	0	0	1.126637
615	32.48968	0.197093	1.439316	0.9896	1045.536077	0.440218	0	0	0	0	0.939067
616	32.683901	0.193764	1.762356	1.184229	1208.32795	0.50876	0	0	0	0	0.924724
617	32.811447	0.187948	1.844736	1.31203	1295.035988	0.545268	0	0	0	0	1.248994
618	32.859832	0.19022	1.896384	1.359258	1409.661101	0.593531	0	0	0	0	1.066976
619	32.884932	0.194464	1.920672	1.382746	1431.262767	0.602626	0	0	0	0	1.848783
620	33.004983	0.202213	2.131044	1.505717	1549.238142	0.652299	0	0	0	0	0.398818
621	33.034831	0.203775	2.050116	1.53473	1599.919887	0.673638	0	0	0	0	0.522193
622	33.105092	0.19617	2.103804	1.605062	1452.96047	0.611761	0	0	0	0	0.599863
623	33.064217	0.195196	1.989876	1.564627	1616.813099	0.680751	0	0	0	0	0.509749
624	32.940955	0.189724	1.937022	1.44147	1498.367439	0.63088	0	0	0	0	0.357462
625	32.94731	0.191697	1.963752	1.447776	1460.376175	0.614884	0	0	0	0	0.366393
626	33.057831	0.189689	2.009112	1.558445	1607.070985	0.676649	0	0	0	0	1.259322
627	32.958524	0.194518	2.066088	1.458022	1530.382137	0.644359	0	0	0	0	1.40269
628	33.126979	0.192146	2.168136	1.626988	1639.036858	0.690108	0	0	0	0	1.789132
629	33.011995	0.189783	2.091696	1.513488	1324.139533	0.557522	0	0	0	0	1.484894
630	32.99153	0.19137	1.976256	1.492262	1661.139629	0.699414	0	0	0	0	1.256619
631	32.859505	0.183743	1.84338	1.359266	1419.67818	0.597748	0	0	0	0	0.568223
632	32.906907	0.179843	1.86084	1.407115	1470.997799	0.619356	0	0	0	0	1.447035
633	32.839526	0.178675	1.77732	1.340194	1373.60766	0.57835	0	0	0	0	1.427474
634	32.856022	0.18014	1.864374	1.356395	1475.228676	0.621137	0	0	0	0	1.142017
635	32.7556	0.183325	1.788552	1.255382	1159.447133	0.488179	0	0	0	0	0.766468
636	32.674052	0.182077	1.644168	1.174204	1158.842913	0.487925	0	0	0	0	0.834143
637	32.450515	0.17871	1.37034	0.951768	1066.07111	0.448864	0	0	0	0	0.561417
638	32.52913	0.18954	1.43832	1.030806	1129.364315	0.475513	0	0	0	0	0.512541
639	32.668073	0.19203	1.649808	1.168733	1222.083924	0.514552	0	0	0	0	0.602251
640	32.789498	0.192837	1.677924	1.29075	1184.48435	0.498721	0	0	0	0	0.578125
641	32.751146	0.198998	1.7517	1.252309	1298.845551	0.546872	0	0	0	0	0.520973
642	32.44855	0.209515	1.496568	0.949799	973.472294	0.409875	0	0	0	0	0.861599
643	32.532504	0.205517	1.608516	1.032952	1050.450859	0.442287	0	0	0	0	1.303638
644	32.583743	0.206525	1.476468	1.083444	1001.679813	0.421752	0	0	0	0	0.560057
645	32.414772	0.206778	1.321452	0.914337	936.054155	0.394121	0	0	0	0	1.077582
646	32.363498	0.201736	1.313904	0.86356	920.446723	0.387549	0	0	0	0	1.010524
647	32.384516	0.198117	1.338144	0.885288	884.432375	0.372386	0	0	0	0	0.834158
648	32.423902	0.203488	1.348824	0.924216	853.195797	0.359234	0	0	0	0	1.089717
649	32.472724	0.205873	1.498212	0.972593	1002.158033	0.421953	0	0	0	0	0.434464
650	32.463582	0.20501	1.397568	0.963214	963.602999	0.40572	0	0	0	0	0.722033
651	32.63364	0.205798	1.688124	1.133352	1061.755961	0.447047	0	0	0	0	0.725877
652	32.783566	0.199346	1.827684	1.284069	1324.014652	0.55747	0	0	0	0	1.78722
653	32.659838	0.196632	1.571424	1.160381	1066.013332	0.448839	0	0	0	0	1.839054
654	32.707834	0.192701	1.762248	1.208502	1229.317748	0.517598	0	0	0	0	1.820016
655	32.899938	0.193907	1.9467	1.400503	1473.493686	0.620407	0	0	0	0	2.116743
656	32.962822	0.197487	1.843404	1.463342	1569.962862	0.661025	0	0	0	0	1.946246
657	32.962761	0.192636	2.025828	1.463521	1513.435691	0.637224	0	0	0	0	1.801325
658	33.087792	0.18485	2.009892	1.587324	1569.355903	0.660769	0	0	0	0	1.517469
659	32.924084	0.185301	1.9035	1.423629	1398.615005	0.58888	0	0	0	0	1.305254
660	32.773287	0.176753	1.727004	1.272875	1437.316058	0.605174	0	0	0	0	1.282702
661	32.79688	0.177405	1.688472	1.29675	1356.734203	0.571246	0	0	0	0	1.127712
662	32.80399	0.176176	1.721808	1.304102	1192.213594	0.501975	0	0	0	0	1.382188

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663	32.821655	0.184529	1.881492	1.321307	1377.717418	0.580081	0	0	0	0	1.118959
664	32.88596	0.186552	1.860732	1.385715	1282.197116	0.539862	0	0	0	0	1.293593
665	32.69743	0.190685	1.60626	1.197753	1259.014357	0.530101	0	0	0	0	1.1563
666	32.697743	0.194842	1.645194	1.19758	1203.635078	0.506784	0	0	0	0	1.590204
667	32.911451	0.203335	2.034252	1.411915	1484.988731	0.625247	0	0	0	0	1.512683
668	32.910139	0.212272	1.892868	1.409391	1403.897001	0.591104	0	0	0	0	0.874107
669	32.81823	0.216755	1.815228	1.316964	1128.303696	0.475066	0	0	0	0	0.692463
670	32.677275	0.207029	1.6107	1.176408	1188.197592	0.500284	0	0	0	0	0.784674
671	32.602586	0.204017	1.51044	1.101864	1184.531326	0.498741	0	0	0	0	0.89655
672	32.851384	0.202629	1.765368	1.350498	1344.109492	0.56593	0	0	0	0	0.776872
673	32.824704	0.207474	1.713252	1.324113	1365.692606	0.575018	0	0	0	0	0.683653
674	32.889577	0.212004	1.9971	1.388783	1399.920381	0.589429	0	0	0	0	0.696013
675	32.868897	0.212854	1.9173	1.367731	1223.046852	0.514958	0	0	0	0	0.919906
676	33.155876	0.211143	2.045292	1.655514	1490.46683	0.627553	0	0	0	0	0.780488
677	33.028203	0.21107	1.910688	1.527983	1590.335233	0.669602	0	0	0	0	0.789039
678	33.040501	0.210554	1.99956	1.540607	1385.609007	0.583403	0	0	0	0	0.903803
679	33.034313	0.207288	1.996668	1.534389	1635.005078	0.68841	0	0	0	0	0.692944
680	32.900273	0.20319	1.806468	1.399783	1449.896228	0.610471	0	0	0	0	0.726596
681	32.993267	0.195354	1.84344	1.492809	1541.32641	0.648968	0	0	0	0	0.681372
682	33.053669	0.19679	1.993092	1.55322	1611.706594	0.678601	0	0	0	0	0.705793
683	33.00448	0.19691	2.033148	1.50375	1447.391111	0.609417	0	0	0	0	1.108419
684	32.997603	0.199779	2.032848	1.497724	1606.471814	0.676397	0	0	0	0	1.222502
685	32.735761	0.202958	1.715112	1.235865	1268.085071	0.533921	0	0	0	0	1.466576
686	32.580914	0.199483	1.642896	1.080269	1112.330462	0.468341	0	0	0	0	1.361535
687	32.765026	0.200899	1.641456	1.264592	1146.606024	0.482773	0	0	0	0	0.568159
688	32.757367	0.202667	1.766208	1.257048	1359.870825	0.572567	0	0	0	0	0.555658
689	32.803682	0.201159	1.635036	1.303165	1336.418904	0.562692	0	0	0	0	0.893409
690	32.881771	0.207069	1.70436	1.381351	1102.675997	0.464276	0	0	0	0	0.765984
691	32.834203	0.206594	2.052948	1.33467	1457.983658	0.613876	0	0	0	0	0.94662
692	33.073897	0.205751	2.020548	1.573614	1523.480277	0.641453	0	0	0	0	0.765107
693	33.10705	0.199725	2.130408	1.606452	1644.665507	0.692478	0	0	0	0	1.115985
694	33.154416	0.19585	2.06256	1.654565	1594.030637	0.671158	0	0	0	0	1.096562
695	32.993886	0.192712	1.946364	1.494061	1552.729622	0.653769	0	0	0	0	0.490216
696	33.020684	0.18586	1.870668	1.520681	1591.054209	0.669905	0	0	0	0	0.866406
697	32.978969	0.188281	1.815924	1.479602	1537.931974	0.647538	0	0	0	0	0.530927
698	33.169077	0.184048	2.03226	1.669344	1606.785789	0.676529	0	0	0	0	0.896649
699	33.007117	0.180544	1.952172	1.505481	1595.236308	0.671666	0	0	0	0	0.956972
700	32.77585	0.182048	1.663272	1.274362	1477.468143	0.62208	0	0	0	0	0.945199
701	32.813702	0.181557	1.692222	1.313852	1293.972034	0.54482	0	0	0	0	0.462605
702	32.764294	0.191202	1.673124	1.265664	1383.505809	0.582518	0	0	0	0	0.509559
703	32.765871	0.202924	1.659816	1.26732	1245.702998	0.524497	0	0	0	0	0.821297
704	32.934461	0.213956	1.957536	1.43539	1460.079709	0.614759	0	0	0	0	0.832464
705	32.822039	0.220217	1.936872	1.322043	1329.215425	0.559659	0	0	0	0	0.7156
706	32.80087	0.222727	1.81866	1.301383	1331.565392	0.560649	0	0	0	0	0.621655
707	32.889924	0.214817	1.841388	1.39051	1340.688505	0.56449	0	0	0	0	0.841872
708	32.994211	0.211225	1.988448	1.493932	1504.785894	0.633582	0	0	0	0	1.424634
709	32.82538	0.21428	1.862652	1.324209	1290.759802	0.543468	0	0	0	0	1.045422
710	32.743625	0.20629	1.652568	1.243341	1310.686336	0.551858	0	0	0	0	1.171477
711	32.730308	0.200814	1.707348	1.229164	1263.154911	0.531845	0	0	0	0	0.901721
712	32.769369	0.195605	1.751568	1.268916	1306.316921	0.550018	0	0	0	0	1.104467
713	32.834282	0.194867	1.872372	1.334376	1442.882167	0.607518	0	0	0	0	1.340879
714	32.783239	0.192815	1.716372	1.283482	1131.713175	0.476502	0	0	0	0	1.327817
715	32.809908	0.200758	1.735236	1.309369	1333.935833	0.561647	0	0	0	0	1.0897
716	33.051324	0.200123	2.025564	1.550575	1622.900373	0.683314	0	0	0	0	2.040744
717	32.99281	0.182288	1.98	1.493102	1540.741759	0.648721	0	0	0	0	1.832936
718	32.91819	0.183164	1.913232	1.417494	1318.021592	0.554946	0	0	0	0	1.085668
719	32.909187	0.190862	1.850304	1.408946	1468.934293	0.618487	0	0	0	0	0.775969
720	32.859772	0.195484	1.795104	1.358595	1419.51989	0.597682	0	0	0	0	1.146609
721	32.866206	0.199327	1.842876	1.365538	1371.178295	0.577328	0	0	0	0	1.430128
722	32.912608	0.200399	2.01846	1.412256	1305.331473	0.549603	0	0	0	0	0.999478
723	32.861399	0.193201	1.918056	1.360379	1452.269984	0.611471	0	0	0	0	0.544095
724	32.795002	0.190924	1.786608	1.293236	1366.434334	0.57533	0	0	0	0	1.016647
725	32.915894	0.19036	1.78518	1.415314	1441.687391	0.607015	0	0	0	0	0.383662
726	32.929385	0.192874	1.863396	1.428773	1506.267645	0.634206	0	0	0	0	0.63325
727	32.824409	0.201593	1.80504	1.32396	1374.440118	0.578701	0	0	0	0	0.617319
728	32.856448	0.205857	1.811484	1.356246	1237.686588	0.521122	0	0	0	0	0.272105
729	33.040809	0.206387	2.169108	1.540108	1528.910352	0.64374	0	0	0	0	0.271623
730	32.897857	0.204458	1.938144	1.397381	1424.377263	0.599727	0	0	0	0	0.670075
731	32.760811	0.196293	1.819428	1.261807	1207.844562	0.508557	0	0	0	0	1.173438
732	32.711481	0.194374	1.893084	1.211595	1306.83536	0.550236	0	0	0	0	0.749447
733	32.739579	0.192214	1.899456	1.239596	1272.87099	0.535936	0	0	0	0	0.872076
734	32.683643	0.189659	1.6593	1.183865	1193.933445	0.502699	0	0	0	0	1.323156
735	32.606522	0.188936	1.555896	1.10713	1098.121541	0.462358	0	0	0	0	1.933887
736	32.671369	0.198689	1.741638	1.171855	1228.169289	0.517114	0	0	0	0	1.465167
737	32.671863	0.20127	1.670592	1.172245	1198.838894	0.504765	0	0	0	0	1.554371
738	32.787708	0.195504	1.758468	1.288416	1313.951442	0.553232	0	0	0	0	1.214878
739	32.866227	0.198782	1.894164	1.366152	1381.158695	0.58153	0	0	0	0	1.571066
740	32.769476	0.199373	1.770096	1.269057	1335.207029	0.562182	0	0	0	0	1.100077
741	32.893095	0.196945	1.884552	1.39292	1286.570994	0.541704	0	0	0	0	1.344769
742	32.881695	0.199327	1.811268	1.38251	1393.431634	0.586697	0	0	0	0	1.130783
743	33.051156	0.20669	2.054796	1.551657	1527.33625	0.643077	0	0	0	0	1.022966
744	32.99167	0.217088	1.969416	1.491802	1492.692168	0.62849	0	0	0	0	1.060516
745	32.895015	0.2151	1.829292	1.394962	1379.817618	0.580965	0	0	0	0	1.095658

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746	32.851723	0.211436	1.740384	1.351495	1375.696149	0.57923	0	0	0	0	0.850849
747	32.734264	0.216254	1.710996	1.233915	1231.397508	0.518474	0	0	0	0	1.215277
748	32.90971	0.221509	2.02962	1.409275	1446.12616	0.608884	0	0	0	0	1.608101
749	33.164012	0.223377	2.1513	1.66388	1637.467876	0.689447	0	0	0	0	1.107037
750	33.230507	0.221495	2.19132	1.73131	1718.186429	0.723434	0	0	0	0	1.678016
751	33.174052	0.224758	2.24379	1.674857	1654.881084	0.696779	0	0	0	0	1.47962
752	33.168818	0.226458	2.121588	1.66955	1242.449336	0.523127	0	0	0	0	1.368121
753	33.062505	0.227631	2.167788	1.563192	1552.850846	0.65382	0	0	0	0	1.261017
754	33.063398	0.224101	1.973928	1.564505	1585.192486	0.667437	0	0	0	0	1.381408
755	33.129677	0.226931	2.1195	1.630809	1556.302751	0.655273	0	0	0	0	1.238784
756	33.065412	0.233673	2.161284	1.56611	1471.640913	0.619627	0	0	0	0	1.800363
757	32.992201	0.240444	2.258784	1.492282	1468.282236	0.618213	0	0	0	0	0.751215
758	33.003289	0.234584	1.99548	1.503499	1468.747924	0.618409	0	0	0	0	0.961646
759	33.0791	0.228962	1.962168	1.579208	1476.326065	0.621599	0	0	0	0	0.730775
760	33.027392	0.22831	2.256084	1.527921	1476.688538	0.621752	0	0	0	0	0.726725
761	32.90406	0.228962	2.175492	1.404529	1441.268068	0.606838	0	0	0	0	0.630685
762	32.993515	0.228913	2.199648	1.494453	1536.151754	0.646789	0	0	0	0	1.077559
763	33.003403	0.21761	1.976988	1.504889	1339.942227	0.564176	0	0	0	0	1.501972
764	33.042139	0.215477	2.044308	1.543692	1557.809748	0.655908	0	0	0	0	1.620445
765	32.976031	0.216283	1.879032	1.47646	1536.220719	0.646818	0	0	0	0	1.517133
766	32.92474	0.225346	1.926576	1.424188	1388.689256	0.5847	0	0	0	0	0.723969
767	32.830427	0.22719	1.801308	1.329682	1241.836938	0.522869	0	0	0	0	0.614225
768	32.916487	0.236823	1.913412	1.415203	1382.466239	0.58208	0	0	0	0	0.714844
769	33.004531	0.232848	1.884348	1.503231	1475.618016	0.621301	0	0	0	0	0.839926
770	32.989894	0.235593	1.915836	1.489198	1322.836737	0.556974	0	0	0	0	1.147081
771	33.008805	0.232999	2.096658	1.508452	1399.25764	0.58915	0	0	0	0	0.913441
772	32.669291	0.217983	1.943424	1.171552	1214.529296	0.511371	0	0	0	0	1.606317
773	32.65643	0.218314	1.565724	1.15807	1038.742624	0.437357	0	0	0	0	0.671682
774	32.881525	0.226644	1.982112	1.382657	1347.939906	0.567543	0	0	0	0	0.971671
775	33.017051	0.235983	1.950444	1.517803	1506.653944	0.634369	0	0	0	0	1.127348
776	32.965869	0.233029	1.895736	1.466347	1430.13217	0.60215	0	0	0	0	0.762705
777	33.013625	0.223739	2.095392	1.5144	1490.026697	0.627368	0	0	0	0	0.830299
778	32.935912	0.222361	1.917816	1.436681	1422.815132	0.599069	0	0	0	0	0.789553
779	32.932553	0.22146	1.833708	1.432342	1416.791388	0.596533	0	0	0	0	0.723808
780	32.841427	0.225909	1.819596	1.341142	1122.716084	0.472714	0	0	0	0	0.7542
781	32.872104	0.234558	1.921062	1.371223	1353.166356	0.569744	0	0	0	0	1.085256
782	32.813341	0.237963	2.046756	1.312273	1287.63124	0.54215	0	0	0	0	0.926008
783	32.935236	0.240864	2.067444	1.435192	1302.25021	0.548306	0	0	0	0	1.087671
784	32.919327	0.23996	1.885296	1.419698	1383.775146	0.582631	0	0	0	0	1.409262
785	32.806043	0.227961	2.0154	1.306959	1342.687457	0.565332	0	0	0	0	1.445387
786	32.913161	0.224988	2.031444	1.414773	1399.370268	0.589198	0	0	0	0	1.106188
787	32.798386	0.22342	1.782324	1.300128	1000.42169	0.421222	0	0	0	0	1.159108
788	33.013091	0.227635	2.046768	1.514766	1512.233512	0.636718	0	0.037738	0.664842	0.00028	1.859812
789	33.047602	0.218506	2.030904	1.54854	1596.870279	0.672354	0	0	0	0	1.356234
790	33.032273	0.238638	2.170452	1.532545	1537.311936	0.647277	0	0	0	0	0.270572
791	32.933338	0.229129	1.922772	1.433762	1365.407949	0.574898	0	0	0	0	0.303072
792	32.826004	0.219347	1.935564	1.327064	1361.01187	0.573047	0	0	0	0	0.581557
793	32.853652	0.215998	1.743624	1.354486	1328.558594	0.559383	0	0	0	0	0.532045
794	32.810069	0.209119	1.6419	1.311547	1113.686214	0.468912	0	0	0	0	0.948571
795	32.818265	0.231699	1.790964	1.319143	1317.040578	0.554533	0	0	0	0	0.813705
796	32.786196	0.267079	2.069148	1.297393	1217.158054	0.512478	0	0.075651	6.885445	0.002899	1.700575
797	32.764398	0.247494	1.840824	1.264622	1186.474604	0.499559	0	0	0	0	1.180339
798	32.826249	0.241033	2.090424	1.326551	1275.415094	0.537007	0	0	0	0	0.737173
799	32.833201	0.240716	1.981008	1.332822	1291.942456	0.543966	0	0	0	0	0.641275
800	32.8808	0.239664	2.057988	1.380602	1224.266751	0.515471	0	0	0	0	0.639464
801	32.855924	0.237535	2.05584	1.35561	1251.312293	0.526859	0	0	0	0	0.554089
802	33.031749	0.245203	2.119692	1.531348	1561.626369	0.657515	0	0	0	0	0.828788
803	33.143532	0.246396	2.176092	1.643096	1729.476868	0.728187	0	0	0	0	0.757438
804	33.186672	0.245447	2.184984	1.686912	1631.282481	0.686843	0	0	0	0	1.441878
805	33.15299	0.244078	2.094756	1.653562	1635.123382	0.68846	0	0	0	0	1.938906
806	32.959871	0.239081	1.992636	1.459875	1319.818318	0.555703	0	0	0	0	0.963373
807	32.938157	0.230079	1.854696	1.438161	1496.849657	0.630241	0	0	0	0	1.131646
808	32.954985	0.23562	2.145144	1.455793	1411.981697	0.594508	0	0	0	0	1.642117
809	32.950733	0.235711	2.105772	1.451211	1473.414076	0.620373	0	0	0	0	1.769296
810	33.20748	0.222142	2.163252	1.708102	1506.140551	0.634153	0	0	0	0	2.12853
811	33.323858	0.215161	2.356956	1.823843	1610.032041	0.677896	0	0	0	0	2.204252
812	33.263211	0.220093	2.430564	1.763027	1647.132663	0.693517	0	0	0	0	2.441619
813	33.288036	0.22229	2.358624	1.787436	1916.193002	0.806803	0	0	0	0	1.797282
814	33.193755	0.224279	2.221236	1.693463	1486.594605	0.625923	0	0	0	0	1.858551
815	33.118163	0.227903	2.226552	1.617762	1579.2213	0.664923	0	0	0	0	1.963941
816	33.153026	0.222607	2.220228	1.652592	1715.550379	0.722324	0	0	0	0	1.950635
817	33.069804	0.228685	2.145516	1.569182	1432.238616	0.603037	0	0	0	0	2.38167
818	33.197477	0.239909	2.381784	1.69742	1725.156062	0.726368	0	0	0	0	2.148134
819	33.238674	0.238757	2.282124	1.738449	1630.321798	0.686439	0	0	0	0	1.944445
820	33.225945	0.231609	2.393208	1.724887	1705.757992	0.718201	0	0	0	0	1.92762
821	33.192864	0.236984	2.358468	1.688516	1773.8427	0.746867	0	0	0	0	2.162695
822	33.266418	0.234929	2.363304	1.763025	1843.337507	0.776128	0	0	0	0	1.47092
823	33.281996	0.23411	2.334096	1.779402	1826.793143	0.769162	0	0	0	0	1.379211
824	33.16328	0.234588	2.370996	1.6613	1782.854922	0.750662	0	0	0	0	1.853414
825	33.253365	0.237979	2.445648	1.751901	1688.071428	0.710754	0	0	0	0	1.547423
826	33.358596	0.234514	2.392692	1.857676	1819.065524	0.765908	0	0	0	0	2.220682
827	33.40193	0.232618	2.591268	1.90054	1928.287389	0.811895	0	0	0	0	2.288094
828	33.12346	0.245573	2.449776	1.62069	1600.00504	0.673674	0	0	0	0	2.670757

Segment S14S151

829	33.172005	0.23951	2.584944	1.669684	1650.207143	0.694811	0	0	0	0	2.347254
830	33.228154	0.234856	2.485464	1.72573	1591.910537	0.670266	0	0	0	0	3.130157
831	33.292201	0.228928	2.58192	1.789321	1756.917564	0.739741	0	0	0	0	2.633284
832	33.407291	0.236888	2.790984	1.905138	1870.214625	0.787444	0	0	0	0	3.69178
833	33.390694	0.241701	2.789868	1.888524	1788.122348	0.75288	0	0	0	0	3.375112
834	33.477694	0.236636	3.058872	1.978099	1945.295027	0.819056	0	0	0	0	3.715557
835	33.441986	0.215516	3.434514	1.941167	2095.705106	0.882386	0	0	0	0	4.511689
836	33.378722	0.225398	3.582264	1.873368	1865.889173	0.785623	0	0	0	0	4.056109
837	33.788081	0.241755	4.272036	2.281339	1989.035574	0.837473	0	0	0	0	6.960797
838	33.797509	0.235641	4.280844	2.291835	2422.899427	1.020149	0	0	0	0	9.02525
839	33.7571	0.232548	4.2744	2.251596	2201.619896	0.926981	0	0	0	0	9.435328
840	33.549327	0.234422	4.027836	2.044431	1819.870653	0.766247	0	0	0	0	9.061219
841	33.594932	0.237124	4.334028	2.090012	1725.336563	0.726444	0	0	0	0	8.267989
842	33.777792	0.217774	4.166244	2.280549	2529.33329	1.064963	0	0	0	0	10.24232
843	33.517322	0.207412	4.044252	2.042354	1822.126937	0.767197	0	0.251746	5.75687	0.002424	10.35478
844	33.1749	0.198575	3.926435	1.742315	266.024548	0.112008	0.575202	0.312271	1.82597	0.000769	10.41676
AVERAGE DIAMETER	**65.39233149**	**MAXIMUM**	**4.334028**	**2.291835**	**2529.33329**	**1.064963**	**0.575202**	**3.24915**	**8.302243**	**0.003496**	**10.41676**
		AVERAGE	**1.705067424**	**1.198414004**	**1239.029656**	**0.52168702**	**0.000684**	**0.00488537**	**0.031536071**	**1.32771E-05**	**1.464382**

MAXIMUM MEASUREMENTS HIGHLIGHTED IN PEACH

LEGEND:
MAXIMUM CORROSION: MAXIMUM DEPTH OF CORROSION IN THE ONE FOOT SECTION OF PIPE.
AVERAGE CORROSION: THE AVERAGE CORROSION FOR EACH ONE FOOT SECTION.
INTEGRATED CORROSION: CORROSION OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED CORROSION: INTEGRATED CORROSION DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE THIS NUMBER TO COMPARE THE EXTENT OF CORROSION IN EACH ONE FOOT SECTION OF PIPE
MAXIMUM BUILDUP: MAXIMUM BUILDUP IN THE ONE FOOT SECTION OF PIPE.
AVERAGE BUILDUP: THE AVERAGE BUILDUP FOR EACH ONE FOOT SECTION.
INTEGRATED BUILDUP: BUILDUP OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED BULDUP: INTEGRATED BUILDUP DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE THIS NUMBER TO COMPARE THE EXTENT OF BUILDUP IN EACH ONE FOOT SECTION OF PIPE
OVALITY: CHANGE IN CIRCULARITY; THE AMOUNT OF OUT-OF-ROUNDNESS

Segment S14S151

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

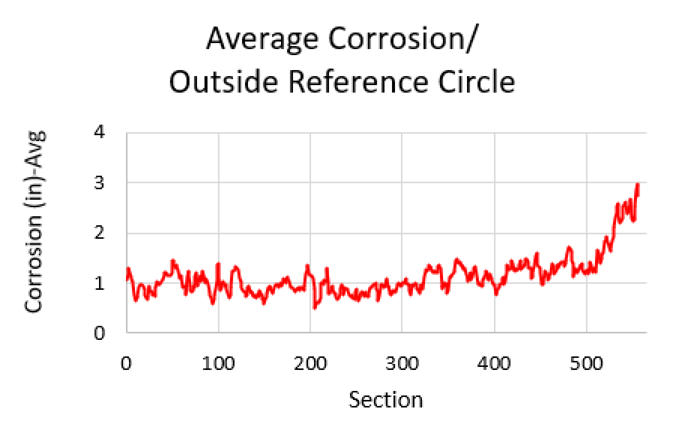
MULTI-SENSOR INSPECTION SUMMARY REPORT FOR: S15 TO S16, 63" RCP, 566 LF INSPECTED LENGTH

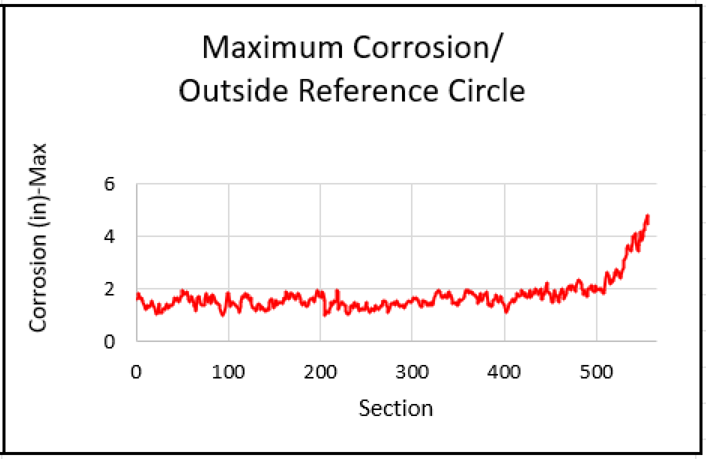
INSPECTION PROCEEDED UPSTREAM FROM S16 TO S15 TO AVOID SIGNIFICANT WATER FLOWING INTO MANHOLE AT S15. THE FLOATING PONTOON WAS USED FOR THIS INSPECTION. WATER LEVEL WAS AT 35%. LIGHT FOG INSIDE PIPE.

MANHOLE S15 HAS A TIE-IN WITH A SIGNIFICANT AMOUNT OF WATER FLOWING INTO THE PIPE AT THIS LOCATION SO THE INSPECTION WAS COMPLETED FROM DOWNSTREAM TO UPSTREAM TO AVOID THIS WATER FLOW. DUE TO THIS TIE-IN, THE HIGHEST CORROSION READINGS ARE NEAR THIS MANHOLE S15. HIGHEST CORROSION LEVELS ARE FROM 528-566 FEET. MAXIMUM CORROSION IS 4.84 INCHES AT 561 FEET. SURFACE DAMAGE PRESENT INCLUDING REINFORCEMENT VISIBLE/CORRODED NEAR MANHOLE S15. AVERAGE CORROSION OVER ENTIRE LENGTH OF PIPE IS 1.13 INCHES.

THE TOTAL DEBRIS AS MEASURED BY THE SONAR IS 164 CF (6.1 CY).

Measurement	*Measurement From Pipe Center (Inches)*
Average Corrosion/Outside Reference Circle	1.13
Maximum Average Corrosion/Outside Reference Circle	2.98
Maximum Corrosion/Outside Reference Circle	4.84





Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

HIGHEST CORROSION READINGS WERE MEASURED BETWEEN 528-562 FEET

Title 1	Minimum Position (ft)	Maximum Position (ft)	Surface Area(in2)/ft
EBMUD	10	567	2375.044046

Position (ft)	Maximum Corrosion (in)	Average Corrosion (in)	Integrated Corrosion (in3)
561	4.842096	2.977363	2901.952558
560	4.630347	2.867901	2872.005047
562	4.49519	2.738245	1554.843569
559	4.476688	2.542393	2863.294941
558	4.26906	2.255437	2446.938263
557	4.268184	2.3203	2635.466175
554	4.214268	2.676886	2678.124277
548	4.148052	2.606088	2567.371534
553	4.034184	2.541733	2763.261926
546	4.012428	2.515297	2429.299536
556	3.998219	2.230074	2349.022503
547	3.981576	2.547213	2172.245772
549	3.909732	2.557882	2522.183763
555	3.836304	2.292014	2230.037625
545	3.765536	2.299061	2359.528113
552	3.67512	2.51953	2729.26176
540	3.660432	2.599893	2286.697186
539	3.560124	2.534114	2637.067323
541	3.552649	2.347617	2159.281026
542	3.526428	2.202833	2077.458952
550	3.493248	2.390645	2601.296842
544	3.48168	2.254694	2129.705972
551	3.468948	2.430326	2572.845202
543	3.44502	2.238435	1859.749905
538	3.36042	2.406318	1956.856033
537	3.144528	2.281345	2475.710231
536	3.122232	2.104084	1525.605199
535	2.833488	1.939541	1889.546674
528	2.757396	1.937405	1889.163534
534	2.725764	1.852014	1737.00855

Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

PACP SCORING REPORT

PACP v7.0 Inspections and Scoring

General Information:

Surveyed by:	Certificate number:	Reviewed by:	Reviewer certificate no.	Owner:	Customer:
F MORENO/NPS	U-913-19012				

P/O number:	Work order no.:	Media label:	Project name:	Start date/time:
			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022	20220519 14:50

Sheet number:	Weather:	Pre-cleaning:	Date cleaned:	Flow control:	Purpose:
	1	N		N	F

Direction:	Technology used:	Inspection status:	Consequence of failure:	Pressure value:
U		CI		

Location:

Drainage area:	Pipe segment ref.:	Street:
	S15S161	COLISEUM WY/ACROSS FROM SWAP MEET

City:	Location code:	Location details:
OAKLAND	B	

Pipe:

Pipe use:	Height:	Width:	Shape:	Material:	Lining method:
SS	63 in.		C	RCP	

Coating method:	Pipe joint length:	Total length:	Length surveyed:	Year constructed:	Year renewed:
		566.000 ft.	566.000 ft.		

Measurements:

Upstream MH No:	Rim to invert:	Rim to grade:	Grade to invert:	Northing:	Easting:	Elevation:
S15						

Downstream MH No:	Rim to invert:	Rim to grade:	Grade to invert:	Northing:	Easting:	Elevation:
S16						

MH coordinate system:	MH vertical datum:	GPS accuracy:

Pipe Ratings

Grade	Structural: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	O&M: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	Overall: Pipe Rating	Pipe Rating Index	LoF	Risk
1	404	404	834	5C4B	1.5	0	0	3	3100	3.0	837	1.5	6.0	
2	46	92				0	0							
3	52	156				1	3							
4	18	72				0	0							
5	22	110				0	0							

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
0.0 ft.		AMH					☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 0.0 ft_4.JPG	S16
0.0 ft.		MWL				35	☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---MWL at 0.0 ft_3.JPG	
0.4 ft.	00:00:50	SRI	S01				☑	8	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 0.4 ft.JPG	
0.4 ft.	00:01:08	SSC	S02				☐	9	3	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 0.4 ft_1.JPG	
24.8 ft.	00:03:36	MGO					☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---MGO at 24.8 ft.JPG	LIGHT STEAM

Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
36.9 ft.	00:04:22	SAV					☐	10	2	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAV at 36.9 ft.JPG	
84.0 ft.	00:08:15	SSC	F02				☐	9	3	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 84.0 ft.JPG	
84.0 ft.	00:07:41	SAV	S03				☐	10	2	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAV at 84.0 ft_1.JPG	
84.0 ft.	00:09:19	SRI	S04				☐	8	10	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 84.0 ft_1.JPG	
84.0 ft.	00:09:46	SRI	S05				☐	2	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 84.0 ft_3.JPG	
84.0 ft.	00:09:50	CM					☐	3	4	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S15'-AMH 'S16'-CM at 84.0 ft.JPG	
157.2 ft.	00:13:31	SSC	S06				☐	10	2	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 157.2 ft_1.JPG	

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
206.5 ft.	00:16:44	SAV	F03				☐	10	2	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAV at 206.5 ft.JPG	
206.5 ft.	00:16:56	SAP	S07				☐	10	2	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 206.5 ft.JPG	
349.7 ft.	00:23:32	SAP	F07				☐	10	2	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 349.7 ft.JPG	
349.7 ft.	00:23:51	SAV	S08				☐	10	2	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAV at 349.7 ft.JPG	
449.9 ft.	00:28:30	SAV	F08				☐	10	2	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAV at 449.9 ft_1.JPG	
449.9 ft.	00:28:35	SAP	S09				☐	10	2	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 449.9 ft.JPG	
464.4 ft.	00:30:07	SRV					☐	11	1	4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRV at 464.4 ft_1.JPG	

Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
464.4 ft.	00:30:15	SRC					☐	11	1	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRC at 464.4 ft.JPG	
475.0 ft.	00:32:08	SRV	S10				☐	11	1	4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRV at 475.0 ft.JPG	
475.0 ft.	00:32:19	SRC	S11				☐	11	1	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRC at 475.0 ft_1.JPG	
550.2 ft.	00:36:26	SRV	F10				☐	11	1	4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRV at 550.2 ft.JPG	
550.2 ft.	00:36:28	SRP	S12				☐	10	2	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRP at 550.2 ft.JPG	
550.2 ft.	00:36:56	SRC	F11				☐	11	1	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRC at 550.2 ft.JPG	
550.2 ft.	00:37:02	SRC	S13				☐	10	2	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRC at 550.2 ft_1.JPG	

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
554.3 ft.	00:38:18	SAM					☐	12		4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAM at 554.3 ft_1.JPG	
563.6 ft.	00:39:17	ID					☑	12		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---ID at 563.6 ft.JPG	
563.6 ft.	00:39:45	SRP	F12				☐	10	2	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRP at 563.6 ft.JPG	
563.6 ft.	00:40:02	SRC	F13				☐	10	2	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRC at 563.6 ft.JPG	
566.0 ft.	00:41:13	SAP	F09				☐	10	2	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 566.0 ft.JPG	
566.0 ft.	00:41:17	SSC	F06				☐	10	2	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 566.0 ft.JPG	
566.0 ft.	00:41:21	SRI	F05				☐	2	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 566.0 ft.JPG	

Segment S15S161

EBMUD

MULTI-SENSOR INSPECTION PROJECT

PREPARED BY: NATIONAL PLANT SERVICES, INC

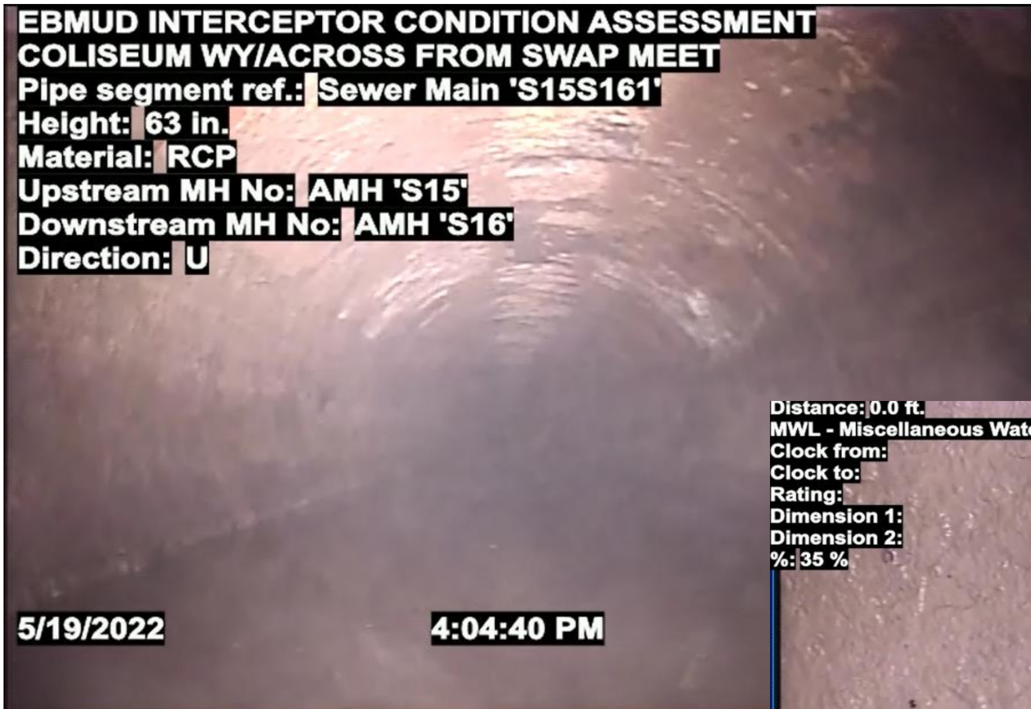
Observations

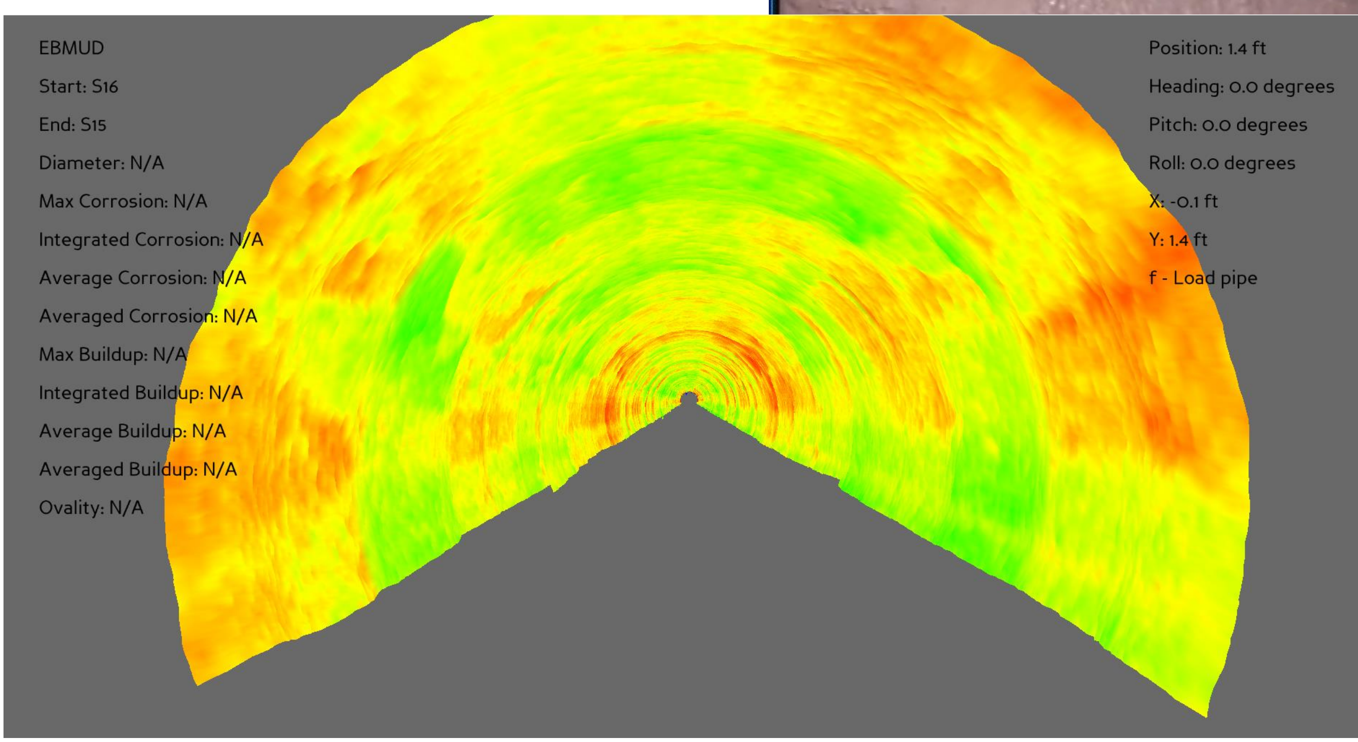
Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
566.0 ft.	00:41:26	SRI	F04				☐	8	10	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 566.0 ft_1.JPG	
566.0 ft.	00:41:30	SRI	F01				☑	8	4	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 566.0 ft_2.JPG	
566.0 ft.	00:42:13	SAM					☐	12		4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAM at 566.0 ft.JPG	
566.0 ft.	00:42:21	AMH					☐				EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 566.0 ft_2.JPG	S15

Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

IMAGE REPORT :
GENERAL INTERIOR VIEW, 0 FEET. STEAM INSIDE PIPE

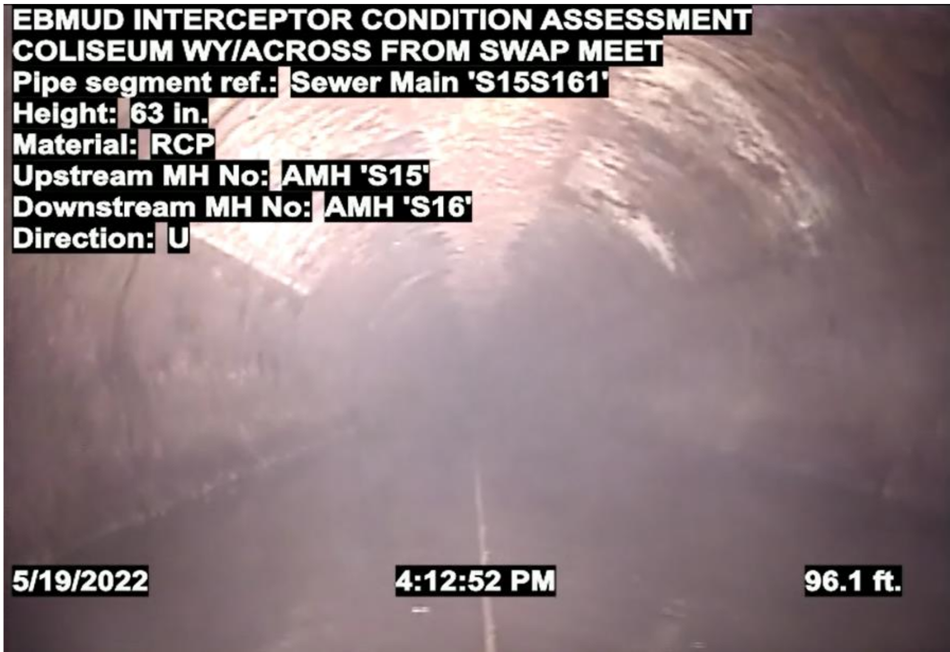


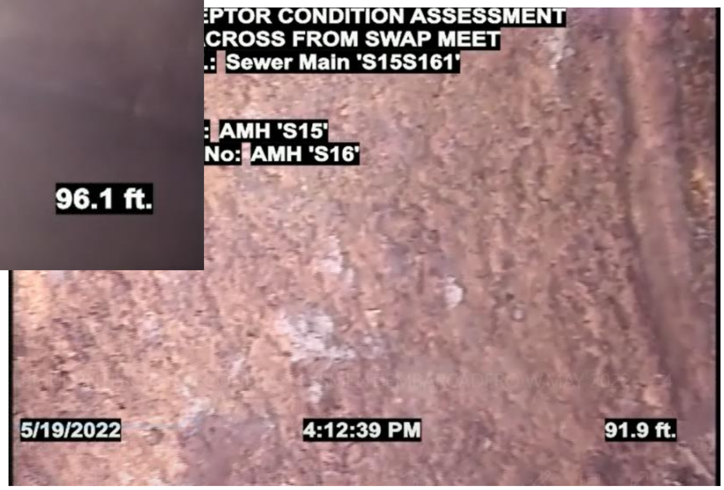


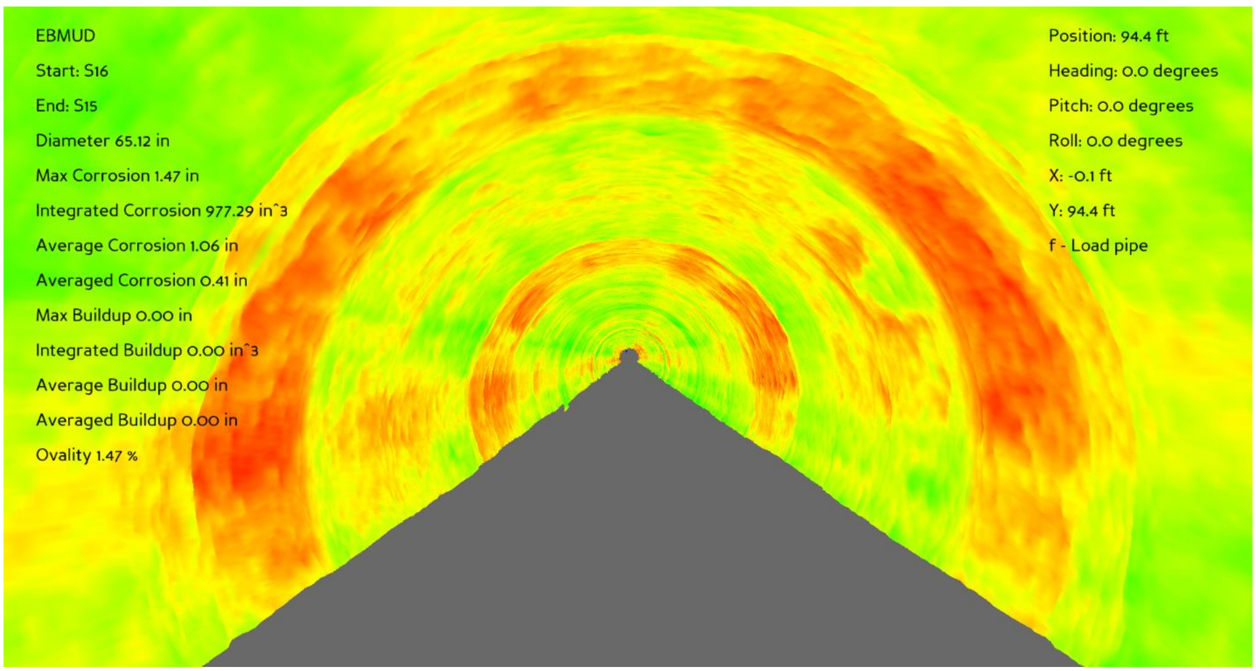
Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

AREA OF INCREASED ROUGHNESS, 90-100 FEET



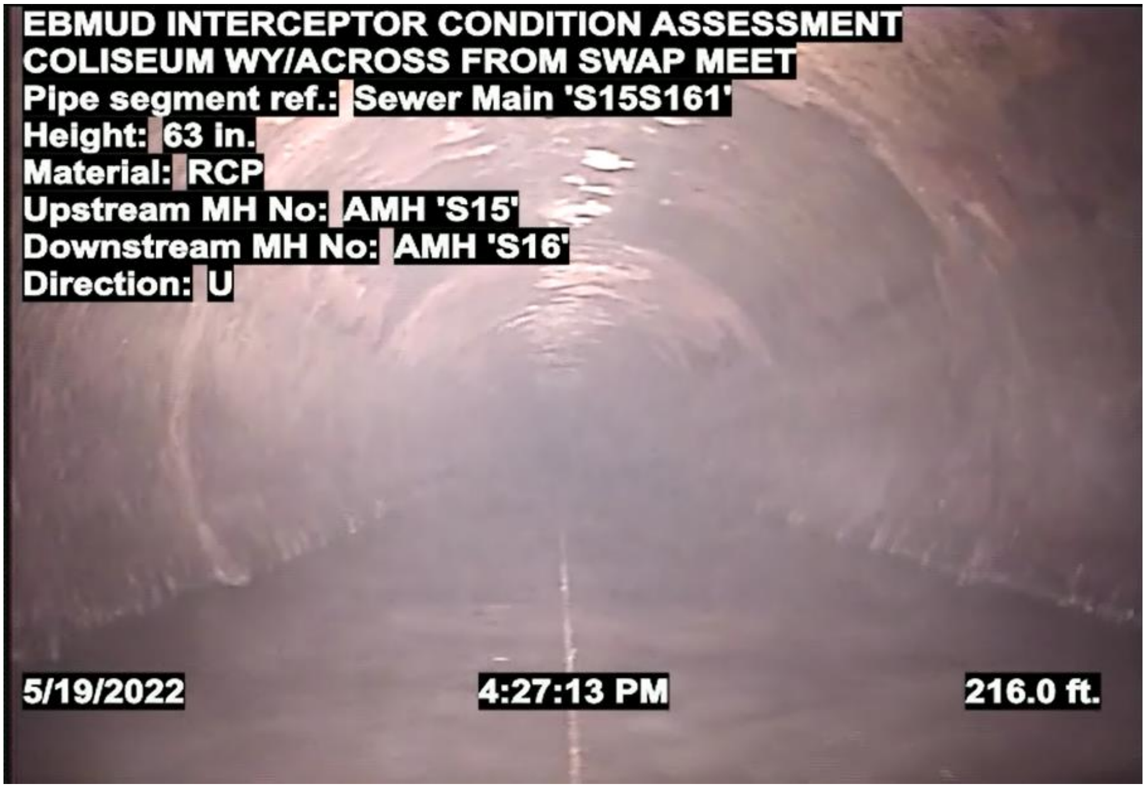


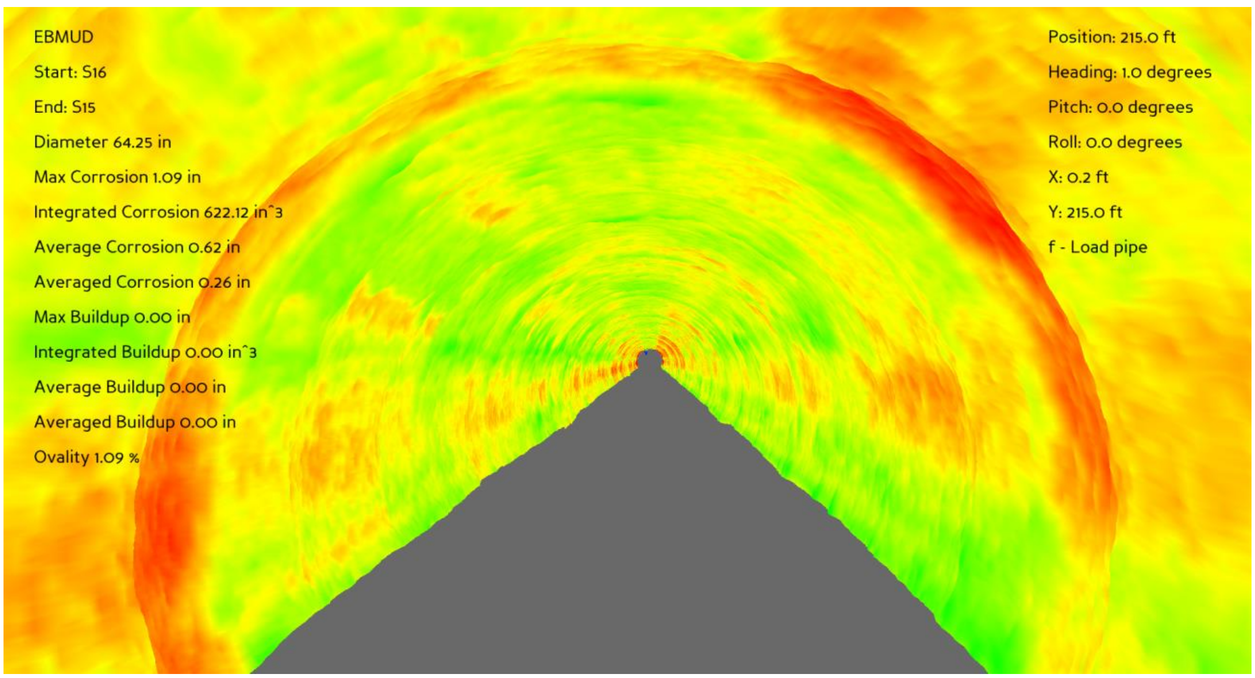


Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

JOINT WITH CORROSION PRESENT, 220 FEET

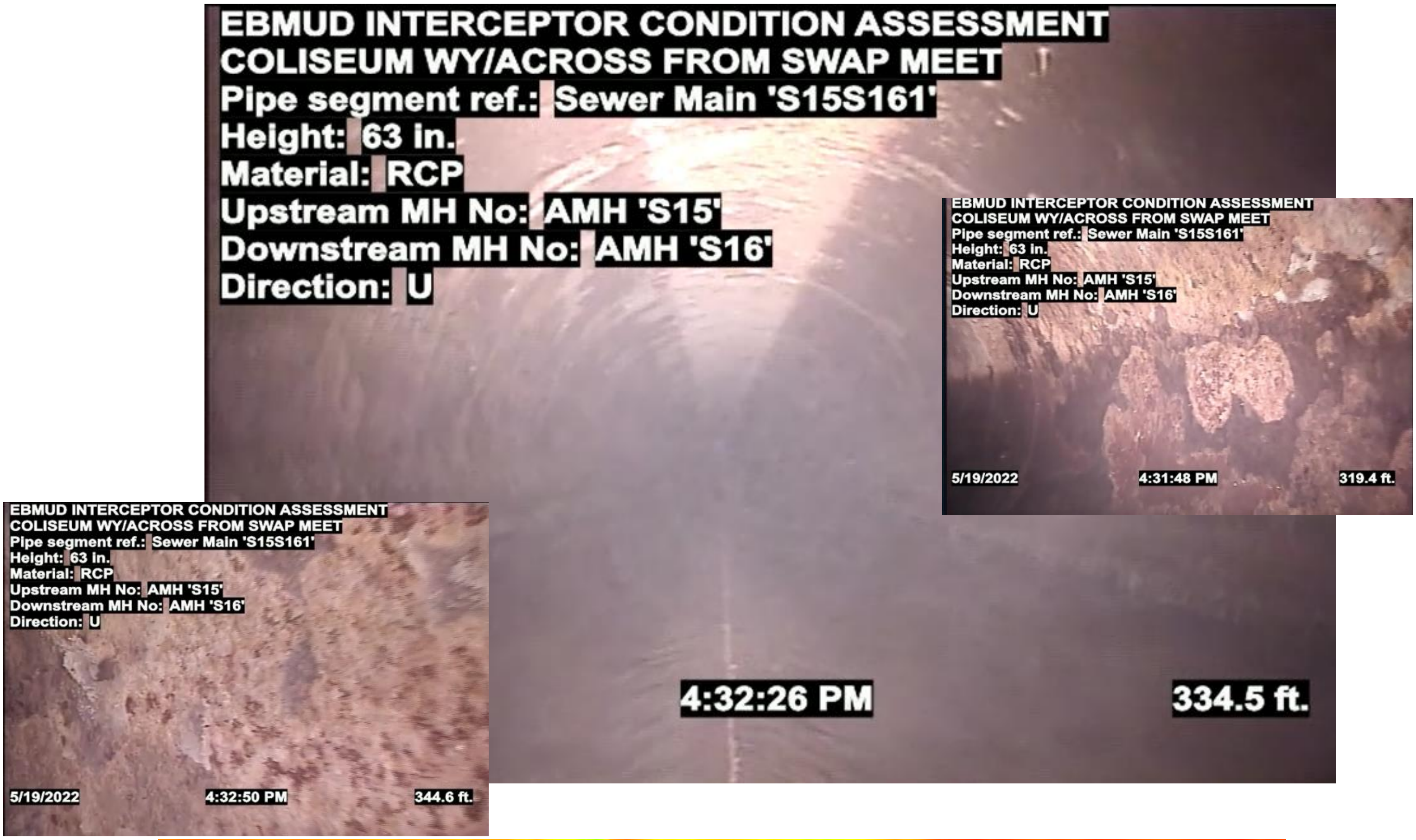


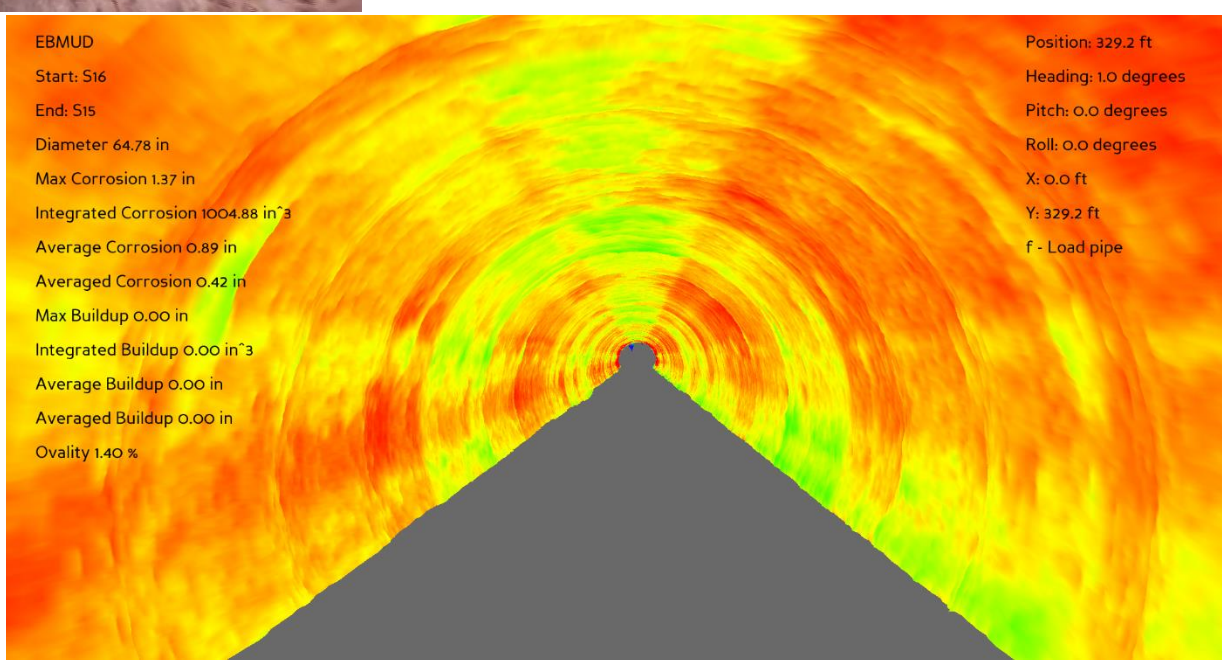


Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

TYPICAL INTERIOR VIEW, 330 FEET

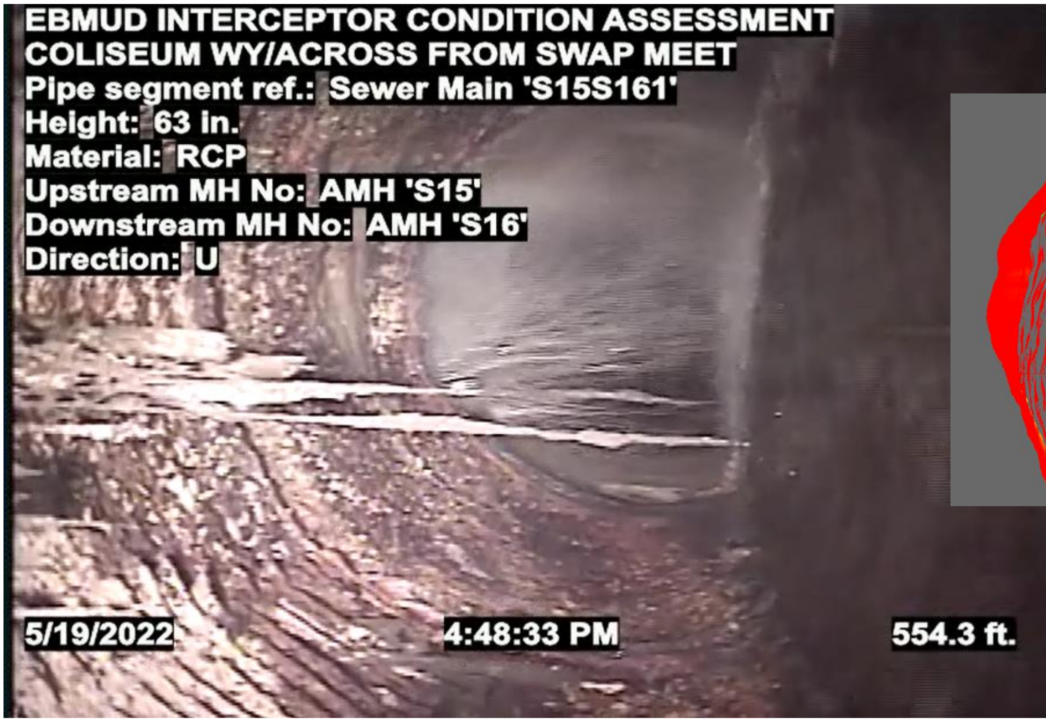


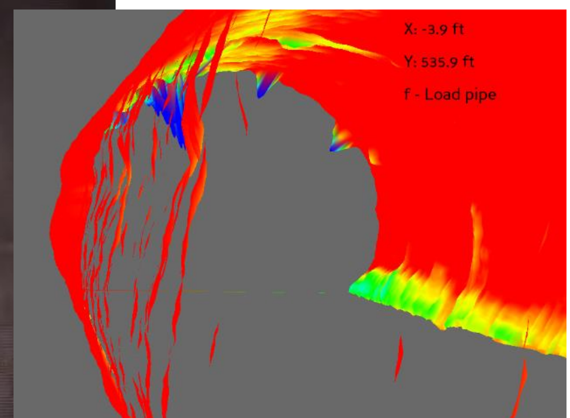


Segment S15S161

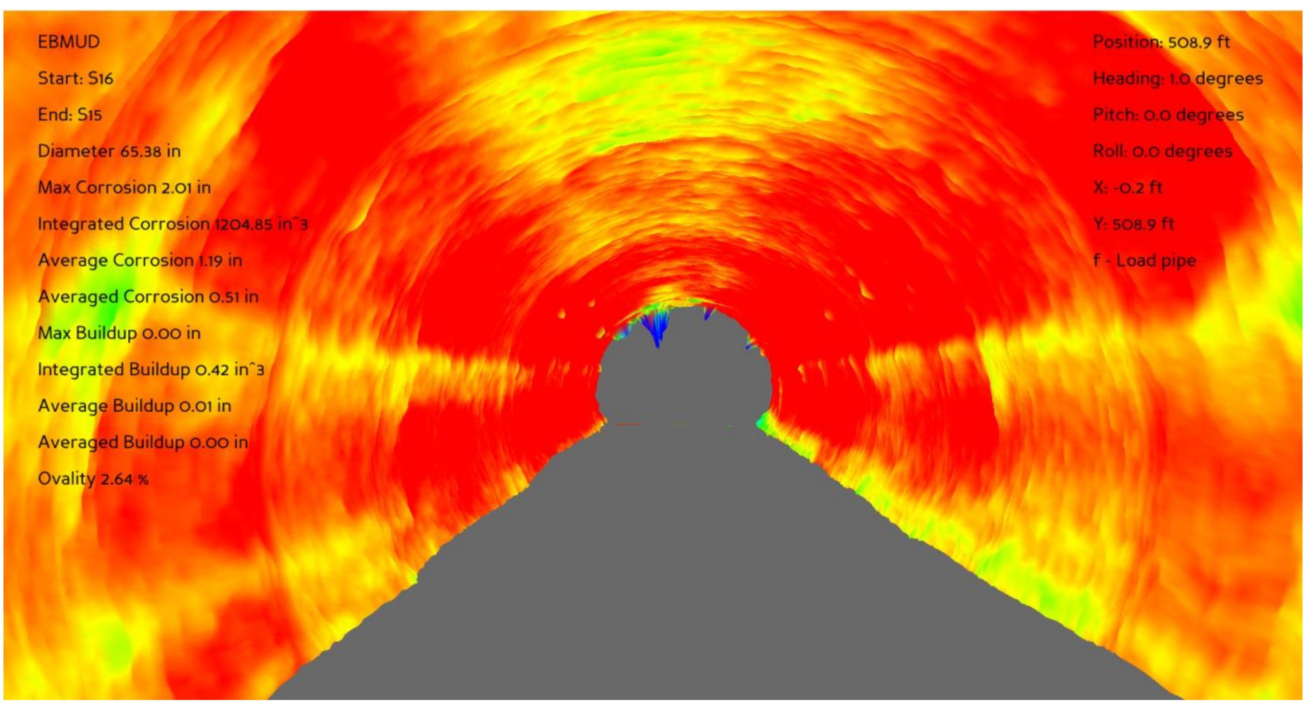
EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

AREA OF HIGHEST CORROSION IS DOWNSTREAM OF S15 DUE TO SIGNIFICANT AMOUNT OF WATER FLOWING INTO THE MANHOLE. MAXIMUM CORROSION TO 4.84 INCHES AT 561 FEET. AREA UPSTREAM OF S15 IS ALSO CORRODED AS MEASURED IN THE S14 TO S15 INSPECTION.





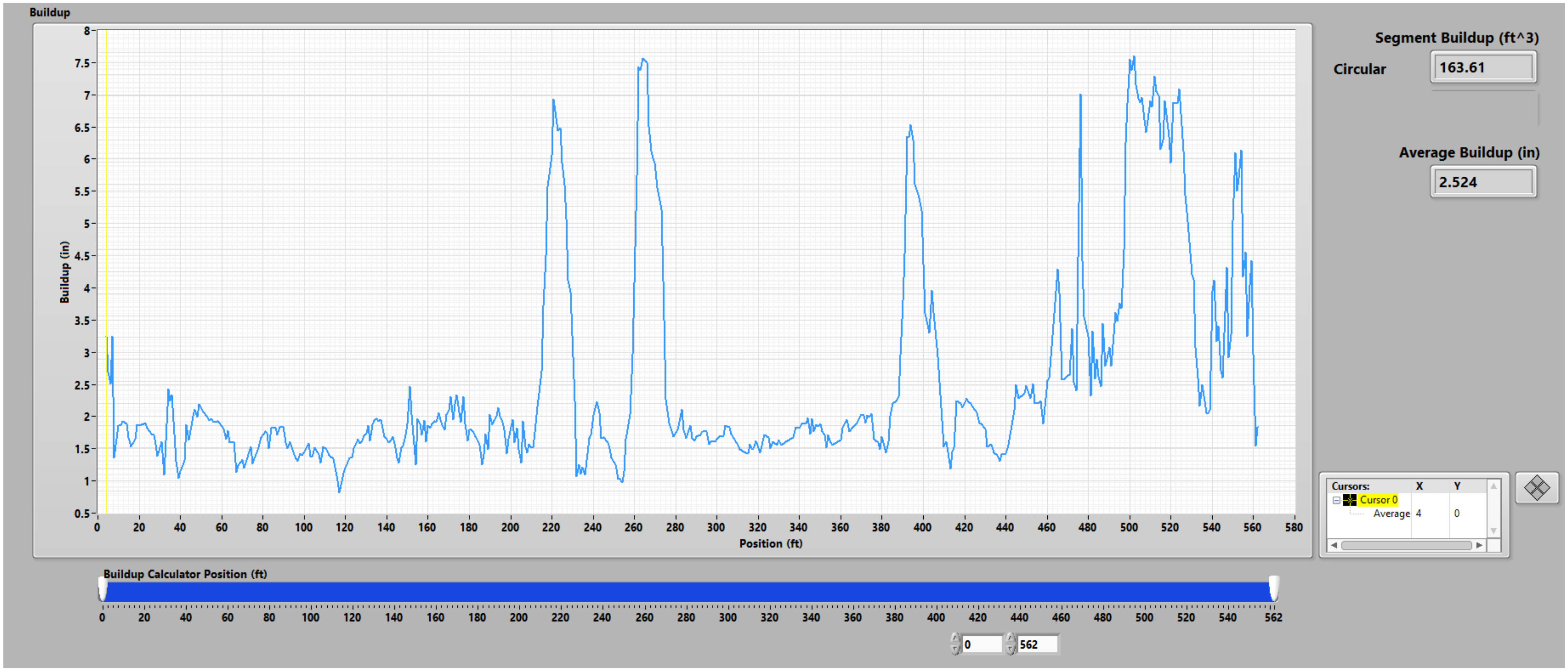
LEFT SIDE VIEW FROM OUTSIDE PIPE



Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

SONAR RESULTS: 164 CF (6.1 CY)



Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT
PREPARED BY: NATIONAL PLANT SERVICES, INC

LASER RESULTS BY 1 FOOT SCAN

Segment S15S161

Title 1	Title 2	Title 3	Minimum Position (ft)	Maximum Position (ft)	Surface Area(in2)/ft
EBMUD	Start: S16	End: S15	10	567	2375.044046

Position (ft)	Circular Radius (in)	Circular Normalized Residual Range	Maximum Corrosion (in)	Average Corrosion (in)	Integrated Corrosion (in3)	Averaged Corrosion (in)	Maximum Buildup (in)	Average Buildup (in)	Integrated Buildup (in3)	Averaged Buildup (in)	Ovality (%)
7	32.547905	0.160054	1.621356	1.048253	1167.06718	0.491388	0	0	0	0	0.847929
8	32.689356	0.190525	1.672932	1.190105	908.731853	0.382617	0	0	0	0	2.092478
9	32.798649	0.216305	1.826124	1.300155	1387.434164	0.584172	0	0	0	0	2.440258
10	32.69967	0.232678	1.686936	1.199448	746.714552	0.3144	0	0	0	0	1.94724
11	32.631458	0.220558	1.599744	1.13168	1203.013127	0.506522	0	0	0	0	1.94852
12	32.594969	0.190116	1.676196	1.094847	1115.03847	0.469481	0	0	0	0	1.931378
13	32.53495	0.146327	1.59408	1.035418	1111.077771	0.467814	0	0	0	0	1.874511
14	32.513527	0.125048	1.51428	1.013422	1141.328123	0.48055	0	0	0	0	1.447399
15	32.272626	0.132712	1.423223	0.772401	866.364053	0.364778	0	0	0	0	1.065717
16	32.150108	0.131015	1.22202	0.649538	699.295352	0.294435	0	0	0	0	1.423794
17	32.164827	0.134446	1.306272	0.664575	734.656217	0.309323	0	0	0	0	1.915358
18	32.200116	0.131295	1.379952	0.700647	678.996345	0.285888	0	0	0	0	2.66378
19	32.241642	0.161536	1.266036	0.742771	733.266744	0.308738	0	0	0	0	2.636857
20	32.407317	0.174955	1.356264	0.908571	902.846066	0.380139	0	0	0	0	2.787867
21	32.46764	0.174905	1.387356	0.9688	868.332704	0.365607	0	0	0	0	2.728415
22	32.480376	0.169581	1.364652	0.981078	1060.366665	0.446462	0	0	0	0	2.398702
23	32.472133	0.173376	1.557504	0.972407	998.800628	0.42054	0	0	0	0	1.934494
24	32.443512	0.173769	1.38012	0.944671	888.135696	0.373945	0	0	0	0	2.129758
25	32.428551	0.168029	1.405488	0.931164	952.619658	0.401096	0	0	0	0	2.581404
26	32.373003	0.173413	1.290492	0.873636	865.957194	0.364607	0	0	0	0	1.956046
27	32.258394	0.172478	1.28052	0.75983	749.552045	0.315595	0	0	0	0	1.566699
28	32.203999	0.165935	1.03794	0.705854	731.02962	0.307796	0	0	0	0	1.376251
29	32.176116	0.162766	1.085328	0.677224	600.80572	0.252966	0	0	0	0	1.465733
30	32.227959	0.154782	1.107324	0.72894	732.62134	0.308466	0	0	0	0	1.859208
31	32.431318	0.149309	1.476132	0.932008	1074.129247	0.452257	0	0	0	0	1.928231
32	32.312786	0.095846	1.114812	0.81223	1009.340203	0.424977	0	0	0	0	0.639953
33	32.349428	0.091007	1.10562	0.84812	865.175134	0.364278	0	0	0	0	0.222754
34	32.317668	0.090037	1.122288	0.815982	911.291369	0.383695	0	0	0	0	0.569393
35	32.251954	0.095717	1.207437	0.750522	852.375216	0.358888	0	0	0	0	0.95867
36	32.298168	0.096944	1.271916	0.797076	831.39428	0.350054	0	0	0	0	1.297965
37	32.242557	0.101722	1.217904	0.743322	922.804404	0.388542	0	0	0	0	0.942399
38	32.405562	0.103116	1.299324	0.906501	905.282456	0.381164	0	0	0	0	1.088953
39	32.510146	0.124811	1.466789	1.008338	1091.242111	0.459462	0	0	0	0	0.959626
40	32.54233	0.129726	1.431996	1.040347	1091.541289	0.459588	0	0	0	0	0.581417
41	32.487705	0.127664	1.31082	0.985644	1111.054326	0.467804	0	0	0	0	0.696976
42	32.475906	0.135382	1.34856	0.976119	800.240763	0.336937	0	0	0	0	0.62576
43	32.46705	0.167446	1.384452	0.965892	1067.685396	0.449543	0	0	0	0	0.933384
44	32.518711	0.176236	1.3752	1.019947	1050.102774	0.44214	0	0	0	0	1.341059
45	32.53842	0.172944	1.410684	1.036724	912.585133	0.384239	0	0	0	0	1.275269
46	32.565312	0.173649	1.423776	1.066578	840.125775	0.353731	0	0	0	0	2.043668
47	32.64614	0.20221	1.63086	1.146752	1279.130941	0.538571	0	0	0	0	1.584763
48	32.724204	0.201186	1.665624	1.226256	1069.995236	0.450516	0	0	0	0	2.554166
49	32.703292	0.20027	1.595808	1.204096	1002.568177	0.422126	0	0	0	0	2.397932
50	32.695716	0.200024	1.618812	1.196263	1183.742268	0.498409	0	0	0	0	2.375508
51	32.656367	0.18795	1.670796	1.157223	1203.611223	0.506774	0	0	0	0	1.59931
52	32.637098	0.184804	1.532976	1.137528	1160.308565	0.488542	0	0	0	0	1.418957
53	32.664672	0.177452	1.579572	1.165852	999.257651	0.420732	0	0	0	0	1.976013
54	32.648705	0.172909	1.69698	1.148635	1142.61392	0.481092	0	0	0	0	1.825597
55	32.700166	0.175026	1.786284	1.201114	1260.34258	0.530661	0	0	0	0	2.479024
56	32.95345	0.181055	1.99476	1.454482	1454.708041	0.612497	0	0	0	0	2.249809
57	32.94276	0.179672	1.849392	1.444128	1224.497525	0.515568	0	0	0	0	1.731602
58	32.890284	0.176447	1.80816	1.389986	1397.149625	0.588263	0	0	0	0	2.156176
59	32.80472	0.190781	1.847052	1.305918	1404.460146	0.591341	0	0	0	0	1.846163
60	32.865393	0.187915	1.82892	1.36527	1130.120453	0.475831	0	0	0	0	1.910409
61	32.829057	0.182886	1.912008	1.328136	1459.74743	0.614619	0	0	0	0	2.088098
62	32.735995	0.182133	1.72872	1.236336	1146.704399	0.482814	0	0	0	0	2.267682
63	32.726273	0.172391	1.613736	1.226713	1155.439326	0.486492	0	0	0	0	0.883997
64	32.58683	0.181431	1.539216	1.087608	1238.176136	0.521328	0	0	0	0	1.977975
65	32.652124	0.165428	1.68366	1.15266	976.080952	0.410974	0	0	0	0	3.138871
66	32.620314	0.158605	1.715592	1.121428	1110.202639	0.467445	0	0	0	0	3.204945
67	32.418027	0.134022	1.598936	0.918879	1022.241648	0.43041	0	0	0	0	1.960389
68	32.430369	0.140819	1.400808	0.930357	746.975677	0.31451	0	0	0	0	1.582319
69	32.430111	0.145995	1.32864	0.93129	1092.505041	0.459994	0	0	0	0	1.75211
70	32.404534	0.15111	1.391364	0.906272	897.439266	0.377862	0	0	0	0	1.932334
71	32.275617	0.138684	1.194816	0.776803	864.298826	0.363909	0	0	0	0	1.692094
72	32.618469	0.1407	1.658352	1.11858	1042.921995	0.439117	0	0	0	0	1.248066
73	32.728176	0.142355	1.703412	1.228408	1095.211771	0.461133	0	0	0	0	2.215415
74	32.653349	0.15119	1.76172	1.153886	1351.148487	0.568894	0	0	0	0	1.867633
75	32.436698	0.15722	1.513187	0.936909	1016.794763	0.428116	0	0	0	0	1.805416
76	32.351642	0.154754	1.464288	0.850284	861.582533	0.362765	0	0	0	0	1.768985
77	32.335233	0.149868	1.4019	0.834261	911.138238	0.38363	0	0	0	0	2.437284
78	32.353274	0.151604	1.412316	0.854223	885.82249	0.372971	0	0	0	0	2.63309
79	32.451677	0.159772	1.4118	0.952093	937.968763	0.394927	0	0	0	0	1.463717
80	32.423522	0.163972	1.368612	0.92334	843.89824	0.355319	0	0	0	0	1.475905
81	32.633582	0.162963	1.626012	1.134828	1293.77551	0.544737	0	0	0	0	2.340633
82	32.715942	0.162536	1.858164	1.215476	1047.663012	0.441113	0	0	0	0	2.516675
83	32.454473	0.168561	1.520748	0.954149	1018.58684	0.428871	0	0	0	0	1.090196
84	32.536558	0.181065	1.580676	1.036876	1058.838714	0.445819	0	0	0	0	1.960986
85	32.568183	0.184072	1.60374	1.068933	986.687333	0.41544	0	0	0	0	2.020825
86	32.64214	0.18441	1.75926	1.14227	1055.832138	0.444553	0	0	0	0	2.824919
87	32.52966	0.175859	1.44396	1.030314	1108.436411	0.466701	0	0	0	0	1.368735

Segment S15S161

88	32.581516	0.184438	1.60002	1.08328	1130.72713	0.476087	0	0	0	0	1.64249
89	32.755734	0.180494	1.76946	1.256094	1225.705409	0.516077	0	0	0	0	2.958133
90	32.656864	0.179208	1.719888	1.157634	1101.910889	0.463954	0	0	0	0	3.138548
91	32.505063	0.169555	1.566708	1.005914	1092.908548	0.460163	0	0	0	0	2.23624
92	32.578327	0.167524	1.489188	1.078435	1013.10073	0.426561	0	0	0	0	1.56617
93	32.575026	0.165321	1.4901	1.074624	1081.529823	0.455373	0	0	0	0	1.439419
94	32.559069	0.163752	1.466028	1.060134	977.292971	0.411484	0	0	0	0	1.471315
95	32.475061	0.15699	1.445316	0.974532	1070.113944	0.450566	0	0	0	0	0.933925
96	32.316256	0.146933	1.37028	0.817048	855.338331	0.360136	0	0	0	0	0.810364
97	32.27445	0.140975	1.309044	0.774717	730.226502	0.307458	0	0	0	0	0.948376
98	32.217441	0.144371	1.10622	0.717105	804.72701	0.338826	0	0	0	0	0.680246
99	32.083226	0.156288	1.01544	0.584114	677.074255	0.285079	0	0	0	0	0.738571
100	32.10728	0.16255	1.03014	0.608448	556.494969	0.234309	0	0	0	0	0.694377
101	32.186565	0.167856	1.134624	0.686529	689.910322	0.290483	0	0	0	0	1.180306
102	32.254536	0.168424	1.11456	0.754971	766.158222	0.322587	0	0	0	0	1.082035
103	32.371217	0.156859	1.33776	0.871912	868.42698	0.365647	0	0	0	0	1.537175
104	32.55096	0.145129	1.780704	1.054173	1242.237585	0.523038	0	0	0	0	2.044502
105	32.848533	0.149018	1.845576	1.351632	1391.238006	0.585774	0	0	0	0	2.965197
106	32.883204	0.148378	1.830432	1.38598	1062.495687	0.447358	0	0	0	0	2.648258
107	32.624346	0.149684	1.7715	1.125795	1294.084089	0.544867	0	0	0	0	1.487879
108	32.343684	0.15185	1.364256	0.843689	876.418502	0.369011	0	0	0	0	1.110504
109	32.420793	0.149439	1.487256	0.920979	944.504218	0.397679	0	0	0	0	1.262916
110	32.499128	0.149224	1.50432	0.999496	738.073929	0.310762	0	0	0	0	1.753157
111	32.518408	0.156416	1.51656	1.019709	1081.124421	0.455202	0	0	0	0	1.873904
112	32.51819	0.148431	1.503288	1.01808	1049.798377	0.442012	0	0	0	0	1.648498
113	32.444346	0.152087	1.397556	0.943197	975.467506	0.410716	0	0	0	0	0.775124
114	32.461194	0.148212	1.406496	0.959319	985.710203	0.415028	0	0	0	0	0.975944
115	32.376246	0.146187	1.371852	0.874402	907.877791	0.382257	0	0	0	0	0.914253
116	32.300395	0.130155	1.27224	0.798911	882.048548	0.371382	0	0	0	0	0.683013
117	32.239584	0.128273	1.230804	0.737916	701.273479	0.295268	0	0	0	0	0.632591
118	32.201472	0.127097	1.125816	0.70224	848.497569	0.357256	0	0	0	0	0.609305
119	32.253327	0.127525	1.347852	0.752217	797.566603	0.335811	0	0	0	0	1.146198
120	32.421578	0.13161	1.505604	0.92138	1009.412716	0.425008	0	0	0	0	1.350048
121	32.735796	0.127987	1.729248	1.233306	1165.610777	0.490774	0	0	0	0	1.799553
122	32.735889	0.124367	1.677324	1.236309	1326.561895	0.558542	0	0	0	0	1.757678
123	32.746167	0.133363	1.761324	1.246831	1354.165384	0.570164	0	0	0	0	2.176651
124	32.757845	0.156078	1.779324	1.258775	1286.75963	0.541783	0	0	0	0	1.765595
125	32.840642	0.163001	1.84554	1.340668	1218.391907	0.512998	0	0	0	0	1.471927
126	32.803488	0.163596	1.697256	1.304774	1308.304054	0.550855	0	0	0	0	1.574882
127	32.768241	0.163936	1.779312	1.270678	1390.418298	0.585428	0	0	0	0	1.875581
128	32.764376	0.156615	1.746324	1.26662	1281.38498	0.539521	0	0	0	0	2.240023
129	32.594945	0.161913	1.590504	1.095701	1175.05439	0.494751	0	0	0	0	1.941015
130	32.539663	0.16487	1.658088	1.040455	1059.947963	0.446286	0	0	0	0	1.872352
131	32.415757	0.169332	1.42656	0.915851	1004.941034	0.423125	0	0	0	0	1.459066
132	32.351755	0.170295	1.2858	0.852264	917.88654	0.386471	0	0	0	0	0.786857
133	32.356713	0.174725	1.309236	0.85752	996.089062	0.419398	0	0	0	0	1.027332
134	32.322525	0.179641	1.263744	0.82235	763.110584	0.321304	0	0	0	0	1.128546
135	32.314494	0.182828	1.278852	0.814916	865.545086	0.364433	0	0.00029	0.000866	0	1.272998
136	32.22346	0.179616	1.17672	0.725122	811.894151	0.341844	0	0	0	0	1.6904
137	32.27162	0.184018	1.300656	0.774332	808.625087	0.340467	0	0.001087	0.005708	0.000002	2.168302
138	32.408838	0.186658	1.4247	0.908288	868.817707	0.365811	0	0	0	0	1.848916
139	32.438552	0.189915	1.42896	0.939454	1063.896127	0.447948	0	0	0	0	2.035673
140	32.32198	0.189414	1.372992	0.823718	867.722075	0.36535	0	0	0	0	1.623651
141	32.342055	0.178907	1.235004	0.843121	897.812711	0.378019	0	0	0	0	1.162444
142	32.283858	0.180434	1.276656	0.78529	818.294173	0.344539	0	0	0	0	1.528401
143	32.312139	0.170348	1.356792	0.812472	872.099429	0.367193	0	0	0	0	1.723501
144	32.228826	0.154893	1.258092	0.728808	807.364972	0.339937	0	0	0	0	0.69114
145	32.226472	0.148632	1.144044	0.725276	778.587659	0.32782	0	0	0	0	0.733793
146	32.257315	0.147992	1.220964	0.755109	844.431874	0.355544	0	0	0	0	0.932512
147	32.213678	0.154069	1.184412	0.715009	793.639879	0.334158	0	0	0	0	0.795155
148	32.258862	0.169406	1.205376	0.757916	817.848909	0.344351	0	0	0	0	1.230172
149	32.290042	0.169946	1.255476	0.78996	842.975496	0.35493	0	0	0	0	1.145359
150	32.237739	0.174685	1.2057	0.737143	784.218715	0.330191	0	0	0	0	1.135367
151	32.33955	0.240149	1.509288	0.83963	972.147166	0.409318	0	0	0	0	1.554535
152	32.283423	0.244536	1.642968	0.78528	1150.990294	0.484619	0	0.002532	0.02565	0.000011	1.407975
153	32.263255	0.246173	1.644456	0.764953	1038.024274	0.437055	0	0.011729	0.322694	0.000136	1.292833
154	32.178549	0.248357	1.50564	0.683434	875.244707	0.368517	0	0.015746	0.265727	0.000112	1.142127
155	32.199069	0.246629	1.331124	0.700003	850.401115	0.358057	0	0	0	0	1.05629
156	32.089856	0.236091	1.26984	0.590742	741.536685	0.31222	0	0.002917	0.011383	0.000005	0.927372
157	32.17224	0.232042	1.561716	0.673628	904.922107	0.381013	0	0.003328	0.089395	0.000038	1.650603
158	32.240166	0.228384	1.546068	0.741007	977.994579	0.41178	0	0	0	0	1.286884
159	32.29569	0.221921	1.418208	0.796772	1008.632376	0.424679	0	0.007076	0.042244	0.000018	1.498647
160	32.403139	0.213907	1.479816	0.903581	1170.380717	0.492783	0	0.002975	0.047985	0.00002	1.960345
161	32.384121	0.211607	1.503972	0.883077	1065.708571	0.448711	0	0	0	0	1.528299
162	32.433059	0.207013	1.498608	0.931406	1102.362808	0.464144	0	0	0	0	1.886633
163	32.354034	0.209145	1.48584	0.852882	968.275547	0.407687	0	0.00006	0.000227	0	1.616231
164	32.338525	0.215687	1.483068	0.838537	1011.089965	0.425714	0	0	0	0	1.528244
165	32.286012	0.219102	1.462956	0.785414	871.174638	0.366804	0	0	0	0	1.341287
166	32.405376	0.219412	1.677156	0.906287	1141.854357	0.480772	0	0	0	0	1.500077
167	32.426412	0.219325	1.646556	0.926625	1176.343175	0.495293	0	0	0	0	1.444522
168	32.478723	0.222371	1.63602	0.978363	1295.981741	0.545666	0	0	0	0	1.175042
169	32.466391	0.228289	1.93146	0.96672	1262.436091	0.531542	0	0	0	0	1.196147
170	32.481778	0.235052	1.836756	0.983856	1258.816775	0.530018	0	0	0	0	1.016943
171	32.426382	0.241771	1.642932	0.929022	1156.455883	0.48692	0	0	0	0	1.032461
172	32.415541	0.239886	1.693896	0.915306	1161.290343	0.488955	0	0	0	0	0.939184
173	32.493568	0.241648	1.653876	0.994067	1203.30716	0.506646	0	0	0	0	0.935105

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174	32.492731	0.242248	1.869954	0.991649	1320.290383	0.555901	0	0	0	0	1.118475
175	32.455862	0.233914	1.867092	0.955476	1180.080102	0.496867	0	0	0	0	1.034637
176	32.573588	0.233141	1.760484	1.074187	1229.466345	0.51766	0	0	0	0	1.136852
177	32.580499	0.232839	1.807008	1.081508	1347.629695	0.567413	0	0	0	0	1.166939
178	32.539271	0.213791	1.621284	1.03732	1243.25266	0.523465	0	0	0	0	1.23009
179	32.514433	0.19072	1.621128	1.012789	1132.148975	0.476685	0	0	0	0	1.124239
180	32.599831	0.17954	1.738092	1.096944	1243.166586	0.523429	0	0	0	0	1.137742
181	32.634555	0.174618	1.741092	1.132811	1233.290387	0.519271	0	0	0	0	1.088863
182	32.586189	0.178865	1.829172	1.084213	1343.85959	0.565825	0	0	0	0	1.1217
183	32.540302	0.18579	1.772952	1.037376	1275.881679	0.537203	0	0	0	0	1.03577
184	32.418755	0.185424	1.650432	0.918069	1091.818984	0.459705	0	0	0	0	1.030115
185	32.417726	0.184597	1.486788	0.916992	1120.741277	0.471882	0	0	0	0	0.986241
186	32.40654	0.190165	1.43496	0.905395	1086.582639	0.4575	0	0	0	0	0.96215
187	32.40549	0.19169	1.37748	0.904346	1004.715807	0.42303	0	0	0	0	0.9236
188	32.377916	0.201954	1.523856	0.876758	1037.345797	0.436769	0	0	0	0	1.156476
189	32.332241	0.200759	1.497816	0.832169	974.986219	0.410513	0	0	0	0	1.131372
190	32.345453	0.204665	1.373436	0.844876	948.364018	0.399304	0	0.002272	0.002797	0.000001	1.102418
191	32.370888	0.20355	1.351524	0.871124	1044.157977	0.439637	0	0.000326	0.001818	0.000001	1.229738
192	32.389444	0.197954	1.369496	0.890058	986.70555	0.415447	0	0	0	0	1.838649
193	32.424618	0.202074	1.431828	0.924766	979.629179	0.412468	0	0.000435	0.005887	0.000002	1.939282
194	32.365632	0.208361	1.628904	0.865971	998.287602	0.420324	0	0.002109	0.010462	0.000004	2.453083
195	32.420489	0.208484	1.61076	0.919477	1064.227216	0.448087	0	0	0	0	2.192531
196	32.406894	0.214844	1.651788	0.906123	1014.794068	0.427274	0	0.001552	0.015146	0.000006	2.221645
197	32.370046	0.214754	1.656216	0.869577	972.438316	0.40944	0	0	0	0	1.714985
198	32.414693	0.221334	1.677348	0.913107	953.977059	0.401667	0	0	0	0	1.49985
199	32.356877	0.222472	1.506864	0.856799	947.561703	0.398966	0	0.001115	0.00393	0.000002	1.526476
200	32.445205	0.206803	1.559808	0.946702	1030.453016	0.433867	0	0.000589	0.000502	0	1.756328
201	32.68967	0.205825	1.75794	1.189098	1238.134338	0.52131	0	0	0	0	1.486316
202	32.763076	0.198791	1.961256	1.264249	1374.780168	0.578844	0	0	0	0	1.992876
203	32.855641	0.20011	1.954512	1.355351	1374.615599	0.578775	0	0	0	0	1.672564
204	32.714568	0.192925	1.8744	1.21415	1331.324862	0.560547	0	0	0	0	1.899046
205	32.690358	0.19772	1.736976	1.190033	1334.655745	0.56195	0	0	0	0	2.284117
206	32.63944	0.200925	1.741584	1.139394	1301.244813	0.547882	0	0	0	0	2.239465
207	32.657683	0.188351	1.702368	1.157601	1347.965543	0.567554	0	0	0	0	2.5672
208	32.65966	0.181503	1.893012	1.162923	1314.08954	0.553291	0	0.078315	0.88321	0.000372	1.526727
209	32.597243	0.178618	1.849505	1.097529	1105.684525	0.465543	0	0.007209	0.101124	0.000043	1.220724
210	32.379701	0.165559	1.556496	0.878814	1019.518011	0.429263	0	0.00134	0.021583	0.000009	0.972098
211	31.968037	0.170443	1.013724	0.481295	506.776255	0.213376	0.033336	0.056115	1.850053	0.000779	1.464047
212	32.082003	0.191373	1.162704	0.582369	621.298779	0.261595	0	0.011774	0.257799	0.000109	1.436333
213	32.111966	0.197073	1.14354	0.615348	596.90858	0.251325	0	0.044849	0.77721	0.000327	1.724987
214	32.125288	0.191534	1.100616	0.622644	524.381072	0.220788	0	0	0	0	1.2728
215	32.125161	0.196876	1.087764	0.62283	622.118452	0.26194	0	0	0	0	1.085821
216	32.137933	0.197187	1.218384	0.641545	675.139591	0.284264	0	0.03002	0.625674	0.000263	2.041524
217	32.193438	0.159629	1.326696	0.6939	774.366949	0.326043	0	0.006824	0.026171	0.000011	1.4129
218	32.50538	0.148321	1.535832	1.00472	819.723283	0.34514	0	0	0	0	1.62918
219	32.505657	0.146942	1.423884	1.003746	906.092803	0.381506	0	0	0	0	1.50269
220	32.469368	0.145173	1.482612	0.967711	1044.313754	0.439703	0	0	0	0	0.85239
221	32.556259	0.164685	1.583616	1.054128	988.85719	0.416353	0	0	0	0	1.195916
222	32.519994	0.173933	1.506672	1.017765	1212.573251	0.510548	0	0	0	0	1.372975
223	32.53071	0.170557	1.582248	1.030023	923.599882	0.388877	0	0	0	0	1.562259
224	32.810114	0.205689	1.992156	1.308785	1389.262718	0.584942	0	0	0	0	2.48298
225	32.525093	0.213658	1.903536	1.024728	994.756342	0.418837	0	0	0	0	2.64354
226	32.283712	0.215147	1.24344	0.788376	668.290657	0.28138	0	0	0	0	2.408805
227	32.301758	0.217013	1.411404	0.801687	799.370116	0.336571	0	0	0	0	1.862385
228	32.386468	0.196361	1.467828	0.887477	947.182492	0.398806	0	0	0	0	2.44952
229	32.425209	0.188657	1.518132	0.926646	720.752068	0.303469	0	0	0	0	2.624676
230	32.431587	0.188867	1.49406	0.934281	1058.383755	0.445627	0	0	0	0	2.157364
231	32.376877	0.187485	1.439184	0.877488	869.081455	0.365922	0	0.001445	0.010965	0.000005	2.145428
232	32.289661	0.165278	1.387164	0.790871	784.608923	0.330356	0	0	0	0	1.695963
233	32.299373	0.158817	1.417344	0.802762	938.47891	0.395142	0	0	0	0	2.071825
234	32.22868	0.148757	1.147812	0.728924	563.742058	0.237361	0	0	0	0	0.905509
235	32.177868	0.152246	1.050648	0.676908	709.740476	0.298833	0	0.004113	0.027398	0.000012	0.50923
236	32.170991	0.147389	1.118052	0.670562	739.725551	0.311458	0	0	0	0	0.446606
237	32.191545	0.150371	1.066776	0.691146	638.656817	0.268903	0	0	0	0	0.768769
238	32.293581	0.164235	1.178964	0.792543	815.532349	0.343376	0	0	0	0	0.870062
239	32.384399	0.186007	1.316178	0.885119	827.839407	0.348557	0	0	0	0	0.907289
240	32.473566	0.196385	1.37532	0.972639	887.25944	0.373576	0	0	0	0	0.91114
241	32.386346	0.206664	1.258488	0.884765	857.007733	0.360839	0	0	0	0	0.924601
242	32.248194	0.223679	1.277592	0.748923	697.994206	0.293887	0	0	0	0	1.378506
243	32.417354	0.22155	1.510548	0.915898	799.283264	0.336534	0	0	0	0	1.570457
244	32.387736	0.194996	1.461324	0.889221	818.765781	0.344737	0	0	0	0	1.05565
245	32.370206	0.185146	1.33152	0.86993	883.451254	0.371973	0	0	0	0	0.394674
246	32.378262	0.187659	1.311516	0.879906	783.084847	0.329714	0	0	0	0	1.000494
247	32.366332	0.17832	1.46274	0.866018	887.2454	0.37357	0	0	0	0	0.7216
248	32.256358	0.156753	1.181592	0.755806	740.869736	0.311939	0	0	0	0	0.322427
249	32.266723	0.153875	1.21398	0.764486	899.814535	0.378862	0	0	0	0	0.593079
250	32.225994	0.154853	1.204596	0.727773	679.688501	0.286179	0	0.004746	0.012527	0.000005	0.894715
251	32.266646	0.150322	1.273188	0.766079	811.328617	0.341606	0	0	0	0	0.759959
252	32.214492	0.130639	1.225452	0.714428	808.341157	0.340348	0	0	0	0	0.932045
253	32.190435	0.133434	1.230948	0.689958	742.293988	0.312539	0	0	0	0	0.624417
254	32.159522	0.129665	1.218144	0.658642	645.158921	0.271641	0	0	0	0	0.602086
255	32.328247	0.142117	1.365624	0.827679	929.6536	0.391426	0	0	0	0	0.763097
256	32.374532	0.142225	1.484472	0.874334	1010.779183	0.425583	0	0	0	0	1.447767
257	32.297808	0.140665	1.388592	0.797708	627.129114	0.264049	0	0	0	0	1.399783
258	32.134466	0.14113	1.239024	0.634813	773.427265	0.325648	0	0.005859	0.076976	0.000032	1.104547
259	32.214883	0.119827	1.113672	0.713366	842.867946	0.354885	0	0	0	0	0.222257

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260	32.239034	0.124298	1.083216	0.735713	791.048613	0.333067	0	0	0	0	0.672095
261	32.314363	0.127905	1.203264	0.811205	918.186369	0.386598	0	0	0	0	0.664748
262	32.335928	0.146397	1.30092	0.833567	882.75907	0.371681	0	0	0	0	0.634745
263	32.326276	0.156585	1.228764	0.822815	961.931749	0.405016	0	0	0	0	0.467257
264	32.248337	0.164567	1.219548	0.745025	885.561704	0.372861	0	0	0	0	1.427535
265	32.265174	0.186782	1.185468	0.759642	702.275158	0.295689	0	0	0	0	1.412304
266	32.31391	0.189137	1.390464	0.809533	896.219832	0.377349	0	0.000726	0.002077	0.000001	1.722675
267	32.251725	0.192354	1.30716	0.748104	711.641532	0.299633	0	0	0	0	1.917938
268	32.227725	0.184743	1.261404	0.727365	663.818096	0.279497	0	0	0	0	1.381434
269	32.242574	0.180225	1.253928	0.740144	829.869353	0.349412	0	0	0	0	1.238769
270	32.336058	0.205818	1.302564	0.834773	890.761267	0.37505	0	0.000247	0.002191	0.000001	1.330902
271	32.405837	0.207653	1.318776	0.904452	756.273933	0.318425	0	0	0	0	1.298979
272	32.39868	0.210429	1.382736	0.89838	879.860129	0.370461	0	0	0	0	1.216003
273	32.413709	0.217238	1.36314	0.913179	896.261172	0.377366	0	0	0	0	1.609034
274	32.461566	0.223367	1.5822	0.95944	906.784725	0.381797	0	0	0	0	1.707054
275	32.479742	0.2167	1.515288	0.979025	901.890562	0.379736	0	0	0	0	1.609906
276	32.466837	0.200975	1.560828	0.965199	917.460112	0.386292	0	0	0	0	2.02408
277	32.499402	0.199343	1.48806	0.998169	959.732417	0.40409	0	0	0	0	1.442671
278	32.392077	0.162027	1.373628	0.891945	938.075067	0.394972	0	0	0	0	0.731788
279	32.360082	0.153554	1.33626	0.858531	796.234396	0.33525	0	0	0	0	0.789084
280	32.147733	0.154237	1.136028	0.649206	673.52239	0.283583	0	0.001851	0.004769	0.000002	0.842316
281	32.233204	0.150336	1.254183	0.733462	750.151323	0.315847	0	0	0	0	0.737473
282	32.42061	0.159178	1.422108	0.919236	983.43086	0.414068	0	0	0	0	0.808867
283	32.482212	0.166957	1.438824	0.980268	1015.59752	0.427612	0	0	0	0	0.904934
284	32.488294	0.171899	1.434972	0.986035	932.171526	0.392486	0	0	0	0	0.969852
285	32.447584	0.173431	1.470486	0.945561	1004.984213	0.423143	0	0	0	0	1.050328
286	32.415641	0.176781	1.497024	0.915763	988.483759	0.416196	0	0	0	0	1.0173
287	32.447289	0.172836	1.378956	0.945537	941.748303	0.396518	0	0	0	0	1.096815
288	32.468171	0.17796	1.472736	0.967821	878.751039	0.369994	0	0	0	0	1.406822
289	32.584028	0.185464	1.558644	1.082184	1253.823809	0.527916	0	0	0	0	1.098086
290	32.42196	0.185637	1.477044	0.923331	805.457301	0.339134	0	0	0	0	1.288985
291	32.451844	0.186056	1.423476	0.952416	714.851593	0.300985	0	0	0	0	1.283854
292	32.339968	0.190786	1.382952	0.839998	942.256503	0.396732	0	0	0	0	1.285407
293	32.289476	0.189512	1.312788	0.790248	709.810783	0.298862	0	0	0	0	1.895815
294	32.277525	0.184517	1.408584	0.776817	695.797845	0.292962	0	0	0	0	1.475437
295	32.338944	0.185607	1.32642	0.840262	913.684002	0.384702	0	0	0	0	1.382909
296	32.325959	0.175952	1.374	0.82717	839.879926	0.353627	0	0.001382	0.001514	0.000001	1.408825
297	32.347445	0.170507	1.413012	0.847781	918.223294	0.386613	0	0	0	0	0.873036
298	32.318616	0.175539	1.260468	0.819344	631.040178	0.265696	0	0	0	0	0.846218
299	32.315612	0.174238	1.384728	0.814545	874.064672	0.36802	0	0	0	0	1.190742
300	32.443247	0.175196	1.521876	0.943486	1073.116592	0.45183	0	0.00536	0.021067	0.000009	2.913951
301	32.478948	0.177975	1.502604	0.9777	864.113108	0.36383	0	0	0	0	2.396596
302	32.507694	0.178165	1.543152	1.010217	889.942487	0.374706	0	0	0	0	2.336511
303	32.455009	0.173898	1.520604	0.954941	934.48773	0.393461	0	0	0	0	1.979472
304	32.461008	0.181413	1.517508	0.963126	867.731797	0.365354	0	0	0	0	2.523215
305	32.451648	0.177778	1.492524	0.951276	941.097725	0.396244	0	0	0	0	2.742095
306	32.491752	0.179312	1.53306	0.991229	1014.854419	0.427299	0	0	0	0	1.914388
307	32.509759	0.184864	1.675188	1.011078	1063.367914	0.447726	0	0	0	0	1.398876
308	32.511338	0.179151	1.635336	1.011331	918.200342	0.386604	0	0	0	0	1.279443
309	32.542359	0.173102	1.61652	1.041273	1029.468465	0.433452	0	0	0	0	1.175094
310	32.58912	0.17464	1.677228	1.087948	1035.452732	0.435972	0	0	0	0	1.140302
311	32.507087	0.167812	1.649005	1.006458	1095.116348	0.461093	0	0	0	0	1.054429
312	32.460441	0.166909	1.602024	0.962025	909.102533	0.382773	0	0	0	0	0.886054
313	32.475704	0.169027	1.473348	0.974272	862.182075	0.363017	0	0	0	0	0.987743
314	32.363437	0.176978	1.433496	0.862205	977.017696	0.411368	0	0.003058	0.029373	0.000012	0.802248
315	32.273009	0.172541	1.335072	0.772676	762.222755	0.32093	0	0	0	0	1.229799
316	32.467098	0.17325	1.349988	0.967395	974.696452	0.410391	0	0	0	0	1.111236
317	32.437059	0.177732	1.549992	0.934935	891.601763	0.375404	0	0	0	0	1.312555
318	32.449381	0.175983	1.529388	0.946665	973.917078	0.410063	0	0	0	0	1.386409
319	32.428546	0.174081	1.549152	0.928613	851.09437	0.358349	0	0	0	0	0.668755
320	32.514177	0.174993	1.497072	1.016775	1089.66253	0.458797	0	0	0	0	0.628729
321	32.460906	0.173376	1.49112	0.967656	847.965639	0.357032	0	0.061911	0.751825	0.000317	1.951366
322	32.392148	0.173822	1.41543	0.891497	923.564488	0.388862	0	0	0	0	1.778716
323	32.380783	0.168649	1.400652	0.880613	805.803489	0.339279	0	0	0	0	1.841571
324	32.339967	0.17036	1.434408	0.839625	840.934202	0.354071	0	0	0	0	1.976201
325	32.286782	0.173351	1.388028	0.787512	790.794626	0.33296	0	0	0	0	1.87616
326	32.463449	0.17714	1.521948	0.96313	1048.386353	0.441418	0	0	0	0	1.86524
327	32.411273	0.17398	1.415364	0.909982	919.517742	0.387158	0	0	0	0	2.220104
328	32.374852	0.176356	1.45386	0.876044	664.935591	0.279968	0	0	0	0	1.874898
329	32.391898	0.179211	1.371252	0.891945	1004.877144	0.423098	0	0	0	0	1.396784
330	32.636827	0.182729	1.68756	1.135773	1217.516831	0.512629	0	0	0	0	2.079544
331	32.739801	0.181846	1.778592	1.241499	1091.800066	0.459697	0	0	0	0	3.072808
332	32.774979	0.183044	1.848972	1.274793	1267.309351	0.533594	0	0	0	0	2.561847
333	32.756162	0.187403	1.89096	1.254687	1263.164965	0.531849	0	0	0	0	2.529161
334	32.80248	0.178549	1.95972	1.301301	1240.097189	0.522137	0	0	0	0	2.550009
335	32.856456	0.182047	1.935636	1.354635	1344.891428	0.56626	0	0	0	0	2.703766
336	32.792736	0.186564	1.905696	1.291887	1280.217269	0.539029	0	0	0	0	2.9292
337	32.821888	0.192779	1.840956	1.321927	1226.815172	0.516544	0	0	0	0	2.708414
338	32.733018	0.198936	1.687932	1.23253	1114.166688	0.469114	0	0	0	0	1.143411
339	32.709738	0.19288	1.718784	1.211337	1197.256996	0.504099	0	0	0	0	3.396172
340	32.744691	0.191887	1.685592	1.246749	1099.868433	0.463094	0	0	0	0	2.709507
341	32.718434	0.201072	1.749966	1.218781	1269.593736	0.534556	0	0	0	0	2.384795
342	32.73982	0.193929	1.7832	1.239874	1310.640994	0.551839	0	0	0	0	2.78296
343	32.720616	0.191234	1.695564	1.220412	1043.104511	0.439194	0	0	0	0	2.930898
344	32.700708	0.186676	1.687812	1.199702	1185.430186	0.499119	0	0	0	0	2.578682
345	32.836646	0.191831	1.86558	1.336546	1301.231727	0.547877	0	0.000014	0.000043	0	2.707044

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346	32.867708	0.197385	1.900416	1.36694	1523.183707	0.641329	0	0	0	0	2.854652
347	32.79784	0.202095	1.711104	1.29864	947.292227	0.398852	0	0	0	0	1.990574
348	32.80737	0.201787	1.768404	1.307288	1350.753386	0.568728	0	0	0	0	2.474094
349	32.454187	0.194896	1.63112	0.954736	994.179717	0.418594	0	0	0	0	2.295687
350	32.39733	0.186998	1.436508	0.896808	710.456706	0.299134	0	0	0	0	2.426445
351	32.498709	0.188676	1.504884	0.999129	1044.030863	0.439584	0	0	0	0	2.565366
352	32.452979	0.192793	1.456116	0.952768	985.385408	0.414891	0	0	0	0	2.041745
353	32.497537	0.177994	1.450368	0.997583	1012.358551	0.426248	0	0	0	0	2.033437
354	32.471775	0.178291	1.483404	0.971478	1001.821313	0.421812	0	0	0	0	2.149994
355	32.286444	0.180413	1.372212	0.785756	596.535964	0.251168	0	0	0	0	1.919121
356	32.363664	0.18216	1.420452	0.863539	921.458799	0.387975	0	0	0	0	2.771587
357	32.612518	0.178141	1.621968	1.113504	1057.625568	0.445308	0	0	0	0	2.67439
358	32.627756	0.180456	1.56642	1.128308	867.648265	0.365319	0	0	0	0	2.552611
359	32.633054	0.179431	1.590048	1.134132	1250.896197	0.526683	0	0	0	0	2.539824
360	32.645782	0.184646	1.594008	1.147619	1241.431471	0.522698	0	0	0	0	2.854997
361	32.69147	0.183684	1.602456	1.192274	1219.224153	0.513348	0	0	0	0	2.643033
362	32.710728	0.182487	1.710372	1.211208	1063.952681	0.447972	0	0	0	0	2.512561
363	32.73444	0.183411	1.731588	1.237212	1386.460686	0.583762	0	0	0	0	2.483037
364	32.944655	0.181543	1.982688	1.446169	1585.738795	0.667667	0	0	0	0	2.801961
365	32.973459	0.183865	1.949856	1.475253	1293.817911	0.544755	0	0	0	0	2.922843
366	32.928036	0.187588	1.911612	1.429608	1430.11942	0.602144	0	0	0	0	2.43011
367	32.933592	0.193985	1.956672	1.434821	1413.028615	0.594948	0	0	0	0	2.676042
368	32.882683	0.196841	1.859034	1.383213	1427.762587	0.601152	0	0	0	0	2.373549
369	32.908236	0.201593	1.903908	1.410825	1218.955551	0.513235	0	0	0	0	1.953161
370	32.823099	0.203506	1.878984	1.324251	1274.251441	0.536517	0	0	0	0	2.915082
371	32.850419	0.203481	1.925976	1.351558	1334.021642	0.561683	0	0	0	0	3.337505
372	32.792974	0.195024	1.780884	1.294691	1232.808298	0.519068	0	0	0	0	3.534496
373	32.769365	0.191866	1.797036	1.27181	1332.894211	0.561208	0	0	0	0	3.425185
374	32.786424	0.194647	1.792812	1.287804	1123.043617	0.472852	0	0	0	0	3.155461
375	32.685137	0.192024	1.730712	1.185507	1089.624636	0.458781	0	0	0	0	3.001196
376	32.687078	0.17934	1.686612	1.187122	1323.733033	0.557351	0	0	0	0	2.271639
377	32.594637	0.173888	1.706508	1.096518	985.827413	0.415078	0	0	0	0	2.199134
378	32.539314	0.170835	1.448316	1.039692	1010.794943	0.42559	0	0	0	0	1.964587
379	32.618332	0.163814	1.644372	1.118888	1152.515747	0.485261	0	0	0	0	2.17664
380	32.710267	0.153492	1.827444	1.210954	1312.249505	0.552516	0	0	0	0	2.421977
381	32.575195	0.160689	1.563276	1.075891	1281.52101	0.539578	0	0	0	0	2.419615
382	32.621184	0.167545	1.589808	1.121829	1198.528693	0.504634	0	0	0	0	2.549389
383	32.731161	0.179186	1.75446	1.23217	1344.899847	0.566263	0	0	0	0	2.516018
384	32.799243	0.188059	1.779888	1.300203	1302.32651	0.548338	0	0	0	0	2.867741
385	32.82738	0.18747	1.797192	1.328415	1197.487556	0.504196	0	0	0	0	2.776052
386	32.822334	0.18868	1.789416	1.323639	1184.297975	0.498643	0	0	0	0	2.882567
387	32.639284	0.189829	1.884516	1.141211	1291.78759	0.5439	0	0	0	0	2.49503
388	32.476581	0.173629	1.481448	0.977739	1034.473387	0.43556	0	0	0	0	2.507818
389	32.484228	0.170536	1.39086	0.985416	943.197274	0.397128	0	0	0	0	2.555815
390	32.490094	0.16803	1.41906	0.989969	1036.820416	0.436548	0	0	0	0	2.22951
391	32.45852	0.166868	1.446474	0.95862	1144.680387	0.481962	0	0	0	0	1.836848
392	32.429451	0.169928	1.35972	0.929952	924.268092	0.389158	0	0	0	0	1.766567
393	32.437702	0.172907	1.410312	0.935882	1025.888407	0.431945	0	0	0	0	1.198849
394	32.5599	0.179406	1.545864	1.058083	1127.525839	0.474739	0	0	0	0	1.370413
395	32.630433	0.181349	1.627704	1.129358	1132.173717	0.476696	0	0	0	0	1.354805
396	32.679996	0.18138	1.701768	1.179846	1226.178373	0.516276	0	0	0	0	1.561846
397	32.734584	0.179383	1.790988	1.235997	1230.046991	0.517905	0	0	0	0	1.475717
398	32.701482	0.183176	1.68258	1.200916	1355.822756	0.570862	0	0	0	0	1.336834
399	32.598068	0.175645	1.562568	1.097235	1376.492479	0.579565	0	0	0	0	0.767798
400	32.548122	0.173681	1.524912	1.048058	1177.49109	0.495777	0	0	0	0	0.845837
401	32.67714	0.173489	1.691724	1.177161	1284.447716	0.54081	0	0	0	0	1.022366
402	32.653368	0.177841	1.720068	1.154124	1192.512817	0.502101	0	0	0	0	1.170447
403	32.583105	0.180496	1.702032	1.085352	1394.830651	0.587286	0	0	0	0	1.192839
404	32.546104	0.180801	1.555452	1.048722	1323.399633	0.557211	0	0	0	0	1.342636
405	32.485134	0.174529	1.443708	0.986811	1028.762558	0.433155	0	0	0	0	1.186567
406	32.470562	0.180424	1.41822	0.971249	1158.234894	0.487669	0	0	0	0	0.99819
407	32.434519	0.175112	1.366008	0.93506	1136.603039	0.478561	0	0	0	0	0.620572
408	32.276976	0.172725	1.125264	0.77712	760.793042	0.320328	0	0	0	0	0.486475
409	32.298513	0.175876	1.14642	0.80118	896.472225	0.377455	0	0	0	0	0.601104
410	32.382758	0.173138	1.239156	0.882818	937.366736	0.394673	0	0	0	0	0.575707
411	32.41708	0.168808	1.446012	0.919409	1129.111106	0.475406	0	0.0023	0.013765	0.000006	1.597328
412	32.466439	0.165941	1.463808	0.968138	1052.852168	0.443298	0	0	0	0	1.191625
413	32.470664	0.171308	1.506036	0.97234	891.283549	0.37527	0	0	0	0	1.803648
414	32.490468	0.18389	1.56606	0.99134	1063.445287	0.447758	0	0	0	0	1.984774
415	32.594298	0.217947	1.606536	1.094947	1150.182039	0.484278	0	0	0	0	1.904925
416	32.616039	0.220357	1.630176	1.116222	846.202605	0.356289	0	0	0	0	2.041949
417	32.487357	0.220106	1.520028	0.987135	942.424485	0.396803	0	0	0	0	2.481182
418	32.535245	0.222583	1.580592	1.037703	1023.729361	0.431036	0	0.01265	0.141801	0.00006	2.564291
419	32.700416	0.202745	1.762536	1.202824	1283.073631	0.540232	0	0	0	0	2.540581
420	32.861196	0.201071	1.834488	1.363461	1199.362846	0.504986	0	0	0	0	2.973399
421	32.825388	0.2075	1.748256	1.325828	1100.833457	0.4635	0	0	0	0	2.897489
422	32.776377	0.207061	1.727904	1.278175	1394.152054	0.587001	0	0	0	0	2.528653
423	32.780709	0.210231	1.759464	1.280964	1250.330645	0.526445	0	0	0	0	2.537882
424	32.815329	0.212714	1.771896	1.315716	1315.322734	0.55381	0	0	0	0	2.21493
425	32.946297	0.210983	1.984236	1.447689	1291.947708	0.543968	0	0	0	0	2.808873
426	32.882194	0.209867	1.915104	1.383594	1302.529931	0.548423	0	0	0	0	2.610323
427	32.739206	0.209928	1.727412	1.241001	1312.969423	0.552819	0	0	0	0	2.714362
428	32.811416	0.209897	1.855116	1.314136	983.2034	0.413973	0	0	0	0	2.74838
429	32.784403	0.2092	1.881216	1.285694	1450.121176	0.610566	0	0	0	0	2.369766
430	32.739402	0.206618	1.7565	1.24044	1197.536982	0.504217	0	0	0	0	2.067588
431	32.765404	0.202561	1.707144	1.265916	1350.077644	0.568443	0	0	0	0	1.626798

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432	32.812143	0.200243	1.781916	1.311381	1163.633124	0.489942	0	0	0	0	1.286459
433	32.870623	0.194384	1.798704	1.371384	1447.595882	0.609503	0	0	0	0	1.517321
434	32.945753	0.192127	1.994484	1.445228	1662.307712	0.699906	0	0	0	0	1.290322
435	32.78297	0.178755	1.708044	1.28425	1375.730211	0.579244	0	0	0	0	1.198066
436	32.810364	0.175131	1.802544	1.312684	1043.300745	0.439276	0	0	0	0	2.671988
437	32.834179	0.175783	1.859076	1.333469	1418.850929	0.5974	0	0	0	0	2.354135
438	32.862025	0.178583	1.90674	1.362472	1506.654722	0.634369	0	0	0	0	2.212597
439	32.848337	0.181563	1.83504	1.349558	1391.839766	0.586027	0	0	0	0	2.356088
440	32.982996	0.184758	2.050704	1.4835	1108.465224	0.466714	0	0	0	0	2.517806
441	32.982615	0.192681	1.986312	1.483554	1628.081793	0.685495	0	0	0	0	2.605988
442	32.914863	0.192575	1.885116	1.414867	1359.377163	0.572359	0	0	0	0	2.50293
443	32.804206	0.195387	1.783536	1.304412	1371.860635	0.577615	0	0	0	0	2.203066
444	32.807115	0.201282	1.88862	1.306218	1214.610002	0.511405	0	0	0	0	2.640952
445	32.787773	0.223316	2.01186	1.292606	1298.784505	0.546846	0	0.044172	0.485921	0.000205	2.914299
446	32.607826	0.221715	1.65126	1.106472	990.51913	0.417053	0	0	0	0	2.651362
447	32.615285	0.220446	1.598568	1.11804	1134.841575	0.477819	0	0	0	0	2.713294
448	32.750001	0.218556	1.872156	1.248673	1145.663997	0.482376	0	0	0	0	2.490639
449	32.818028	0.218167	1.80588	1.318877	1222.02081	0.514526	0	0	0	0	2.470049
450	33.039794	0.221605	2.048064	1.539264	1543.232287	0.64977	0	0	0	0	2.51374
451	33.041016	0.222853	2.092788	1.539614	1520.175441	0.640062	0	0	0	0	2.459065
452	33.096275	0.215709	2.231807	1.596649	1445.88357	0.608782	0	0	0	0	2.067834
453	32.850105	0.21954	1.953132	1.351003	1230.589722	0.518133	0	0	0	0	3.164994
454	32.822676	0.220147	1.879848	1.323406	1170.041802	0.49264	0	0	0	0	3.38787
455	32.790271	0.205325	1.852812	1.291186	1298.621141	0.546778	0	0	0	0	3.337397
456	32.702628	0.211029	1.86198	1.202562	1396.191837	0.587859	0	0	0	0	2.826699
457	32.458862	0.201578	1.531248	0.957554	890.217015	0.374821	0	0	0	0	2.318917
458	32.472974	0.20953	1.502148	0.970246	1058.38499	0.445628	0	0	0	0	1.720537
459	32.526456	0.20127	1.518384	1.02481	1043.099919	0.439192	0	0	0	0	1.745073
460	32.722201	0.214245	1.961784	1.222198	1330.418795	0.560166	0	0	0	0	2.744451
461	32.737337	0.213607	1.803708	1.23809	1090.967205	0.459346	0	0	0	0	2.771543
462	32.712378	0.218246	1.787808	1.213524	1027.77204	0.432738	0	0	0	0	2.874402
463	32.606708	0.219789	1.674816	1.107844	1199.845591	0.505189	0	0	0	0	2.203156
464	32.568457	0.197181	1.561776	1.071724	1058.995343	0.445885	0	0	0	0	2.286663
465	32.576268	0.200375	1.501092	1.077422	1108.265251	0.466629	0	0	0	0	2.150083
466	32.642371	0.196414	1.659048	1.14396	1053.417692	0.443536	0	0	0	0	2.144019
467	32.70412	0.193721	1.935432	1.204356	1390.453611	0.585443	0	0.005224	0.053414	0.000022	2.134789
468	32.903127	0.192288	2.049792	1.402634	1426.31151	0.600541	0	0	0	0	2.482147
469	32.8944	0.192975	1.853196	1.39415	1437.438882	0.605226	0	0	0	0	2.53001
470	32.813383	0.191048	1.932168	1.315737	1120.146437	0.471632	0	0	0	0	2.86957
471	32.682739	0.187267	1.646364	1.181922	1233.832506	0.519499	0	0	0	0	1.538295
472	32.698819	0.186237	1.722252	1.201327	1338.89866	0.563736	0	0	0	0	1.793263
473	32.760509	0.182344	1.828836	1.25869	1400.621924	0.589725	0	0	0	0	1.920871
474	32.849125	0.195611	1.969073	1.347466	1289.713316	0.543027	0	0	0	0	2.385457
475	32.814149	0.21217	2.075604	1.312376	1391.454814	0.585865	0	0	0	0	1.853736
476	32.891224	0.214004	2.126808	1.389348	1295.005007	0.545255	0	0	0	0	2.765199
477	32.863301	0.216684	2.007672	1.361928	1425.513629	0.600205	0	0.011395	0.106455	0.000045	2.546813
478	32.91287	0.227594	1.963188	1.411886	1375.09283	0.578976	0	0	0	0	2.248268
479	32.911945	0.2339	2.15412	1.413797	1496.290585	0.630005	0	0	0	0	2.849796
480	32.906138	0.233996	2.1111	1.406539	1345.337181	0.566447	0	0	0	0	3.372309
481	32.9106	0.235795	2.000784	1.409292	1539.117658	0.648038	0	0	0	0	2.181588
482	32.834562	0.229365	2.002308	1.333509	1402.803783	0.590643	0	0	0	0	2.319354
483	32.881325	0.210755	1.919388	1.380031	1415.548774	0.596009	0	0	0	0	2.107325
484	32.947872	0.240544	2.088996	1.445958	1186.597107	0.499611	0	0	0	0	1.96373
485	33.09108	0.240726	2.253444	1.588207	1325.706812	0.558182	0	0	0	0	3.674451
486	33.207409	0.241588	2.388636	1.705874	1842.016481	0.775572	0	0	0	0	2.959658
487	33.223326	0.235198	2.334156	1.721156	1558.575803	0.65623	0	0	0	0	2.441533
488	33.180975	0.241296	2.31408	1.677654	1612.932951	0.679117	0	0	0	0	2.595044
489	33.125141	0.233129	2.218944	1.623106	1262.246803	0.531462	0	0	0	0	2.679661
490	32.953904	0.22974	2.038812	1.451197	1318.458198	0.55513	0	0	0	0	2.410271
491	32.900018	0.222303	1.992312	1.400484	1481.814416	0.62391	0	0	0	0	2.396329
492	32.636724	0.217519	1.794444	1.135404	1086.035234	0.45727	0	0	0	0	1.873318
493	32.804093	0.213051	1.983672	1.303519	1308.402121	0.550896	0	0	0	0	2.772178
494	32.725086	0.220641	1.805172	1.22925	1201.095668	0.505715	0	0	0	0	2.222926
495	32.716231	0.22537	1.715556	1.217088	1204.114853	0.506986	0	0	0	0	1.786611
496	32.712226	0.225625	1.713156	1.211033	1111.112417	0.467828	0	0	0	0	2.002816
497	32.741376	0.234434	2.002332	1.244192	1347.092299	0.567186	0	0.003645	0.030292	0.000013	3.124455
498	32.81774	0.236133	1.997184	1.315994	1185.418035	0.499114	0	0	0	0	2.834141
499	32.848829	0.228097	2.008128	1.350206	1386.374776	0.583726	0	0	0	0	2.89876
500	32.801692	0.241056	2.134164	1.298169	1261.527214	0.53116	0	0	0	0	2.800055
501	32.891109	0.242617	2.163936	1.388032	1383.451966	0.582495	0	0	0	0	3.049296
502	32.770552	0.248036	1.962156	1.267066	1247.3901	0.525207	0	0	0	0	2.567671
503	32.712423	0.241204	1.921764	1.207497	992.197445	0.41776	0	0	0	0	2.390489
504	32.681979	0.245031	1.910952	1.178304	1170.756289	0.492941	0	0	0	0	2.128583
505	32.750989	0.257258	2.130432	1.248576	1242.99985	0.523359	0	0	0	0	2.478349
506	32.744222	0.251773	1.975536	1.241508	1149.389063	0.483944	0	0	0	0	2.105416
507	32.780384	0.243085	2.03586	1.278416	1115.977722	0.469877	0	0	0	0	2.119001
508	32.688229	0.24008	2.006316	1.187183	1204.847659	0.507295	0	0.011549	0.415212	0.000175	2.6427
509	32.84327	0.228236	1.954848	1.339784	1223.760241	0.515258	0	0	0	0	2.024616
510	32.924681	0.220503	2.030532	1.422031	1427.218107	0.600923	0	0	0	0	2.65314
511	32.875528	0.218652	2.03394	1.374663	1460.126908	0.614779	0	0	0	0	3.103497
512	32.725486	0.204003	1.90104	1.223063	1408.076497	0.592863	0	0	0	0	2.735485
513	32.783306	0.189165	1.845552	1.28256	1393.754566	0.586833	0	0	0	0	2.12547
514	32.7633	0.188869	1.860408	1.262772	1431.719263	0.602818	0	0	0	0	2.77282
515	32.798615	0.191681	1.949172	1.297963	1488.578451	0.626758	0	0	0	0	2.601457
516	32.728067	0.176316	2.4405	1.22516	1282.559531	0.540015	0	0	0	0	1.174123
517	33.122266	0.17559	2.674824	1.618416	1884.785044	0.793579	0	0	0	0	2.950985

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518	33.147909	0.184001	2.552388	1.64547	1599.922392	0.673639	0	0	0	0	3.102429
519	33.107159	0.185617	2.55186	1.606855	1782.734381	0.750611	0	0	0	0	3.252424
520	32.897244	0.189268	2.215788	1.397467	1445.179131	0.608485	0	0	0	0	4.078979
521	32.912662	0.192103	2.314908	1.412191	1645.208778	0.692707	0	0	0	0	4.043196
522	32.981683	0.20137	2.2578	1.480363	1391.985366	0.586088	0	0	0	0	4.360615
523	33.056623	0.208452	2.37924	1.556486	1648.659805	0.69416	0	0	0	0	4.26822
524	33.094231	0.218093	2.312712	1.593538	1338.268288	0.563471	0	0	0	0	3.188067
525	33.332334	0.218212	2.58792	1.833789	1775.239223	0.747455	0	0	0	0	4.845081
526	33.347262	0.233708	2.64324	1.84873	1868.967464	0.786919	0	0	0	0	4.501753
527	33.339053	0.246139	2.517792	1.841951	1836.45026	0.773228	0	0	0	0	4.104515
528	33.435547	0.246371	2.757396	1.937405	1889.163534	0.795423	0	0	0	0	3.883024
529	33.310845	0.232527	2.640036	1.810938	1655.387929	0.696993	0	0	0	0	3.357322
530	33.238461	0.231549	2.65578	1.738629	1949.666805	0.820897	0	0	0	0	3.666093
531	33.207219	0.211431	2.487732	1.707744	1704.56341	0.717698	0	0	0	0	3.415023
532	33.132163	0.209156	2.399016	1.634249	1720.100414	0.724239	0	0	0	0	4.01801
533	33.231996	0.198324	2.460264	1.73437	1718.415397	0.72353	0	0	0	0	4.039021
534	33.350322	0.223122	2.725764	1.852014	1737.00855	0.731358	0	0	0	0	4.326494
535	33.43747	0.22479	2.833488	1.939541	1889.546674	0.795584	0	0	0	0	4.709679
536	33.601628	0.22832	3.122232	2.104084	1525.605199	0.642348	0	0	0	0	4.596666
537	33.777288	0.237695	3.144528	2.281345	2475.710231	1.042385	0	0	0	0	4.867436
538	33.900823	0.240256	3.36042	2.406318	1956.856033	0.823924	0	0	0	0	5.466035
539	34.026842	0.226524	3.560124	2.534114	2637.067323	1.110324	0	0	0	0	6.316884
540	34.093554	0.224023	3.660432	2.599893	2286.697186	0.962802	0	0	0	0	7.139514
541	33.846604	0.248376	3.552649	2.347617	2159.281026	0.909154	0	0	0	0	5.798907
542	33.699958	0.218304	3.526428	2.202833	2077.458952	0.874703	0	0	0	0	7.224767
543	33.73446	0.218396	3.44502	2.238435	1859.749905	0.783038	0	0	0	0	7.127879
544	33.752078	0.225889	3.48168	2.254694	2129.705972	0.896702	0	0	0	0	7.023745
545	33.794817	0.221363	3.765536	2.299061	2359.528113	0.993467	0	0	0	0	7.70957
546	34.011076	0.222789	4.012428	2.515297	2429.299536	1.022844	0	0	0	0	7.660398
547	34.042689	0.215625	3.981576	2.547213	2172.245772	0.914613	0	0	0	0	7.399652
548	34.100962	0.213749	4.148052	2.606088	2567.371534	1.080978	0	0	0	0	8.949023
549	34.053549	0.229062	3.909732	2.557882	2522.183763	1.061952	0	0	0	0	8.878223
550	33.884216	0.225016	3.493248	2.390645	2601.296842	1.095263	0	0	0	0	7.830045
551	33.923319	0.226534	3.468948	2.430326	2572.845202	1.083283	0	0	0	0	8.089776
552	34.013017	0.220767	3.67512	2.51953	2729.26176	1.149142	0	0	0	0	8.009399
553	34.035372	0.221376	4.034184	2.541733	2763.261926	1.163457	0	0	0	0	8.806775
554	34.169729	0.215495	4.214268	2.676886	2678.124277	1.12761	0	0.029533	0.132544	0.000056	10.65912
555	33.787375	0.207663	3.836304	2.292014	2230.037625	0.938946	0	0.003984	0.063288	0.000027	9.65779
556	33.724841	0.236717	3.998219	2.230074	2349.022503	0.989044	0	0.02948	0.398645	0.000168	9.405112
557	33.814232	0.242324	4.268184	2.3203	2635.466175	1.109649	0	0.00181	0.010428	0.000004	9.747865
558	33.750434	0.228552	4.26906	2.255437	2446.938263	1.030271	0	0.004037	0.021713	0.000009	9.872221
559	34.025125	0.256116	4.476688	2.542393	2863.294941	1.205576	0	0.168861	3.744496	0.001577	10.61005
560	34.25427	0.519164	4.630347	2.867901	2872.005047	1.209243	0	1.127508	51.507635	0.021687	12.63701
561	34.184981	0.717189	4.842096	2.977363	2901.952558	1.221852	0.066528	2.109746	103.205368	0.043454	15.02815
562	34.028165	0.380316	4.49519	2.738245	1554.843569	0.654659	0	1.757166	65.609678	0.027625	10.60689
AVERAGE DIAMETER	**65.26301819**	**MAXIMUM**	**4.842096**	**2.977363**	**2901.952558**	**1.221852**	**0.066528**	**2.109746**	**103.205368**	**0.043454**	**15.02815**
		AVERAGE	**1.727443489**	**1.132945032**	**1150.079676**	**0.4842351**	**0.00017961**	**0.01026323**	**0.417763714**	**0.0001759**	**2.187491**

MAXIMUM MEASUREMENTS HIGHLIGHTED IN PEACH

LEGEND:

MAXIMUM CORROSION: MAXIMUM DEPTH OF CORROSION IN THE ONE FOOT SECTION OF PIPE.
AVERAGE CORROSION: THE AVERAGE CORROSION FOR EACH ONE FOOT SECTION.
INTEGRATED CORROSION: CORROSION OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED CORROSION: INTEGRATED CORROSION DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE THIS NUMBER TO COMPARE THE EXTENT OF CORROSION IN EACH ONE FOOT SECTION OF PIPE
MAXIMUM BUILDUP: MAXIMUM BUILDUP IN THE ONE FOOT SECTION OF PIPE.
AVERAGE BUILDUP: THE AVERAGE BUILDUP FOR EACH ONE FOOT SECTION.
INTEGRATED BUILDUP: BUILDUP OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED BULDUP: INTEGRATED BUILDUP DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE THIS NUMBER TO COMPARE THE EXTENT OF BUILDUP IN EACH ONE FOOT SECTION OF PIPE
OVALITY: CHANGE IN CIRCULARITY; THE AMOUNT OF OUT-OF-ROUNDNESS

Segment S15S161

EBMUD
MULTI-SENSOR INSPECTION PROJECT

MULTI-SENSOR INSPECTION SUMMARY REPORT FOR: S38 S39, 78" RCP, 1,410.1 LF INSPECTED LENGTH

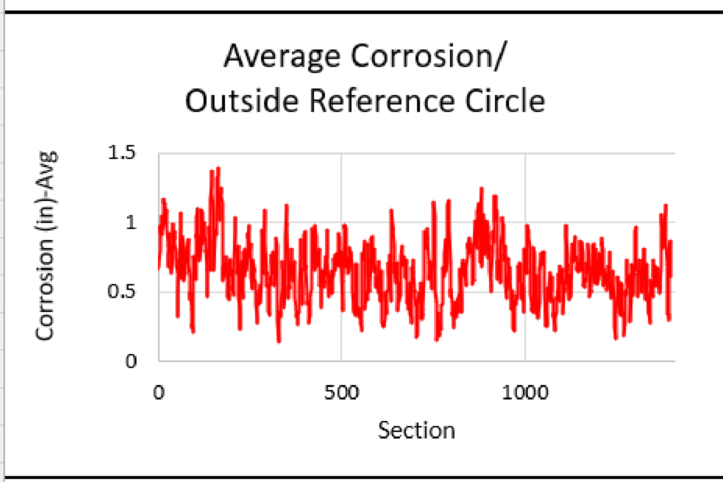
INSPECTION PROCEEDED DOWNSTREAM FROM S38 TO S39. THE FLOATING PONTOON WAS USED FOR THIS INSPECTION. WATER LEVEL WAS AT 35% DURING THIS INSPECTION.

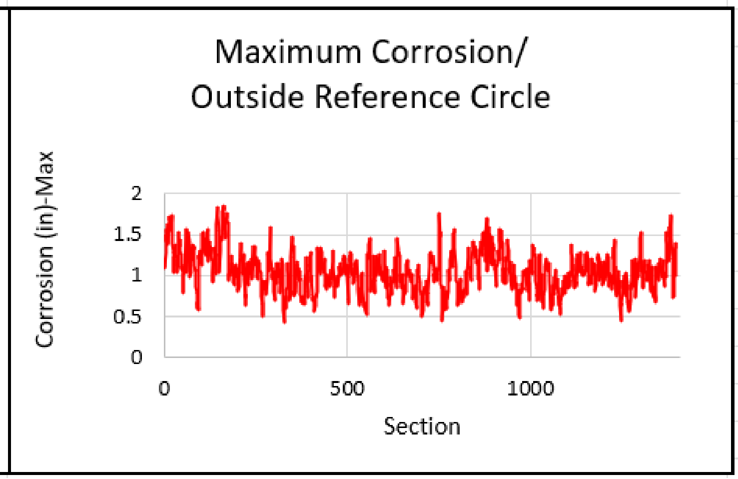
THE AS-BUILTS SAY THIS LINE WAS 78", BUT THE OVERALL WALL CONDITION LOOKS IN GOOD CONDITION, BUT THE DIAMETER MEASURES AN AVERAGE OF 81 INCHES. THEREFORE, WE USED AN 80 INCH AS-BUILT TO PLOT THE 2D AND 3D MODELS.

SURFACE ROUGHNESS, SURFACE SPALLING, AND SURFACE AGGREGATE VISIBLE. MAXIMUM CORROSION/MEASUREMENT OUTSIDE REFERENCE CIRCLE TO 1.86 INCHES AT 172 FEET. AVERAGE CORROSION OVER ENTIRE LENGTH OF PIPE IS 0.66 INCHES.

THE TOTAL DEBRIS AS MEASURED BY THE SONAR IS 586 CF (21.7 CY).

Measurement	Measurement From Pipe Center (Inches)
Average Corrosion/Outside Reference Circle	0.66
Maximum Average Corrosion/Outside Reference Circle	1.40
Maximum Corrosion/Outside Reference Circle	1.86





Segment S38S391

EBMUD
MULTI-SENSOR INSPECTION PROJECT

PACP SCORING REPORT

PACP v7.0 Inspections and Scoring

General Information:

Surveyed by:	Certificate number:	Reviewed by:	Reviewer certificate no.	Owner:	Customer:
F MORENO/NPS	U-913-19012				

P/O number:	Work order no.:	Media label:	Project name:	Start date/time:
			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022	20220520 11:24

Sheet number:	Weather:	Pre-cleaning:	Date cleaned:	Flow control:	Purpose:
	1	N		N	F

Direction:	Technology used:	Inspection status:	Consequence of failure:	Pressure value:
D		CI		

Location:

Drainage area:	Pipe segment ref.:	Street:
	S38S391	EMBARCADERO/S. OF 9TH AVE

City:	Location code:	Location details:
OAKLAND	B	

Pipe:

Pipe use:	Height:	Width:	Shape:	Material:	Lining method:
SS	77 in.		C	RCP	

Coating method:	Pipe joint length:	Total length:	Length surveyed:	Year constructed:	Year renewed:
		1,410.100 ft.	1,410.100 ft.		

Measurements:

Upstream MH No:	Rim to invert:	Rim to grade:	Grade to invert:	Northing:	Easting:	Elevation:
S38						

Downstream MH No:	Rim to invert:	Rim to grade:	Grade to invert:	Northing:	Easting:	Elevation:
S39						

MH coordinate system:	MH vertical datum:	GPS accuracy:

Additional Information:

Pipe Ratings

Grade	Structural: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	O&M: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	Overall: Pipe Rating	Pipe Rating Index	LoF	Risk
1	564	564	1,124	2Z1Z	1.3	0	0	2	2100	2.0	1,126	1.3	3.0	
2	280	560				1	2							
3	0	0				0	0							
4	0	0				0	0							
5	0	0				0	0							

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
0.0 ft.		AMH					☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 0.0 ft_5.JPG	S38
0.0 ft.		MWL				35	☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---MWL at 0.0 ft_4.JPG	
0.0 ft.	00:00:57	SRI	S01				☐	8 / 4		1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 0.0 ft_2.JPG	
0.0 ft.	00:01:33	SSC	S02				☐	8 / 4		1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 0.0 ft_1.JPG	
10.0 ft.	00:02:36	SAV	S03				☐	8 / 4		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAV at 10.0 ft.JPG	

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Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
948.7 ft.	00:45:50	IWJ					☑	10 / 2		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---IWJ at 948.7 ft.JPG	
1,410.1 ft.	01:06:05	SAV	F03				☐	8 / 4		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAV at 1_410.1 ft.JPG	
1,410.1 ft.	01:06:09	SSC	F02				☐	8 / 4		1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 1_410.1 ft.JPG	
1,410.1 ft.	01:06:12	SRI	F01				☐	8 / 4		1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SRI at 1_410.1 ft.JPG	
1,410.1 ft.	01:06:23	AMH					☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 1_410.1 ft.JPG	S39

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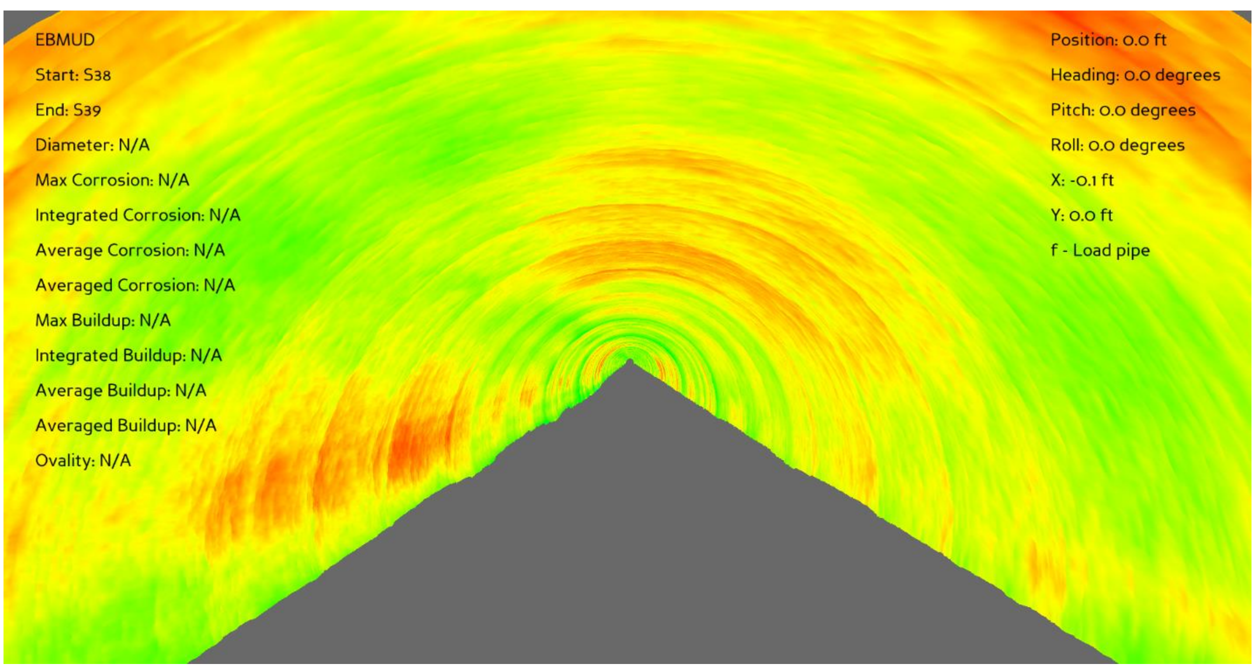
IMAGE REPORT

TYPICAL INTERIOR VIEW, 0 FEET



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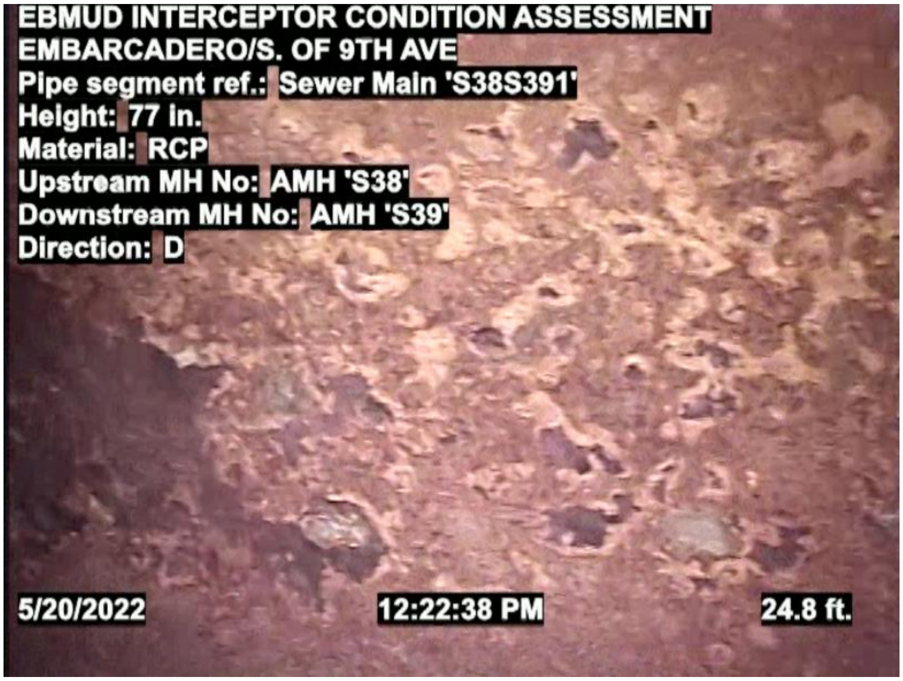
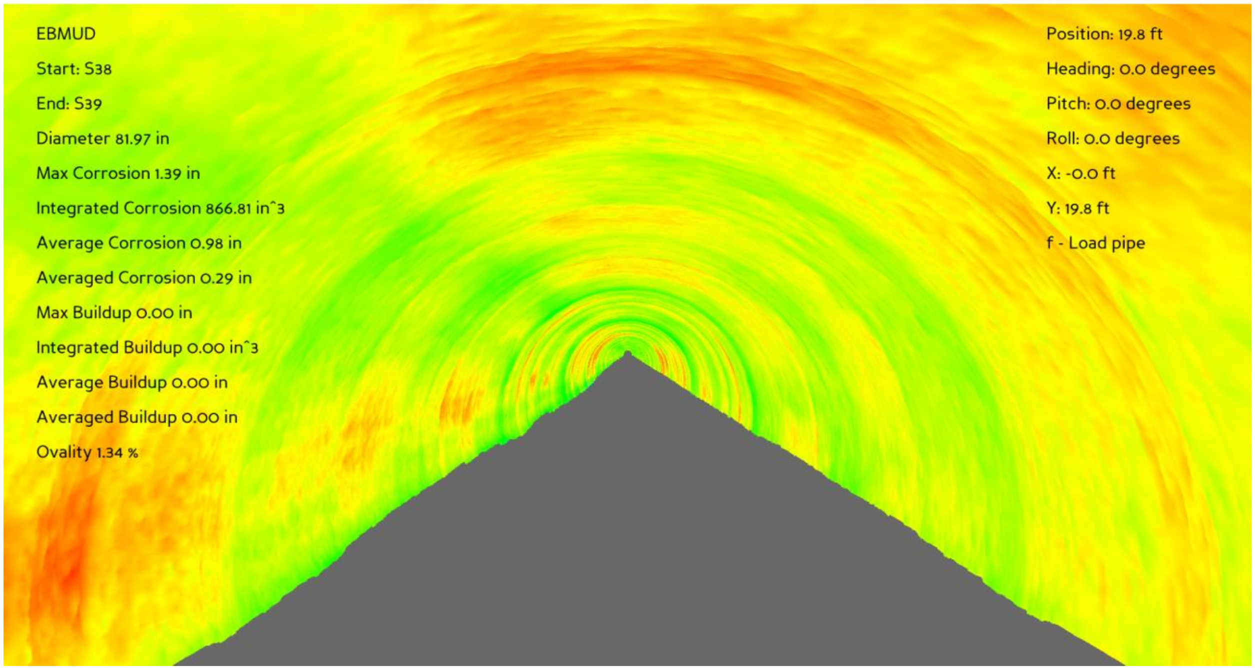
TYPICAL SURFACE CONDITION, 25 FEET





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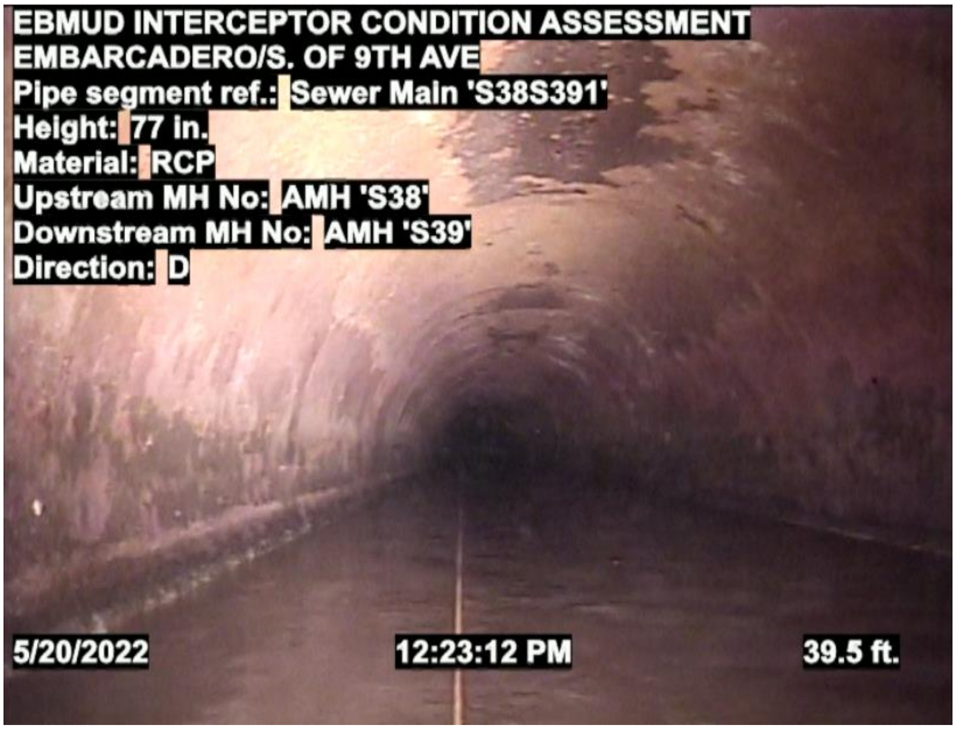
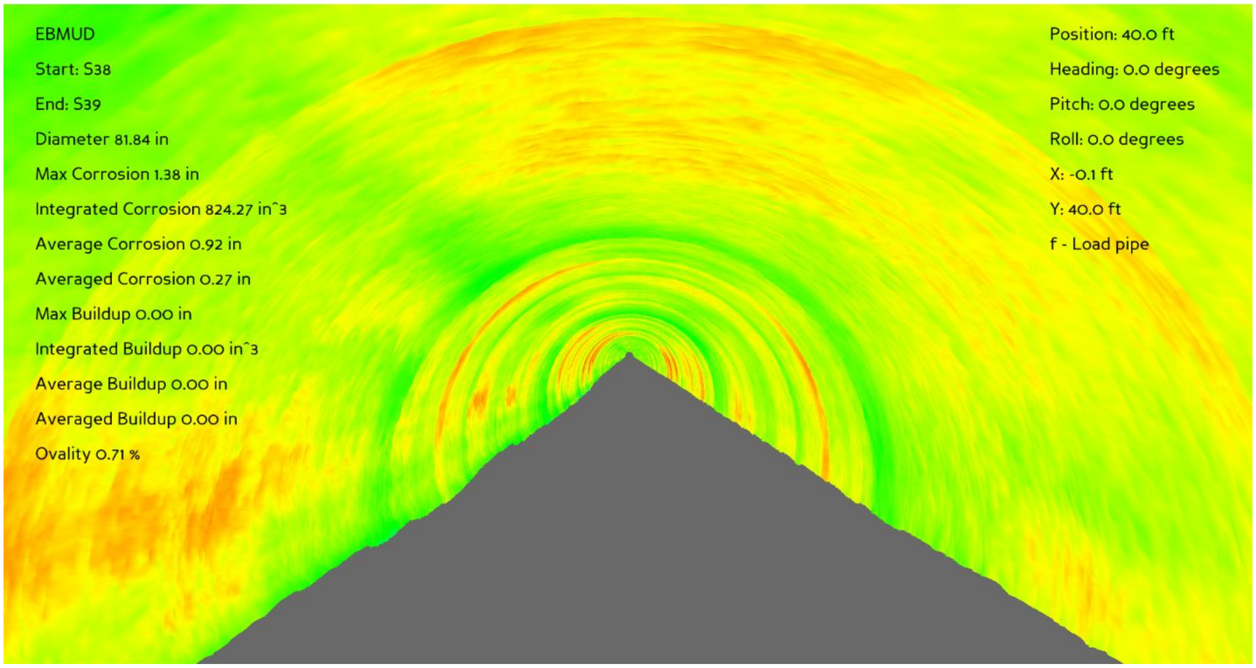
TYPICAL SURFACE CONDITION, 40 FEET





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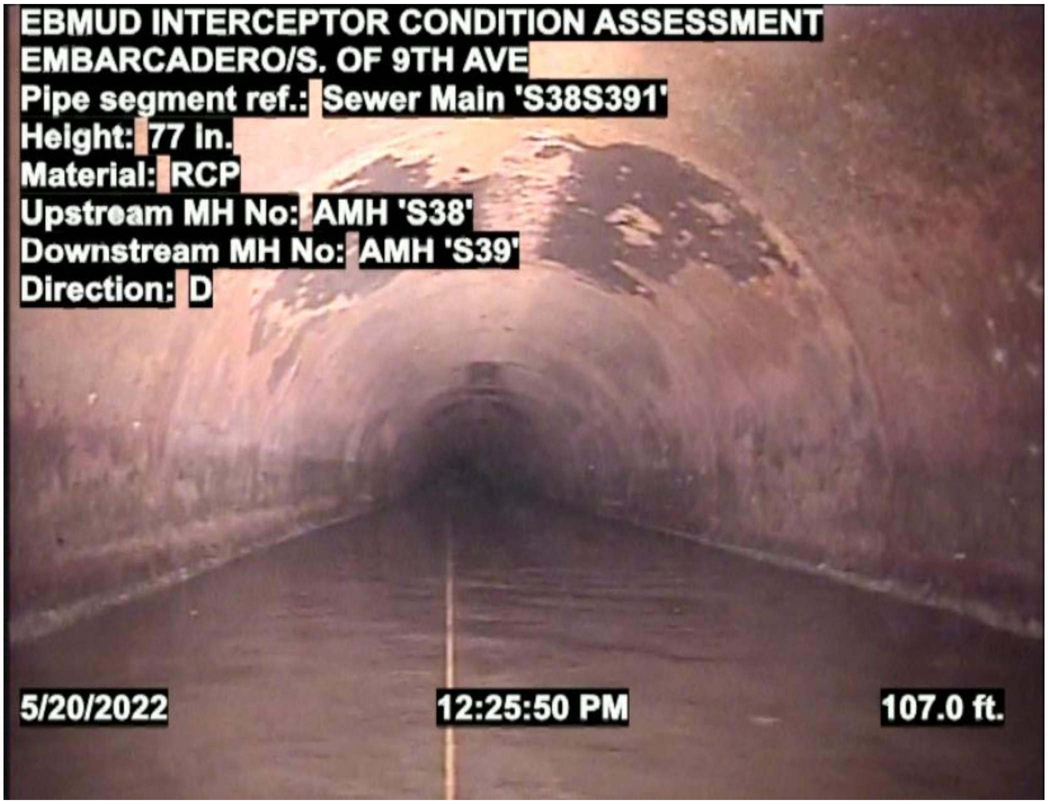
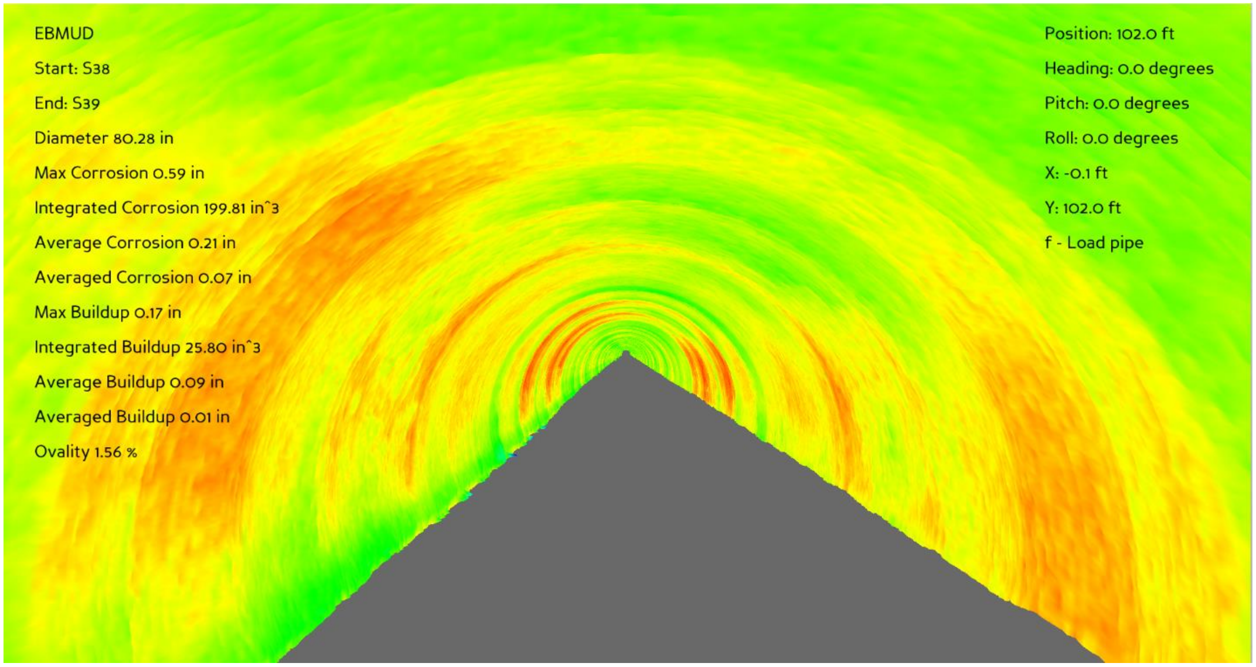
TYPICAL INTERIOR VIEW, 107 FEET





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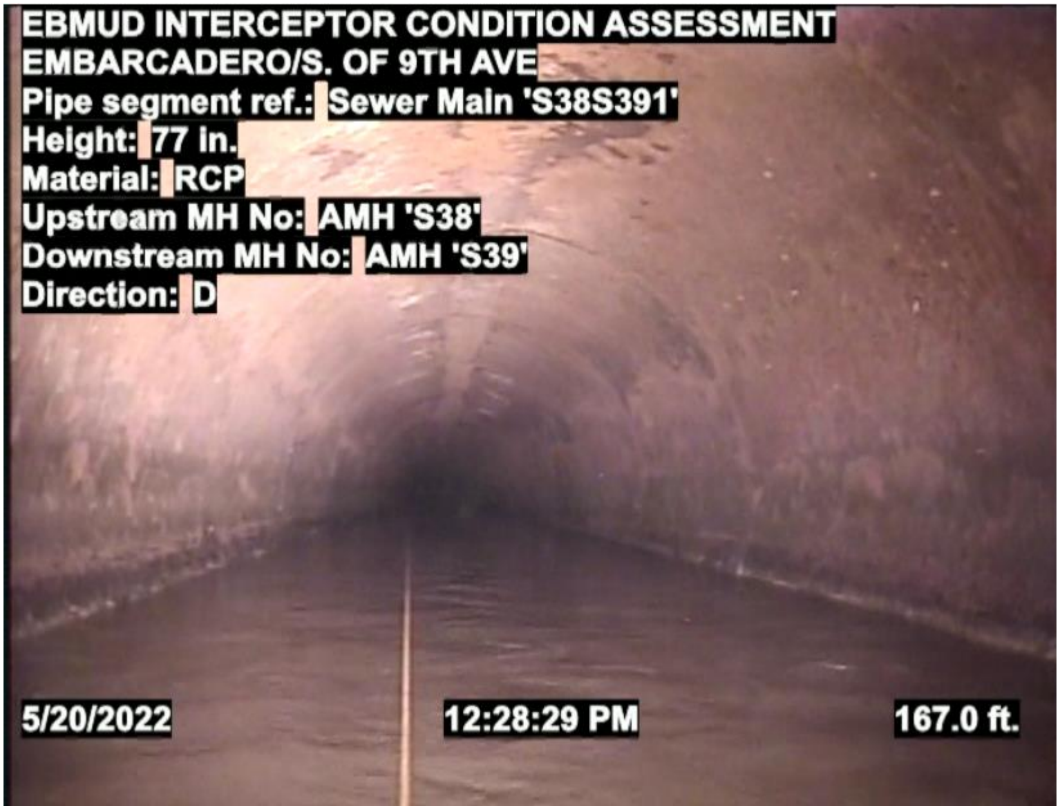
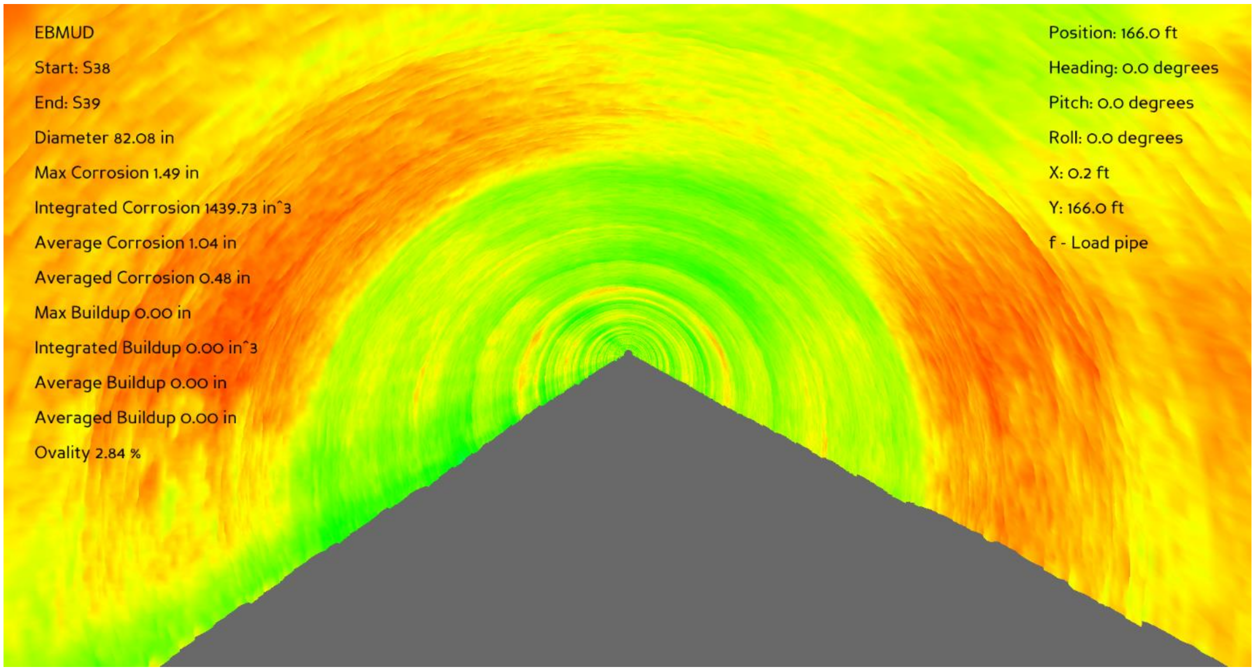
AREA OF MAXIMUM CORROSION AT 172 FEET TO 1.86 INCHES. AVERAGE CORROSION TO 1.29 INCHES.





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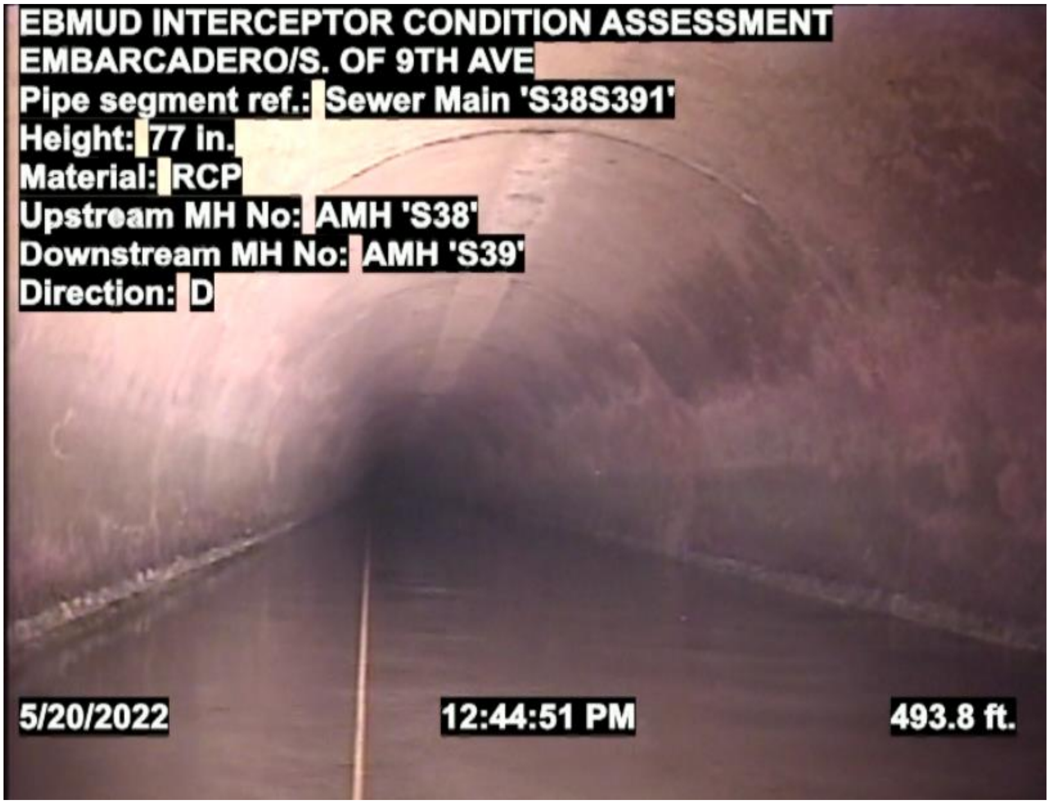
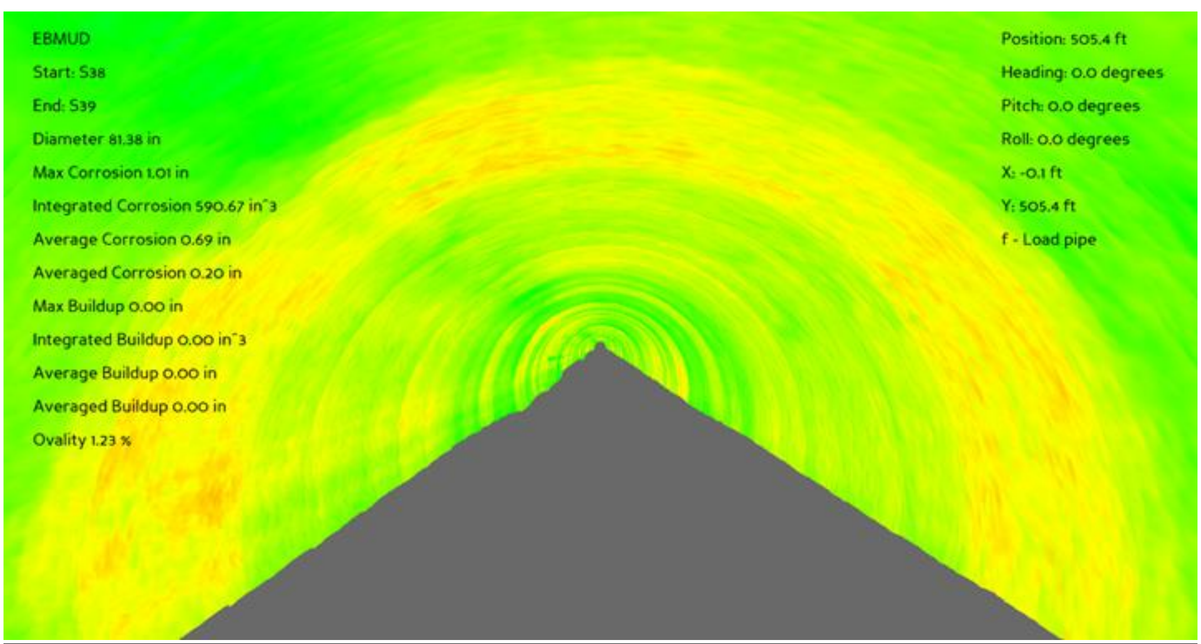
TYPICAL INTERIOR VIEW 493 FEET





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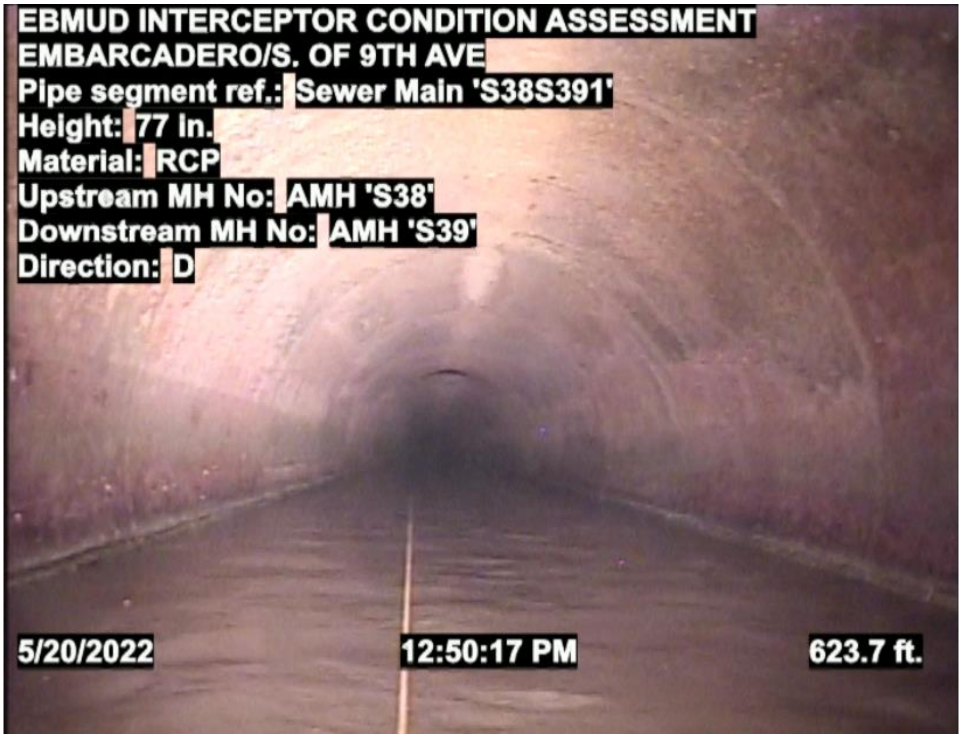
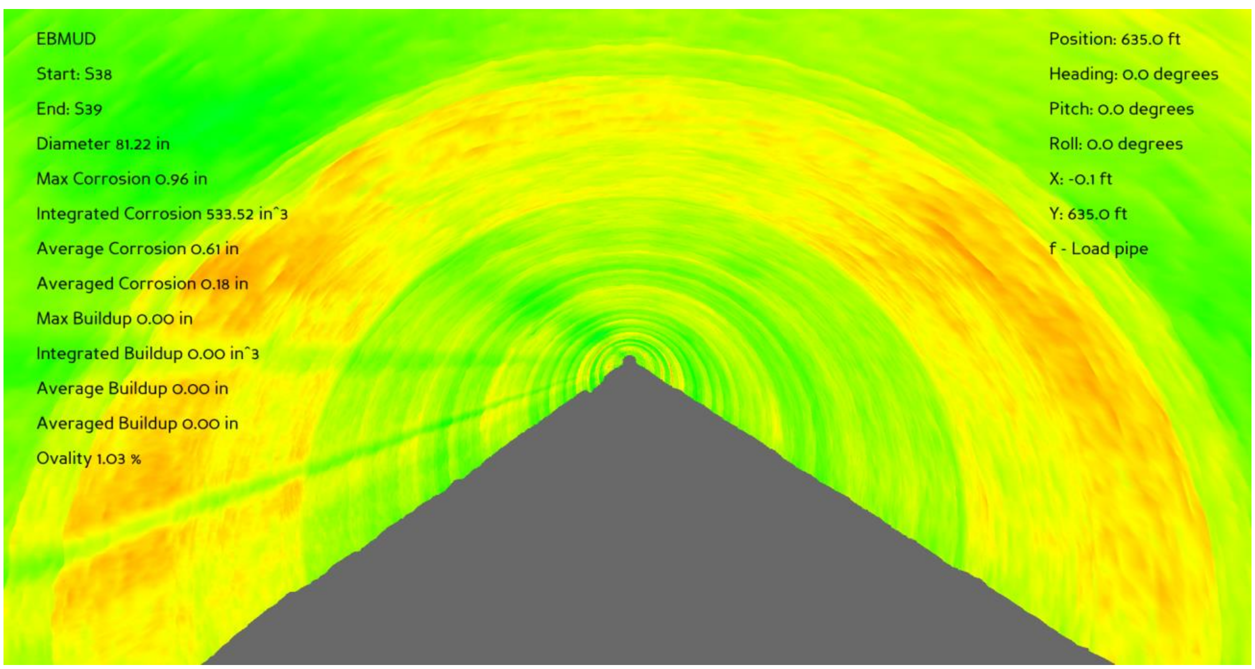
TYPICAL INTERIOR VIEW 623 FEET





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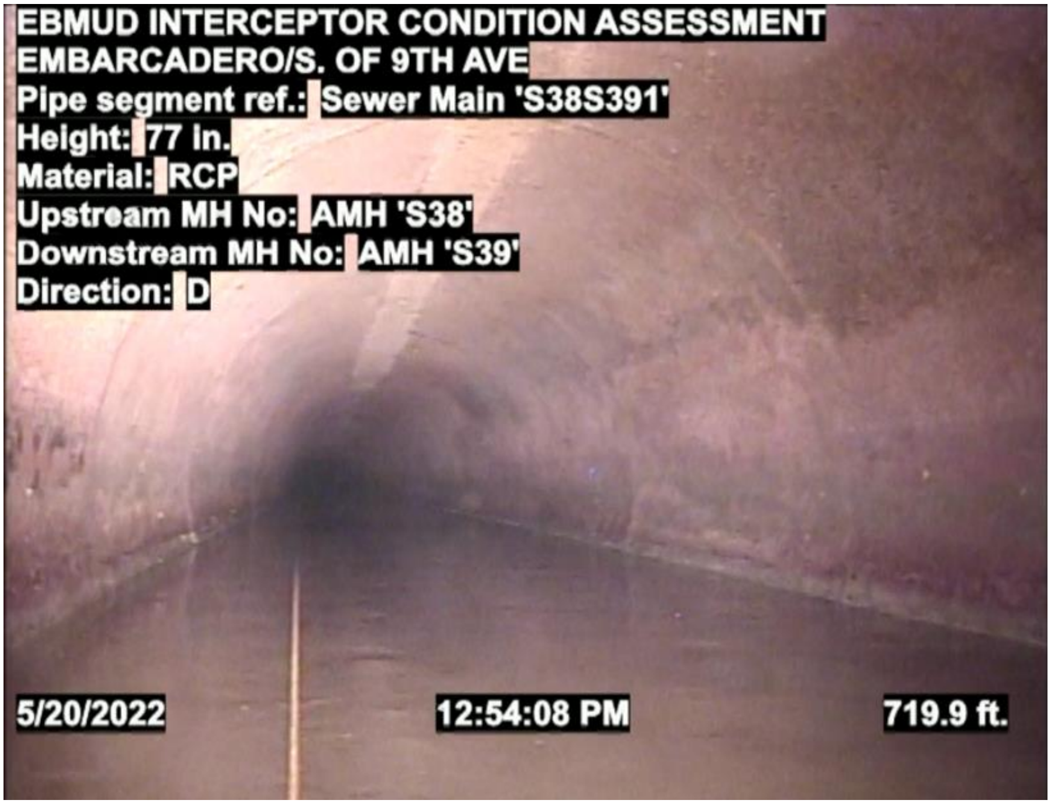
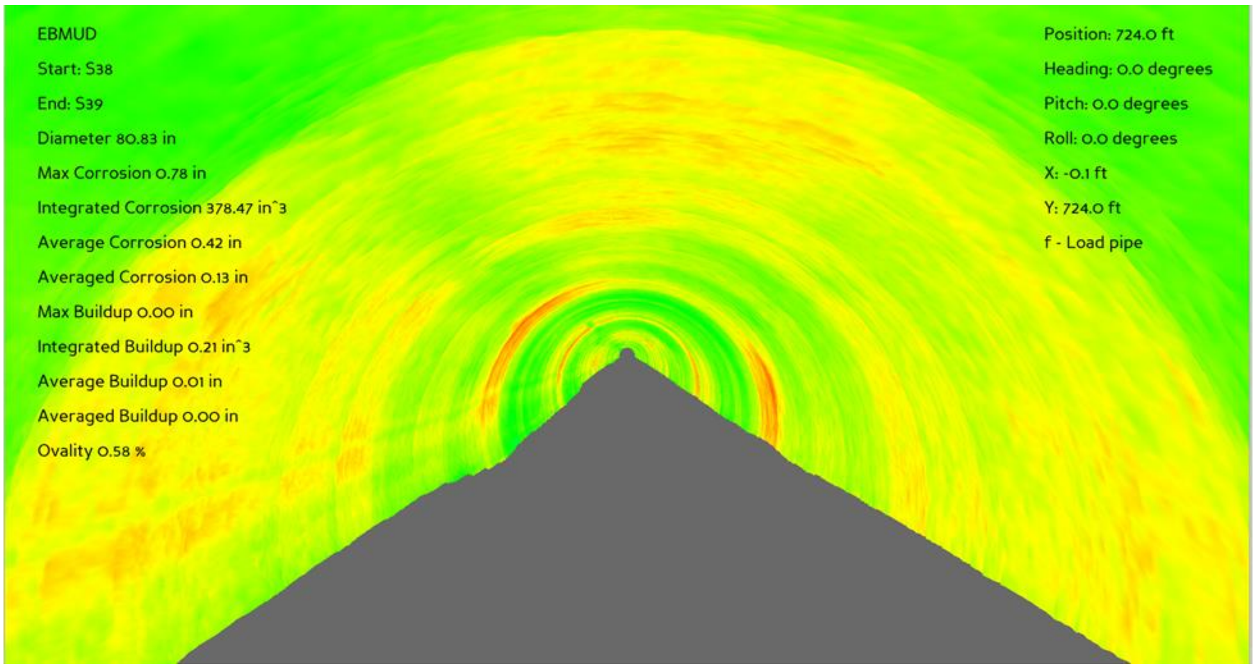
TYPICAL INTERIOR VIEW, 719 FEET





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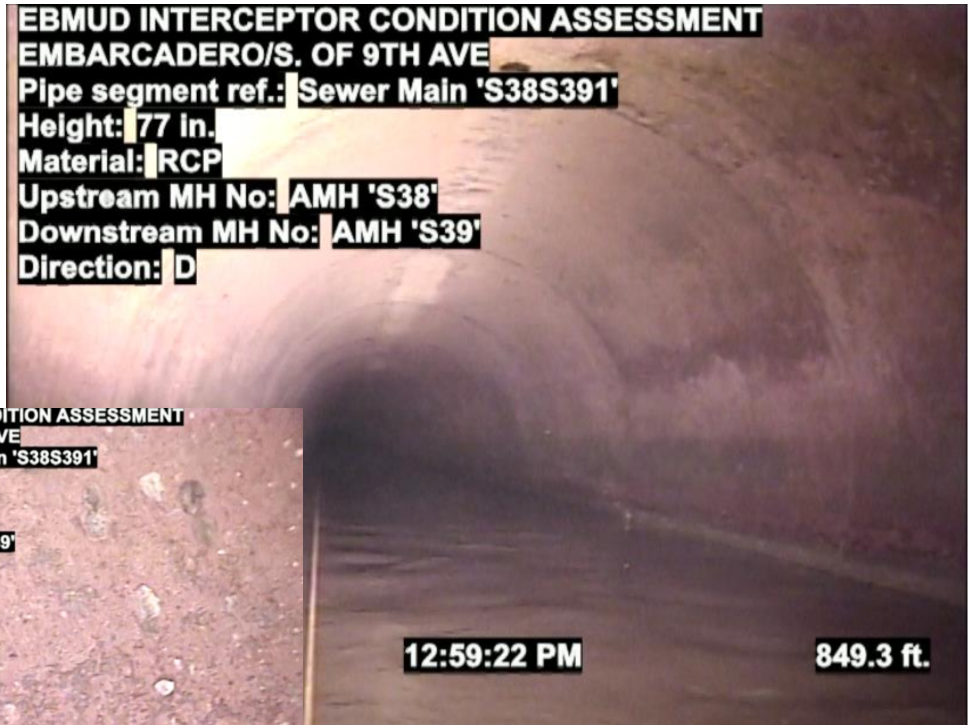
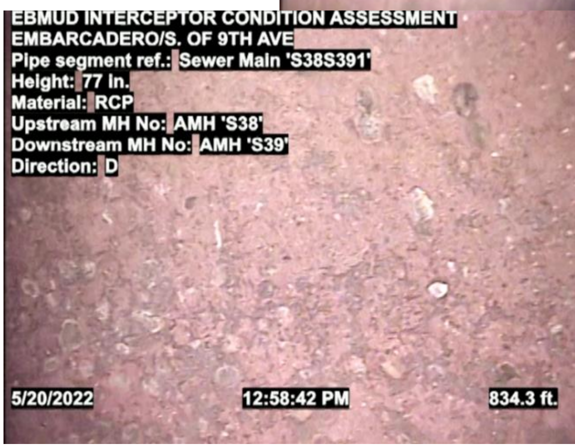
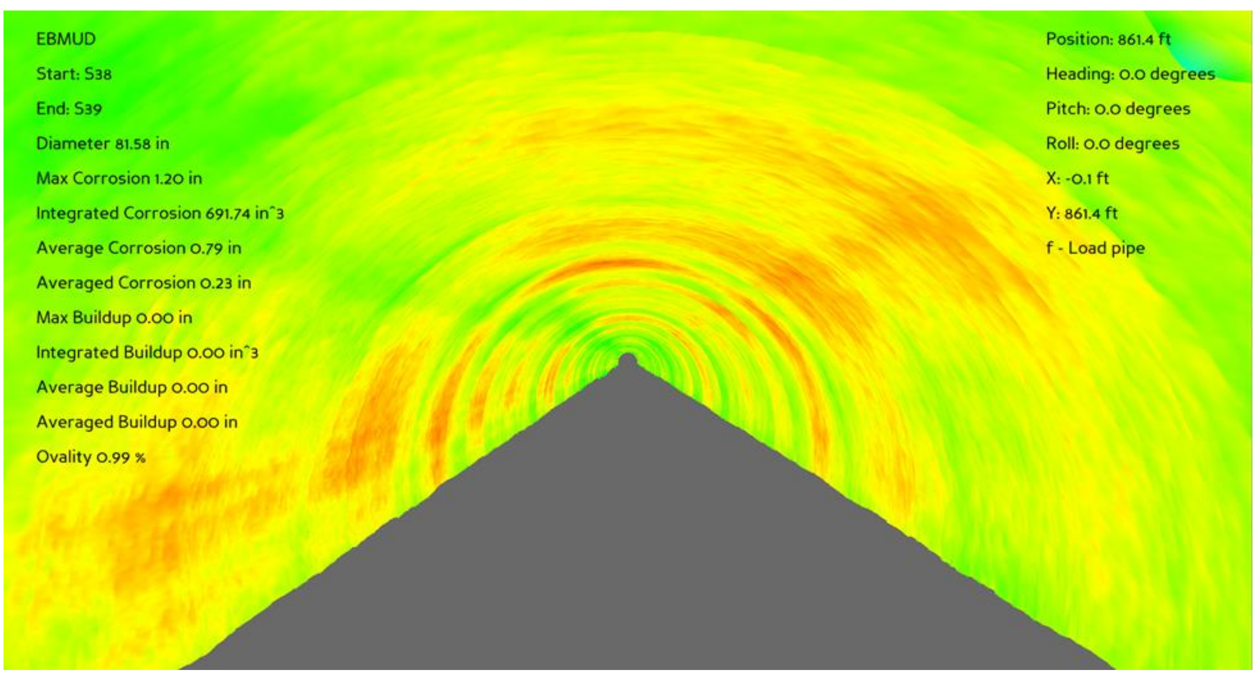
TYPICAL INTERIOR VIEW PAST 149 FEET







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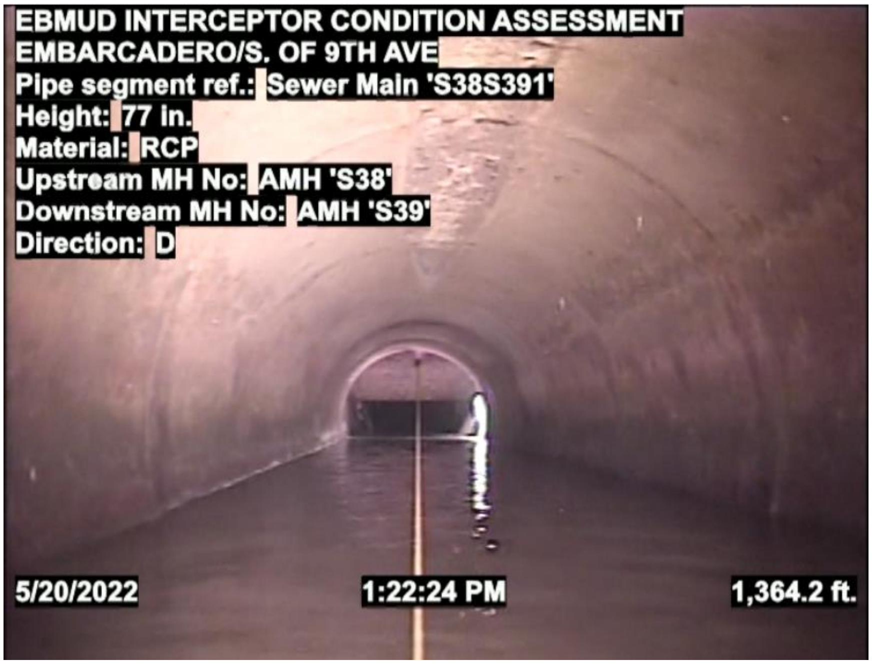
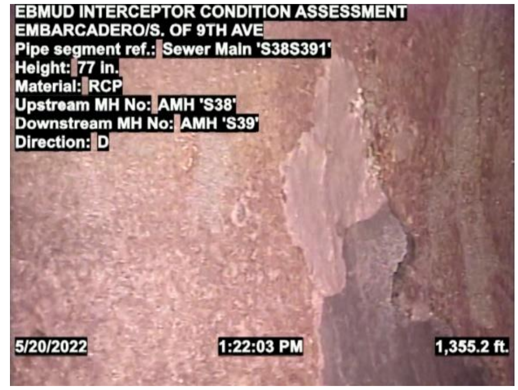
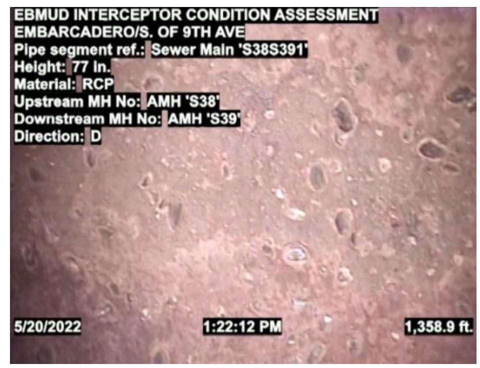
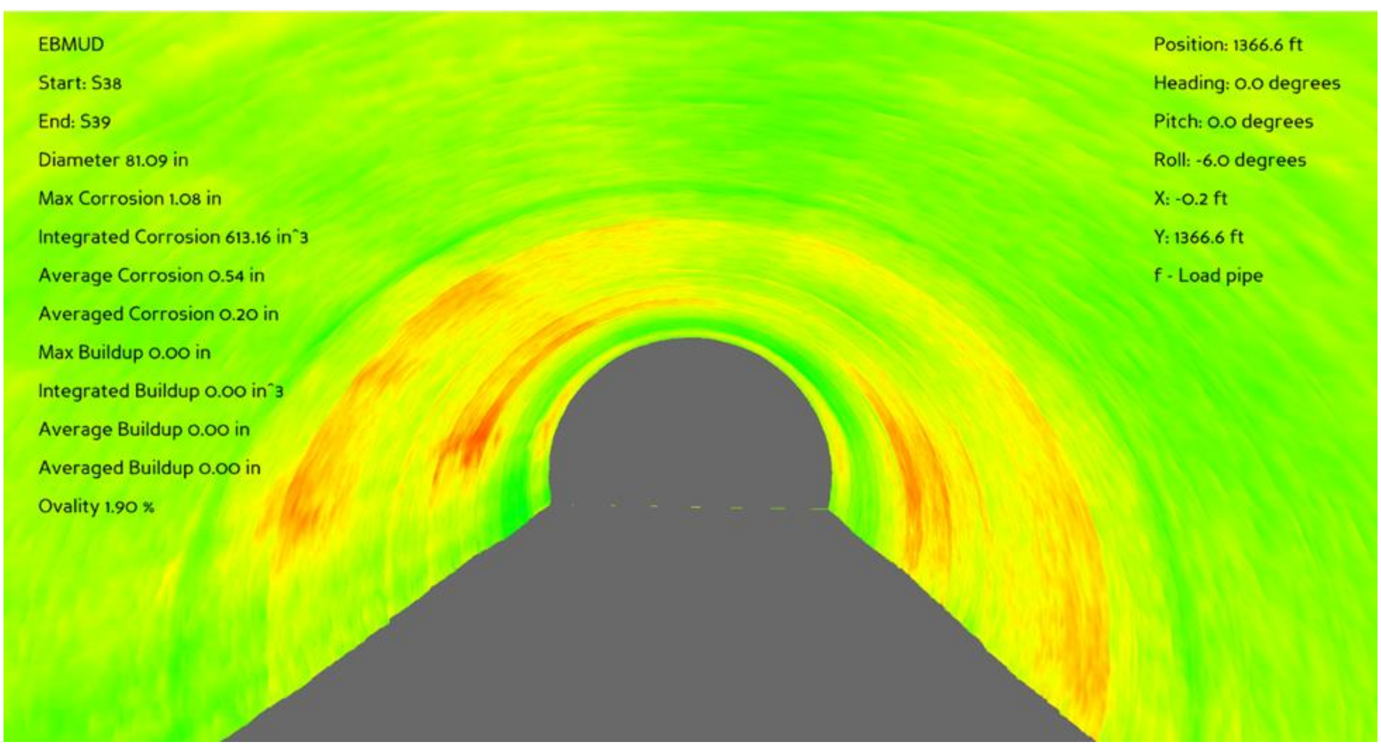
TYPICAL VIEW, END OF PIPE









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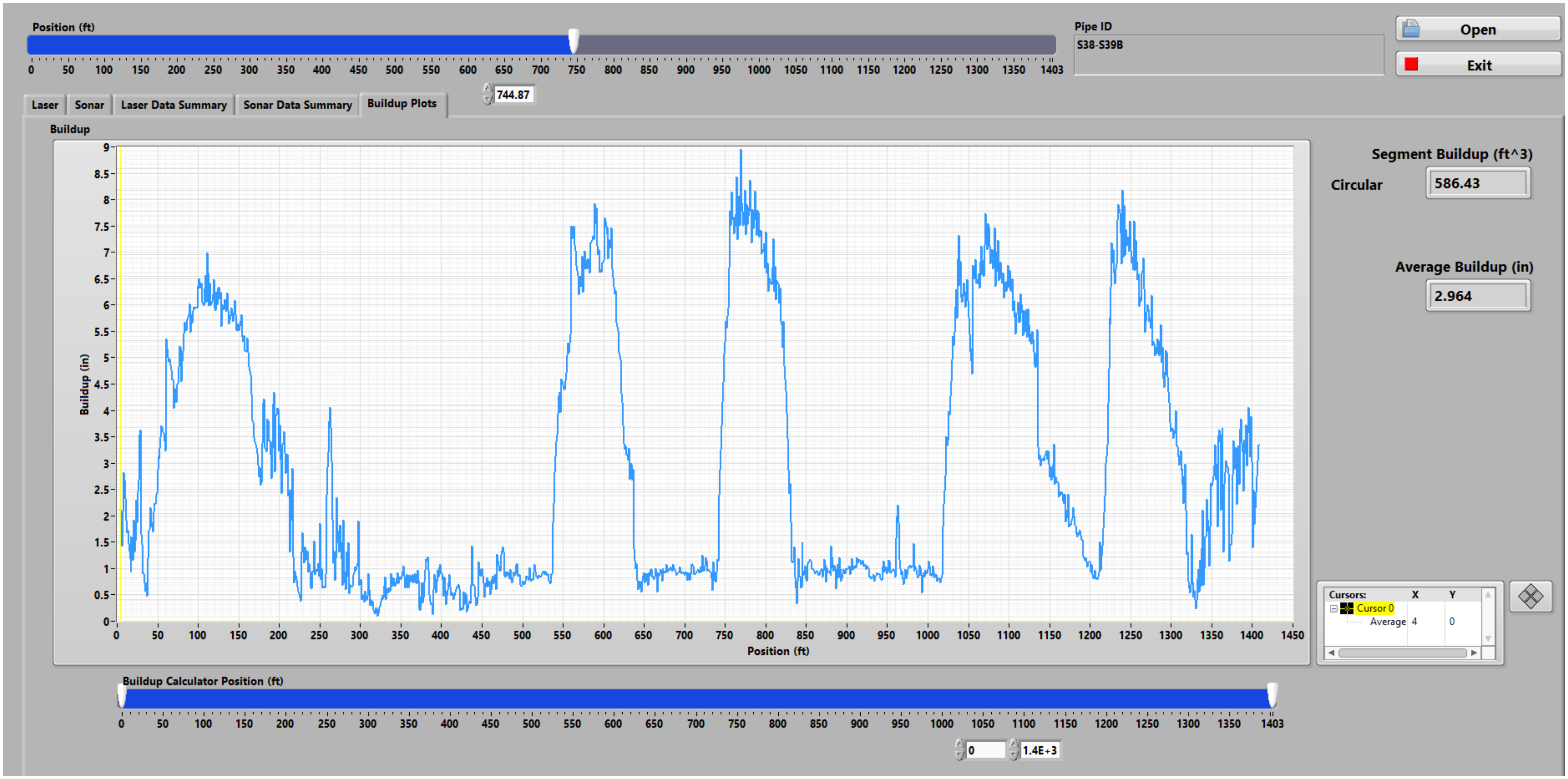
EBMUD
MULTI-SENSOR INSPECTION PROJECT

SONAR RESULTS: 586 CF (21.7 CY)



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LASER RESULTS BY 1 FOOT SCAN

Segment S38S391

Title 1 EBMUD	Title 2 Start: S38	Title 3 End: S39	Minimum Position (ft) 5	Maximum Position (ft) 1413	Surface Area(in2)/ft 3015.928947						
Position (ft)	Circular Radius (in)		Maximum Corrosion (in)	Average Corrosion (in)	Integrated Corrosion (in3)	Averaged Corrosion (in)	Maximum Buildup (in)	Average Buildup (in)	Integrated Buildup (in3)	Averaged Buildup (in)	Ovality (%)
10	40.666638		1.19928	0.666234	578.948713	0.191964	0	0	0	0	0.818515
11	40.696104		1.098972	0.695755	516.837152	0.171369	0	0	0	0	0.862772
12	40.79983		1.287432	0.799415	703.648901	0.233311	0	0	0	0	0.828718
13	40.973444		1.495572	0.973027	821.520525	0.272394	0	0	0	0	0.688895
14	40.92775		1.423116	0.92734	787.438029	0.261093	0	0	0	0	1.388354
15	40.978851		1.563672	0.978294	710.68348	0.235643	0	0	0	0	1.758015
16	40.910298		1.4001	0.909857	886.88751	0.294068	0	0	0	0	1.600965
17	41.046902		1.63182	1.046429	926.907966	0.307337	0	0	0	0	1.387947
18	41.028187		1.492452	1.02774	783.477644	0.25978	0	0	0	0	1.42982
19	40.984671		1.390212	0.984315	866.805515	0.287409	0	0	0	0	1.343833
20	40.947894		1.381836	0.947578	728.987399	0.241712	0	0	0	0	1.307549
21	40.980705		1.614288	0.980192	919.316881	0.30482	0	0	0	0	1.668966
22	40.99762		1.580856	0.997168	767.423256	0.254457	0	0	0	0	1.03042
23	41.16948		1.7292	1.16891	914.220585	0.303131	0	0	0	0	0.999546
24	41.134165		1.681304	1.133594	1010.07233	0.334913	0	0	0	0	1.217071
25	41.144662		1.70346	1.144121	1069.248259	0.354534	0	0	0	0	1.256431
26	41.078525		1.59276	1.077936	799.754984	0.265177	0	0	0	0	1.268662
27	40.995232		1.548324	0.994684	805.378433	0.267042	0	0	0	0	1.122454
28	40.9924		1.546416	0.991812	723.026249	0.239736	0	0	0	0	1.286134
29	41.095304		1.730544	1.09464	1024.386584	0.339659	0	0	0	0	1.272627
30	41.040514		1.68744	1.040011	700.087266	0.23213	0	0	0	0	1.126295
31	41.017768		1.417896	1.017422	895.521263	0.29693	0	0	0	0	0.815334
32	40.962957		1.392588	0.962678	875.870772	0.290415	0	0	0	0	0.683505
33	40.838352		1.282404	0.838146	770.431234	0.255454	0	0	0	0	0.457798
34	40.674641		1.041816	0.674393	620.485802	0.205736	0	0	0	0	0.680374
35	40.76359		1.174092	0.76333	607.100409	0.201298	0	0	0	0	0.447296
36	40.774547		1.161204	0.774289	728.381067	0.241511	0	0	0	0	0.207214
37	40.780821		1.235178	0.780877	753.34446	0.249789	0	0.002471	0.007905	0.000003	0.318769
38	40.805226		1.233552	0.804988	787.031226	0.260958	0	0	0	0	0.451194
39	40.923007		1.344852	0.922687	662.760825	0.219753	0	0	0	0	0.610135
40	40.919995		1.382268	0.919633	824.267292	0.273305	0	0	0	0	0.712105
41	40.860164		1.272216	0.859808	766.158885	0.254037	0	0	0	0	0.817012
42	40.789469		1.225704	0.789139	683.668999	0.226686	0	0	0	0	0.899471
43	40.629106		1.03122	0.628776	469.469662	0.155663	0	0	0	0	0.872668
44	40.680692		1.187604	0.68031	592.551775	0.196474	0	0	0	0	0.909754
45	40.663405		1.138836	0.663005	608.382886	0.201723	0	0	0	0	1.042539
46	40.74522		1.117356	0.74488	531.435897	0.17621	0	0	0	0	1.137461
47	40.78842		1.143804	0.78819	655.667677	0.217402	0	0	0	0	0.608033
48	40.988033		1.534644	0.98773	870.610164	0.288671	0	0	0	0	0.585957
49	40.905794		1.389816	0.905467	831.924375	0.275843	0	0	0	0	0.518829
50	40.881004		1.367088	0.8807	760.199525	0.252061	0	0	0	0	0.615213
51	40.900959		1.357092	0.900605	778.190782	0.258027	0	0	0	0	0.782088
52	40.942008		1.411816	0.941664	877.763648	0.291043	0	0	0	0	0.741809
53	40.942046		1.430832	0.941599	921.217539	0.305451	0	0	0	0	0.877174
54	40.847597		1.278888	0.847212	761.355702	0.252445	0	0	0	0	0.873834

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55	40.795146		1.26672	0.794722	675.491523	0.223975	0	0	0	0	2.114584
56	40.73972		1.218618	0.739747	748.876521	0.248307	0	0.002141	0.01071	0.000004	1.911639
57	40.69899		1.074156	0.698937	652.650942	0.216401	0	0.009276	0.018353	0.000006	1.43948
58	40.686052		1.110636	0.686036	628.635732	0.208439	0	0.010884	0.01835	0.000006	1.280008
59	40.642883		1.055496	0.64371	511.964187	0.169753	0	0.015712	0.053284	0.000018	1.459408
60	40.469484		0.951786	0.475166	446.466526	0.148036	0	0.055015	1.508915	0.0005	1.444052
61	40.302765		0.779532	0.317669	337.424318	0.111881	0.077796	0.097219	3.56549	0.001182	1.6235
62	40.507685		1.02366	0.511178	434.980186	0.144228	0	0.021144	0.395508	0.000131	1.016629
63	40.732308		1.12998	0.732089	666.189533	0.22089	0	0	0	0	1.533668
64	40.728319		1.115604	0.728076	768.984022	0.254974	0	0	0	0	1.598774
65	40.66346		1.043688	0.663234	748.482499	0.248176	0	0	0	0	1.332698
66	40.716514		1.049232	0.716336	799.290313	0.265023	0	0	0	0	1.084755
67	40.954514		1.476744	0.95426	1031.87884	0.342143	0	0	0	0	1.523108
68	41.068522		1.562028	1.068126	1304.398897	0.432503	0	0	0	0	2.164926
69	40.81567		1.186296	0.815441	1000.360254	0.331692	0	0	0	0	1.141146
70	40.791609		1.177212	0.791448	797.815996	0.264534	0	0	0	0	0.910351
71	40.60363		1.037064	0.603666	775.656699	0.257187	0	0.00076	0.000611	0	0.912074
72	40.602751		1.301412	0.602588	659.275743	0.218598	0	0	0	0	0.799012
73	40.847682		1.321872	0.847438	957.468089	0.31747	0	0	0	0	1.321438
74	40.895118		1.495104	0.894789	806.079919	0.267274	0	0	0	0	1.74272
75	40.900348		1.523928	0.899966	938.314098	0.311119	0	0	0	0	1.601905
76	40.845774		1.424388	0.845484	950.930489	0.315303	0	0.004672	0.015236	0.000005	1.496243
77	40.639507		1.104624	0.639238	626.699178	0.207796	0	0	0	0	0.99525
78	40.6059		0.986736	0.605748	587.014681	0.194638	0	0	0	0	0.581504
79	40.574913		0.975078	0.574678	472.165668	0.156557	0	0	0	0	1.128116
80	40.648208		1.042608	0.648241	652.221308	0.216259	0	0.004582	0.018872	0.000006	0.353005
81	40.648266		1.094028	0.648906	692.270404	0.229538	0	0.02389	0.141795	0.000047	0.539844
82	40.63038		1.204248	0.631128	457.419399	0.151668	0	0.008964	0.032017	0.000011	0.731062
83	40.790312		1.345836	0.793058	879.670942	0.291675	0	0.023534	0.187133	0.000062	0.984642
84	40.779104		1.340652	0.782845	878.975302	0.291444	0	0.039266	0.372841	0.000124	1.47898
85	40.823518		1.384452	0.823658	983.30989	0.326039	0	0.009734	0.04788	0.000016	1.722485
86	40.781295		1.36344	0.785409	795.196059	0.263665	0	0.019929	0.208412	0.000069	1.904923
87	40.710498		1.192848	0.711016	766.712967	0.254221	0	0.006284	0.140411	0.000047	1.528242
88	40.784583		1.250628	0.784203	943.329091	0.312782	0	0	0	0	1.563021
89	40.871541		1.353564	0.871159	1084.730654	0.359667	0	0	0	0	1.673242
90	40.877424		1.318464	0.877075	997.211152	0.330648	0	0	0	0	1.604792
91	40.849404		1.343364	0.849019	922.609679	0.305912	0	0	0	0	1.661217
92	40.690225		1.139976	0.689857	844.332471	0.279958	0	0	0	0	1.63882
93	40.62741		1.060992	0.627082	775.490819	0.257132	0	0	0	0	1.626182
94	40.602786		1.065624	0.602472	597.139979	0.197995	0	0	0	0	1.502771
95	40.439911		0.885132	0.440027	448.326219	0.148653	0	0.002067	0.014278	0.000005	0.882278
96	40.499932		0.871626	0.499755	598.380361	0.198407	0	0	0	0	0.937584
97	40.380402		0.786816	0.380214	402.887046	0.133586	0	0	0	0	0.80324
98	40.303884		0.656484	0.304704	328.026025	0.108765	0	0.007464	0.040831	0.000014	0.837251
99	40.231193		0.591432	0.241685	313.574433	0.103973	0.038376	0.052219	1.837389	0.000609	1.112192
100	40.264356		0.67302	0.274312	342.282634	0.113492	0.012504	0.037311	2.33086	0.000773	1.274674
101	40.214774		0.572904	0.237096	255.334718	0.084662	0.093624	0.046498	4.465243	0.001481	1.309514
102	40.140693		0.586212	0.206598	199.80967	0.066251	0.171312	0.088749	25.799256	0.008554	1.560164
103	40.50416		0.935316	0.507747	591.665677	0.19618	0	0.028151	0.63604	0.000211	2.088984
104	40.75255		1.240764	0.752782	1071.139467	0.355161	0	0.003742	0.022086	0.000007	2.765276

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105	40.746706		1.21056	0.746515	1010.420668	0.335028	0	0.001243	0.00329	0.000001	2.72954
106	40.754907		1.294704	0.754407	834.848099	0.276813	0	0	0	0	2.716597
107	40.668217		1.185444	0.670526	933.731891	0.3096	0	0.015799	0.077595	0.000026	2.604444
108	40.59375		1.147548	0.600289	845.571455	0.280368	0	0.039848	0.733329	0.000243	2.693979
109	40.592941		1.158744	0.600621	801.022272	0.265597	0	0.042317	1.037139	0.000344	2.839395
110	40.585956		1.133028	0.594463	817.542006	0.271075	0.021504	0.060605	1.556392	0.000516	2.767733
111	40.911353		1.293132	0.910886	1061.722295	0.352038	0	0	0	0	2.421848
112	40.894821		1.294935	0.894267	1215.699532	0.403093	0	0	0	0	2.628735
113	41.043823		1.517676	1.043168	1318.323199	0.43712	0	0	0	0	2.728622
114	41.100235		1.522332	1.099637	1485.152345	0.492436	0	0	0	0	2.58814
115	41.107212		1.497072	1.106532	1565.317335	0.519017	0	0	0	0	2.716842
116	40.929396		1.4721	0.929138	1286.960446	0.426721	0	0.002609	0.022522	0.000007	2.701724
117	40.841477		1.309212	0.844859	1117.462764	0.37052	0	0.023788	0.320301	0.000106	2.99623
118	40.721465		1.277628	0.727642	1034.81931	0.343118	0	0.025798	0.546333	0.000181	3.154502
119	40.826084		1.33212	0.828978	1084.682694	0.359651	0	0.019314	0.224382	0.000074	2.793623
120	40.901699		1.445196	0.902115	1242.571712	0.412003	0	0.005258	0.060878	0.00002	2.586648
121	40.826461		1.310856	0.831395	1029.930288	0.341497	0	0.025596	0.603876	0.0002	2.809446
122	40.746754		1.26504	0.751222	966.427785	0.320441	0	0.031745	0.336271	0.000111	2.812565
123	40.798332		1.252164	0.802482	1076.211463	0.356842	0	0.033269	0.865908	0.000287	2.799692
124	40.88426		1.392876	0.883768	1341.81137	0.444908	0	0	0	0	2.288031
125	40.965564		1.385124	0.965035	1427.556594	0.473339	0	0	0	0	2.313113
126	41.09257		1.511244	1.092029	1598.905172	0.530153	0	0	0	0	2.312316
127	41.06861		1.569552	1.06821	1562.648242	0.518132	0	0	0	0	2.08926
128	40.955566		1.387254	0.955743	1435.263378	0.475894	0	0.011511	0.143533	0.000048	1.937139
129	40.845368		1.175292	0.845014	1143.356806	0.379106	0	0	0	0	1.928956
130	40.864666		1.266048	0.864751	1268.630296	0.420643	0	0.020801	0.097738	0.000032	1.811123
131	40.915855		1.245972	0.915514	1153.378341	0.382429	0	0	0	0	1.843882
132	40.975701		1.32507	0.979647	1572.900328	0.521531	0	0.149926	1.427881	0.000473	2.181446
133	40.998011		1.42212	1.001131	1508.976363	0.500336	0	0.16368	1.953146	0.000648	2.391408
134	40.96983		1.314756	0.969466	1409.450177	0.467335	0	0	0	0	2.232833
135	40.919681		1.367928	0.919378	1152.17284	0.382029	0	0	0	0	1.874875
136	40.877841		1.301787	0.878707	1354.39996	0.449082	0	0.044038	0.618701	0.000205	2.710317
137	40.854472		1.341264	0.855779	1303.684481	0.432266	0	0.010105	0.06996	0.000023	2.84932
138	40.79257		1.21722	0.792106	1155.707977	0.383201	0	0	0	0	2.666326
139	40.804565		1.210932	0.80399	993.066314	0.329274	0	0	0	0	2.816128
140	40.6568		1.19688	0.667495	1005.762329	0.333483	0	0.080067	3.21614	0.001066	2.896821
141	40.441651		0.965256	0.468565	653.240396	0.216597	0.321606	0.235549	13.125311	0.004352	3.114373
142	40.433424		0.923484	0.469252	641.618439	0.212743	0.395496	0.291116	20.374376	0.006756	3.616631
143	40.684418		1.041612	0.690468	933.653118	0.309574	0	0.036754	1.000779	0.000332	2.303629
144	40.84039		1.245468	0.847428	1280.715255	0.42465	0	0.346827	9.70057	0.003216	2.293644
145	40.968889		1.336212	0.968724	1445.914923	0.479426	0	0.005691	0.016699	0.000006	2.172745
146	40.955804		1.288644	0.955464	1395.903179	0.462844	0	0	0	0	1.987477
147	40.930046		1.2843	0.929741	1311.476294	0.43485	0	0	0	0	1.731898
148	40.874453		1.248642	0.874144	1276.990437	0.423415	0	0	0	0	1.553733
149	40.717879		1.26234	0.717552	1078.936855	0.357746	0	0	0	0	1.607194
150	40.654162		1.012596	0.657112	926.116182	0.307075	0	0.115896	1.236287	0.00041	1.720376
151	40.841479		1.27218	0.841248	1220.685415	0.404746	0	0	0	0	1.320899
152	41.169353		1.63278	1.177718	1891.902786	0.627304	0	0.39573	5.156087	0.00171	2.9904
153	41.266513		1.809384	1.269247	1971.024343	0.653538	0	0.157237	2.296183	0.000761	3.205502
154	41.379298		1.836084	1.3786	2028.370453	0.672552	0	0	0	0	3.154375

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155	41.293839		1.733352	1.293042	1488.910048	0.493682	0	0	0	0	3.209462
156	41.217699		1.748064	1.218135	1952.763543	0.647483	0	0.031939	0.131119	0.000043	3.052938
157	41.087908		1.556412	1.087489	1695.671591	0.562239	0	0.004054	0.023893	0.000008	2.818772
158	41.081608		1.557144	1.08093	1577.457117	0.523042	0	0	0	0	3.135544
159	40.802626		1.344096	0.814958	1118.669334	0.37092	0	0.697066	10.220991	0.003389	3.293962
160	40.651227		1.040004	0.659362	1046.029701	0.346835	0	0.395535	6.485383	0.00215	1.937582
161	40.89821		1.306092	0.902021	1430.298035	0.474248	0	0.20695	2.945669	0.000977	2.291661
162	40.940312		1.307772	0.940188	1413.899182	0.468811	0	0.009404	0.027153	0.000009	2.311479
163	40.942039		1.31862	0.941954	1293.240562	0.428803	0	0.018619	0.081732	0.000027	2.359915
164	40.943475		1.47054	0.943841	1457.204281	0.483169	0	0.028391	0.502627	0.000167	2.411867
165	40.915308		1.43886	0.915012	1350.405255	0.447758	0	0.004671	0.01734	0.000006	2.53775
166	41.03839		1.489476	1.037564	1439.728496	0.477375	0	0	0	0	2.837025
167	41.127307		1.58796	1.126514	1547.28417	0.513037	0	0	0	0	2.866853
168	41.264575		1.69995	1.264187	1796.130515	0.595548	0	0.016343	0.052709	0.000017	2.309058
169	41.31721		1.77456	1.31666	1911.591548	0.633832	0	0.002976	0.013563	0.000004	2.533592
170	41.342276		1.829856	1.341488	1897.073662	0.629018	0	0	0	0	2.869679
171	41.399731		1.795392	1.398986	2025.351528	0.671551	0	0	0	0	2.672434
172	41.295764		1.859568	1.295281	1938.118372	0.642627	0	0.001977	0.010735	0.000004	2.495579
173	41.157428		1.6191	1.156727	1687.419826	0.559503	0	0	0	0	2.411921
174	41.102868		1.50378	1.10224	1526.0995	0.506013	0	0	0	0	2.427038
175	41.021072		1.448928	1.02052	1609.284483	0.533595	0	0	0	0	2.619455
176	41.063749		1.703484	1.063094	1352.136476	0.448332	0	0	0	0	3.448608
177	41.178748		1.653228	1.178092	1652.53186	0.547935	0	0	0	0	3.328481
178	41.214026		1.729212	1.213284	1624.05193	0.538491	0	0	0	0	3.34781
179	41.25035		1.75032	1.249534	1670.693147	0.553956	0	0	0	0	3.527425
180	41.227264		1.71264	1.226444	1708.858838	0.566611	0	0	0	0	3.231358
181	41.195125		1.640112	1.194286	1486.45851	0.492869	0	0	0	0	3.152398
182	41.135575		1.645116	1.134713	1587.234962	0.526284	0	0	0	0	3.114724
183	40.883916		1.379616	0.883095	1013.050916	0.3359	0	0	0	0	3.038019
184	40.584863		0.94104	0.587035	701.008695	0.232435	0	0.011397	0.103923	0.000034	1.974121
185	40.577987		0.963456	0.578082	741.663707	0.245916	0	0.001702	0.009199	0.000003	1.916742
186	40.675251		1.018692	0.67493	926.921396	0.307342	0	0	0	0	2.212465
187	40.699542		1.03248	0.699234	852.553558	0.282684	0	0	0	0	2.121582
188	40.627923		1.03614	0.627634	814.265013	0.269988	0	0	0	0	1.95324
189	40.606394		1.004568	0.606039	774.493677	0.256801	0	0	0	0	2.053543
190	40.660258		1.071696	0.659882	766.756376	0.254236	0	0	0	0	2.154778
191	40.656021		1.039548	0.655698	806.820942	0.26752	0	0	0	0	2.085609
192	40.761567		1.241724	0.76208	1025.228698	0.339938	0	0.009203	0.083653	0.000028	1.717697
193	40.668812		1.066896	0.6707	934.348071	0.309804	0	0.015877	0.160609	0.000053	1.908383
194	40.713532		1.152	0.714758	902.997671	0.299409	0	0.011638	0.071554	0.000024	2.23706
195	40.595847		0.991944	0.59829	663.183117	0.219893	0	0.022509	0.226457	0.000075	1.986148
196	40.543778		0.994608	0.545908	626.493513	0.207728	0	0.038805	0.287414	0.000095	1.879917
197	40.470023		0.939156	0.48093	619.073047	0.205268	0.060444	0.108703	3.262166	0.001082	2.1762
198	40.45518		0.91866	0.469554	621.514655	0.206077	0.1002	0.120892	4.087438	0.001355	2.11821
199	40.475781		0.893256	0.487212	503.340093	0.166894	0.063588	0.073509	1.814824	0.000602	1.861703
200	40.438215		0.87786	0.439277	493.26186	0.163552	0	0.009319	0.15586	0.000052	1.440438
201	40.48059		1.022844	0.483556	567.079832	0.188028	0	0.035831	0.409935	0.000136	1.870214
202	40.650353		1.05054	0.650158	722.4079	0.239531	0	0	0	0	1.643352
203	40.74039		1.107516	0.740187	831.416987	0.275675	0	0	0	0	1.702681
204	40.7379		1.129488	0.737684	997.73546	0.330822	0	0	0	0	1.636372

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205	40.702489		1.065024	0.702263	848.000143	0.281174	0	0	0	0	1.592569
206	40.693471		1.096128	0.693259	818.809401	0.271495	0	0	0	0	1.541234
207	40.627231		0.975264	0.626981	719.785005	0.238661	0	0	0	0	1.394074
208	40.660767		1.092366	0.660848	817.947366	0.271209	0	0.004074	0.00848	0.000003	1.611204
209	40.570301		0.912444	0.570616	677.767649	0.224729	0	0.007624	0.048837	0.000016	1.679195
210	40.502502		0.809292	0.505539	472.708257	0.156737	0	0.04275	0.307468	0.000102	1.625193
211	40.539228		0.82956	0.539922	579.536504	0.192159	0	0.012646	0.041645	0.000014	1.520912
212	40.472845		0.865749	0.478047	550.0462	0.18238	0	0.041576	0.644301	0.000214	1.584677
213	40.491861		0.858048	0.494121	509.468572	0.168926	0	0.021283	0.252298	0.000084	1.421374
214	40.671886		1.039488	0.671599	755.018483	0.250344	0	0	0	0	1.528968
215	40.710936		1.034772	0.710696	823.556615	0.273069	0	0	0	0	1.254645
216	40.94207		1.349388	0.941878	1065.959489	0.353443	0	0	0	0	0.998156
217	41.011764		1.367244	1.011571	1073.315227	0.355882	0	0	0	0	0.984896
218	41.043247		1.389408	1.043066	1205.969068	0.399867	0	0	0	0	0.875006
219	40.965225		1.350024	0.965017	878.72985	0.291363	0	0	0	0	1.076731
220	40.824755		1.247184	0.824559	923.678648	0.306267	0	0	0	0	1.027707
221	40.781796		1.221408	0.781579	743.606223	0.24656	0	0	0	0	0.960321
222	40.692528		1.0782	0.692334	596.708736	0.197852	0	0	0	0	0.762345
223	40.632006		1.013604	0.631829	687.888067	0.228085	0	0	0	0	0.489616
224	40.634658		1.047492	0.634396	651.593303	0.216051	0	0	0	0	0.616556
225	40.68912		1.260024	0.688808	618.016682	0.204918	0	0	0	0	0.954905
226	40.835121		1.242768	0.834777	814.050751	0.269917	0	0	0	0	0.945264
227	40.799418		1.19436	0.79914	790.234952	0.26202	0	0	0	0	0.575855
228	40.468298		0.9636	0.470345	480.66353	0.159375	0	0.015266	0.211173	0.00007	0.851446
229	40.388646		0.731712	0.391156	369.322672	0.122457	0	0.01996	0.1931	0.000064	0.934273
230	40.30473		0.773088	0.309768	268.727777	0.089103	0.019188	0.073968	1.162538	0.000385	0.664055
231	40.203875		0.627972	0.23191	270.863366	0.089811	0.068892	0.065834	6.65164	0.002206	0.792001
232	40.595719		1.04184	0.595583	614.900336	0.203884	0	0.000956	0.003908	0.000001	1.311105
233	40.719069		1.158732	0.718757	788.206291	0.261348	0	0	0	0	2.056106
234	40.526523		0.894204	0.528279	477.523585	0.158334	0	0.014862	0.062036	0.000021	2.024373
235	40.517279		0.905076	0.518439	562.555498	0.186528	0	0.017948	0.188999	0.000063	1.679894
236	40.622273		0.932712	0.622184	693.35959	0.229899	0	0.001356	0.004935	0.000002	1.395795
237	40.568652		0.9387	0.568455	626.827122	0.207839	0	0	0	0	1.445468
238	40.472478		0.881784	0.47226	428.639585	0.142125	0	0	0	0	1.50957
239	40.454651		0.880668	0.454701	438.525302	0.145403	0	0.00432	0.006964	0.000002	1.704684
240	40.614769		1.099116	0.614559	713.57808	0.236603	0	0	0	0	1.598171
241	40.791204		1.159824	0.790986	713.570371	0.236601	0	0	0	0	1.712622
242	40.744482		1.075644	0.744255	674.841609	0.223759	0	0	0	0	1.688946
243	40.609726		1.081128	0.60964	700.621808	0.232307	0	0.001225	0.003636	0.000001	1.439189
244	40.61186		1.02576	0.612225	687.032928	0.227801	0	0.00897	0.031719	0.000011	1.366107
245	40.811202		1.153788	0.81097	954.044312	0.316335	0	0	0	0	1.274685
246	40.768176		1.068276	0.767961	756.13172	0.250713	0	0	0	0	1.235836
247	40.786204		1.210452	0.785887	789.658416	0.261829	0	0	0	0	1.386558
248	40.795453		1.111512	0.795301	912.433404	0.302538	0	0	0	0	0.764924
249	40.699805		0.980436	0.699674	774.013987	0.256642	0	0	0	0	0.83551
250	40.657686		0.963036	0.65754	609.297169	0.202026	0	0	0	0	0.516303
251	40.729431		1.31484	0.729221	845.822796	0.280452	0	0	0	0	0.44361
252	40.922444		1.327104	0.922214	1031.253737	0.341936	0	0	0	0	0.469077
253	40.899034		1.364892	0.898838	892.275232	0.295854	0	0	0	0	0.711822
254	40.887429		1.189608	0.887247	813.397061	0.2697	0	0	0	0	0.813923

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255	40.978771		1.359075	0.978577	1118.985288	0.371025	0	0	0	0	0.809143
256	40.80299		1.170678	0.802813	898.080333	0.297779	0	0	0	0	0.779405
257	40.753661		1.140348	0.753439	699.835007	0.232046	0	0	0	0	1.167505
258	40.759536		1.145328	0.7593	903.518565	0.299582	0	0	0	0	1.058422
259	40.839513		1.228392	0.839311	840.11802	0.27856	0	0	0	0	0.892271
260	40.846054		1.223736	0.845873	903.018059	0.299416	0	0	0	0	0.725393
261	40.727011		1.125444	0.726826	705.575017	0.233949	0	0	0	0	0.639665
262	40.614714		0.971568	0.614529	534.208592	0.177129	0	0	0	0	0.498254
263	40.528728		0.961776	0.529059	554.514876	0.183862	0	0.00627	0.023482	0.000008	0.490378
264	40.521898		1.085208	0.522541	520.929568	0.172726	0	0.012599	0.064936	0.000022	0.697083
265	40.666032		1.11714	0.665642	639.59208	0.212071	0	0	0	0	1.736669
266	40.725446		1.1925	0.724956	782.285026	0.259384	0	0	0	0	2.078907
267	40.738852		1.177416	0.738372	743.358182	0.246477	0	0	0	0	1.891158
268	40.677571		1.140588	0.677359	688.430518	0.228265	0	0.000748	0.001722	0.000001	1.746588
269	40.650768		1.13058	0.650328	693.212209	0.22985	0	0	0	0	1.919254
270	40.670558		1.1217	0.670097	694.628389	0.23032	0	0	0	0	2.350328
271	40.604243		1.065564	0.603945	713.860014	0.236697	0	0	0	0	1.908666
272	40.569319		1.028928	0.569099	631.610386	0.209425	0	0	0	0	1.299211
273	40.563509		0.876048	0.563342	685.943469	0.22744	0	0	0	0	0.762968
274	40.511834		0.801216	0.511688	526.224094	0.174482	0	0	0	0	0.585779
275	40.401959		0.759492	0.404431	457.79642	0.151793	0	0.032734	0.329239	0.000109	0.480054
276	40.316813		0.653244	0.320727	330.24042	0.109499	0	0.067644	0.951643	0.000316	0.584451
277	40.274865		0.5025	0.278166	255.341231	0.084664	0.067284	0.108117	1.083161	0.000359	0.443548
278	40.265811		0.544274	0.273855	305.951085	0.101445	0.079769	0.078352	1.880085	0.000623	0.626159
279	40.426198		0.946224	0.426755	484.690441	0.16071	0	0.01454	0.156827	0.000052	0.275025
280	40.430028		0.897636	0.429984	477.975949	0.158484	0	0.002464	0.009132	0.000003	0.387827
281	40.514776		0.87018	0.515428	390.062166	0.129334	0	0.033752	0.06287	0.000021	1.257313
282	40.415642		0.879384	0.417196	495.63858	0.16434	0	0.041808	0.267341	0.000089	1.066247
283	40.413827		0.830376	0.414602	390.981702	0.129639	0	0.02719	0.107845	0.000036	0.747126
284	40.475372		0.860244	0.475489	545.569241	0.180896	0	0.002166	0.006243	0.000002	0.581739
285	40.54572		0.903156	0.546428	412.710395	0.136844	0	0.012988	0.024463	0.000008	0.755763
286	40.553135		0.948028	0.55346	609.884414	0.202221	0	0.009647	0.029067	0.00001	1.077306
287	40.443761		0.876588	0.445874	480.190279	0.159218	0	0.034918	0.240034	0.00008	1.107902
288	40.421178		0.778956	0.421018	458.526972	0.152035	0	0	0	0	0.786129
289	40.579251		0.96162	0.579084	582.060916	0.192996	0	0	0	0	1.239566
290	40.634627		0.969744	0.634419	616.537135	0.204427	0	0	0	0	1.497481
291	40.849614		1.24056	0.849407	961.450535	0.318791	0	0	0	0	1.268785
292	40.95007		1.284504	0.949879	888.371233	0.29456	0	0	0	0	1.242625
293	40.8972		1.18908	0.897007	1038.347985	0.344288	0	0	0	0	1.051458
294	40.836807		1.289928	0.836524	882.612714	0.29265	0	0	0	0	1.211798
295	40.771229		1.250784	0.770883	910.507229	0.301899	0	0	0	0	1.398927
296	40.638389		1.05	0.638117	683.911578	0.226766	0	0	0	0	1.278679
297	41.089771		1.577616	1.089418	1139.500553	0.377827	0	0	0	0	2.266359
298	40.949369		1.595916	0.949038	1058.173846	0.350862	0	0	0	0	2.411503
299	40.910572		1.356	0.910255	1054.605817	0.349679	0	0	0	0	2.349141
300	40.904421		1.24536	0.904185	684.800062	0.227061	0	0	0	0	1.969662
301	40.869287		1.203444	0.869081	913.885737	0.30302	0	0	0	0	1.901421
302	40.61975		1.081812	0.621587	646.817797	0.214467	0	0.025346	0.11908	0.000039	1.949137
303	40.646923		1.086516	0.649692	670.652253	0.22237	0	0.036595	0.277528	0.000092	2.198073
304	40.600074		0.95106	0.601881	507.675834	0.168331	0	0.030447	0.15734	0.000052	1.887736

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305	40.545165		1.021956	0.544901	555.3142	0.184127	0	0	0	0	1.159427
306	40.553168		1.055112	0.554765	562.100611	0.186377	0	0.016399	0.205472	0.000068	1.575695
307	40.437276		0.835848	0.44424	431.03354	0.142919	0.02808	0.06907	1.039546	0.000345	1.689429
308	40.439035		0.803892	0.442471	425.365585	0.14104	0	0.038306	0.305534	0.000101	1.411997
309	40.356792		0.810132	0.365368	311.13398	0.103164	0	0.034814	1.567275	0.00052	1.169733
310	40.323013		0.715776	0.330394	336.110457	0.111445	0.0498	0.043195	0.76635	0.000254	1.299772
311	40.367496		0.685884	0.36804	304.915964	0.101102	0	0.00921	0.026885	0.000009	1.015133
312	40.483078		1.02912	0.482856	469.027311	0.155517	0	0	0	0	0.507683
313	40.615058		1.05258	0.614888	636.104571	0.210915	0	0.001682	0.006637	0.000002	1.621744
314	40.558002		0.909132	0.557762	552.454595	0.183179	0	0	0	0	1.357924
315	40.591992		0.910608	0.591762	506.78862	0.168037	0	0	0	0	1.284051
316	40.617038		0.986208	0.616817	543.679365	0.180269	0	0	0	0	0.842442
317	40.765395		1.140552	0.765147	833.462328	0.276353	0	0	0	0	0.824368
318	40.714374		1.073328	0.714184	700.907993	0.232402	0	0	0	0	0.836516
319	40.638084		1.005252	0.637884	525.567953	0.174264	0	0	0	0	0.735419
320	40.636094		0.973812	0.635918	663.857397	0.220117	0	0	0	0	0.827037
321	40.793764		1.145184	0.793556	699.4732	0.231926	0	0	0	0	1.320534
322	40.791276		1.1049	0.791095	747.050844	0.247702	0	0	0	0	1.338611
323	40.771549		1.034616	0.771428	758.936426	0.251643	0	0	0	0	0.913482
324	40.590681		1.045188	0.59056	572.928982	0.189968	0	0	0	0	0.904234
325	40.549464		0.818556	0.549358	509.722921	0.16901	0	0	0	0	0.795789
326	40.562595		0.795432	0.562488	509.590612	0.168966	0	0	0	0	0.741896
327	40.658566		0.988584	0.658457	648.104863	0.214894	0	0	0	0	0.620279
328	40.685343		1.113504	0.6852	641.311018	0.212641	0	0	0	0	0.580624
329	40.830254		1.121724	0.830086	766.858036	0.254269	0	0	0	0	0.61944
330	40.893444		1.198176	0.893268	819.437779	0.271703	0	0	0	0	1.377716
331	40.832074		1.127676	0.831903	805.587378	0.267111	0	0	0	0	1.418364
332	40.774642		1.072428	0.774482	726.486502	0.240883	0	0	0	0	1.32386
333	40.740288		1.024776	0.740133	591.929961	0.196268	0	0	0	0	1.144769
334	40.574493		0.953664	0.574545	568.348877	0.188449	0	0.003893	0.024067	0.000008	0.693075
335	40.286963		0.575544	0.292874	287.028872	0.095171	0	0.03749	0.707636	0.000235	0.75211
336	40.090737		0.425448	0.143743	128.426182	0.042583	0.245856	0.103306	22.288195	0.00739	0.640303
337	40.196115		0.509244	0.224268	185.056849	0.06136	0.162816	0.111153	8.610971	0.002855	0.830834
338	40.246384		0.628128	0.290195	194.696508	0.064556	0.221388	0.126041	11.153026	0.003698	1.361833
339	40.300531		0.690792	0.33172	291.829831	0.096763	0.122076	0.090015	6.417488	0.002128	0.967389
340	40.344259		0.74934	0.362295	331.468099	0.109906	0.071976	0.057691	2.719067	0.000902	0.959618
341	40.350732		0.659916	0.365295	278.518438	0.092349	0.064236	0.051075	1.653438	0.000548	1.060666
342	40.306266		0.5949	0.317988	248.909308	0.082532	0.041628	0.033547	1.122503	0.000372	0.811322
343	40.380247		0.823248	0.383681	381.422164	0.126469	0	0.024469	0.390123	0.000129	0.56527
344	40.537195		0.855504	0.536921	415.94543	0.137916	0	0	0	0	0.312057
345	40.660162		1.149072	0.659861	591.063746	0.195981	0	0	0	0	0.599377
346	40.724494		1.124028	0.724142	701.154052	0.232484	0	0	0	0	0.828301
347	40.678043		1.06608	0.677681	615.856497	0.204201	0	0	0	0	0.793006
348	40.629554		0.935664	0.629225	561.372158	0.186136	0	0	0	0	0.823899
349	40.632615		0.941328	0.632469	500.190877	0.16585	0	0.000314	0.000446	0	0.955638
350	40.548651		0.87789	0.549387	438.342396	0.145342	0	0.005017	0.01946	0.000006	0.738619
351	40.491017		0.856908	0.494616	398.093551	0.131997	0	0.014933	0.382091	0.000127	0.906717
352	40.367609		0.701352	0.383798	346.500504	0.11489	0.078792	0.061558	1.980704	0.000657	1.196285
353	40.486764		0.792192	0.48732	356.09579	0.118072	0	0.004021	0.092916	0.000031	0.242277
354	40.694152		1.121136	0.693948	644.245303	0.213614	0	0	0	0	0.255638

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355	40.781986		1.125036	0.78178	643.179474	0.213261	0	0	0	0	0.242486
356	40.901718		1.22358	0.901569	787.378547	0.261073	0	0	0	0	0.782654
357	41.131402		1.4646	1.131223	977.263453	0.324034	0	0	0	0	0.623665
358	41.022712		1.43196	1.022518	1005.715748	0.333468	0	0	0	0	0.71677
359	40.98015		1.301256	0.979914	688.166248	0.228177	0	0	0	0	0.948088
360	40.992751		1.341168	0.992527	964.343204	0.31975	0	0	0	0	0.987537
361	40.62583		1.36776	0.62567	544.135459	0.180421	0	0	0	0	0.745766
362	40.449626		0.757902	0.449573	406.722804	0.134858	0	0.003017	0.003433	0.000001	0.928672
363	40.477551		0.803232	0.47799	373.888692	0.123971	0	0.011793	0.051569	0.000017	1.044673
364	40.505618		0.770004	0.505438	459.47994	0.152351	0	0	0	0	1.113224
365	40.549707		0.880248	0.549503	509.816319	0.169041	0	0	0	0	1.01214
366	40.547361		0.9312	0.54717	452.19126	0.149934	0	0	0	0	1.106653
367	40.52484		0.798096	0.525003	398.239057	0.132045	0	0.000975	0.001257	0	1.135471
368	40.541443		0.86274	0.541251	479.39418	0.158954	0	0	0	0	1.272596
369	40.609842		1.03914	0.609593	584.627554	0.193847	0	0	0	0	0.881138
370	40.762047		1.1256	0.761793	711.10176	0.235782	0	0	0	0	0.796265
371	40.811574		1.108752	0.811323	614.509867	0.203755	0	0	0	0	0.85518
372	40.774395		1.161732	0.774124	694.693986	0.230342	0	0	0	0	0.973514
373	40.696832		1.055604	0.696595	684.438983	0.226941	0	0	0	0	0.548508
374	40.603051		0.950136	0.60282	559.044811	0.185364	0	0	0	0	0.493853
375	40.577427		0.981732	0.577203	527.635283	0.17495	0	0	0	0	0.504752
376	40.66652		1.09092	0.666273	572.452241	0.18981	0	0	0	0	0.473046
377	40.670339		1.063716	0.670129	614.260274	0.203672	0	0	0	0	0.748074
378	40.719305		1.05822	0.719081	691.579331	0.229309	0	0	0	0	1.201638
379	40.671333		0.932808	0.671139	453.95973	0.150521	0	0	0	0	0.746347
380	40.615751		0.954984	0.615552	582.512094	0.193145	0	0	0	0	0.530609
381	40.509042		0.81924	0.508836	480.678541	0.15938	0	0	0	0	0.602634
382	40.468344		0.768876	0.468142	415.665954	0.137824	0	0	0	0	0.581364
383	40.373434		0.739536	0.379613	323.736198	0.107342	0	0.017736	0.614628	0.000204	0.717566
384	40.315305		0.674136	0.321388	311.782753	0.103379	0	0.027726	0.719171	0.000238	0.568362
385	40.303662		0.724908	0.314543	289.040056	0.095838	0	0.047386	2.035412	0.000675	0.665254
386	40.333412		0.667536	0.334052	346.551537	0.114907	0	0.02373	0.11966	0.00004	0.639819
387	40.356372		0.743172	0.357334	325.855615	0.108045	0	0.009856	0.06565	0.000022	0.762356
388	40.260232		0.691626	0.268755	256.726649	0.085124	0	0.047056	1.674045	0.000555	0.777136
389	40.312722		0.66402	0.317068	300.60683	0.099673	0	0.033917	0.498934	0.000165	0.68815
390	40.348598		0.6867	0.34904	328.488999	0.108918	0	0.005714	0.067672	0.000022	0.514637
391	40.355539		0.650304	0.358414	302.695224	0.100366	0	0.017127	0.257298	0.000085	0.575777
392	40.404026		0.724428	0.40418	377.047736	0.125019	0	0.00441	0.032984	0.000011	0.584078
393	40.463158		0.778788	0.462968	464.688796	0.154078	0	0	0	0	0.517247
394	40.557439		0.933288	0.557328	478.717036	0.15873	0	0	0	0	0.513287
395	40.742813		1.02992	0.74272	605.429778	0.200744	0	0	0	0	0.445538
396	40.798618		1.233324	0.798501	733.922822	0.243349	0	0	0	0	0.418619
397	40.879629		1.186164	0.87953	857.33584	0.284269	0	0	0	0	0.275796
398	40.856964		1.139988	0.856866	629.287579	0.208655	0	0	0	0	0.273798
399	40.682593		0.98268	0.682501	531.128523	0.176108	0	0	0	0	0.260913
400	40.530375		0.800712	0.530285	482.291105	0.159915	0	0	0	0	0.350864
401	40.412182		0.729048	0.412047	335.937224	0.111388	0	0	0	0	0.443813
402	40.578298		0.9477	0.578083	547.578628	0.181562	0	0	0	0	0.671802
403	40.654949		1.013184	0.654693	552.051102	0.183045	0	0	0	0	0.966883
404	40.678323		1.092384	0.678262	622.25009	0.206321	0	0.004712	0.029607	0.00001	1.486001

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405	40.739374		1.125072	0.739008	695.91656	0.230747	0	0	0	0	1.417794
406	40.792884		1.118436	0.792578	813.479163	0.269728	0	0	0	0	1.369155
407	40.911913		1.223494	0.911658	833.531136	0.276376	0	0	0	0	1.158357
408	40.93155		1.2702	0.931261	888.716647	0.294674	0	0	0	0	1.240739
409	40.913746		1.279824	0.913495	726.653895	0.240939	0	0	0	0	0.990497
410	40.664478		0.919968	0.664378	584.292502	0.193735	0	0	0	0	0.578631
411	40.691849		0.99096	0.691752	647.401427	0.214661	0	0	0	0	0.369228
412	40.482777		0.778332	0.482674	467.18573	0.154906	0	0	0	0	0.437608
413	40.465098		0.777924	0.464988	362.143397	0.120077	0	0	0	0	0.330411
414	40.405059		0.699288	0.405062	409.982458	0.135939	0	0.001593	0.000904	0	0.397255
415	40.422604		0.694344	0.422486	406.682453	0.134845	0	0	0	0	0.379751
416	40.430342		0.732048	0.430233	411.321295	0.136383	0	0	0	0	0.297576
417	40.435257		0.712164	0.435159	323.616985	0.107303	0	0	0	0	0.212772
418	40.347605		0.646452	0.350727	340.206709	0.112803	0	0.036829	0.413309	0.000137	0.992983
419	40.268598		0.553836	0.273838	261.933404	0.08685	0.011988	0.037424	0.906328	0.000301	0.835322
420	40.287292		0.560016	0.28965	265.670141	0.088089	0	0.021082	0.281627	0.000093	0.778591
421	40.32977		0.64176	0.331658	329.685139	0.109315	0	0.026858	0.310492	0.000103	0.928469
422	40.361383		0.696528	0.363718	335.245688	0.111158	0	0.020051	0.19206	0.000064	1.003005
423	40.449706		0.745704	0.44987	466.281638	0.154606	0	0.008161	0.022834	0.000008	1.047944
424	40.477572		0.73218	0.477442	462.704236	0.15342	0	0	0	0	1.016733
425	40.520212		0.801516	0.520096	427.497729	0.141747	0	0	0	0	0.855374
426	40.701068		1.139382	0.70083	686.990716	0.227787	0	0	0	0	0.800458
427	40.83124		1.243608	0.830969	770.644398	0.255525	0	0	0	0	1.065983
428	40.963116		1.336344	0.962836	921.969962	0.3057	0	0	0	0	0.959319
429	40.919964		1.237416	0.919682	787.010036	0.260951	0	0	0	0	1.118428
430	40.833402		1.199016	0.833078	790.487895	0.262104	0	0	0	0	1.08444
431	40.849885		1.215636	0.849584	799.880142	0.265218	0	0	0	0	1.015756
432	40.858068		1.203912	0.857802	774.963277	0.256957	0	0	0	0	1.022721
433	40.796261		1.116624	0.796062	786.263853	0.260704	0	0	0	0	0.925078
434	40.658055		1.024284	0.657865	634.478396	0.210376	0	0	0	0	0.38495
435	40.711844		1.038192	0.711645	691.624151	0.229324	0	0	0	0	0.357461
436	40.76889		1.063272	0.76869	566.422647	0.18781	0	0	0	0	0.811291
437	40.978233		1.337556	0.978072	873.993294	0.289792	0	0	0	0	1.139715
438	40.902952		1.287696	0.902818	896.670212	0.297311	0	0	0	0	0.715701
439	40.824296		1.102596	0.824148	746.314081	0.247457	0	0	0	0	0.667209
440	40.783707		1.10694	0.783522	596.566651	0.197805	0	0	0	0	0.598426
441	40.683744		1.09614	0.683601	615.923348	0.204223	0	0	0	0	0.773852
442	40.723808		1.070976	0.723617	683.301096	0.226564	0	0	0	0	0.521961
443	40.720586		1.030524	0.720452	706.471705	0.234247	0	0	0	0	0.226979
444	40.717254		1.035288	0.71709	558.256662	0.185103	0	0	0	0	0.420747
445	40.742351		1.100076	0.742204	731.09662	0.242412	0	0	0	0	0.244738
446	40.811929		1.202316	0.81175	724.284149	0.240153	0	0	0	0	0.159628
447	40.722182		1.02738	0.72198	612.549193	0.203105	0	0	0	0	0.30536
448	40.674943		1.040868	0.674728	611.886728	0.202885	0	0	0	0	0.782577
449	40.671794		1.019532	0.671579	625.519305	0.207405	0	0	0	0	1.305037
450	40.547742		0.867684	0.547447	489.003298	0.16214	0	0	0	0	1.279559
451	40.581285		0.94398	0.580893	472.581835	0.156695	0	0	0	0	2.155086
452	40.424941		1.01466	0.435509	418.502309	0.138764	0	0.029394	0.715204	0.000237	1.890538
453	40.378551		0.830964	0.390229	336.697875	0.11164	0	0.042893	1.354679	0.000449	1.582618
454	40.658786		1.00062	0.658506	568.520461	0.188506	0	0	0	0	1.501017

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455	40.652786		0.973992	0.65251	548.389599	0.181831	0	0	0	0	1.387823
456	40.593631		0.923988	0.593408	549.419292	0.182172	0	0	0	0	1.393667
457	40.565613		0.884544	0.565411	508.155324	0.16849	0	0	0	0	1.681
458	40.604328		0.933216	0.604135	513.423322	0.170237	0	0	0	0	0.855995
459	40.576852		0.867792	0.576695	438.731015	0.145471	0	0.000297	0.000519	0	1.069302
460	40.565777		0.889644	0.565592	532.562238	0.176583	0	0	0	0	0.994675
461	40.572452		0.928572	0.572296	462.066917	0.153209	0	0	0	0	0.862916
462	40.52947		0.879228	0.529279	460.973972	0.152846	0	0	0	0	1.364555
463	40.75787		1.067436	0.757658	646.664956	0.214417	0	0	0	0	1.887713
464	40.701781		1.01928	0.701631	630.562413	0.209077	0	0	0	0	1.386802
465	40.69247		0.97974	0.692302	613.75359	0.203504	0	0	0	0	1.399857
466	40.622623		0.967224	0.62249	565.385339	0.187466	0	0	0	0	0.718495
467	40.706509		1.044876	0.706302	644.168501	0.213589	0	0	0	0	1.28811
468	40.761443		1.167504	0.761227	708.851354	0.235036	0	0	0	0	1.238064
469	40.95252		1.250268	0.952306	848.868761	0.281462	0	0	0	0	0.867521
470	40.939321		1.29612	0.939049	772.57335	0.256164	0	0	0	0	0.920451
471	40.729786		1.152864	0.729528	698.517152	0.231609	0	0	0	0	0.848276
472	40.518789		0.869952	0.518539	464.812873	0.154119	0	0	0	0	1.058367
473	40.461252		0.736368	0.461069	439.223246	0.145634	0	0	0	0	0.686031
474	40.5279		0.877827	0.527706	444.124794	0.14726	0	0	0	0	0.783039
475	40.58385		0.975036	0.583676	523.382653	0.173539	0	0	0	0	0.7084
476	40.577658		0.886164	0.577448	444.324877	0.147326	0	0	0	0	0.463353
477	40.612692		0.923856	0.612506	525.239637	0.174155	0	0	0	0	0.353455
478	40.593307		0.942036	0.593112	528.619215	0.175276	0	0	0	0	0.357392
479	40.563641		0.86466	0.563451	526.543436	0.174587	0	0	0	0	0.467784
480	40.659792		0.97614	0.659586	490.785657	0.162731	0	0	0	0	0.592086
481	40.661272		1.006836	0.661074	619.011262	0.205247	0	0	0	0	0.670809
482	40.491088		0.93486	0.491229	445.128734	0.147593	0	0.001745	0.007897	0.000003	1.073508
483	40.525491		0.913656	0.526597	409.849771	0.135895	0	0.012053	0.103074	0.000034	0.712888
484	40.597565		0.865776	0.597326	506.452342	0.167926	0	0	0	0	0.597767
485	40.618616		0.990876	0.618383	516.985775	0.171418	0	0	0	0	0.330133
486	40.70081		1.079856	0.700566	639.629048	0.212084	0	0	0	0	0.486746
487	40.734281		1.111764	0.734011	660.441119	0.218984	0	0	0	0	0.269049
488	40.741749		1.093044	0.741441	537.643314	0.178268	0	0	0	0	0.696085
489	40.661698		0.99	0.6614	590.044795	0.195643	0	0	0	0	1.235786
490	40.751726		1.155576	0.75146	678.041086	0.22482	0	0	0	0	0.815939
491	40.769355		1.093284	0.769099	692.154348	0.2295	0	0	0	0	0.605823
492	40.674768		1.022064	0.674511	503.754607	0.167031	0	0	0	0	0.683569
493	40.703192		1.083336	0.702956	632.338097	0.209666	0	0	0	0	0.87065
494	40.75431		1.074552	0.754122	604.592572	0.200466	0	0	0	0	0.631691
495	40.751622		1.011912	0.751428	598.339688	0.198393	0	0	0	0	0.556663
496	40.778798		1.080756	0.778588	678.012007	0.22481	0	0	0	0	0.90771
497	40.700623		1.027047	0.700405	659.939115	0.218818	0	0	0	0	1.117883
498	40.692121		1.139484	0.691888	505.636616	0.167655	0	0	0	0	1.090008
499	40.798982		1.213848	0.798636	670.92989	0.222462	0	0	0	0	1.046569
500	40.855577		1.159692	0.855396	646.193271	0.21426	0	0	0	0	0.78773
501	40.920539		1.252344	0.920302	823.466164	0.273039	0	0	0	0	0.889983
502	40.889831		1.213884	0.889637	816.962009	0.270882	0	0	0	0	1.045409
503	40.837992		1.156164	0.837816	618.394353	0.205043	0	0	0	0	0.789025
504	40.726384		1.049064	0.726163	654.991796	0.217177	0	0	0	0	1.095788

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505	40.688635		1.01034	0.688373	590.665315	0.195849	0	0	0	0	1.234827
506	40.68084		1.076928	0.680534	591.732796	0.196202	0	0	0	0	1.590536
507	40.73679		1.053396	0.736546	604.727658	0.200511	0	0	0	0	1.399829
508	40.793668		1.133136	0.793388	713.493643	0.236575	0	0	0	0	1.001918
509	40.670255		0.99213	0.669986	583.566039	0.193495	0	0	0	0	0.651751
510	40.380415		0.718608	0.388121	317.369818	0.105231	0.021648	0.031483	0.542119	0.00018	0.652364
511	40.364566		0.653784	0.370971	280.879515	0.093132	0	0.029643	0.577762	0.000192	0.491707
512	40.35866		0.740484	0.367766	324.424355	0.10757	0.000216	0.041274	1.137746	0.000377	0.520499
513	40.44342		0.75528	0.447341	403.494503	0.133788	0	0.016084	0.234973	0.000078	0.717666
514	40.574997		0.976824	0.574785	360.341188	0.119479	0	0	0	0	0.622006
515	40.872877		1.217148	0.872755	780.546923	0.258808	0	0	0	0	0.66164
516	40.980718		1.238244	0.980624	859.444973	0.284969	0	0	0	0	0.705269
517	40.955166		1.168428	0.95509	791.798579	0.262539	0	0	0	0	0.564304
518	40.983594		1.28556	0.983502	924.695431	0.306604	0	0	0	0	0.208409
519	40.958999		1.27026	0.958901	869.535843	0.288314	0	0	0	0	0.242497
520	40.75993		1.029444	0.759837	702.965731	0.233084	0	0	0	0	0.408735
521	40.726697		1.016616	0.726588	615.141456	0.203964	0	0	0	0	0.627931
522	40.679171		1.093968	0.678999	626.643577	0.207778	0	0	0	0	0.443725
523	40.749184		1.003734	0.749055	661.461455	0.219323	0	0	0	0	0.567847
524	40.701099		0.981324	0.700985	634.345253	0.210332	0	0	0	0	0.723936
525	40.674015		0.898128	0.673926	425.797	0.141183	0	0	0	0	0.740006
526	40.635429		0.910632	0.635317	618.508628	0.205081	0	0	0	0	0.632433
527	40.657713		0.932004	0.657599	564.19976	0.187073	0	0	0	0	0.516633
528	40.731463		0.9867	0.731321	621.439416	0.206052	0	0	0	0	0.412092
529	40.671019		0.986292	0.67091	564.51952	0.187179	0	0	0	0	0.292502
530	40.673241		1.058844	0.673073	537.96731	0.178375	0	0	0	0	0.800221
531	40.822262		1.140588	0.822041	687.988594	0.228118	0	0	0	0	0.667634
532	40.759663		1.0167	0.759554	693.416068	0.229918	0	0	0	0	0.271654
533	40.737661		1.058064	0.737497	615.287558	0.204013	0	0	0	0	0.448063
534	40.776391		1.142556	0.776203	696.775035	0.231032	0	0	0	0	0.451202
535	40.785939		1.184808	0.785769	688.876917	0.228413	0	0	0	0	0.617221
536	40.69164		0.970464	0.691509	492.012321	0.163138	0	0	0	0	0.67538
537	40.632111		0.941664	0.631971	559.544032	0.18553	0	0	0	0	0.514008
538	40.601669		0.9012	0.601521	565.708821	0.187574	0	0	0	0	0.391368
539	40.507294		0.818016	0.508428	389.400053	0.129114	0	0.01273	0.095709	0.000032	0.893297
540	40.38149		0.64434	0.384552	316.480787	0.104936	0	0.011165	0.118483	0.000039	0.923038
541	40.356223		0.650571	0.357532	298.227364	0.098884	0	0.009399	0.069564	0.000023	0.26859
542	40.473027		0.84384	0.472874	413.38625	0.137068	0	0	0	0	0.659864
543	40.476924		0.777804	0.476768	445.140696	0.147597	0	0	0	0	0.741493
544	40.478304		0.804516	0.47816	406.944479	0.134932	0	0	0	0	0.601542
545	40.333696		0.676404	0.334146	294.714189	0.097719	0	0.00601	0.05252	0.000017	0.357651
546	40.383152		0.740124	0.383027	374.286005	0.124103	0	0	0	0	0.388801
547	40.623893		0.973824	0.623686	515.289319	0.170856	0	0	0	0	0.887288
548	40.696524		1.001364	0.696322	554.435003	0.183836	0	0	0	0	1.22076
549	40.704466		1.029144	0.704231	628.958077	0.208545	0	0	0	0	1.064987
550	40.661359		0.904956	0.661173	581.785895	0.192904	0	0	0	0	0.879122
551	40.6059		0.854436	0.605736	528.751821	0.17532	0	0	0	0	0.803655
552	40.412417		0.833544	0.414831	369.784724	0.122611	0	0.021366	0.334759	0.000111	0.693934
553	40.322565		0.610872	0.324728	299.14437	0.099188	0	0.018004	0.139933	0.000046	0.57206
554	40.318668		0.654708	0.318754	277.029254	0.091855	0	0.01439	0.031124	0.00001	0.283784

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555	40.373172		0.665948	0.377604	326.243381	0.108173	0	0.028471	1.675449	0.000556	0.744198
556	40.391749		0.667284	0.392584	365.327122	0.121133	0	0.018968	0.134632	0.000045	0.749294
557	40.344699		0.608592	0.345427	323.132446	0.107142	0	0.015306	0.085606	0.000028	0.675329
558	40.353034		0.584748	0.352942	295.757677	0.098065	0	0	0	0	0.38378
559	40.332572		0.603672	0.334822	319.721465	0.106011	0	0.035156	0.503516	0.000167	0.40444
560	40.264825		0.553248	0.271868	276.697026	0.091745	0.07938	0.083225	1.772785	0.000588	0.358958
561	40.248991		0.524088	0.257227	235.408453	0.078055	0.11376	0.111586	2.405082	0.000797	0.418028
562	40.211867		0.518976	0.222658	222.618225	0.073814	0.099132	0.070571	2.832725	0.000939	0.512198
563	40.428083		0.92094	0.427975	508.480438	0.168598	0	0.001199	0.001333	0	0.636839
564	40.649364		1.165176	0.64908	779.33823	0.258407	0	0	0	0	1.092805
565	40.776536		1.262076	0.776258	777.940864	0.257944	0	0	0	0	1.12929
566	40.770291		1.266864	0.769949	946.802627	0.313934	0	0	0	0	1.383732
567	40.774516		1.2282	0.774088	1061.30128	0.351899	0	0	0	0	1.761066
568	40.761874		1.200792	0.761443	936.153578	0.310403	0	0	0	0	1.816975
569	40.733674		1.377904	0.733098	977.681835	0.324173	0	0	0	0	2.121043
570	40.872973		1.458918	0.872366	1153.565096	0.382491	0	0	0	0	2.210604
571	40.783482		1.22628	0.783086	1006.560631	0.333748	0	0	0	0	1.926614
572	40.524063		1.059204	0.524025	618.15672	0.204964	0	0.000833	0.003466	0.000001	1.715825
573	40.371264		0.807612	0.371775	476.656928	0.158046	0	0.008899	0.06021	0.00002	1.497973
574	40.502427		0.94116	0.502138	599.494721	0.198776	0	0	0	0	1.366722
575	40.492746		0.924408	0.492498	642.643225	0.213083	0	0	0	0	1.249313
576	40.452428		0.931386	0.452203	549.534332	0.182211	0	0	0	0	1.179632
577	40.478961		0.926076	0.478749	580.261886	0.192399	0	0	0	0	1.066134
578	40.447824		0.798396	0.447627	378.928497	0.125642	0	0	0	0	0.909846
579	40.807595		1.246644	0.807465	951.020019	0.315332	0	0	0	0	0.414986
580	40.843972		1.16274	0.843856	860.954377	0.285469	0	0	0	0	0.211059
581	40.778693		1.061532	0.778594	813.878539	0.26986	0	0	0	0	0.160231
582	40.657007		1.016376	0.656916	725.321757	0.240497	0	0	0	0	0.374322
583	40.503727		0.78468	0.503633	584.868786	0.193927	0	0	0	0	0.431413
584	40.514162		0.811308	0.514064	540.848901	0.179331	0	0	0	0	0.5464
585	40.505234		0.888432	0.505094	552.591948	0.183224	0	0	0	0	0.805794
586	40.506333		0.940128	0.506152	630.243658	0.208972	0	0	0	0	1.129998
587	40.734529		1.2435	0.734291	899.190701	0.298147	0	0	0	0	1.141516
588	40.740845		0.991812	0.740717	778.250083	0.258047	0	0	0	0	0.798991
589	40.698325		1.000632	0.698147	802.658935	0.26614	0	0	0	0	1.114842
590	40.88189		1.19358	0.881709	1112.745692	0.368956	0	0	0	0	1.108777
591	40.903761		1.203084	0.903477	1044.122294	0.346203	0	0	0	0	1.539903
592	40.775438		1.192284	0.775188	990.875461	0.328547	0	0	0	0	1.358767
593	40.697578		1.083684	0.697254	1020.842217	0.338484	0	0	0	0	1.787901
594	40.733118		1.10676	0.732714	965.869614	0.320256	0	0	0	0	2.1288
595	40.646105		1.0191	0.645792	839.023987	0.278198	0	0	0	0	1.843826
596	40.762423		1.169088	0.76197	1168.131161	0.387321	0	0	0	0	1.837543
597	40.817022		1.272714	0.816569	1169.873574	0.387898	0	0	0	0	1.781898
598	40.790712		1.231356	0.790173	1103.995268	0.366055	0	0	0	0	2.016228
599	40.705022		1.14288	0.704472	840.036678	0.278533	0	0	0	0	2.086249
600	40.663967		1.059768	0.663402	929.975085	0.308354	0	0	0	0	2.055073
601	40.548024		1.019556	0.550419	704.650922	0.233643	0	0.025569	0.396642	0.000132	2.152374
602	40.531334		1.002252	0.53725	645.343169	0.213978	0.059748	0.092503	1.367572	0.000453	2.110071
603	40.607229		1.056048	0.610848	764.418458	0.25346	0	0.035323	0.72388	0.00024	1.789458
604	40.600587		1.015812	0.602368	842.547722	0.279366	0	0.026244	0.25652	0.000085	1.391892

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605	40.530691		0.938016	0.534536	701.194989	0.232497	0	0.047225	0.595856	0.000198	1.455764
606	40.56523		0.99774	0.565794	735.819632	0.243978	0	0.011006	0.064146	0.000021	1.538606
607	40.539119		0.95442	0.539484	673.116275	0.223187	0	0.009944	0.066508	0.000022	1.568875
608	40.488275		0.949524	0.488867	649.895038	0.215488	0	0.011131	0.06859	0.000023	1.809652
609	40.491142		0.917904	0.492936	569.750957	0.188914	0	0.035586	0.30353	0.000101	1.854764
610	40.649309		1.08672	0.64915	770.9076	0.255612	0	0.002755	0.005518	0.000002	1.826401
611	40.725896		1.308036	0.725543	980.101592	0.324975	0	0	0	0	1.496243
612	40.611547		1.11876	0.611255	698.946138	0.231752	0	0.000604	0.002078	0.000001	1.507834
613	40.438752		0.837276	0.440436	542.010078	0.179716	0	0.02365	0.215657	0.000072	1.52231
614	40.43096		0.895668	0.433954	559.232136	0.185426	0	0.031248	0.355967	0.000118	1.4695
615	40.590876		1.110312	0.591114	813.71102	0.269804	0	0.006998	0.038084	0.000013	1.706964
616	40.636451		1.070196	0.636163	849.669932	0.281727	0	0.001584	0.004675	0.000002	2.019879
617	40.656305		1.067844	0.65581	736.305733	0.244139	0	0	0	0	1.937803
618	40.597568		1.061316	0.597138	832.170404	0.275925	0	0.000863	0.005436	0.000002	2.139477
619	40.484843		1.040826	0.486636	638.935675	0.211854	0	0.010204	0.631784	0.000209	1.481327
620	40.266616		0.73488	0.288176	310.215492	0.102859	0.08904	0.05271	4.744004	0.001573	1.856115
621	40.204277		0.719748	0.248436	278.794954	0.092441	0.220056	0.067929	13.270002	0.0044	1.817884
622	40.231822		0.738588	0.270065	314.620483	0.10432	0.146712	0.064719	9.345906	0.003099	1.801301
623	40.245883		0.751488	0.27958	301.542507	0.099983	0.13452	0.05718	8.236017	0.002731	1.727524
624	40.214458		0.639816	0.253666	279.078181	0.092535	0.22128	0.068942	10.666189	0.003537	1.589828
625	40.297405		0.84774	0.313208	302.540158	0.100314	0.077772	0.077584	5.193465	0.001722	1.600045
626	40.368374		0.90588	0.371506	486.302986	0.161245	0	0.033933	0.515244	0.000171	1.268386
627	40.421356		0.861336	0.421124	491.41053	0.162938	0	0	0	0	1.0099
628	40.500945		0.980268	0.500717	673.302162	0.223249	0	0	0	0	0.948562
629	40.461008		0.914832	0.460885	546.359853	0.181158	0	0.003846	0.016275	0.000005	0.925736
630	40.368212		0.770592	0.369298	422.322681	0.140031	0	0.013342	0.104903	0.000035	0.787092
631	40.34454		0.76458	0.346709	304.843286	0.101078	0	0.014422	0.128816	0.000043	0.824799
632	40.386929		0.907338	0.390734	433.171118	0.143628	0	0.036088	0.546193	0.000181	0.855437
633	40.495266		0.944988	0.495181	542.298508	0.179811	0	0.001587	0.000681	0	0.855805
634	40.5219		0.9129	0.523447	590.971254	0.19595	0	0.026664	0.119006	0.000039	1.305844
635	40.610338		0.963228	0.610111	533.524287	0.176902	0	0	0	0	1.027432
636	40.710532		1.079004	0.710284	703.141658	0.233143	0	0	0	0	0.893811
637	40.63032		1.059276	0.63004	590.581538	0.195821	0	0	0	0	0.993044
638	40.59413		0.936852	0.593914	498.81612	0.165394	0	0	0	0	0.92727
639	40.754695		1.227456	0.754374	640.01949	0.212213	0	0	0	0	1.024696
640	40.766609		1.17018	0.766278	692.235347	0.229526	0	0	0	0	0.836935
641	40.606193		1.053396	0.606465	534.069187	0.177083	0	0.006261	0.030647	0.00001	0.995191
642	40.418527		0.84072	0.433488	361.706987	0.119932	0.059268	0.053064	1.562811	0.000518	1.11599
643	40.550753		1.054134	0.55063	462.607346	0.153388	0	0.000105	0.000365	0	0.851748
644	40.824407		1.341708	0.824245	736.354622	0.244155	0	0	0	0	1.061845
645	41.047628		1.385772	1.047458	811.106463	0.268941	0	0	0	0	1.46085
646	41.090676		1.458936	1.090512	959.826361	0.318252	0	0	0	0	1.611678
647	40.990602		1.318782	0.990453	954.074542	0.316345	0	0	0	0	1.287049
648	40.970894		1.274868	0.970749	859.455454	0.284972	0	0	0	0	1.258433
649	40.933406		1.240848	0.933262	777.679263	0.257857	0	0	0	0	1.220461
650	40.969795		1.279596	0.969668	829.484965	0.275035	0	0	0	0	0.924701
651	40.832757		1.2507	0.832554	758.173153	0.25139	0	0	0	0	0.90838
652	40.67233		0.986928	0.672177	568.102168	0.188367	0	0	0	0	0.446859
653	40.639262		0.915372	0.639132	463.805872	0.153785	0	0	0	0	0.416244
654	40.709801		1.023708	0.709696	677.25146	0.224558	0	0	0	0	0.167239

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655	40.603667		0.944088	0.603558	528.192674	0.175134	0	0	0	0	0.199056
656	40.633932		0.886608	0.633835	505.416311	0.167582	0	0	0	0	0.165796
657	40.570904		0.851004	0.570797	481.098379	0.159519	0	0	0	0	0.141822
658	40.697091		0.97308	0.696973	610.156987	0.202311	0	0	0	0	0.224755
659	40.708284		0.994716	0.70817	562.550712	0.186527	0	0	0	0	0.231353
660	40.666296		1.008312	0.666154	565.483066	0.187499	0	0	0	0	0.690765
661	40.55726		0.818088	0.557119	497.274935	0.164883	0	0	0	0	0.56492
662	40.444019		0.773064	0.443956	392.247205	0.130059	0	0.000628	0.001905	0.000001	0.5105
663	40.367688		0.647244	0.369269	279.782701	0.092768	0	0.012096	0.064924	0.000022	0.367785
664	40.565818		0.880548	0.565668	493.861692	0.163751	0	0	0	0	0.330021
665	40.557805		0.890496	0.557637	486.279438	0.161237	0	0	0	0	0.3503
666	40.433459		0.77868	0.433409	370.281935	0.122775	0	0.00014	0.000346	0	0.601846
667	40.461846		0.780336	0.461931	379.479746	0.125825	0	0.001875	0.004016	0.000001	0.531083
668	40.47248		0.803556	0.472326	407.997309	0.135281	0	0.000411	0.000822	0	0.423501
669	40.505363		0.839868	0.505188	445.263461	0.147637	0	0	0	0	0.51441
670	40.582474		0.980628	0.58228	499.621251	0.165661	0	0	0	0	0.509704
671	40.762029		1.136628	0.76179	516.858307	0.171376	0	0	0	0	0.257551
672	40.830909		1.18875	0.830699	786.470312	0.260772	0	0	0	0	0.2265
673	40.719702		1.102794	0.719581	571.413584	0.189465	0	0.00028	0.000761	0	0.544343
674	40.688968		1.010316	0.688792	652.949193	0.2165	0	0	0	0	0.29403
675	40.756548		1.0626	0.756418	564.351763	0.187124	0	0	0	0	0.473684
676	40.743086		1.027404	0.742946	713.167584	0.236467	0	0	0	0	1.17358
677	40.704931		1.002132	0.704772	520.527714	0.172593	0	0	0	0	1.100757
678	40.746766		1.073124	0.746604	648.392714	0.214989	0	0	0	0	0.863407
679	40.752126		1.022268	0.751965	677.661965	0.224694	0	0	0	0	0.670961
680	40.699349		0.986412	0.699184	614.768792	0.203841	0	0	0	0	0.734488
681	40.68661		1.016556	0.686426	561.444008	0.18616	0	0	0	0	0.734368
682	40.626334		0.939624	0.626142	513.565344	0.170284	0	0	0	0	0.768055
683	40.596106		0.9242	0.595891	513.638192	0.170308	0	0	0	0	0.858538
684	40.675618		0.982536	0.675422	513.33947	0.170209	0	0	0	0	0.94742
685	40.736576		1.0191	0.736436	621.341046	0.20602	0	0	0	0	1.280624
686	40.720014		1.019472	0.719848	616.750942	0.204498	0	0	0	0	1.214019
687	40.560268		0.84915	0.560106	480.240597	0.159235	0	0	0	0	1.027061
688	40.41813		0.705504	0.41793	255.811766	0.08482	0	0	0	0	1.050208
689	40.449379		0.838068	0.449542	420.568905	0.139449	0	0.003746	0.012581	0.000004	1.062543
690	40.436339		0.794088	0.436402	345.237931	0.114472	0	0.001937	0.018007	0.000006	0.984361
691	40.363094		0.723396	0.375814	296.519744	0.098318	0.012624	0.038369	1.78082	0.00059	0.948673
692	40.48968		0.853548	0.490941	395.921582	0.131277	0	0.009021	0.105539	0.000035	0.563219
693	40.533236		0.837876	0.533013	465.307362	0.154283	0	0	0	0	0.393122
694	40.571358		0.878832	0.571181	492.759264	0.163386	0	0	0	0	0.399007
695	40.530528		0.816744	0.530352	413.095478	0.136971	0	0	0	0	0.79641
696	40.44599		0.781296	0.445843	400.494744	0.132793	0	0.000394	0.000822	0	0.588113
697	40.338092		0.667176	0.33926	299.047219	0.099156	0	0.011889	0.181873	0.00006	0.404819
698	40.318363		0.623064	0.319126	275.85853	0.091467	0	0.004373	0.036272	0.000012	0.317332
699	40.274208		0.593964	0.278623	216.102131	0.071654	0	0.035928	0.788432	0.000261	0.221983
700	40.553947		0.96006	0.553791	471.038796	0.156184	0	0	0	0	0.720879
701	40.673383		1.07166	0.673231	591.825025	0.196233	0	0	0	0	0.781918
702	40.63225		1.038324	0.632028	484.300918	0.160581	0	0	0	0	1.052413
703	40.658615		1.106934	0.65837	537.611507	0.178257	0	0	0	0	1.204475
704	40.731384		1.134984	0.731162	670.914119	0.222457	0	0	0	0	1.250933

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705	40.67089		1.026768	0.670702	566.872511	0.18796	0	0	0	0	1.117236
706	40.494511		0.916068	0.494311	421.318379	0.139698	0	0	0	0	0.84446
707	40.500301		0.881604	0.500067	439.066715	0.145583	0	0	0	0	0.54991
708	40.511218		0.893268	0.51128	455.923938	0.151172	0	0.00146	0.012639	0.000004	0.98192
709	40.471092		0.83364	0.473611	397.597637	0.131833	0	0.010224	0.067837	0.000022	1.395571
710	40.390457		0.773904	0.396772	369.191578	0.122414	0	0.042858	0.480565	0.000159	1.130968
711	40.426331		0.770316	0.427866	368.949117	0.122333	0	0.009086	0.070868	0.000023	1.085135
712	40.405207		0.7407	0.408785	289.397503	0.095956	0	0.019462	0.166398	0.000055	1.017373
713	40.342267		0.731568	0.352298	282.069418	0.093527	0	0.040099	2.174901	0.000721	0.899848
714	40.13288		0.506508	0.173054	132.801978	0.044034	0.238692	0.124104	14.963351	0.004961	0.88407
715	40.152568		0.579888	0.190768	144.549127	0.047929	0.205344	0.131121	13.225486	0.004385	0.800173
716	40.259894		0.62196	0.28746	203.94816	0.067624	0.095292	0.081269	4.757536	0.001577	1.002805
717	40.297051		0.768216	0.346831	254.761922	0.084472	0.177096	0.115731	11.499302	0.003813	1.640072
718	40.400409		0.813366	0.42081	354.898513	0.117675	0	0.048246	2.822819	0.000936	1.365044
719	40.500902		0.850704	0.500736	369.015656	0.122356	0	0.000099	0.000173	0	1.248454
720	40.503113		0.83592	0.502819	376.768939	0.124926	0	0	0	0	0.989846
721	40.495215		0.87042	0.495062	444.149412	0.147268	0	0.000209	0.001847	0.000001	0.694179
722	40.47616		0.836976	0.476374	429.241595	0.142325	0	0.002938	0.008253	0.000003	0.680213
723	40.452538		0.762804	0.452261	349.72326	0.115959	0	0	0	0	0.770034
724	40.416679		0.775884	0.419605	378.473572	0.125492	0	0.01135	0.211904	0.00007	0.583416
725	40.565309		0.945384	0.565152	502.73783	0.166694	0	0	0	0	0.382
726	40.400402		0.834852	0.400964	331.930085	0.110059	0	0.010335	0.036439	0.000012	0.251082
727	40.313122		0.668868	0.313111	249.782436	0.082821	0	0.00049	0.000954	0	0.244698
728	40.308262		0.671124	0.308576	265.584292	0.088061	0	0.008903	0.039645	0.000013	0.23561
729	40.342274		0.628224	0.342701	263.574027	0.087394	0	0.012643	0.073091	0.000024	0.382373
730	40.33326		0.645456	0.33367	269.993335	0.089522	0	0.003722	0.015574	0.000005	0.421548
731	40.379541		0.797788	0.379663	312.917207	0.103755	0	0.003832	0.016281	0.000005	0.455101
732	40.60744		1.113492	0.607239	471.028756	0.15618	0	0	0	0	0.485962
733	40.890576		1.189332	0.890372	772.304298	0.256075	0	0	0	0	1.170768
734	40.924459		1.24974	0.92429	862.073159	0.28584	0	0	0	0	0.853011
735	40.934737		1.262004	0.93455	843.677635	0.279741	0	0	0	0	0.683113
736	40.92344		1.277004	0.923222	735.972734	0.244029	0	0	0	0	0.343392
737	40.883611		1.21896	0.883382	827.413802	0.274348	0	0	0	0	0.226471
738	40.810032		1.14054	0.809858	654.607404	0.21705	0	0	0	0	0.516655
739	40.844365		1.18704	0.844196	750.12174	0.24872	0	0	0	0	0.847368
740	40.89895		1.196424	0.898764	699.391953	0.231899	0	0	0	0	0.955757
741	40.865038		1.194444	0.864885	760.486768	0.252157	0	0	0	0	0.63436
742	40.895268		1.246656	0.895107	764.231	0.253398	0	0	0	0	0.537212
743	40.955605		1.240248	0.955441	924.709103	0.306608	0	0	0	0	0.39327
744	40.924916		1.249176	0.924766	778.700529	0.258196	0	0	0	0	0.329228
745	40.717315		1.06728	0.71715	559.734799	0.185593	0	0	0	0	0.461701
746	40.607908		0.927012	0.607763	532.784599	0.176657	0	0	0	0	0.536276
747	40.611434		1.016868	0.611311	551.942762	0.183009	0	0	0	0	0.456521
748	40.594034		1.0041	0.593888	464.41937	0.153989	0	0	0	0	0.454339
749	40.701304		0.99072	0.70118	606.685033	0.20116	0	0	0	0	0.535207
750	40.697104		0.969252	0.697012	634.001767	0.210218	0	0	0	0	0.36324
751	40.72479		0.987864	0.724671	545.170082	0.180764	0	0	0	0	0.22357
752	40.691984		1.090104	0.691821	633.996909	0.210216	0	0	0	0	0.390946
753	40.565257		0.931788	0.565295	521.938488	0.173061	0	0.000636	0.000899	0	0.545626
754	40.520412		0.939816	0.521438	460.913794	0.152826	0	0.020515	0.128165	0.000042	0.755954

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755	40.567188		1.00224	0.567428	538.296933	0.178485	0	0.00446	0.016788	0.000006	0.709114
756	40.619441		1.014528	0.619249	624.439788	0.207047	0	0	0	0	0.607246
757	40.73242		1.125636	0.732199	789.967927	0.261932	0	0	0	0	1.140309
758	40.792932		1.187724	0.792666	887.76361	0.294358	0	0	0	0	1.325708
759	40.923758		1.473312	0.923377	1103.811795	0.365994	0	0	0	0	1.609634
760	41.128688		1.713588	1.128069	1404.719685	0.465767	0	0	0	0	2.406463
761	41.148233		1.764624	1.147502	1306.884519	0.433327	0	0	0	0	2.782957
762	41.051896		1.473168	1.051252	1356.899236	0.449911	0	0	0	0	2.625283
763	41.040235		1.535172	1.03962	1446.108386	0.47949	0	0	0	0	2.632255
764	40.996292		1.438632	0.995784	1372.138917	0.454964	0	0	0	0	2.18546
765	40.509847		0.896028	0.51024	717.529098	0.237913	0	0.00533	0.025201	0.000008	1.681962
766	40.419109		0.845124	0.428449	551.067804	0.182719	0.03714	0.058532	1.37518	0.000456	2.069571
767	40.29246		0.745704	0.309721	391.824028	0.129918	0.076464	0.06255	4.64843	0.001541	1.709468
768	40.109566		0.4614	0.169155	157.18074	0.052117	0.169524	0.065733	19.704296	0.006533	1.213193
769	40.10965		0.444732	0.156684	130.689377	0.043333	0.22224	0.064243	14.57113	0.004831	1.044866
770	40.191851		0.710244	0.215955	261.033012	0.086551	0	0.041011	6.711975	0.002226	1.115141
771	40.351104		0.726492	0.350995	418.703046	0.138831	0	0.000019	0	0	1.101774
772	40.346158		0.750264	0.346134	462.390933	0.153316	0	0.004194	0.015415	0.000005	0.952822
773	40.302758		0.864324	0.306523	426.107206	0.141286	0	0.017367	0.563875	0.000187	0.935248
774	40.166272		0.676116	0.188587	213.096599	0.070657	0.088062	0.048628	5.524507	0.001832	1.477878
775	40.185372		0.57672	0.197314	186.546348	0.061854	0.055452	0.035426	1.735265	0.000575	1.054014
776	40.273179		0.692184	0.274295	352.211827	0.116784	0	0.013215	0.183994	0.000061	0.871576
777	40.287052		0.693552	0.28691	361.796148	0.119962	0	0	0	0	0.753565
778	40.285162		0.68088	0.285294	357.823103	0.118644	0	0.002475	0.022656	0.000008	0.855646
779	40.234154		0.595908	0.234418	252.579636	0.083749	0	0.004078	0.045903	0.000015	0.542699
780	40.289666		0.710424	0.290756	372.97549	0.123669	0	0.008558	0.432988	0.000144	0.770112
781	40.385025		0.804192	0.384848	488.469981	0.161963	0	0	0	0	0.916309
782	40.408061		0.715152	0.407916	446.367564	0.148003	0	0	0	0	0.81631
783	40.409887		0.815964	0.409752	518.250855	0.171838	0	0	0	0	0.764571
784	40.468378		0.828084	0.468219	594.436815	0.197099	0	0	0	0	0.99805
785	40.63268		0.957	0.632509	810.944351	0.268887	0	0	0	0	1.114038
786	40.677387		1.077432	0.677193	620.926024	0.205882	0	0	0	0	1.157958
787	40.611503		0.939072	0.611318	803.44807	0.266402	0	0	0	0	1.085679
788	40.646883		0.993432	0.646699	851.431602	0.282312	0	0	0	0	1.102381
789	40.727142		1.152948	0.726846	863.440158	0.286293	0	0	0	0	1.193223
790	40.783487		1.196268	0.783108	1016.047486	0.336894	0	0	0	0	1.504795
791	40.885559		1.278384	0.885192	1147.063679	0.380335	0	0	0	0	1.499824
792	40.879341		1.262328	0.879047	1128.762195	0.374267	0	0	0	0	1.231608
793	40.794714		1.299852	0.794445	702.344382	0.232878	0	0	0	0	1.050914
794	40.643924		1.11228	0.64367	816.185937	0.270625	0	0	0	0	1.034628
795	40.644046		1.111668	0.643714	887.764692	0.294359	0	0	0	0	1.392222
796	40.709974		1.10736	0.709598	834.304428	0.276633	0	0	0	0	1.587693
797	40.773974		1.241532	0.773719	922.07702	0.305736	0	0	0	0	1.390889
798	41.074094		1.515072	1.073727	1467.729949	0.486659	0	0	0	0	2.016364
799	41.133147		1.50462	1.132783	1390.928768	0.461194	0	0	0	0	2.197166
800	41.158195		1.536696	1.157832	1535.894853	0.509261	0	0	0	0	2.134154
801	41.133664		1.56462	1.133289	1527.055114	0.50633	0	0	0	0	2.112042
802	41.074179		1.566876	1.073807	1350.496239	0.447788	0	0	0	0	1.931709
803	40.961124		1.33308	0.960768	1187.620243	0.393783	0	0	0	0	2.016108
804	40.710186		1.107396	0.7099	950.948895	0.315309	0	0	0	0	1.773284

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805	40.469207		0.944832	0.470913	587.060714	0.194653	0	0.009048	0.14927	0.000049	1.675949
806	40.503425		0.933024	0.503978	638.279834	0.211636	0	0.005623	0.032408	0.000011	1.871664
807	40.518643		0.94164	0.519147	613.83293	0.20353	0	0.005829	0.068166	0.000023	1.927514
808	40.431513		0.9252	0.436108	528.145722	0.175119	0	0.035004	1.07726	0.000357	1.92885
809	40.371223		0.744888	0.378216	467.334534	0.154955	0.051384	0.043121	0.881484	0.000292	1.797675
810	40.332291		0.754668	0.343413	400.797506	0.132894	0.052344	0.060321	1.611872	0.000534	1.648842
811	40.342757		0.69516	0.352987	444.447439	0.147367	0.039	0.06083	2.170849	0.00072	1.605119
812	40.319055		0.642564	0.330933	329.850981	0.10937	0.073356	0.06618	1.992731	0.000661	1.476213
813	40.378235		0.810708	0.378371	477.556975	0.158345	0	0.009006	0.014447	0.000005	0.709251
814	40.23389		0.660576	0.243697	298.146667	0.098857	0	0.029354	1.568738	0.00052	1.253204
815	40.283074		0.737724	0.288197	331.844183	0.110031	0	0.030295	0.763309	0.000253	1.438688
816	40.319251		0.849786	0.319977	325.281302	0.107854	0	0.007637	0.038432	0.000013	1.225431
817	40.432839		0.956892	0.432504	539.197741	0.178783	0	0	0	0	1.35712
818	40.411347		0.832008	0.411093	533.813716	0.176998	0	0	0	0	1.172604
819	40.342965		0.793092	0.342729	358.478067	0.118862	0	0	0	0	1.157717
820	40.317075		0.734496	0.31749	384.155532	0.127376	0	0.009245	0.053332	0.000018	1.212751
821	40.323123		0.72102	0.324338	330.190882	0.109482	0	0.014499	0.138951	0.000046	0.934024
822	40.329936		0.682212	0.332396	442.723727	0.146795	0	0.022342	0.262012	0.000087	1.408113
823	40.372478		0.77628	0.373295	443.297527	0.146985	0	0.00682	0.096639	0.000032	1.471192
824	40.392534		0.802644	0.392811	498.882238	0.165416	0	0.004101	0.021535	0.000007	1.390769
825	40.455558		0.789732	0.455313	405.817093	0.134558	0	0	0	0	1.322037
826	40.456529		0.795288	0.456396	595.237827	0.197365	0	0.000484	0.001299	0	1.253205
827	40.425397		0.816252	0.425195	517.711467	0.171659	0	0	0	0	1.232181
828	40.356329		0.724332	0.356763	400.503239	0.132796	0	0.00705	0.038864	0.000013	1.068194
829	40.470369		0.833676	0.470239	601.575076	0.199466	0	0	0	0	0.917619
830	40.486585		0.838848	0.486435	565.179096	0.187398	0	0	0	0	1.645431
831	40.476353		0.855516	0.476177	519.232735	0.172163	0	0	0	0	1.974129
832	40.66625		1.043028	0.666026	728.41865	0.241524	0	0	0	0	1.985807
833	40.622991		1.045896	0.622813	648.927088	0.215167	0	0	0	0	1.398659
834	40.463384		1.012128	0.467702	443.233394	0.146964	0	0.018174	0.637096	0.000211	1.217846
835	40.352352		0.760944	0.357958	361.722533	0.119937	0	0.024652	0.504931	0.000167	1.28189
836	40.395711		0.838992	0.397315	410.996003	0.136275	0	0.012305	0.133882	0.000044	1.437205
837	40.608178		1.037586	0.607865	606.527893	0.201108	0	0	0	0	1.319559
838	40.712118		1.224492	0.711693	653.607477	0.216718	0	0	0	0	1.967207
839	40.704723		1.234512	0.70434	534.983951	0.177386	0	0	0	0	2.09488
840	40.633237		1.338504	0.632864	561.406236	0.186147	0	0	0	0	2.036461
841	40.735902		1.27176	0.735576	626.786747	0.207825	0	0	0	0	1.951358
842	40.62055		1.089156	0.62023	519.818512	0.172358	0	0	0	0	1.919286
843	40.651854		1.085172	0.651574	477.382864	0.158287	0	0	0	0	1.773027
844	40.698873		1.108356	0.698566	623.689055	0.206798	0	0	0	0	2.218743
845	40.69742		1.06368	0.697094	641.15269	0.212589	0	0	0	0	1.727769
846	40.651915		1.015848	0.651468	526.852794	0.17469	0	0	0	0	1.80201
847	40.55808		0.933988	0.558226	495.180185	0.164188	0	0.002089	0.005316	0.000002	1.470026
848	40.560609		0.987696	0.560757	465.989207	0.154509	0	0.003206	0.021659	0.000007	1.350269
849	40.539142		0.995688	0.538826	475.670428	0.157719	0	0	0	0	1.353301
850	40.688107		1.208004	0.687849	591.146492	0.196008	0	0	0	0	1.13299
851	40.759688		1.341264	0.759417	688.764368	0.228376	0	0	0	0	1.025409
852	40.85086		1.406808	0.850562	748.440933	0.248163	0	0	0	0	1.130227
853	40.814636		1.341	0.81429	623.737081	0.206814	0	0	0	0	1.193884
854	40.852524		1.3356	0.852199	806.799577	0.267513	0	0	0	0	0.684761

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855	40.865682		1.31868	0.865334	719.92958	0.238709	0	0	0	0	0.928045
856	40.854566		1.291272	0.85421	694.167773	0.230167	0	0	0	0	1.177087
857	40.892376		1.358376	0.891978	848.967439	0.281495	0	0	0	0	1.344864
858	40.811229		1.254672	0.810861	612.703113	0.203156	0	0	0	0	1.04805
859	40.777722		1.235472	0.77736	733.443078	0.24319	0	0	0	0	1.172562
860	40.802658		1.328376	0.802287	624.591349	0.207098	0	0	0	0	1.10906
861	40.790743		1.203216	0.79043	691.740349	0.229362	0	0	0	0	0.98786
862	40.850787		1.19694	0.850521	489.357463	0.162258	0	0	0	0	1.385965
863	40.833549		1.156068	0.833301	731.904967	0.24268	0	0	0	0	1.05111
864	40.761212		1.1847	0.760977	707.95662	0.234739	0	0	0	0	0.800937
865	40.698178		1.010928	0.697952	595.465598	0.19744	0	0	0	0	0.763807
866	40.672102		0.977412	0.67188	518.858881	0.172039	0	0	0	0	0.632366
867	40.55422		0.95604	0.554796	469.246525	0.155589	0	0.016602	0.192123	0.000064	0.643344
868	40.591244		0.977988	0.591033	543.29152	0.180141	0	0	0	0	0.593686
869	40.57923		0.836232	0.579066	414.347582	0.137386	0	0	0	0	0.601682
870	40.815233		1.211952	0.814978	704.976065	0.233751	0	0	0	0	1.510542
871	40.855775		1.244496	0.855485	801.196007	0.265655	0	0	0	0	1.492427
872	40.986922		1.381524	0.9866	828.144691	0.27459	0	0	0	0	1.501545
873	41.016842		1.413888	1.016539	818.382432	0.271353	0	0	0	0	1.350061
874	40.927921		1.361964	0.927607	813.790609	0.269831	0	0	0	0	1.363573
875	40.875747		1.2942	0.875414	667.747134	0.221407	0	0	0	0	1.352532
876	40.889659		1.32936	0.889306	716.200691	0.237473	0	0	0	0	1.414148
877	40.812327		1.25446	0.811909	691.946203	0.229431	0	0	0	0	1.547857
878	40.874134		1.317948	0.873858	767.23454	0.254394	0	0	0	0	1.029656
879	40.999512		1.373328	0.999243	705.761394	0.234011	0	0	0	0	1.417473
880	41.081188		1.505229	1.080909	871.444404	0.288947	0	0	0	0	1.414704
881	41.144099		1.532592	1.143844	1057.030721	0.350483	0	0	0	0	1.113327
882	41.094501		1.478172	1.094259	821.755864	0.272472	0	0	0	0	0.894724
883	41.108602		1.486536	1.108327	912.995776	0.302725	0	0	0	0	1.18201
884	40.954186		1.414644	0.953939	831.999868	0.275869	0	0	0	0	1.29056
885	40.873909		1.315512	0.873619	666.766245	0.221082	0	0	0	0	1.0637
886	40.713634		1.166676	0.713362	589.009769	0.1953	0	0	0	0	0.955649
887	40.9196		1.315452	0.919391	802.218121	0.265994	0	0	0	0	0.741394
888	41.085044		1.505292	1.08481	871.972458	0.289122	0	0	0	0	0.441197
889	41.255032		1.704384	1.254792	1173.068488	0.388958	0	0	0	0	0.642575
890	41.182544		1.546836	1.182304	916.615678	0.303925	0	0	0	0	0.40688
891	40.889404		1.287306	0.889166	789.879059	0.261902	0	0	0	0	0.467797
892	40.74653		1.08426	0.746293	572.167003	0.189715	0	0	0	0	0.451713
893	40.67784		1.054488	0.677541	551.735696	0.182941	0	0	0	0	0.71814
894	40.910083		1.437333	0.909722	671.375429	0.22261	0	0	0	0	2.065426
895	41.012922		1.5873	1.012499	876.077687	0.290484	0	0	0	0	1.973444
896	41.020939		1.44318	1.020533	832.455687	0.27602	0	0	0	0	1.631429
897	41.061644		1.50798	1.061231	856.419823	0.283966	0	0	0	0	1.724478
898	40.855104		1.48218	0.854739	754.233925	0.250083	0	0	0	0	1.644407
899	40.773346		1.154352	0.772951	556.377271	0.18448	0	0	0	0	1.783578
900	40.7838		1.155048	0.783518	703.930522	0.233404	0	0	0	0	1.517778
901	40.784865		1.16835	0.784608	724.383609	0.240186	0	0	0	0	1.010583
902	40.847385		1.22094	0.847122	694.900872	0.23041	0	0	0	0	1.307937
903	40.79565		1.132104	0.795465	628.891491	0.208523	0	0	0	0	1.43935
904	40.922044		1.467132	0.921754	774.347314	0.256753	0	0	0	0	1.704608

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905	41.012372		1.412856	1.012068	866.634076	0.287352	0	0	0	0	1.92389
906	40.965895		1.371348	0.965561	780.60883	0.258829	0	0	0	0	2.419906
907	40.878998		1.303008	0.878704	715.630156	0.237283	0	0	0	0	1.985641
908	40.835871		1.31016	0.835571	778.421045	0.258103	0	0	0	0	2.101662
909	40.925542		1.340604	0.925204	756.827582	0.250943	0	0	0	0	2.460227
910	40.748294		1.127064	0.747982	612.185265	0.202984	0	0	0	0	1.529806
911	40.797877		1.183692	0.797653	697.051635	0.231123	0	0	0	0	1.249675
912	40.837073		1.192416	0.836817	670.532496	0.22233	0	0	0	0	1.15466
913	40.789116		1.07622	0.788913	557.848675	0.184967	0	0	0	0	0.903336
914	40.661576		1.091892	0.661313	545.422614	0.180847	0	0	0	0	1.15105
915	40.543384		0.879024	0.543238	486.661045	0.161364	0	0.000038	0.000173	0	1.11113
916	40.543287		0.866052	0.543072	441.863768	0.14651	0	0	0	0	1.079561
917	40.502521		0.87414	0.502261	377.820429	0.125275	0	0	0	0	1.026894
918	40.626786		1.1193	0.627207	550.47384	0.182522	0	0.004701	0.033016	0.000011	0.993587
919	40.78662		1.154148	0.7863	637.035414	0.211224	0	0	0	0	1.333153
920	40.874892		1.245804	0.874512	703.445518	0.233243	0	0	0	0	1.560707
921	40.934906		1.297758	0.934568	845.104349	0.280214	0	0	0	0	1.368318
922	40.878098		1.282968	0.877722	730.426799	0.24219	0	0	0	0	1.405809
923	40.861714		1.191336	0.86137	623.227471	0.206645	0	0	0	0	1.270208
924	40.893443		1.559712	0.893137	772.43081	0.256117	0	0	0	0	1.283391
925	41.194624		1.556244	1.1943	872.613078	0.289335	0	0	0	0	1.113715
926	41.120554		1.477908	1.120232	1011.643257	0.335433	0	0	0	0	1.094013
927	41.015907		1.442568	1.015615	816.603627	0.270764	0	0	0	0	1.260876
928	41.030224		1.346748	1.029955	938.848172	0.311297	0	0	0	0	1.053943
929	41.114431		1.457388	1.114205	852.749734	0.282749	0	0	0	0	1.293244
930	41.197225		1.547778	1.196995	1024.400109	0.339663	0	0	0	0	1.509258
931	41.099991		1.426914	1.099757	918.545724	0.304565	0	0	0	0	1.388777
932	41.078338		1.389228	1.078097	933.019647	0.309364	0	0	0	0	1.339038
933	40.801624		1.259088	0.801436	727.27635	0.241145	0	0	0	0	0.722206
934	40.587317		0.925908	0.587095	516.567259	0.17128	0	0	0	0	0.779466
935	40.723363		1.08354	0.723137	638.679176	0.211769	0	0	0	0	1.109256
936	40.655883		1.004724	0.655682	515.403424	0.170894	0	0	0	0	1.185868
937	40.653451		1.036104	0.653213	574.669486	0.190545	0	0	0	0	1.179208
938	40.632465		0.90948	0.632243	489.818477	0.16241	0	0	0	0	1.227807
939	40.697314		1.059024	0.697082	542.111085	0.179749	0	0	0	0	1.473532
940	40.73385		1.100556	0.733578	645.660124	0.214083	0	0	0	0	1.501164
941	40.567737		0.911136	0.567474	459.802756	0.152458	0	0	0	0	1.381474
942	40.600542		1.0467	0.600262	569.395619	0.188796	0	0	0	0	0.821322
943	40.808115		1.21992	0.807848	712.840325	0.236358	0	0	0	0	0.524998
944	40.819189		1.161276	0.818923	728.125692	0.241427	0	0	0	0	0.611937
945	40.927016		1.237824	0.926796	711.382043	0.235875	0	0	0	0	0.82769
946	40.993963		1.356312	0.993746	753.496379	0.249839	0	0	0	0	0.892211
947	41.039897		1.438308	1.039673	893.906686	0.296395	0	0	0	0	0.675321
948	41.019312		1.39116	1.019097	874.619745	0.29	0	0	0	0	1.24326
949	40.980137		1.306692	0.979939	801.745751	0.265837	0	0	0	0	1.053435
950	40.763027		1.239756	0.762768	681.306721	0.225903	0	0	0	0	0.728881
951	40.769652		1.078584	0.76948	669.906896	0.222123	0	0	0	0	0.367991
952	40.738646		1.074408	0.738494	674.345521	0.223595	0	0	0	0	0.307835
953	40.7522		1.022916	0.752043	595.391722	0.197416	0	0	0	0	0.524924
954	40.718924		1.132704	0.718753	639.38075	0.212001	0	0	0	0	0.509901

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955	40.837098		1.175232	0.83692	691.788133	0.229378	0	0	0	0	0.660282
956	40.73788		1.017012	0.737727	550.114667	0.182403	0	0	0	0	0.573411
957	40.549922		0.943038	0.549784	471.840741	0.15645	0	0	0	0	0.672424
958	40.456718		0.859164	0.459494	395.687419	0.131199	0	0.003357	0.104969	0.000035	0.999236
959	40.606764		1.00818	0.606614	528.92926	0.175379	0	0	0	0	0.191397
960	40.551022		0.914304	0.550844	482.945727	0.160132	0	0	0	0	0.320512
961	40.510883		0.8211	0.510711	383.020761	0.126999	0	0	0	0	0.531667
962	40.65234		1.013148	0.652138	589.760256	0.195548	0	0	0	0	0.667918
963	40.711979		1.128036	0.711743	532.121377	0.176437	0	0	0	0	0.775411
964	40.742678		1.067622	0.742465	593.585103	0.196817	0	0	0	0	0.638717
965	40.714906		1.015524	0.71474	573.221192	0.190065	0	0	0	0	0.455175
966	40.585989		0.977178	0.585919	487.158406	0.161528	0	0.001981	0.007185	0.000002	0.696678
967	40.674463		0.969264	0.674293	563.441918	0.186822	0	0	0	0	0.34255
968	40.626324		0.95124	0.626162	562.499408	0.18651	0	0	0	0	0.37881
969	40.619494		0.85524	0.61934	488.842318	0.162087	0	0	0	0	0.528841
970	40.452085		0.909504	0.451919	418.011657	0.138601	0	0	0	0	0.568406
971	40.371194		0.631236	0.371177	268.303974	0.088962	0	0.000857	0.001768	0.000001	0.472551
972	40.396322		0.77694	0.396571	352.673001	0.116937	0	0.001666	0.004467	0.000001	0.46644
973	40.482883		0.794328	0.482724	431.501737	0.143074	0	0	0	0	0.496871
974	40.490491		0.82044	0.490338	418.359311	0.138717	0	0	0	0	0.413268
975	40.506462		0.805056	0.506328	440.130187	0.145935	0	0	0	0	0.405268
976	40.408016		0.672264	0.407884	351.127843	0.116424	0	0	0	0	0.237938
977	40.418061		0.696324	0.417932	363.350558	0.120477	0	0	0	0	0.302802
978	40.239158		0.530244	0.240214	196.776868	0.065246	0	0.018676	0.10487	0.000035	0.360094
979	40.20019		0.492324	0.21571	178.420399	0.059159	0.069696	0.058213	2.565782	0.000851	0.628697
980	40.290122		0.70326	0.299108	247.812431	0.082168	0	0.042829	1.54414	0.000512	0.770607
981	40.399354		0.734028	0.40198	299.210492	0.09921	0	0.01663	0.139096	0.000046	0.95878
982	40.442639		0.829344	0.445111	363.267055	0.120449	0	0.011133	0.125676	0.000042	1.243903
983	40.409606		0.806376	0.414085	331.407639	0.109886	0	0.011996	0.229666	0.000076	0.709333
984	40.431071		0.782496	0.432815	387.556093	0.128503	0	0.008736	0.055581	0.000018	0.369563
985	40.473602		0.883536	0.473746	363.870552	0.12065	0	0.00458	0.014883	0.000005	0.448545
986	40.470963		0.907608	0.47077	403.155398	0.133675	0	0.000854	0.002078	0.000001	0.437677
987	40.4584		0.821352	0.458327	383.418053	0.127131	0	0.003487	0.014653	0.000005	0.340045
988	40.470842		0.840228	0.470587	381.03347	0.12634	0	0	0	0	0.367814
989	40.474664		0.833184	0.47468	360.096589	0.119398	0	0.003299	0.008622	0.000003	0.479004
990	40.515003		0.943032	0.514758	417.06029	0.138286	0	0.001066	0.001209	0	0.605022
991	40.693886		1.059744	0.693552	572.164865	0.189714	0	0	0	0	0.892567
992	40.660082		1.031064	0.659789	580.795621	0.192576	0	0	0	0	1.243006
993	40.579778		1.002216	0.579495	514.270727	0.170518	0	0	0	0	1.320548
994	40.71581		1.05096	0.715481	471.423243	0.156311	0	0	0	0	1.215822
995	40.709816		1.0479	0.709508	647.393445	0.214658	0	0	0	0	1.086027
996	40.697098		1.06806	0.696813	632.585634	0.209748	0	0	0	0	0.949143
997	40.69436		1.052496	0.694115	672.506229	0.222985	0	0	0	0	0.902544
998	40.68216		0.980064	0.681946	500.190495	0.16585	0	0	0	0	0.62378
999	40.484704		0.96402	0.484978	487.993387	0.161805	0	0.002689	0.012526	0.000004	0.846881
1000	40.446673		0.828072	0.448541	406.672815	0.134842	0	0.005496	0.07179	0.000024	0.605671
1001	40.47012		0.815304	0.469922	405.117601	0.134326	0	0	0	0	0.568474
1002	40.53735		1.086288	0.537143	472.827094	0.156777	0	0	0	0	0.709033
1003	40.550921		0.954996	0.550694	434.076581	0.143928	0	0	0	0	1.047324
1004	40.53643		0.89622	0.53622	457.859969	0.151814	0	0	0	0	0.912082

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1005	40.377885		0.869688	0.379905	329.233198	0.109165	0	0.013381	0.116	0.000038	0.744336
1006	40.345449		0.693408	0.347806	298.884884	0.099102	0	0.012416	0.213654	0.000071	0.489269
1007	40.595048		1.012728	0.594828	538.45444	0.178537	0	0	0	0	0.6482
1008	40.816628		1.185012	0.81639	721.486352	0.239225	0	0	0	0	0.412514
1009	40.788203		1.116096	0.78798	701.025541	0.232441	0	0	0	0	0.450314
1010	40.745817		1.196724	0.745573	633.676728	0.21011	0	0	0	0	0.505227
1011	40.68953		1.031616	0.689289	570.024987	0.189005	0	0	0	0	0.554769
1012	40.641465		1.054296	0.6412	559.694766	0.18558	0	0	0	0	0.482892
1013	40.654633		1.05762	0.654349	582.455131	0.193126	0	0	0	0	0.451516
1014	40.635405		1.023108	0.63516	403.702228	0.133857	0	0	0	0	0.430503
1015	40.869497		1.326444	0.869149	760.443845	0.252142	0	0	0	0	1.379699
1016	40.979602		1.381248	0.979223	819.161098	0.271612	0	0	0	0	1.373242
1017	40.933482		1.301568	0.93311	765.752551	0.253903	0	0	0	0	1.359018
1018	40.903558		1.341054	0.903195	738.883058	0.244994	0	0	0	0	1.375704
1019	40.898027		1.29594	0.897652	761.730026	0.252569	0	0	0	0	1.729426
1020	40.887894		1.24152	0.887508	542.104257	0.179747	0	0	0	0	1.653749
1021	40.822295		1.259364	0.821862	760.845382	0.252276	0	0	0	0	1.791405
1022	40.695958		1.161936	0.695529	611.15115	0.202641	0	0	0	0	1.828185
1023	40.630913		1.056492	0.630609	522.418293	0.17322	0	0	0	0	1.042068
1024	40.566617		0.939624	0.566331	490.928009	0.162778	0	0	0	0	1.034186
1025	40.487921		0.945216	0.490274	401.610537	0.133163	0	0.011853	0.141547	0.000047	0.864789
1026	40.397024		0.849144	0.405756	321.097842	0.106467	0.02922	0.034098	0.645591	0.000214	0.920952
1027	40.354107		0.745644	0.367334	292.071753	0.096843	0.096828	0.067509	1.508005	0.0005	1.020688
1028	40.380444		0.772116	0.389938	310.651071	0.103003	0.049452	0.049554	0.914124	0.000303	1.047085
1029	40.378164		0.687552	0.387038	301.632015	0.100013	0	0.028212	0.595139	0.000197	1.189628
1030	40.343258		0.705906	0.356785	289.779738	0.096083	0.011766	0.041128	1.357959	0.00045	1.168815
1031	40.568538		0.916572	0.569817	494.644231	0.164011	0	0.007363	0.090517	0.00003	1.023746
1032	40.690984		1.042452	0.690672	597.352105	0.198066	0	0	0	0	0.775102
1033	40.820793		1.230636	0.820441	651.275079	0.215945	0	0	0	0	0.794292
1034	40.775866		1.25808	0.775606	653.553234	0.2167	0	0	0	0	0.646475
1035	40.661844		0.9603	0.661661	619.052734	0.205261	0	0	0	0	0.665393
1036	40.614805		0.934452	0.614602	544.539118	0.180554	0	0	0	0	0.74252
1037	40.467146		0.867672	0.466968	431.762761	0.143161	0	0	0	0	0.495836
1038	40.344802		0.668856	0.347606	385.966214	0.127976	0	0.026366	0.293844	0.000097	0.639453
1039	40.547372		1.023924	0.547603	535.886699	0.177685	0	0.002512	0.019847	0.000007	1.328872
1040	40.617825		0.96648	0.617611	609.120164	0.201968	0	0	0	0	1.652796
1041	40.500427		0.860856	0.500232	549.648527	0.182248	0	0	0	0	1.657277
1042	40.477891		0.805368	0.477694	539.602146	0.178917	0	0	0	0	1.68658
1043	40.38935		0.777168	0.390921	459.036179	0.152204	0	0.011648	0.130708	0.000043	1.459149
1044	40.30576		0.602616	0.311607	340.315769	0.112839	0.00018	0.028244	0.791411	0.000262	1.442449
1045	40.321785		0.694764	0.325999	342.385272	0.113526	0	0.036539	0.476594	0.000158	1.359865
1046	40.325046		0.77304	0.334528	352.157795	0.116766	0	0.044546	1.312069	0.000435	1.341276
1047	40.418513		0.836064	0.421439	413.043946	0.136954	0	0.061935	0.478584	0.000159	0.823301
1048	40.453238		0.817968	0.457723	405.648933	0.134502	0.071208	0.102105	0.742132	0.000246	1.323845
1049	40.472209		0.905196	0.475846	466.339606	0.154626	0	0.047619	0.568693	0.000189	1.412764
1050	40.662252		1.108536	0.661912	574.780945	0.190582	0	0.001576	0.002023	0.000001	1.371381
1051	40.719304		1.210308	0.718904	673.593209	0.223345	0	0	0	0	1.359559
1052	40.776725		1.159446	0.776287	734.928383	0.243682	0	0	0	0	1.307753
1053	40.688165		1.072092	0.687761	645.451634	0.214014	0	0	0	0	1.123179
1054	40.725177		1.121016	0.7248	701.925835	0.23274	0	0	0	0	1.165385

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1055	40.748918		1.156776	0.748676	662.229688	0.219577	0	0	0	0	0.788799
1056	40.697098		1.056456	0.696821	714.001615	0.236744	0	0	0	0	1.239681
1057	40.791176		1.088292	0.790872	760.86483	0.252282	0	0	0	0	1.48979
1058	40.744636		1.076784	0.744365	802.691104	0.266151	0	0	0	0	1.067774
1059	40.759257		1.142868	0.759029	814.985731	0.270227	0	0	0	0	0.842269
1060	40.794641		1.146816	0.794426	636.657167	0.211098	0	0	0	0	0.74029
1061	40.705441		1.10472	0.705216	769.764968	0.255233	0	0	0	0	0.744582
1062	40.580493		0.950232	0.580295	646.778818	0.214454	0	0	0	0	0.683027
1063	40.523642		0.937956	0.523857	574.553717	0.190506	0	0.001785	0.01472	0.000005	0.796225
1064	40.254593		0.571668	0.266886	249.475655	0.082719	0.062352	0.06723	2.791443	0.000926	1.300422
1065	40.24375		0.624708	0.255096	270.933981	0.089834	0.057636	0.078629	3.407932	0.00113	1.330495
1066	40.404518		0.766164	0.406242	450.497761	0.149373	0	0.014022	0.143497	0.000048	1.219346
1067	40.421394		0.744864	0.421747	500.3253	0.165894	0	0.005871	0.016595	0.000006	1.163018
1068	40.288491		0.738792	0.2971	321.963953	0.106754	0	0.055927	3.058882	0.001014	1.204995
1069	40.244776		0.652932	0.255139	250.637293	0.083105	0.0594	0.070217	2.234511	0.000741	1.330375
1070	40.256625		0.627624	0.267173	299.617178	0.099345	0.071064	0.057314	2.277672	0.000755	1.413103
1071	40.38812		0.739812	0.392534	443.874765	0.147177	0	0.032316	0.875951	0.00029	1.494256
1072	40.537811		0.878652	0.537625	634.139845	0.210264	0	0	0	0	1.798275
1073	40.45101		0.771876	0.45084	398.783376	0.132226	0	0	0	0	1.758022
1074	40.5097		0.97374	0.509693	592.574395	0.196482	0	0.00129	0.010562	0.000004	1.748248
1075	40.506747		0.879864	0.507127	558.746011	0.185265	0	0.004931	0.019219	0.000006	1.586526
1076	40.529582		0.856812	0.530213	564.153873	0.187058	0	0.006559	0.035697	0.000012	1.544462
1077	40.641726		1.068576	0.641536	742.490531	0.24619	0	0	0	0	1.341876
1078	40.54433		0.91632	0.544141	662.620143	0.219707	0	0	0	0	1.400102
1079	40.429046		0.887532	0.429557	484.508431	0.16065	0	0.002887	0.021466	0.000007	1.043478
1080	40.526588		0.874644	0.526433	563.192147	0.186739	0	0	0	0	1.019268
1081	40.505338		0.828096	0.505181	632.853365	0.209837	0	0	0	0	1.06538
1082	40.597807		0.88638	0.597655	709.8339	0.235362	0	0	0	0	1.034297
1083	40.609144		0.951804	0.608992	720.930576	0.239041	0	0	0	0	0.964691
1084	40.471735		0.892704	0.471586	599.622523	0.198819	0	0	0	0	1.032187
1085	40.425873		0.722556	0.426173	491.256545	0.162887	0	0.007277	0.031114	0.00001	1.117168
1086	40.348123		0.702984	0.349379	371.165294	0.123068	0	0.013787	0.092397	0.000031	1.070126
1087	40.319218		0.645084	0.320572	387.234361	0.128396	0	0.011826	0.163661	0.000054	0.920893
1088	40.349088		0.751212	0.350953	382.589714	0.126856	0	0.018041	0.141295	0.000047	1.527191
1089	40.346782		0.709044	0.348171	405.349615	0.134403	0	0.019486	0.28654	0.000095	1.491305
1090	40.219424		0.60318	0.22766	256.859996	0.085168	0	0.049328	2.089239	0.000693	1.200248
1091	40.209941		0.51696	0.217321	241.547188	0.08009	0.01212	0.036729	1.741408	0.000577	1.059575
1092	40.204799		0.583668	0.213843	231.805311	0.07686	0.004752	0.041859	2.169136	0.000719	1.012826
1093	40.313376		0.660096	0.314662	365.216265	0.121096	0	0.012609	0.141214	0.000047	1.322855
1094	40.35628		0.763752	0.356587	395.195125	0.131036	0	0.003019	0.018532	0.000006	1.201572
1095	40.413764		0.791796	0.413766	459.050249	0.152209	0	0.001182	0.004408	0.000001	1.202615
1096	40.467844		0.851868	0.467723	571.96246	0.189647	0	0	0	0	0.711371
1097	40.441051		0.759756	0.440937	521.824005	0.173023	0	0	0	0	0.743876
1098	40.53917		0.86238	0.539078	622.880113	0.20653	0	0	0	0	0.755306
1099	40.63018		0.933132	0.630081	646.182726	0.214257	0	0	0	0	0.646349
1100	40.587913		0.884532	0.587807	687.974226	0.228114	0	0	0	0	0.694665
1101	40.501552		0.7935	0.501434	569.018577	0.188671	0	0	0	0	0.940566
1102	40.433503		0.780528	0.433392	510.246345	0.169184	0	0	0	0	1.034361
1103	40.507563		0.99672	0.507443	568.873647	0.188623	0	0	0	0	0.752599
1104	40.687537		0.992868	0.687428	841.401702	0.278986	0	0	0	0	1.058771

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1105	40.655931		0.897816	0.655843	664.290106	0.220261	0	0	0	0	0.615135
1106	40.578399		0.879744	0.578309	700.618456	0.232306	0	0	0	0	0.525506
1107	40.571383		0.886656	0.571289	562.618467	0.186549	0	0	0	0	0.470768
1108	40.605665		0.903948	0.605572	677.126198	0.224517	0	0	0	0	0.607108
1109	40.575362		0.852192	0.57527	679.298945	0.225237	0	0	0	0	0.477919
1110	40.608781		0.955992	0.608673	658.163132	0.218229	0	0	0	0	0.793115
1111	40.665697		0.992256	0.665589	784.289799	0.260049	0	0	0	0	0.894497
1112	40.641959		1.028304	0.641775	675.160935	0.223865	0	0	0	0	0.996672
1113	40.439523		0.843504	0.439955	422.400835	0.140057	0	0.002652	0.057202	0.000019	0.829667
1114	40.341331		0.841044	0.346053	326.807533	0.10836	0	0.033847	0.529552	0.000176	0.952426
1115	40.506859		0.947472	0.506656	540.023827	0.179057	0	0	0	0	0.91631
1116	40.538342		0.933576	0.538118	556.726245	0.184595	0	0	0	0	1.020525
1117	40.503955		0.872976	0.503734	510.91205	0.169405	0	0	0	0	1.120096
1118	40.520399		0.947232	0.521196	492.675476	0.163358	0	0.014983	0.061582	0.00002	1.088401
1119	40.615319		1.04796	0.615093	634.431648	0.21036	0	0	0	0	0.909805
1120	40.661529		1.024944	0.661377	701.321797	0.232539	0	0	0	0	0.569136
1121	40.824457		1.303776	0.824308	827.591473	0.274407	0	0	0	0	0.587155
1122	40.983318		1.382244	0.983161	1059.388658	0.351264	0	0	0	0	0.56394
1123	40.904657		1.283844	0.904502	865.103866	0.286845	0	0	0	0	0.58927
1124	40.770684		1.200984	0.770539	790.52261	0.262116	0	0	0	0	0.296363
1125	40.654499		1.05336	0.654325	654.421975	0.216989	0	0	0	0	0.677179
1126	40.698974		1.045872	0.698824	684.142716	0.226843	0	0	0	0	0.548061
1127	40.704556		1.13202	0.704369	768.256074	0.254733	0	0	0	0	0.648111
1128	40.443524		0.846204	0.447776	458.720558	0.152099	0	0.066891	0.648194	0.000215	0.662571
1129	40.522743		0.961608	0.523375	544.309107	0.180478	0	0.002225	0.008295	0.000003	0.811328
1130	40.624264		0.979692	0.624118	702.095574	0.232796	0	0.000281	0.000326	0	0.873404
1131	40.570804		0.96684	0.570639	594.357028	0.197073	0	0.003579	0.002792	0.000001	0.865429
1132	40.569428		0.901296	0.569174	524.960396	0.174063	0	0	0	0	0.700217
1133	40.507685		0.914616	0.507455	505.934826	0.167754	0	0	0	0	0.751261
1134	40.512309		0.859716	0.512103	523.666526	0.173634	0	0	0	0	0.680379
1135	40.464187		0.857604	0.464294	466.604534	0.154713	0	0.010292	0.05279	0.000018	0.794514
1136	40.766724		1.198908	0.766467	659.010098	0.21851	0	0	0	0	1.151856
1137	40.843348		1.265124	0.843028	829.880393	0.275166	0	0	0	0	1.593045
1138	40.715424		1.033512	0.715176	600.80952	0.199212	0	0	0	0	1.236733
1139	40.722871		1.071564	0.722616	700.948172	0.232415	0	0	0	0	1.086512
1140	40.761258		1.207224	0.760998	719.372267	0.238524	0	0	0	0	1.029734
1141	40.726005		1.058604	0.72578	677.810794	0.224744	0	0	0	0	1.191324
1142	40.757802		1.104612	0.757553	699.581514	0.231962	0	0	0	0	1.402122
1143	40.756342		1.074816	0.756058	709.51498	0.235256	0	0	0	0	1.178125
1144	40.817149		1.153572	0.816866	701.220045	0.232505	0	0	0	0	0.869629
1145	40.900495		1.288668	0.900221	735.95276	0.244022	0	0	0	0	0.952241
1146	40.73428		1.17882	0.734063	651.857495	0.216138	0	0	0	0	0.750388
1147	40.757049		1.037664	0.756833	602.118759	0.199646	0	0	0	0	0.714837
1148	40.737195		1.057032	0.736978	668.148455	0.22154	0	0	0	0	0.667842
1149	40.743613		1.107636	0.743343	593.877929	0.196914	0	0	0	0	0.803381
1150	40.681992		1.032432	0.681709	553.450479	0.183509	0	0	0	0	0.855813
1151	40.653875		0.998832	0.653571	611.767161	0.202845	0	0	0	0	1.055091
1152	40.674646		1.07028	0.674294	594.38578	0.197082	0	0	0	0	1.131187
1153	40.715629		1.044108	0.715287	574.306501	0.190424	0	0	0	0	0.895502
1154	40.670132		1.012056	0.669849	598.078195	0.198306	0	0	0	0	0.782222

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1155	40.663614		1.01688	0.663331	564.501802	0.187173	0	0	0	0	0.742155
1156	40.667181		1.061268	0.666873	586.487176	0.194463	0	0	0	0	0.799143
1157	40.642662		1.00224	0.64234	506.466137	0.16793	0	0	0	0	0.876774
1158	40.689951		1.057308	0.689596	604.177084	0.200329	0	0	0	0	0.958703
1159	40.872666		1.260384	0.872296	743.145047	0.246407	0	0	0	0	1.153391
1160	40.788323		1.172184	0.787881	696.695636	0.231005	0	0	0	0	1.428623
1161	40.746081		1.121166	0.745624	645.269954	0.213954	0	0	0	0	1.405188
1162	40.657284		1.150704	0.656882	616.189372	0.204312	0	0	0	0	1.390146
1163	40.669181		1.051464	0.668781	464.07277	0.153874	0	0	0	0	1.394636
1164	40.783163		1.23162	0.782699	703.647921	0.233311	0	0	0	0	1.548113
1165	40.859548		1.285716	0.859109	799.017748	0.264933	0	0	0	0	1.53243
1166	40.776736		1.187904	0.776311	594.869986	0.197243	0	0	0	0	1.32541
1167	40.607705		0.97998	0.611052	548.164704	0.181757	0	0.010364	0.140943	0.000047	1.104297
1168	40.543788		0.87468	0.546063	432.629096	0.143448	0	0.020871	0.217861	0.000072	1.197683
1169	40.556802		0.9168	0.560447	490.41856	0.162609	0	0.018801	0.301186	0.0001	1.259154
1170	40.539997		0.94452	0.547601	479.598572	0.159022	0	0.023455	0.599869	0.000199	1.178424
1171	40.519668		0.911988	0.532104	452.667097	0.150092	0.037632	0.0648	1.366643	0.000453	1.279608
1172	40.573136		1.000224	0.580404	478.531325	0.158668	0	0.032269	0.501899	0.000166	1.259215
1173	40.601914		0.979764	0.605546	554.652653	0.183908	0	0.020588	0.274642	0.000091	1.139848
1174	40.56946		0.914904	0.572549	460.007673	0.152526	0	0.013847	0.081649	0.000027	1.059431
1175	40.580547		0.908664	0.581477	505.988251	0.167772	0	0.005919	0.097306	0.000032	1.036556
1176	40.628576		1.070892	0.630936	573.95179	0.190307	0	0.014645	0.141921	0.000047	0.869278
1177	40.714534		1.202592	0.714226	567.025803	0.18801	0	0	0	0	1.559596
1178	40.633563		1.013784	0.633309	488.391192	0.161937	0	0	0	0	1.191334
1179	40.671549		1.009356	0.671343	618.153731	0.204963	0	0	0	0	1.060737
1180	40.779922		1.154892	0.779737	680.814342	0.22574	0	0	0	0	0.772172
1181	40.846318		1.137564	0.846098	690.321366	0.228892	0	0	0	0	0.998259
1182	40.833499		1.15296	0.833307	686.699434	0.227691	0	0	0	0	0.928237
1183	40.740071		1.025808	0.739848	637.693852	0.211442	0	0	0	0	1.099714
1184	40.651654		1.122924	0.6513	533.649681	0.176944	0	0	0	0	1.610755
1185	40.693604		1.048104	0.693173	602.403754	0.199741	0	0	0	0	1.467782
1186	40.493945		0.853188	0.496121	381.023438	0.126337	0	0.010459	0.138333	0.000046	1.546721
1187	40.462746		0.806244	0.463874	381.463384	0.126483	0	0.00327	0.022337	0.000007	1.307841
1188	40.502259		0.876792	0.503983	421.295179	0.13969	0	0.005949	0.117304	0.000039	1.244252
1189	40.511891		0.891396	0.51179	375.913839	0.124643	0	0.002093	0.009523	0.000003	1.149829
1190	40.494518		0.885444	0.49542	396.7289	0.131545	0	0.005858	0.054977	0.000018	1.185814
1191	40.544144		0.942048	0.544482	431.109134	0.142944	0	0.002985	0.016998	0.000006	1.29302
1192	40.697005		1.082766	0.696592	599.446942	0.19876	0	0	0	0	1.306542
1193	40.792205		1.234524	0.791938	630.74325	0.209137	0	0	0	0	0.512174
1194	40.805282		1.195128	0.805062	663.29075	0.219929	0	0	0	0	0.363631
1195	40.833123		1.255248	0.832919	650.673816	0.215746	0	0	0	0	0.492631
1196	40.85185		1.201728	0.851606	758.133024	0.251376	0	0	0	0	0.764031
1197	40.62794		1.018932	0.62766	517.124587	0.171464	0	0	0	0	0.880332
1198	40.612606		0.94638	0.612372	513.193451	0.170161	0	0	0	0	0.879593
1199	40.568849		0.98046	0.571066	404.903825	0.134255	0	0.01081	0.078909	0.000026	1.199524
1200	40.60291		1.019496	0.604864	470.540877	0.156019	0	0.011396	0.221533	0.000073	1.637093
1201	40.571219		0.980688	0.570878	503.827573	0.167056	0	0	0	0	0.916996
1202	40.81026		1.17282	0.809995	562.324522	0.186452	0	0	0	0	0.78886
1203	40.741409		1.104912	0.741151	641.683916	0.212765	0	0	0	0	0.64439
1204	40.743809		1.130556	0.743456	708.256686	0.234839	0	0	0	0	0.89385

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1205	40.693994		1.090572	0.69355	554.65932	0.18391	0	0	0	0	0.895685
1206	40.575202		0.972588	0.574829	469.965093	0.155828	0	0.000683	0.001905	0.000001	0.960227
1207	40.534193		1.005924	0.555125	411.520435	0.136449	0	0.043224	1.547215	0.000513	0.97457
1208	40.54442		0.88512	0.564278	480.941959	0.159467	0.009396	0.030744	1.085171	0.00036	1.1123
1209	40.592995		0.966552	0.592759	576.220542	0.191059	0	0	0	0	0.815556
1210	40.708146		1.03602	0.707858	649.690331	0.21542	0	0	0	0	1.174503
1211	40.66898		0.94386	0.668716	543.306187	0.180146	0	0	0	0	1.141043
1212	40.776169		1.161432	0.775882	667.134696	0.221204	0	0	0	0	1.199651
1213	40.756992		1.133898	0.756639	640.332831	0.212317	0	0	0	0	1.308621
1214	40.702774		1.107768	0.702426	588.591728	0.195161	0	0	0	0	1.29238
1215	40.682805		1.075848	0.682464	535.04379	0.177406	0	0	0	0	1.354269
1216	40.62749		0.977412	0.627143	573.601301	0.190191	0	0	0	0	1.356462
1217	40.718634		1.099212	0.718222	510.02922	0.169112	0	0	0	0	1.305728
1218	40.8882		1.262556	0.8878	708.463943	0.234907	0	0	0	0	1.253218
1219	40.869562		1.24038	0.869198	736.73636	0.244282	0	0	0	0	1.210938
1220	40.837746		1.16892	0.8374	632.665702	0.209775	0	0	0	0	1.157525
1221	40.862259		1.22964	0.861923	784.378556	0.260079	0	0	0	0	1.095512
1222	40.797344		1.230192	0.796982	627.940221	0.208208	0	0	0	0	1.090396
1223	40.548567		0.857136	0.54821	407.689147	0.135179	0	0	0	0	1.141297
1224	40.557485		0.902484	0.55714	492.013269	0.163138	0	0	0	0	1.035233
1225	40.664845		1.028604	0.664538	579.284723	0.192075	0	0	0	0	1.243432
1226	40.60235		0.923172	0.602047	516.012776	0.171096	0	0	0	0	1.242902
1227	40.568521		0.966648	0.568332	447.64921	0.148428	0	0.000475	0.000406	0	1.12838
1228	40.565738		0.943236	0.565465	502.971191	0.166772	0	0	0	0	1.131415
1229	40.617723		0.992028	0.617418	534.882518	0.177352	0	0	0	0	1.214331
1230	40.628557		0.989184	0.628274	529.507271	0.17557	0	0	0	0	1.149838
1231	40.584344		0.923436	0.584123	516.044788	0.171106	0	0	0	0	1.199458
1232	40.521706		0.832632	0.521571	455.86176	0.151151	0	0	0	0	0.718858
1233	40.514071		0.899178	0.51387	499.82204	0.165727	0	0	0	0	0.382451
1234	40.599352		0.96366	0.599194	605.169968	0.200658	0	0	0	0	0.182912
1235	40.564661		0.90666	0.564514	559.50632	0.185517	0	0	0	0	0.169187
1236	40.688193		1.33362	0.687974	707.596596	0.23462	0	0	0	0	0.693035
1237	40.66785		1.251408	0.667622	742.064326	0.246048	0	0	0	0	0.774274
1238	40.616333		1.209216	0.616013	594.036167	0.196966	0	0	0	0	1.041315
1239	40.675515		1.427712	0.675184	744.781125	0.246949	0	0.000547	0.001731	0.000001	1.603116
1240	40.793984		1.36818	0.793617	788.600478	0.261478	0	0	0	0	1.225459
1241	40.689147		1.055268	0.689006	779.828403	0.25857	0	0	0	0	0.545133
1242	40.553108		1.115394	0.552969	628.681396	0.208454	0	0	0	0	0.320836
1243	40.458965		0.741804	0.458836	478.379195	0.158618	0	0	0	0	0.388021
1244	40.455983		0.9159	0.455853	532.580533	0.176589	0	0	0	0	0.371422
1245	40.570566		0.915084	0.570442	657.601582	0.218043	0	0	0	0	0.421219
1246	40.525788		0.810972	0.525641	565.872733	0.187628	0	0	0	0	0.77015
1247	40.46368		0.782964	0.463521	546.519452	0.181211	0	0	0	0	1.00807
1248	40.509199		0.999396	0.509041	575.608906	0.190856	0	0	0	0	1.162505
1249	40.661953		1.050156	0.661784	819.20097	0.271625	0	0	0	0	0.649039
1250	40.567939		0.95586	0.567788	609.787571	0.202189	0	0	0	0	0.281012
1251	40.464545		0.84018	0.464413	480.548035	0.159337	0	0	0	0	0.208503
1252	40.423913		0.843732	0.423752	488.237225	0.161886	0	0	0	0	0.242917
1253	40.395805		0.936132	0.396128	414.703173	0.137504	0	0.006313	0.023154	0.000008	0.341674
1254	40.332737		0.723816	0.333543	369.913233	0.122653	0	0.008253	0.066948	0.000022	0.296954

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1255	40.240659		0.642096	0.249664	280.920652	0.093146	0	0.042755	3.098008	0.001027	0.491597
1256	40.138649		0.454776	0.157435	143.628967	0.047623	0.08688	0.04724	4.567138	0.001514	0.415626
1257	40.26189		0.603132	0.269568	244.680192	0.081129	0	0.022169	2.798689	0.000928	0.762778
1258	40.342016		0.653652	0.341888	333.80665	0.110681	0	0	0	0	1.098176
1259	40.356151		0.643332	0.356053	406.498034	0.134784	0	0	0	0	0.855713
1260	40.471577		0.824316	0.47142	569.009479	0.188668	0	0	0	0	1.25137
1261	40.609903		0.908448	0.609727	676.113312	0.224181	0	0	0	0	1.329284
1262	40.613369		0.949356	0.613167	711.843518	0.236028	0	0	0	0	1.334755
1263	40.601681		0.942912	0.601501	733.337514	0.243155	0	0	0	0	1.197717
1264	40.512981		0.783456	0.512834	661.935118	0.21948	0	0	0	0	1.083685
1265	40.450908		0.951408	0.45077	486.909071	0.161446	0	0	0	0	1.022722
1266	40.429509		0.997896	0.430273	480.588668	0.15935	0	0.009891	0.098632	0.000033	1.969846
1267	40.361225		0.852996	0.361716	466.813361	0.154783	0	0.003771	0.038911	0.000013	1.953604
1268	40.330637		0.82452	0.333461	345.41453	0.11453	0	0.016101	0.273192	0.000091	1.668104
1269	40.475538		0.982092	0.475363	565.933048	0.187648	0	0.001445	0.00517	0.000002	1.292664
1270	40.443274		0.978516	0.443037	502.897515	0.166747	0	0	0	0	1.184316
1271	40.407052		0.7593	0.406803	433.938518	0.143882	0	0	0	0	1.323927
1272	40.571681		1.035984	0.57135	661.690111	0.219398	0	0	0	0	1.516346
1273	40.554386		0.920772	0.55413	598.46216	0.198434	0	0	0	0	1.300691
1274	40.513539		0.828972	0.513345	614.232447	0.203663	0	0	0	0	0.862773
1275	40.422338		0.756816	0.422152	505.863187	0.16773	0	0	0	0	0.854186
1276	40.387468		0.678264	0.387308	449.821651	0.149149	0	0	0	0	0.734387
1277	40.315465		0.606936	0.317117	377.9759	0.125327	0	0.027647	0.266013	0.000088	0.722662
1278	40.351216		0.687936	0.351347	363.033403	0.120372	0	0.001823	0.002651	0.000001	0.633079
1279	40.340084		0.65688	0.340259	368.917146	0.122323	0	0.002355	0.019931	0.000007	0.563769
1280	40.164032		0.558108	0.185508	210.173087	0.069688	0	0.046456	5.93316	0.001967	0.661525
1281	40.269628		0.702312	0.27445	349.572848	0.115909	0	0.023396	0.43391	0.000144	0.514835
1282	40.466779		0.875508	0.466645	506.539552	0.167955	0	0	0	0	0.257017
1283	40.508714		0.879768	0.508564	531.178519	0.176124	0	0	0	0	0.352456
1284	40.474135		0.826824	0.47401	468.108819	0.155212	0	0	0	0	0.426111
1285	40.488287		0.983886	0.488147	510.501814	0.169269	0	0	0	0	0.550188
1286	40.730528		1.196556	0.730312	800.736086	0.265502	0	0	0	0	0.787283
1287	40.686109		1.10298	0.685901	746.836404	0.247631	0	0	0	0	0.812269
1288	40.56416		1.065468	0.563968	671.323482	0.222593	0	0	0	0	0.706392
1289	40.562844		0.977424	0.562668	565.989	0.187667	0	0	0	0	0.682087
1290	40.590717		0.88788	0.590525	625.137903	0.207279	0	0	0	0	0.912021
1291	40.544628		0.865752	0.544447	649.969741	0.215512	0	0	0	0	1.036791
1292	40.574107		1.13244	0.573832	625.11452	0.207271	0	0	0	0	1.42247
1293	40.611957		1.142616	0.611667	664.544281	0.220345	0	0	0	0	1.348736
1294	40.61786		1.123224	0.617611	586.816235	0.194572	0	0	0	0	0.748666
1295	40.626267		1.20552	0.62598	708.888089	0.235048	0	0	0	0	0.852796
1296	40.506878		0.98124	0.507988	423.837694	0.140533	0	0.016356	0.130292	0.000043	0.681247
1297	40.275484		0.738924	0.290458	309.034418	0.102467	0	0.06737	4.345436	0.001441	0.815556
1298	40.503874		0.969528	0.505775	494.47699	0.163955	0	0.009635	0.335386	0.000111	0.455928
1299	40.578998		0.958884	0.578839	566.507564	0.187838	0	0	0	0	0.250833
1300	40.569263		0.954108	0.569089	520.232305	0.172495	0	0	0	0	0.200743
1301	40.609819		1.030392	0.60963	589.422219	0.195436	0	0	0	0	0.377696
1302	40.698336		1.150248	0.698118	626.832927	0.207841	0	0	0	0	0.341744
1303	40.661763		1.109148	0.661563	688.649151	0.228337	0	0	0	0	0.218726
1304	40.587693		1.0623	0.587485	591.89045	0.196255	0	0	0	0	0.149945

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1305	40.479694		0.983976	0.479527	460.86699	0.152811	0	0	0	0	0.252108
1306	40.578503		1.059336	0.57828	572.090693	0.18969	0	0	0	0	1.185607
1307	40.70512		1.26438	0.704837	683.200415	0.226531	0	0	0	0	1.162722
1308	40.846354		1.295976	0.846099	912.077555	0.30242	0	0	0	0	0.936427
1309	40.861412		1.433652	0.861096	791.828835	0.262549	0	0	0	0	1.068684
1310	40.932555		1.444692	0.932228	956.062996	0.317004	0	0	0	0	1.019134
1311	40.973967		1.527036	0.973593	1031.315608	0.341956	0	0	0	0	1.48365
1312	40.944451		1.507068	0.944086	1042.354379	0.345616	0	0	0	0	1.754235
1313	40.703312		1.05714	0.703156	735.38934	0.243835	0	0	0	0	0.962598
1314	40.670749		1.1619	0.670599	706.783198	0.23435	0	0	0	0	0.303154
1315	40.657569		0.986568	0.657428	710.548288	0.235598	0	0	0	0	0.566161
1316	40.467365		0.85218	0.467233	466.477971	0.154671	0	0	0	0	0.431643
1317	40.579459		1.010664	0.579271	645.221351	0.213938	0	0	0	0	0.743179
1318	40.629223		1.113816	0.628931	647.927619	0.214835	0	0	0	0	0.79156
1319	40.617958		1.06422	0.617851	628.232033	0.208305	0	0.00686	0.015476	0.000005	0.869393
1320	40.652704		1.154544	0.652436	649.257968	0.215276	0	0	0	0	0.798219
1321	40.73609		1.180584	0.735863	757.031767	0.251011	0	0	0	0	0.688607
1322	40.679914		1.069776	0.679721	702.262705	0.232851	0	0	0	0	0.482148
1323	40.685484		1.038948	0.685283	647.930513	0.214836	0	0	0	0	0.846106
1324	40.639363		1.046556	0.639174	683.921571	0.22677	0	0	0	0	0.70444
1325	40.577115		0.944916	0.576915	579.646224	0.192195	0	0	0	0	0.482001
1326	40.57055		0.968208	0.570316	546.443475	0.181186	0	0	0	0	0.273931
1327	40.499091		0.958032	0.49894	489.188265	0.162202	0	0.001455	0.003169	0.000001	0.304732
1328	40.494209		0.937248	0.494071	482.67508	0.160042	0	0.000641	0.000122	0	0.277547
1329	40.673754		1.054524	0.673441	594.273452	0.197045	0	0	0	0	0.734527
1330	40.688839		1.123896	0.688507	628.514843	0.208398	0	0	0	0	0.977802
1331	40.73005		1.085712	0.729777	689.596048	0.228651	0	0	0	0	0.888925
1332	40.693229		1.085736	0.69292	676.124721	0.224185	0	0	0	0	1.152995
1333	40.757479		1.156668	0.757168	738.616561	0.244905	0	0	0	0	1.224766
1334	40.786265		1.187268	0.785918	719.975895	0.238724	0	0	0	0	1.127544
1335	40.818448		1.19106	0.818118	781.029064	0.258968	0	0	0	0	1.092137
1336	40.723667		1.11126	0.723416	720.948079	0.239047	0	0	0	0	0.809036
1337	40.444076		0.8157	0.44382	429.520897	0.142417	0	0	0	0	0.89873
1338	40.517007		0.892464	0.517048	494.29478	0.163895	0	0.00121	0.007281	0.000002	1.078763
1339	40.556995		1.029624	0.556718	567.64053	0.188214	0	0	0	0	1.178374
1340	40.696618		1.086036	0.696339	701.142038	0.23248	0	0	0	0	1.059324
1341	40.703323		1.114272	0.703088	722.53353	0.239572	0	0	0	0	0.783677
1342	40.609369		1.103712	0.609227	568.921627	0.188639	0	0	0	0	0.475192
1343	40.559301		0.860976	0.559172	628.915067	0.208531	0	0	0	0	0.496523
1344	40.511223		0.814944	0.511085	556.850012	0.184636	0	0	0	0	0.741137
1345	40.342226		0.73986	0.344092	318.400894	0.105573	0	0.01603	0.207975	0.000069	0.856907
1346	40.388542		0.850728	0.390533	375.356715	0.124458	0	0.01258	0.140757	0.000047	0.471572
1347	40.471919		0.864816	0.476028	553.959702	0.183678	0	0.045172	0.720946	0.000239	0.882956
1348	40.342361		0.830784	0.349833	351.506116	0.11655	0.019248	0.052625	1.094333	0.000363	1.070904
1349	40.267598		0.732792	0.277671	321.887283	0.106729	0.096324	0.081797	2.840723	0.000942	0.916694
1350	40.266389		0.679296	0.275755	315.607775	0.104647	0	0.032431	1.570655	0.000521	0.724744
1351	40.436214		0.744096	0.43603	437.256533	0.144982	0	0	0	0	0.894513
1352	40.519073		0.942096	0.518861	651.54719	0.216035	0	0	0	0	0.900883
1353	40.586246		1.107036	0.58597	540.125284	0.179091	0	0	0	0	1.056871
1354	40.488252		0.978624	0.488021	549.944578	0.182347	0	0	0	0	1.294989

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1355	40.570454		1.04592	0.570298	675.419234	0.223951	0	0.003083	0.010274	0.000003	2.173949
1356	40.560233		1.085232	0.559876	639.077454	0.211901	0	0	0	0	2.231168
1357	40.496128		1.013412	0.495777	579.250136	0.192064	0	0	0	0	2.129377
1358	40.47137		0.945372	0.471097	542.844077	0.179992	0	0	0	0	1.674049
1359	40.635593		1.001472	0.635288	768.416872	0.254786	0	0	0	0	1.792017
1360	40.73843		1.15146	0.738108	770.01946	0.255318	0	0	0	0	1.821239
1361	40.605777		1.034568	0.607431	706.210064	0.23416	0	0.021125	0.416914	0.000138	1.023999
1362	40.667769		1.083552	0.66752	747.285075	0.247779	0	0	0	0	1.244399
1363	40.685434		1.203888	0.685004	714.926402	0.23705	0	0	0	0	2.442512
1364	40.540565		1.157916	0.541553	600.847217	0.199225	0	0.010075	0.092803	0.000031	2.376905
1365	40.573171		1.140276	0.573003	639.501267	0.212041	0	0.001032	0.002251	0.000001	2.366722
1366	40.543587		1.07628	0.543295	613.158969	0.203307	0	0	0	0	1.903971
1367	40.680587		1.040172	0.68036	768.605942	0.254849	0	0	0	0	1.673553
1368	40.652868		0.973788	0.652646	666.916892	0.221132	0	0	0	0	1.791789
1369	40.612306		1.087524	0.612082	656.467732	0.217667	0	0	0	0	1.719778
1370	40.606951		1.018248	0.60679	696.63332	0.230985	0	0	0	0	0.890759
1371	40.66499		1.164984	0.66479	658.518668	0.218347	0	0	0	0	1.04832
1372	40.670921		1.180296	0.670865	792.427116	0.262747	0	0.000914	0.003099	0.000001	0.807321
1373	40.593402		1.117116	0.593187	624.911601	0.207204	0	0	0	0	0.930167
1374	40.585089		1.021272	0.584908	651.168729	0.21591	0	0	0	0	0.733288
1375	40.521642		0.870972	0.521791	547.054837	0.181389	0	0.005757	0.024673	0.000008	0.890962
1376	40.538933		0.858708	0.539122	609.743718	0.202174	0	0.002995	0.01366	0.000005	0.977958
1377	40.557088		0.901092	0.557177	620.848073	0.205856	0	0.00603	0.012664	0.000004	0.830972
1378	40.489352		1.038588	0.489218	525.464538	0.17423	0	0	0	0	0.68618
1379	40.686703		0.97236	0.686547	783.155908	0.259673	0	0	0	0	1.370362
1380	40.780207		1.301232	0.779986	971.587681	0.322152	0	0	0	0	1.587492
1381	41.057555		1.522176	1.057244	1245.049617	0.412825	0	0	0	0	1.962697
1382	41.001211		1.443828	1.000929	1221.68283	0.405077	0	0	0	0	1.820809
1383	40.931633		1.342308	0.931382	1139.668158	0.377883	0	0	0	0	1.522702
1384	40.84598		1.17708	0.845756	1001.971686	0.332227	0	0	0	0	1.199137
1385	40.816151		1.208412	0.815877	1017.854989	0.337493	0	0	0	0	1.20554
1386	40.864079		1.352904	0.863852	1076.393732	0.356903	0	0	0	0	1.420117
1387	40.824672		1.17192	0.824416	956.344707	0.317098	0	0	0	0	2.030906
1388	40.88716		1.27674	0.886906	1190.467063	0.394726	0	0	0	0	1.979782
1389	41.024448		1.585716	1.024132	1309.599835	0.434228	0	0	0	0	2.194342
1390	41.020531		1.585056	1.02015	1287.38801	0.426863	0	0	0	0	2.471479
1391	40.978179		1.473144	0.977732	1207.884809	0.400502	0	0	0	0	2.687042
1392	41.099863		1.748184	1.099223	1410.967252	0.467838	0	0	0	0	3.197511
1393	41.131584		1.72926	1.130841	1417.048592	0.469855	0	0	0	0	3.352518
1394	40.933261		1.694652	0.932872	1260.014792	0.417787	0	0	0	0	2.106545
1395	40.861259		1.448748	0.860905	1131.904346	0.375309	0	0	0	0	2.058133
1396	40.699884		1.215132	0.699583	994.984041	0.32991	0	0	0	0	1.864636
1397	40.607152		1.061664	0.607266	788.271322	0.261369	0	0.00013	0.002225	0.000001	1.902502
1398	40.421826		0.771048	0.42509	569.454129	0.188815	0	0.017956	0.260541	0.000086	2.074921
1399	40.337043		0.727884	0.34504	438.900446	0.145527	0.038916	0.046251	1.158871	0.000384	1.830377
1400	40.336222		0.75096	0.345713	473.614613	0.157038	0	0.044273	1.59406	0.000529	1.735486
1401	40.282431		0.754992	0.301781	342.364305	0.113519	0.101004	0.054296	3.383514	0.001122	1.579543
1402	40.504562		1.001892	0.506859	644.929877	0.213841	0	0.013338	0.733201	0.000243	2.106361
1403	40.7106		1.24152	0.71029	959.346346	0.318093	0	0	0	0	2.768745
1404	40.8172		1.320156	0.816888	997.216996	0.33065	0	0	0	0	2.649642

Segment S38S391

1405	40.869868		1.341264	0.869509	1076.802537	0.357038	0	0	0	0	2.742814
1406	40.846383		1.393416	0.846052	1162.542897	0.385468	0	0	0	0	2.518321
1407	40.665933		1.1412	0.665553	941.137692	0.312056	0	0	0	0	2.819338
1408	40.616754		1.002168	0.616404	106.564604	0.035334	0	0	0	0	2.856593
AVERAGE DIAMETER	**81.30733256**	**MAXIMUM**	**1.859568**	**1.398986**	**2028.370453**	**0.672552**	**0.395496**	**0.697066**	**25.799256**	**0.008554**	**3.616631**
		AVERAGE	**1.049400415**	**0.655015538**	**657.6833953**	**0.218069928**	**0.004711822**	**0.00951841**	**0.360291103**	**0.000119459**	**1.1466838**

MAXIMUM MEASUREMENTS HIGHLIGHTED IN PEACH

LEGEND:

MAXIMUM CORROSION: MAXIMUM DEPTH OF CORROSION IN THE ONE FOOT SECTION OF PIPE.
AVERAGE CORROSION: THE AVERAGE CORROSION FOR EACH ONE FOOT SECTION.
INTEGRATED CORROSION: CORROSION OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED CORROSION: INTEGRATED CORROSION DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE TO COMPARE THE EXTENT OF CORROSION IN EACH ONE FOOT SECTION OF PIPE
MAXIMUM BUILDUP: MAXIMUM BUILDUP IN THE ONE FOOT SECTION OF PIPE.
AVERAGE BUILDUP: THE AVERAGE BUILDUP FOR EACH ONE FOOT SECTION.
INTEGRATED BUILDUP: BUILDUP OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED BULDUP: INTEGRATED BUILDUP DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE THIS NUMBER TO COMPARE THE EXTENT OF BUILDUP IN EACH ONE FOOT SECTION OF PIPE
OVALITY: CHANGE IN CIRCULARITY; THE AMOUNT OF OUT-OF-ROUNDNESS

EBMUD
MULTI-SENSOR INSPECTION PROJECT

MULTI-SENSOR INSPECTION SUMMARY REPORT FOR: S47 S48, 105" HORSESHOE RCP, 707.8 LF INSPECTED LENGTH

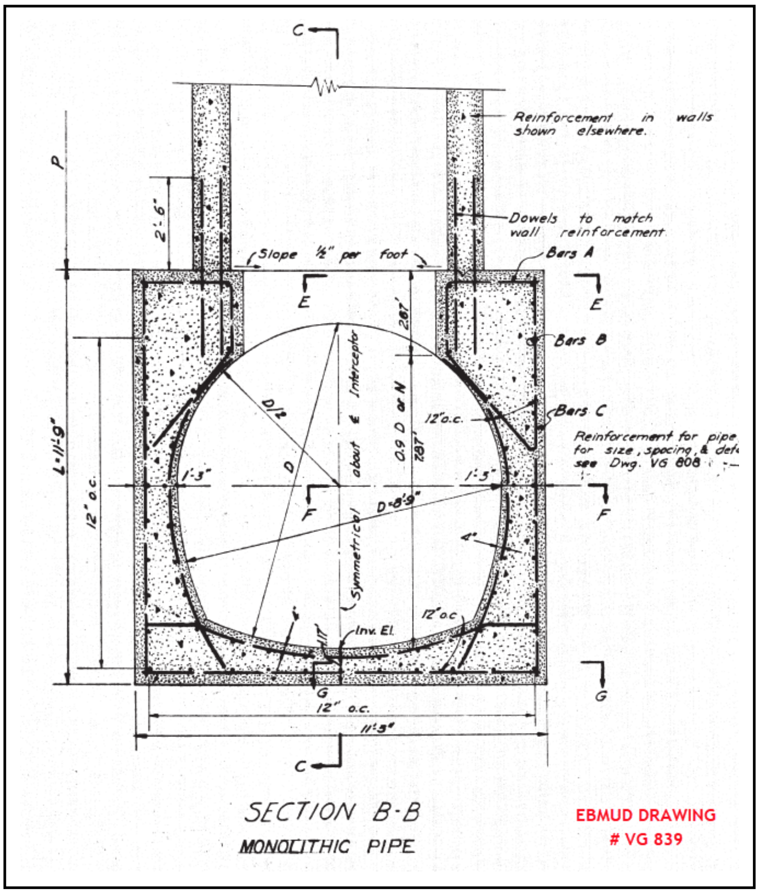
INSPECTION PROCEEDED DOWNSTREAM FROM S47 TO S48. THE FLOATING PONTOON WAS USED FOR THIS INSPECTION. WATER LEVEL WAS AT 40% DURING THIS INSPECTION.

SURFACE AGGREGATE PROJECTING AND SURFACE SPALLING THROUGHOUT. MAXIMUM CORROSION/MEASUREMENT OUTSIDE REFERENCE CIRCLE TO 5.85 INCHES WHERE SURFACE REINFORCEMENT IS VISIBLE AND CORRODED. THE FIRST 16 FEET HAS THE HIGHEST LEVELS OF SURFACE CORROSION, WHICH IS LIKELY DUE TO THE INCOMING PIPE FLOWS INTO S47. AVERAGE CORROSION OVER ENTIRE LENGTH OF PIPE IS 1.34 INCHES.

SONAR HEAD WAS OBSCURED BY RAGS OR OTHER DEBRIS SO NO SONAR DATA WAS OBTAINED.

AS-BUILT DIMENSIONS

The dimensions available from the EBMUD as-built reference drawings were recreated in NPS' 3D modeling software so that a comparison of 3D laser measured values vs. as-built dimensions could be compared in order to produce the 3D virtual model of the pipe interior.

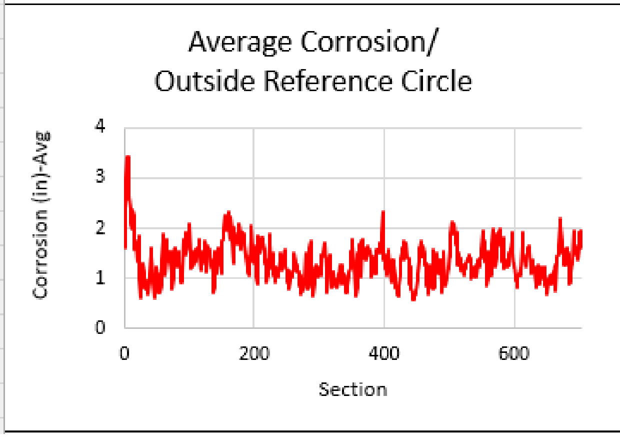


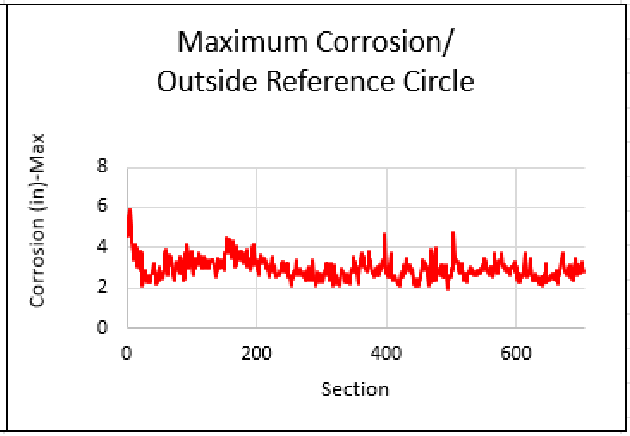
Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

LASER SCAN SUMMARY RESULTS

Measurement	Measurement From Pipe Center (Inches)
Average Corrosion/Outside Reference Circle	1.34
Maximum Average Corrosion/Outside Reference Circle	3.43
Maximum Corrosion/Outside Reference Circle	5.85





PACP SCORING REPORT

PACP v7.0 Inspections and Scoring

General Information:

Surveyed by:	Certificate number:	Reviewed by:	Reviewer certificate no.	Owner:	Customer:
F MORENO/NPS	U-913-19012				

P/O number:	Work order no.:	Media label:	Project name:	Start date/time:
			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022	20220518 12:00

Sheet number:	Weather:	Pre-cleaning:	Date cleaned:	Flow control:	Purpose:
	1	N		N	F

Direction:	Technology used:	Inspection status:	Consequence of failure:	Pressure value:
D		CI		

Location:

Drainage area:	Pipe segment ref.:	Street:
	S47S481	EMBARCADERO

City:	Location code:	Location details:
OAKLAND	L	

Pipe:

Pipe use:	Height:	Width:	Shape:	Material:	Lining method:
SS	105 in.	105 in.	H	RCP	

Coating method:	Pipe joint length:	Total length:	Length surveyed:	Year constructed:	Year renewed:
		707.800 ft.	707.800 ft.	1950	

Measurements:

Upstream MH No:	Rim to invert:	Rim to grade:	Grade to invert:	Northing:	Easting:	Elevation:
S47						

Downstream MH No:	Rim to invert:	Rim to grade:	Grade to invert:	Northing:	Easting:	Elevation:
S48						

MH coordinate system:	MH vertical datum:	GPS accuracy:

Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

Pipe Ratings

Grade	Structural: Amount of Defects	Structural: Segment Grade	Structural: Pipe Rating	Structural: Quick Rating	Structural: Pipe Rating Index	O&M: Amount of Defects	O&M: Segment Grade	O&M: Pipe Rating	O&M: Quick Rating	O&M: Pipe Rating Index	Overall: Pipe Rating	Overall: Pipe Rating Index	Overall: LoF	Overall: Risk
1	142	142	604	5444	2.1	0	0	1,142	342Z	2.0	1,746	2.0	5.4	
2	0	0				565	1,130							
3	142	426				4	12							
4	4	16				0	0							
5	4	20				0	0							

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	Value Inches (mm) 2nd	%	Joint	Circumferential Location At/From	Circumferential Location To	Rating	Image Ref.	Remarks
0.0 ft.		AMH					☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-AMH at 0.0 ft_1.JPG	S47
0.0 ft.		MWL				40	☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-MWL at 0.0 ft_1.JPG	
0.0 ft.	00:00:49	SAP	S01				☐	9 /	3	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SAP at 0.0 ft.JPG	
0.0 ft.	00:02:38	SSC	S03				☐	9 /	3	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SSC at 0.0 ft_1.JPG	

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	Value Inches (mm) 2nd	%	Joint	Circumferential Location At/From	Circumferential Location To	Rating	Image Ref.	Remarks
0.0 ft.	00:01:18	SRV	S02				☐	10 /	2	4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SRV at 0.0 ft.JPG	
0.0 ft.	00:01:37	SRC	S04				☐	10 /	2	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SRC at 0.0 ft_1.JPG	
10.0 ft.	00:04:19	SRC	F04				☐	10 /	2	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SRC at 10.0 ft.JPG	
10.0 ft.	00:04:24	SRV	F02				☐	10 /	2	4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SRV at 10.0 ft.JPG	
10.0 ft.	00:05:25	DAE	S05			5	☐	9 /		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 10.0 ft.JPG	
10.0 ft.	00:06:31	DAE	S06			5	☐	3 /		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 10.0 ft_1.JPG	

Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
11.7 ft.	00:08:02	SRV					☐	10	11	4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SRV at 11.7 ft.JPG	
11.7 ft.	00:08:18	SRC					☐	10	11	5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SRC at 11.7 ft.JPG	
30.9 ft.	00:09:42	IW	S07				☐	9		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 30.9 ft_1.JPG	
30.9 ft.	00:10:20	IW	S08				☐	3		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 30.9 ft_2.JPG	
201.2 ft.	00:18:42	ID					☐	1		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-ID at 201.2 ft.JPG	
201.2 ft.	00:19:44	DAE				5	☐	1		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 201.2 ft.JPG	

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
284.5 ft.	00:25:23	IW					☐	9	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 284.5 ft.JPG	
284.5 ft.	00:25:47	DAE				5	☐	9	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 284.5 ft.JPG	
319.0 ft.	00:28:51	IW					☐	1	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 319.0 ft.JPG	
319.0 ft.	00:29:09	DAE				5	☐	2	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 319.0 ft.JPG	
359.5 ft.	00:31:34	IW					☐	9	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 359.5 ft_1.JPG	
359.5 ft.	00:31:53	DAE				5	☐	2	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 359.5 ft.JPG	

Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
364.1 ft.	00:33:13	IW					☐	9	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 364.1 ft_1.JPG	
364.1 ft.	00:33:36	DAE				5	☐	1	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 364.1 ft.JPG	
364.1 ft.	00:34:19	SRV					☐	11		4	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SRV at 364.1 ft.JPG	
364.1 ft.	00:34:43	SRC					☐	11		5	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SRC at 364.1 ft_1.JPG	
401.4 ft.	00:37:13	IW					☐	9	10	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 401.4 ft.JPG	
401.4 ft.	00:37:25	DAE				5	☐	9	10	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 401.4 ft.JPG	

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
435.9 ft.	00:39:51	ID					☐	11		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-ID at 435.9 ft.JPG	
435.9 ft.	00:40:09	DAE				5	☐	11		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 435.9 ft.JPG	
484.5 ft.	00:43:06	ID					☐	12		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-ID at 484.5 ft.JPG	
484.5 ft.	00:43:17	DAE				5	☐	9	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 484.5 ft_1.JPG	
564.5 ft.	00:48:49	ID					☐	9	12	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-ID at 564.5 ft.JPG	
564.5 ft.	00:49:09	DAE				5	☐	9	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 564.5 ft.JPG	

Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
689.7 ft.	00:54:35	IW					☐	1	3	2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 689.7 ft.JPG	
707.8 ft.	00:56:59	IW	F08				☐	3		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 707.8 ft.JPG	
707.8 ft.	00:57:05	IW	F07				☐	9		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-IW at 707.8 ft_1.JPG	
707.8 ft.	00:57:09	DAE	F06			5	☐	3		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 707.8 ft.JPG	
707.8 ft.	00:57:14	DAE	F05			5	☐	9		2	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-DAE at 707.8 ft_1.JPG	
707.8 ft.	00:57:18	SSC	F03				☐	9	3	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SSC at 707.8 ft.JPG	

Observations

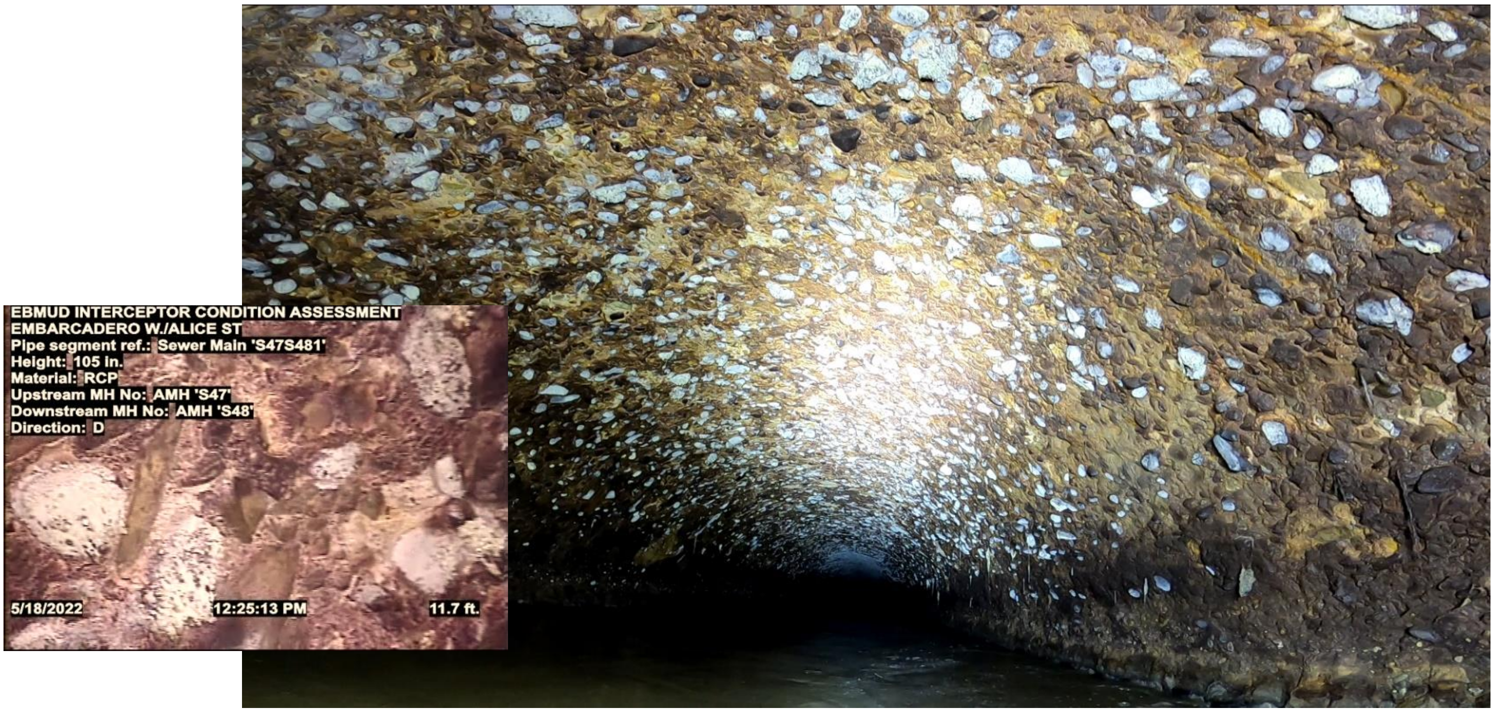
Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
707.8 ft.	00:57:23	SAP	F01				☐	9	3	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-SAP at 707.8 ft.JPG	
707.8 ft.	00:57:45	AMH					☐				EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S47'-AMH 'S48'-AMH at 707.8 ft.JPG	S48

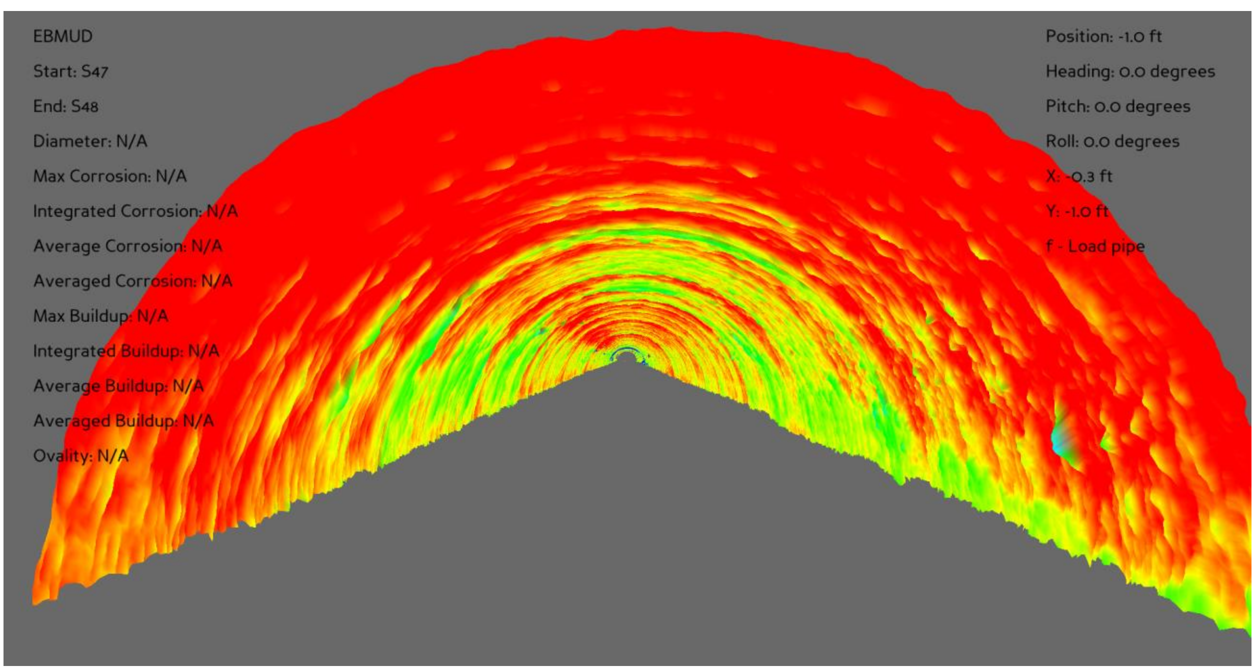
Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

IMAGE REPORT

HIGHEST CORROSION LEVELS IN FIRST 16 FEET DOWNSTREAM OF S47, LIKELY DUE TO INCOMING WATER FROM THE SIPHON AND LATERAL. SURFACE REINFORCEMENT VISIBLE AND CORRODED. MAXIMUM CORROSION TO 5.85 INCHES AT 7 FEET. GO PRO VIDEO WAS ALSO OBTAINED ON THIS SEGMENT TO PROVIDE HIGHER QUALITY VIDEO TO EBMUD.

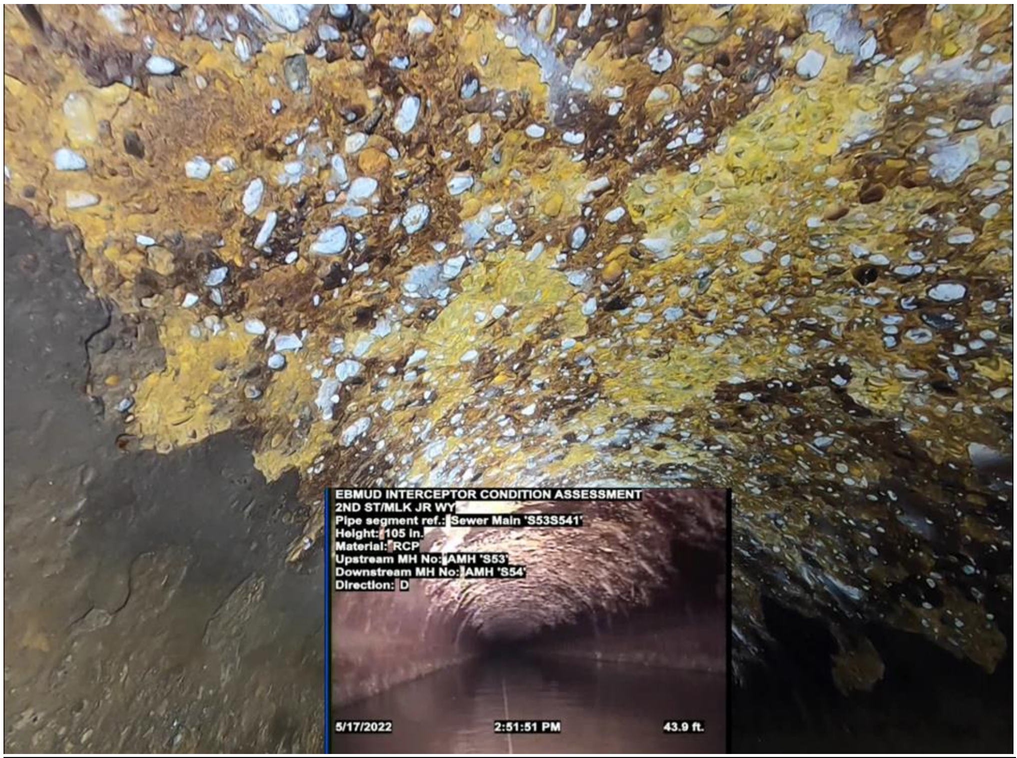


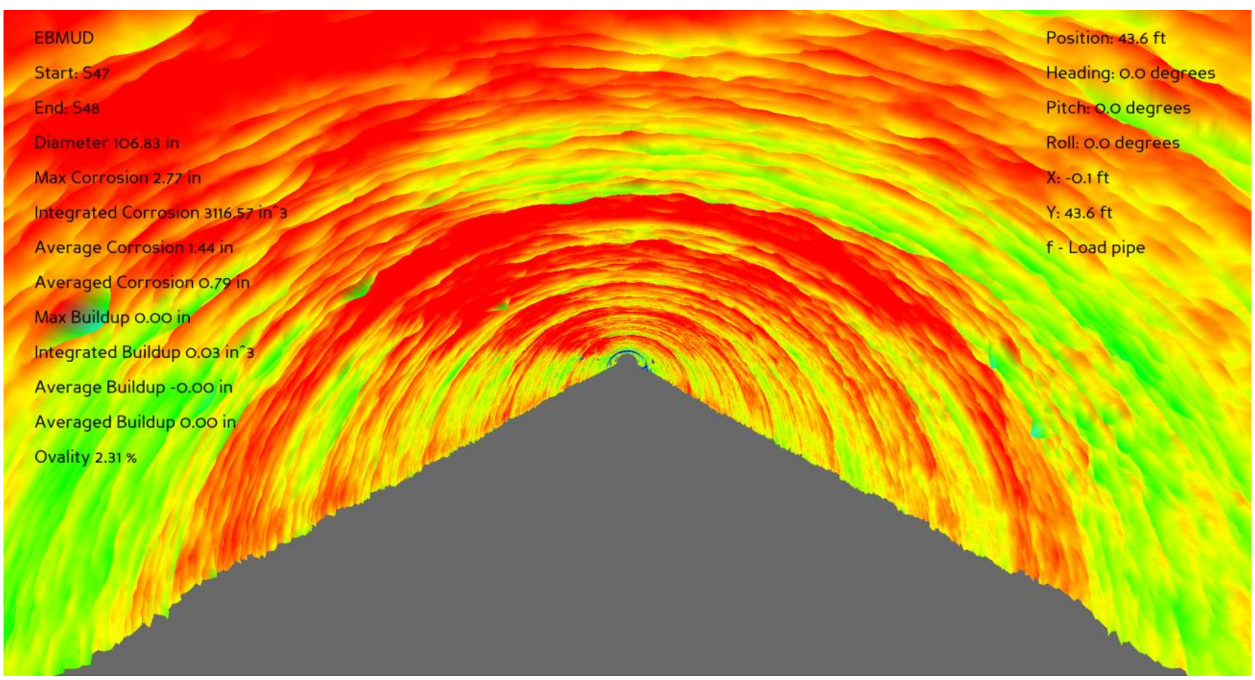


Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

TYPICAL INTERIOR VIEW, 44 FEET

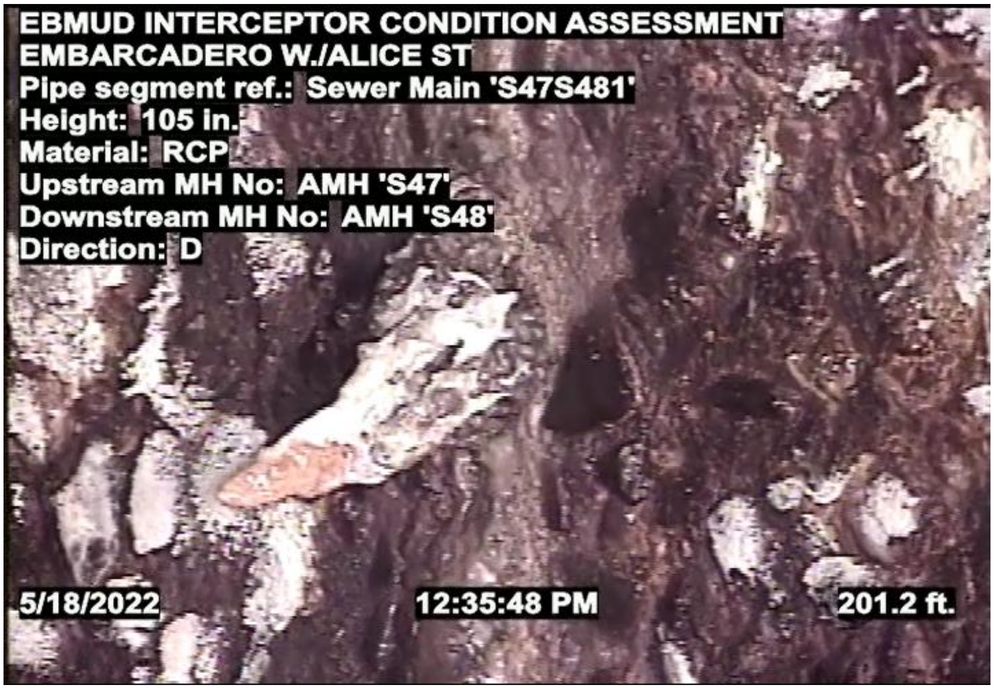


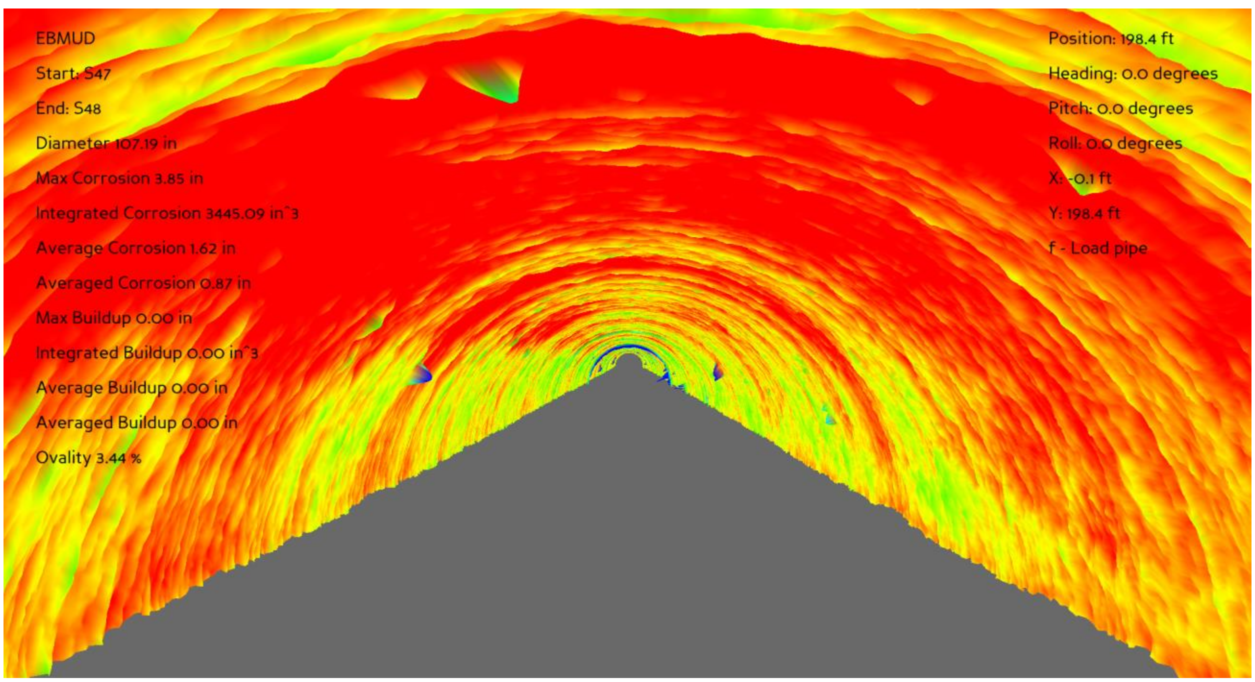


Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

INFILTRATION DRIPPER AT 201.2 FEET. INFILTRATION DRIPPERS AND WEEPERS WERE PRESENT THROUGHOUT PIPELINE SEGMENT.

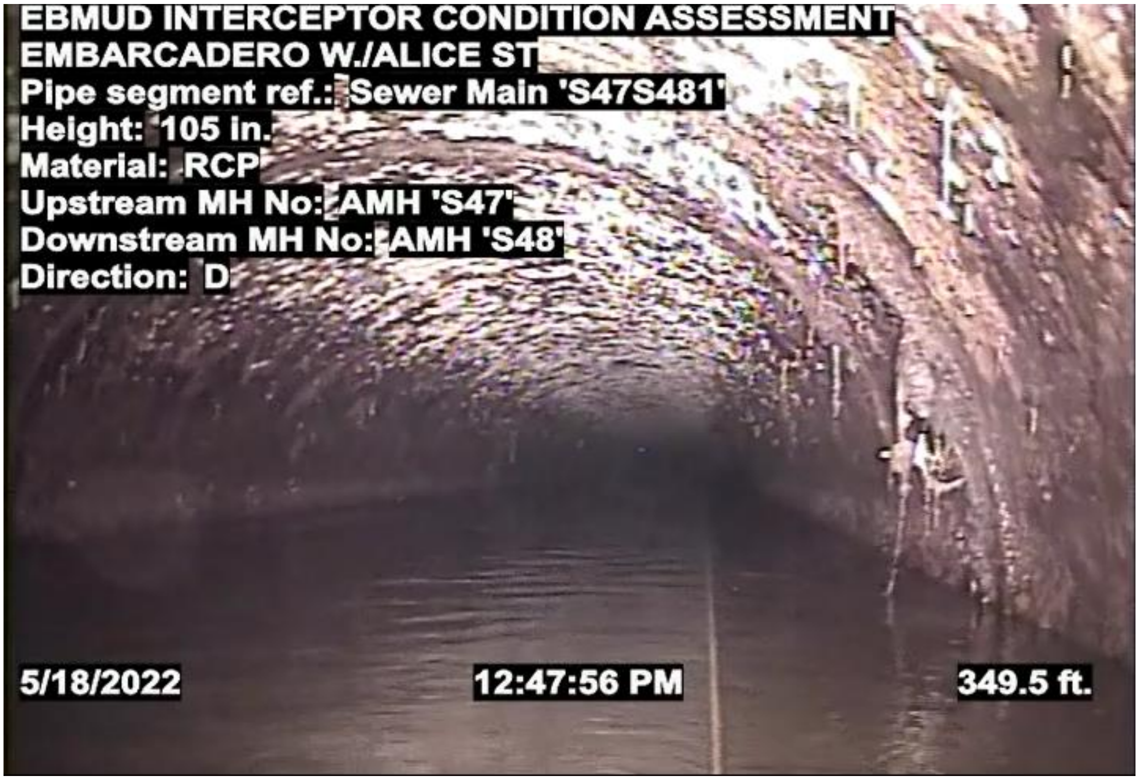


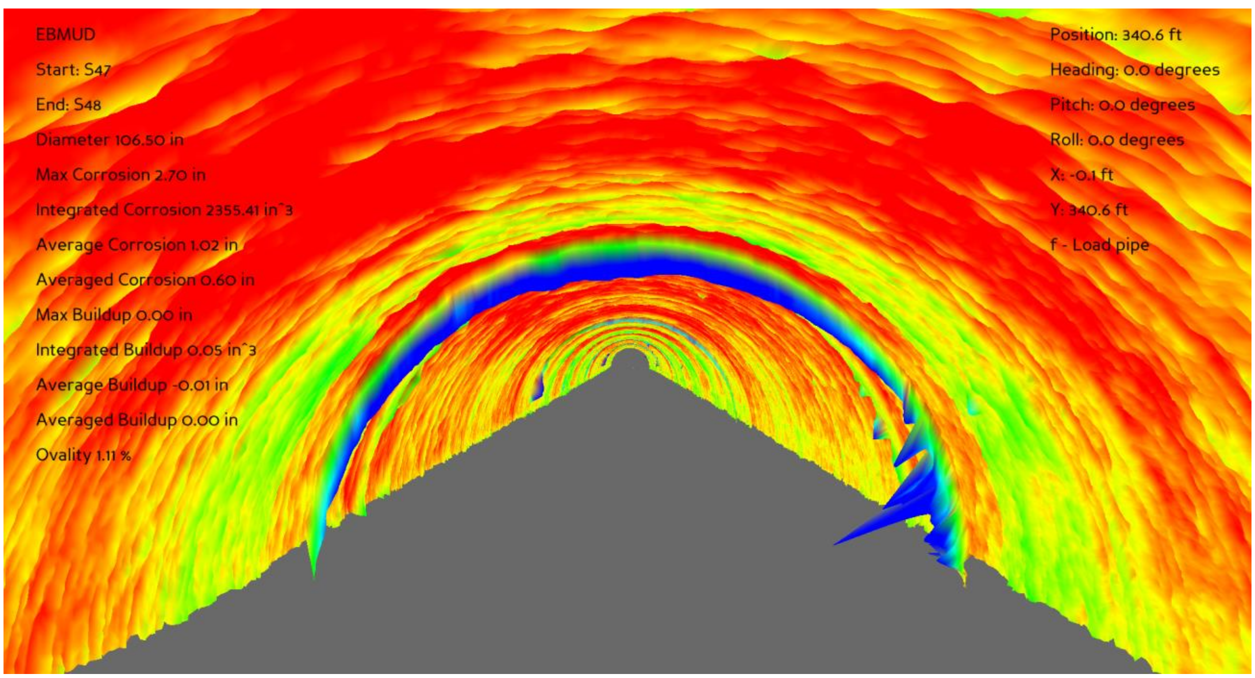


Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

INTERIOR VIEW, 340 FEET

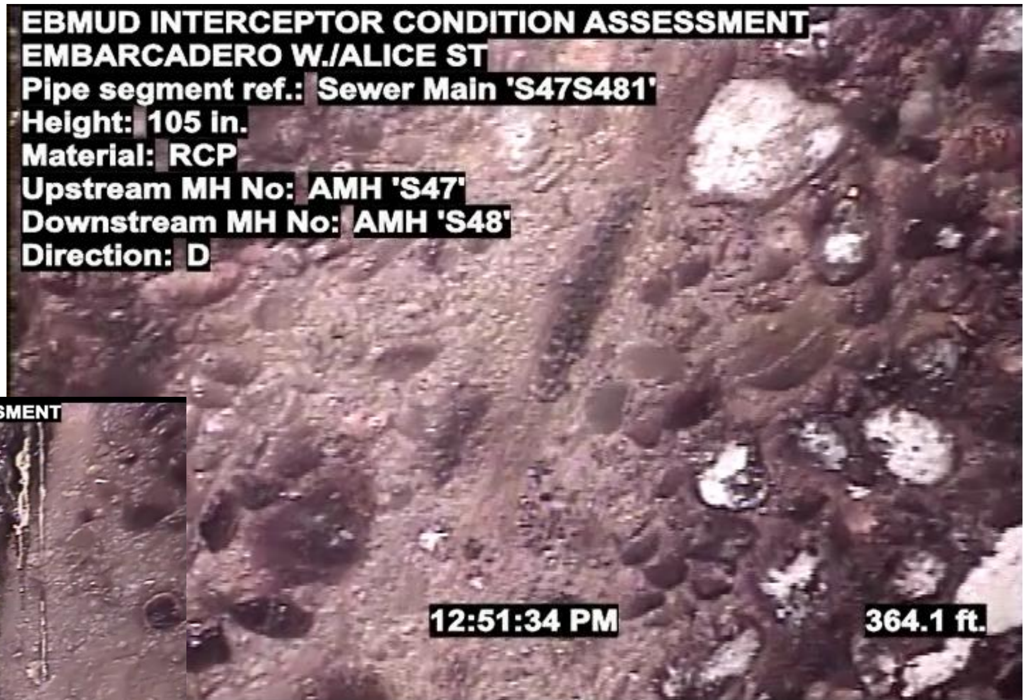


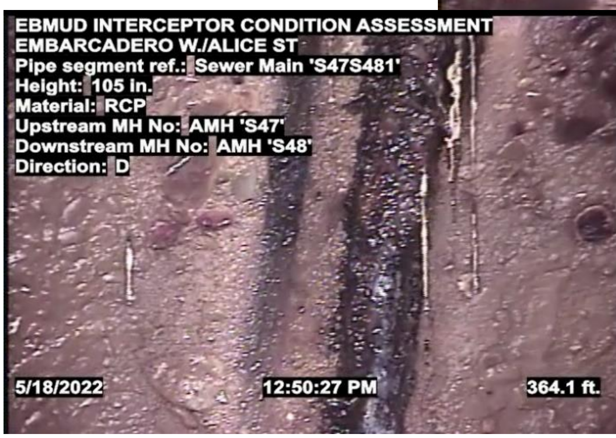


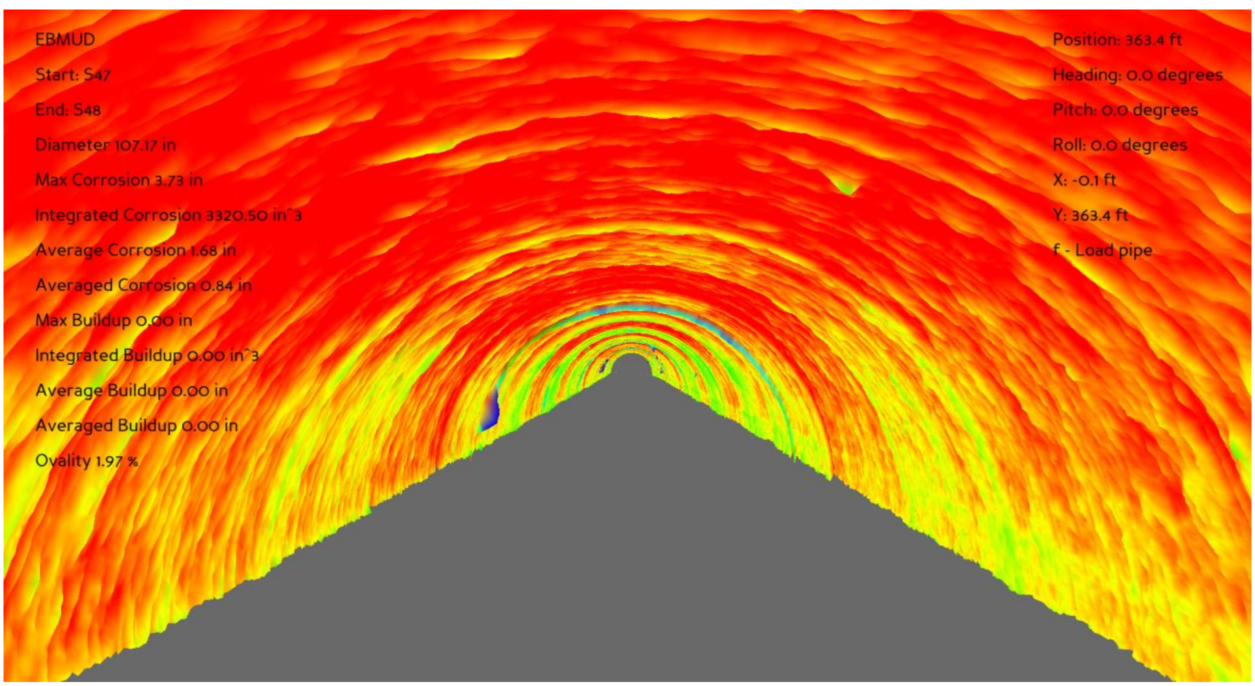
Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

SURFACE REINFORCEMENT VISIBLE AND CORRODED AT 365 FEET.
MAXIMUM CORROSION TO 3.55 INCHES.

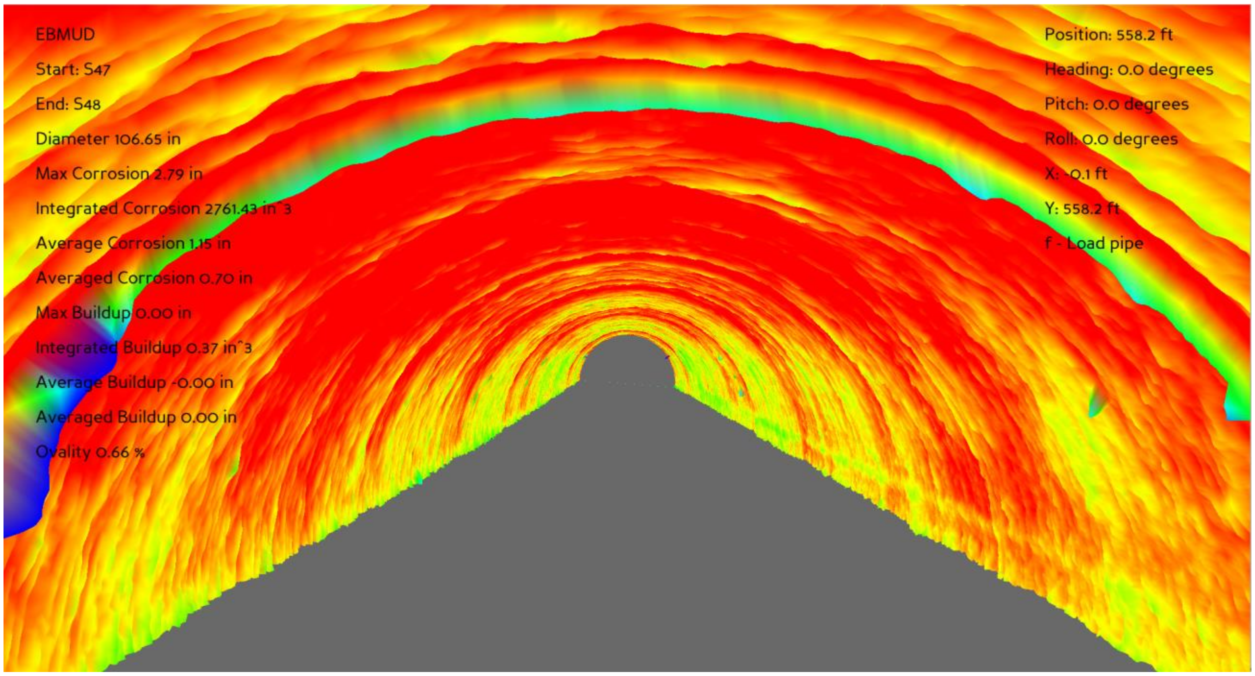






Segment S47S481

MANY JOINTS ARE PRONOUNCED WHEN THE SURROUNDING PIPE IS CORRODED. THEY APPEAR TO HAVE A TYPE OF SEALANT OR COATING IN THE JOINT. SOME LOOK LIKE THEY MAY BE SEALING RINGS, BUT WE ARE UNCERTAIN; 564 FEET.



Segment S47S481

LASER RESULTS BY 1 FOOT SCAN

Segment S47S481

Title 1 EBMUD	Title 2 Start: S47	Title 3 End: S48	Minimum Position (ft) 10	Maximum Position (ft) 709	Surface Area(in2)/ft 3958.406744						
Position (ft)	Circular Radius (in)		Maximum Corrosion (in)	Average Corrosion (in)	Integrated Corrosion (in3)	Averaged Corrosion (in)	Maximum Buildup (in)	Average Buildup (in)	Integrated Buildup (in3)	Averaged Buildup (in)	Ovality (%)
0	32.106419		4.565472	1.600381	661.689594	0.167161	0	15.030138	1310.751727	0.331131	13.55779
1	54.535155		4.612872	2.981922	1121.991603	0.283445	0	-0.352916	418.523514	0.10573	7.965469
4	54.64928		5.561052	3.42356	472.387042	0.119338	0	0.000155	0.000233	0	4.774499
5	54.381378		5.836284	3.143286	3900.99532	0.985496	0	-0.001673	0.367995	0.000093	5.545383
6	54.063273		5.092764	2.554207	2990.345329	0.755442	0	-0.000003	0.001431	0	5.322893
7	54.453509		5.852496	3.425991	2935.534027	0.741595	0	0	0	0	6.615691
8	54.204828		5.065464	2.903115	3232.19197	0.816539	0	0	0	0	4.941012
9	54.058708		4.432686	2.631905	3248.703212	0.82071	0	0	0	0	6.518407
10	53.962191		4.241184	2.398484	3505.340364	0.885543	0	-0.000498	0.016448	0.000004	5.076529
11	53.843995		3.719928	2.093508	3215.838303	0.812407	0	-0.000218	0.043194	0.000011	4.425762
12	53.77928		3.377508	1.998058	2622.333986	0.662472	0	0	0	0	3.022308
13	53.916021		3.720516	2.191513	3417.505552	0.863354	0	0	0	0	3.194237
14	53.981565		4.122492	2.350519	3419.384768	0.863829	0	0	0	0	2.314149
15	53.929887		3.987048	2.24154	3264.266843	0.824642	0	-0.027684	1.335673	0.000337	3.326085
16	53.866891		4.029864	2.1132	3070.546291	0.775703	0	0	0	0	3.639841
17	53.558254		3.07293	1.571842	2740.300198	0.692274	0	-0.000797	0.069469	0.000018	2.115901
18	53.686888		3.17124	1.759626	2939.170871	0.742514	0	-0.000465	0.013678	0.000003	3.339824
19	53.585144		3.621972	1.736924	2781.089233	0.702578	0	-0.00318	0.322576	0.000081	4.28632
20	53.304892		3.118572	1.347656	2484.936939	0.627762	0	-0.014876	2.534878	0.00064	3.923905
21	53.372781		2.925108	1.346389	2575.066947	0.650531	0	-0.007246	0.927	0.000234	4.920314
22	53.341597		3.0948	1.329637	2577.663272	0.651187	0	-0.008613	1.425749	0.00036	4.048721
23	53.650951		3.81684	1.720616	2985.281478	0.754162	0	0	0	0	3.878837
24	53.650546		3.72054	1.860367	2502.62925	0.632231	0	0	0	0	4.886256
25	53.180794		2.790444	0.980151	2371.286945	0.599051	0	-0.036264	4.161991	0.001051	3.777558
26	52.920899		2.108796	0.611489	2135.468292	0.539477	0.402732	-0.091153	19.150914	0.004838	2.637975
27	53.143934		2.408388	0.909283	2187.526944	0.552628	0.035364	-0.03623	2.817738	0.000712	3.230839
28	53.247694		2.52462	1.112594	2054.683583	0.519068	0	-0.025229	1.066984	0.00027	4.456649
29	53.36264		2.912916	1.262176	2653.076946	0.670239	0	-0.00118	0.058949	0.000015	3.601543
30	53.373807		2.752404	1.302046	2597.946473	0.656311	0	-0.002663	0.055661	0.000014	3.162905
31	53.274714		2.705208	1.115123	2317.824937	0.585545	0	-0.014784	0.536432	0.000136	4.942828
32	53.065788		2.275236	0.817852	2322.18786	0.586647	0.064428	-0.037312	2.381388	0.000602	2.653843
33	53.086124		2.586036	0.777312	2288.650492	0.578175	0	-0.015814	1.369537	0.000346	1.947663
34	53.158747		2.55954	0.939709	2593.261974	0.655128	0	-0.019631	1.341244	0.000339	1.157016
35	53.123012		2.286096	0.836556	2273.394554	0.574321	0	-0.024405	1.508633	0.000381	1.459612
36	53.078748		2.3022	0.75545	2051.084293	0.518159	0.17214	-0.03407	1.510936	0.000382	1.884041
37	53.158347		2.342988	0.953629	2368.148212	0.598258	0.037764	-0.009816	0.698212	0.000176	1.077969
38	52.986625		2.257424	0.691266	2076.499617	0.52458	0	-0.058767	10.32733	0.002609	1.99162
39	53.154279		2.655312	0.917191	2307.778128	0.583007	0	-0.033741	2.199509	0.000556	2.750872
40	53.227704		2.687592	1.092666	2349.926109	0.593655	0	-0.004648	0.324681	0.000082	2.368622
41	53.438741		2.833668	1.467392	2929.191542	0.739993	0	-0.000189	0.004009	0.000001	3.776126
42	53.486849		3.253992	1.618951	3184.107385	0.804391	0	0	0	0	2.47484
43	53.416504		2.767656	1.444189	3116.571567	0.78733	0	-0.000629	0.033508	0.000008	2.311558
44	53.138646		2.72682	1.074094	2459.827664	0.621419	0	-0.037478	2.774093	0.000701	3.072404
45	53.163577		2.703384	1.015632	2273.680063	0.574393	0.021168	-0.07377	1.005753	0.000254	4.228203

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46	53.063458		2.503388	0.910414	2259.316893	0.570764	0	-0.08386	6.125386	0.001547	2.596254
47	52.844411		2.214756	0.609396	1912.622835	0.48318	0.415368	-0.136163	25.639869	0.006477	1.800436
48	52.939346		2.277444	0.749732	2281.950279	0.576482	0.19524	-0.121562	11.065196	0.002795	2.490727
49	52.960688		2.70294	0.762732	2124.044056	0.536591	0.076584	-0.152639	12.306995	0.003109	1.776346
50	53.154916		2.94786	0.933423	2476.522278	0.625636	0	-0.041803	2.483338	0.000627	2.278919
51	53.334111		3.064392	1.230993	579.712339	0.146451	0	-0.002141	0.010981	0.000003	1.660543
52	53.250132		2.369832	1.024996	459.741651	0.116143	0	-0.056578	0.475738	0.00012	1.762187
53	53.287091		2.822028	1.081459	451.253665	0.113999	0	0	0	0	2.34286
54	53.058479		2.624964	0.713226	1719.859421	0.434483	0	-0.028608	1.775826	0.000449	2.728111
55	53.119887		2.501988	0.829226	726.033788	0.183416	0	-0.030391	0.715461	0.000181	2.058958
56	53.031188		2.500788	0.69899	1961.938069	0.495638	0.060732	-0.019904	2.538194	0.000641	2.319186
57	53.140481		2.429328	0.865926	2552.905923	0.644933	0	-0.016307	1.149161	0.00029	1.820144
58	53.187776		2.854074	0.987825	2151.436645	0.543511	0	-0.048411	0.719734	0.000182	1.490163
59	53.447709		3.223644	1.379344	658.713875	0.166409	0	-0.022201	0.051754	0.000013	3.582389
60	53.624537		3.716148	1.73988	727.523569	0.183792	0	0	0	0	1.825347
61	53.696157		3.908088	1.884746	849.501392	0.214607	0	0	0	0	1.301411
62	53.448554		3.75582	1.512122	1855.481946	0.468745	0	0	0	0	1.622093
63	53.294306		2.893416	1.234243	1356.192704	0.342611	0	0	0	0	1.117813
64	53.250965		2.651664	1.045963	1972.840147	0.498392	0	-0.00101	0.003461	0.000001	1.649616
65	53.419714		3.364776	1.372157	3283.539911	0.82951	0	-0.001864	0.039995	0.00001	2.073
66	53.6373		3.609396	1.769132	1710.020218	0.431997	0	0	0	0	1.88162
67	53.475612		3.516912	1.466246	1771.635031	0.447563	0	0	0	0	1.409998
68	53.51041		3.15384	1.451697	1250.67203	0.315953	0	0	0	0	1.223233
69	53.450321		3.235338	1.344606	1995.365037	0.504083	0	0	0	0	1.43984
70	53.515259		3.591252	1.518404	1440.933808	0.364019	0	0	0	0	1.822492
71	53.476114		3.387084	1.53471	705.880196	0.178324	0	0	0	0	2.539029
72	53.419706		3.010836	1.341256	562.652732	0.142141	0	0	0	0	1.724203
73	53.332952		2.632212	1.125798	2174.425626	0.549318	0	0	0	0	0.8839
74	53.300807		2.338488	1.099683	2395.892167	0.605267	0	-0.002181	0.072942	0.000018	0.865462
75	53.123935		2.474076	0.776208	2299.946565	0.581028	0	-0.009269	0.523341	0.000132	1.851546
76	53.218503		2.530692	0.972408	2208.632717	0.55796	0	-0.000228	0.002419	0.000001	1.147585
77	53.534922		3.330876	1.534372	2219.057134	0.560594	0	0	0	0	1.207024
78	53.572371		3.22662	1.607565	2327.138651	0.587898	0	0	0	0	2.209455
79	53.452682		2.842008	1.33013	2169.856249	0.548164	0	0	0	0	1.192029
80	53.426523		3.11136	1.293591	2512.440591	0.63471	0	0	0	0	2.033969
81	53.426583		3.229348	1.392611	2850.96688	0.720231	0	0	0	0	1.850114
82	53.37598		2.794512	1.241301	2574.199722	0.650312	0	0	0	0	2.554421
83	53.298703		2.732928	1.221643	2401.256585	0.606622	0	0	0	0	1.699465
84	53.509003		3.575304	1.545573	1380.645921	0.348788	0	0	0	0	2.023397
85	53.43167		3.414096	1.346946	2625.23376	0.663205	0	0	0	0	0.979114
86	53.336172		2.73648	1.184967	2604.81769	0.658047	0	-0.00158	0.070594	0.000018	1.082595
87	53.369266		2.791296	1.234428	1310.617318	0.331097	0	0	0	0	2.197165
88	53.175495		2.372556	0.906494	2376.371838	0.600335	0	-0.000317	0.007731	0.000002	1.957179
89	53.188309		2.368476	0.910449	2395.348775	0.60513	0	-0.001187	0.041077	0.00001	1.618929
90	53.273625		2.457864	1.053039	2542.670375	0.642347	0	-0.000798	0.044068	0.000011	1.200001
91	53.281464		3.437916	1.092797	2024.689441	0.511491	0	-0.012074	0.05943	0.000015	1.091213
92	53.633693		3.758928	1.792051	3091.887782	0.781094	0	0	0	0	2.175773
93	53.480168		3.569604	1.530058	2848.013999	0.719485	0	0	0	0	1.816315
94	53.489199		4.145316	1.475355	2930.075084	0.740216	0	0	0	0	1.903931
95	53.623042		3.74436	1.92101	1779.337184	0.449508	0	0	0	0	2.303194
96	53.509378		2.965548	1.495026	2719.222167	0.686949	0	0	0	0	1.358814

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97	53.599478		3.513282	1.600791	2791.643085	0.705244	0	0	0	0	0.850115
98	53.59818		3.43122	1.620373	2820.223029	0.712464	0	0	0	0	1.838096
99	53.615744		3.217608	1.64928	3025.200927	0.764247	0	0	0	0	1.090048
100	53.668243		3.485868	1.75524	3217.139843	0.812736	0	0	0	0	0.772489
101	53.75264		3.811506	2.096871	2997.923264	0.757356	0	0	0	0	2.412347
102	53.439871		3.05586	1.500629	2617.804288	0.661328	0	0	0	0	1.339604
103	53.268463		2.63334	1.17823	2485.42	0.627884	0	-0.000852	0.021802	0.000006	1.826627
104	53.33827		3.209412	1.24381	2354.396499	0.594784	0	0	0	0	1.691152
105	53.482062		3.29028	1.482018	3035.611171	0.766877	0	-0.001202	0.029007	0.000007	1.601325
106	53.538122		3.508884	1.540178	2943.825753	0.74369	0	0	0	0	2.301182
107	53.320838		3.001812	1.237745	2326.626573	0.587768	0	-0.000665	0.010329	0.000003	0.980519
108	53.383116		3.1611	1.304186	2690.34437	0.679653	0	0	0	0	1.690586
109	53.505692		3.29799	1.44759	3166.113984	0.799846	0	0	0	0	1.516674
110	53.406941		3.116616	1.342382	2577.81972	0.651227	0	0	0	0	1.269176
111	53.489598		3.535632	1.487614	3336.752659	0.842953	0	0	0	0	1.727497
112	53.561064		3.456276	1.571858	2836.433883	0.716559	0	0	0	0	1.673414
113	53.54178		3.733476	1.592118	3189.7434	0.805815	0	0	0	0	1.67531
114	53.519205		3.447864	1.527438	3283.268079	0.829442	0	0	0	0	2.177283
115	53.556894		3.106632	1.521819	2742.301102	0.692779	0	0	0	0	2.369374
116	53.600177		3.552792	1.777987	3260.375295	0.823658	0	0	0	0	2.353248
117	53.435717		3.355104	1.427005	3060.635844	0.773199	0	0	0	0	1.737142
118	53.332613		2.9817	1.170657	2852.015782	0.720496	0	0	0	0	1.359588
119	53.378359		3.159276	1.331707	3017.640499	0.762337	0	0	0	0	1.822779
120	53.397498		3.384552	1.299024	3329.410739	0.841099	0	0	0	0	1.453211
121	53.468252		3.558564	1.487898	3507.183039	0.886009	0	-0.00036	0.000229	0	2.057399
122	53.473386		3.332136	1.541055	3432.506497	0.867143	0	0	0	0	1.158168
123	53.400231		2.997432	1.307208	2616.028821	0.660879	0	0	0	0	1.440692
124	53.606933		3.353952	1.72367	3855.176196	0.973921	0	0	0	0	1.440514
125	53.642746		3.42474	1.747575	3546.194865	0.895864	0	0	0	0	1.660592
126	53.547616		3.244284	1.605279	3506.051867	0.885723	0	0	0	0	1.299834
127	53.419892		2.9502	1.374576	2974.531369	0.751447	0	0	0	0	1.982242
128	53.30811		3.180828	1.138512	3317.525213	0.838096	0	-0.010566	0.103962	0.000026	2.641646
129	53.450563		3.175032	1.471896	3349.785566	0.846246	0	-0.019778	0.264764	0.000067	1.618386
130	53.559787		3.374076	1.641566	3548.776125	0.896516	0	0	0	0	1.727962
131	53.49201		3.282936	1.46003	3380.927135	0.854113	0	0	0	0	1.963997
132	53.518234		3.418536	1.560092	2878.407283	0.727163	0	0	0	0	2.002595
133	53.51293		3.31626	1.518776	3729.539241	0.942182	0	0	0	0	2.001964
134	53.366929		3.41166	1.221149	3141.187629	0.793548	0	0	0	0	2.025311
135	53.394545		3.158448	1.37987	3330.959412	0.84149	0	0	0	0	1.973526
136	53.303426		3.127368	1.308207	2909.06646	0.734908	0	0	0	0	2.613389
137	53.238344		3.01704	1.139864	2981.007931	0.753083	0	-0.027872	1.130466	0.000286	2.112449
138	53.021267		2.5761	0.719284	2468.312274	0.623562	0	-0.055014	3.524302	0.00089	1.447039
139	53.138309		2.702184	0.829581	2819.051664	0.712168	0	-0.014695	0.792038	0.0002	1.572328
140	53.27172		2.886744	1.0598	2582.448183	0.652396	0	-0.024226	0.594801	0.00015	1.151624
141	53.54173		3.480408	1.539053	3575.38091	0.903237	0	0	0	0	2.024931
142	53.463057		3.265092	1.438323	3293.681437	0.832073	0	0	0	0	1.92466
143	53.359121		2.94222	1.25173	2965.337124	0.749124	0	0	0	0	2.079193
144	53.303444		2.99112	1.103068	2913.449123	0.736016	0	-0.063984	0.564996	0.000143	1.443299
145	53.427858		3.309048	1.431902	3184.368775	0.804457	0	-0.000156	0.001385	0	2.345799
146	53.498498		3.392088	1.604123	3368.719658	0.851029	0	0	0	0	3.164742
147	53.293785		3.063612	1.272701	3316.467876	0.837829	0	-0.030634	0.940983	0.000238	1.289714

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148	53.433426		3.09324	1.490452	3107.443826	0.785024	0	0	0	0	1.915172
149	53.398084		3.134592	1.393902	3356.002601	0.847817	0	0	0	0	2.208514
150	53.312364		3.024876	1.156237	3114.220792	0.786736	0	-0.025779	0.311883	0.000079	4.794884
151	53.233411		2.913276	1.07634	2868.268875	0.724602	0	-0.105441	4.176428	0.001055	3.730022
152	53.5305		3.465936	1.729918	3085.523734	0.779486	0	0	0	0	1.980352
153	53.604159		3.706572	1.770166	3613.401715	0.912842	0	0	0	0	2.185999
154	53.734707		3.84702	1.990149	3875.205424	0.978981	0	0	0	0	2.639818
155	53.788102		4.48554	2.269256	3838.520462	0.969714	0	0	0	0	2.046401
156	53.793358		4.440204	2.045128	3329.597085	0.841146	0	0	0	0	2.867186
157	53.860898		4.351128	2.237627	4069.606016	1.028092	0	0	0	0	2.606628
158	53.801069		3.726486	1.936978	3763.3391	0.950721	0	-0.009691	0.117821	0.00003	2.070918
159	53.866654		4.389372	2.148623	4256.513804	1.07531	0	0	0	0	2.82407
160	53.923118		4.119048	2.17041	4043.700101	1.021547	0	0	0	0	2.789551
161	53.834103		4.327884	2.317087	3987.158439	1.007263	0	0	0	0	4.026186
162	53.725161		3.932868	2.087387	3792.456703	0.958077	0	0	0	0	2.789402
163	53.604074		3.442176	1.76912	3388.613258	0.856055	0	0	0	0	2.766121
164	53.753592		4.048344	2.190211	3871.249317	0.977982	0	0	0	0	3.669976
165	53.782313		4.322556	2.234348	3868.52857	0.977294	0	0	0	0	3.575969
166	53.696948		3.854232	1.976375	3893.225328	0.983533	0	0	0	0	3.610175
167	53.648074		3.66198	1.738332	3765.789299	0.95134	0	0	0	0	3.677591
168	53.391359		3.090972	1.282917	3234.196463	0.817045	0	-0.001449	0.005913	0.000001	2.884045
169	53.458493		3.137448	1.467705	3239.486949	0.818382	0	-0.000748	0.002353	0.000001	2.097887
170	53.687853		4.048512	2.001706	3569.706288	0.901804	0	0	0	0	2.316065
171	53.593773		3.3837	1.664015	3381.230351	0.85419	0	0	0	0	2.187839
172	53.719526		3.501036	1.876447	3556.531459	0.898475	0	0	0	0	2.790461
173	53.620555		3.676692	1.788808	3446.978758	0.8708	0	0	0	0	2.564722
174	53.613486		3.603084	1.779397	3448.126246	0.871089	0	0	0	0	2.947686
175	53.719161		3.842088	1.85844	3294.228661	0.832211	0	0	0	0	2.862471
176	53.597277		3.411024	1.685364	3691.917747	0.932678	0	0	0	0	2.496802
177	53.594869		3.578292	1.750712	3408.927704	0.861187	0	-0.008114	0.033787	0.000009	2.319678
178	53.800703		3.822054	2.075337	3588.602184	0.906577	0	0	0	0	3.224592
179	53.693513		3.551568	1.920842	3520.24828	0.889309	0	0	0	0	3.76939
180	53.490794		3.252432	1.563103	3302.113013	0.834203	0	0	0	0	3.125923
181	53.594504		3.430848	1.6972	2862.430759	0.723127	0	0	0	0	1.653647
182	53.663211		3.58356	1.804529	3745.732891	0.946273	0	0	0	0	1.356252
183	53.700106		3.7605	1.900391	3672.52561	0.927779	0	0	0	0	0.713312
184	53.685317		3.543144	1.878945	3621.933341	0.914998	0	0	0	0	1.524446
185	53.553595		3.353556	1.757119	3394.516302	0.857546	0	-0.004395	0.044038	0.000011	1.374168
186	53.52791		3.899016	1.660857	3300.113178	0.833697	0	0	0	0	1.668802
187	53.46858		3.067752	1.470689	3182.444543	0.803971	0	0	0	0	1.189165
188	53.520422		3.373572	1.464802	3295.989816	0.832656	0	0	0	0	2.521828
189	53.465038		3.520728	1.427591	3276.323317	0.827687	0	-0.000945	0.006542	0.000002	2.36461
190	53.357495		3.260016	1.224212	3048.9447	0.770245	0	-0.001905	0.053601	0.000014	1.689323
191	53.321837		2.930952	1.132246	3186.517843	0.805	0	0	0	0	1.527875
192	53.31076		2.848752	1.073818	2478.231919	0.626068	0	0	0	0	1.868054
193	53.428644		3.31734	1.431673	3099.235014	0.78295	0	0	0	0	1.300586
194	53.388455		3.113388	1.264729	2936.570096	0.741857	0	0	0	0	0.97672
195	53.541322		4.00254	1.74829	3637.320782	0.918885	0	-0.000243	0.002433	0.000001	2.06177
196	53.755032		4.170108	1.884864	3136.439669	0.792349	0	0	0	0	3.822782
197	53.755377		3.963372	2.067806	3633.709988	0.917973	0	-0.000942	0.003116	0.000001	4.19249
198	53.593025		3.84738	1.622785	3445.085659	0.870321	0	0	0	0	3.437173

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199	53.45525		3.155316	1.34049	2786.609571	0.703973	0	0	0	0	3.166472
200	53.535208		3.288852	1.627784	3226.165042	0.815016	0	0	0	0	2.290203
201	53.388375		3.248652	1.303945	2831.42635	0.715294	0	-0.001478	0.009427	0.000002	2.302711
202	53.433124		2.841528	1.436752	2528.338195	0.638726	0	0	0	0	3.909537
203	53.376583		3.4206	1.326588	2721.667448	0.687566	0	0	0	0	3.176323
204	53.202013		2.665061	1.024023	2531.375783	0.639494	0	-0.008042	0.492966	0.000125	1.627067
205	53.175495		2.763168	0.87349	2588.221904	0.653854	0	-0.021359	0.334111	0.000084	0.82764
206	53.408184		3.169956	1.365915	2861.224022	0.722822	0	0	0	0	1.551119
207	53.671704		3.3639	1.858978	3129.009219	0.790472	0	-0.06722	0.279647	0.000071	1.550259
208	53.622981		3.609924	1.743381	3570.42104	0.901984	0	0	0	0	1.937432
209	53.525367		3.363744	1.539998	3409.364687	0.861297	0	0	0	0	2.178353
210	53.493147		3.327768	1.489755	3212.708231	0.811617	0	0	0	0	2.035585
211	53.54735		3.26466	1.596919	2978.529452	0.752457	0	0	0	0	2.023335
212	53.687519		3.522312	1.81196	3438.577275	0.868677	0	0	0	0	1.215047
213	53.695947		3.507372	1.804016	3500.755471	0.884385	0	0	0	0	0.856036
214	53.624889		3.27762	1.687123	3219.730915	0.813391	0	0	0	0	0.890377
215	53.640156		3.027588	1.719526	2939.291963	0.742544	0	0	0	0	0.536501
216	53.545676		2.991036	1.580798	3408.329116	0.861036	0	0	0	0	0.677985
217	53.486569		2.946036	1.440426	3174.304227	0.801915	0	0	0	0	1.279865
218	53.393556		2.84496	1.281928	2349.645277	0.593584	0	0	0	0	1.311302
219	53.375662		3.112728	1.349438	3369.565326	0.851243	0	-0.000504	0.017431	0.000004	1.105284
220	53.177703		2.540892	0.933009	2124.457714	0.536695	0	-0.004245	0.094406	0.000024	0.601701
221	53.254434		2.813272	1.079612	2419.050624	0.611117	0	-0.001051	0.069179	0.000017	0.793047
222	53.267314		2.797032	1.053204	2458.572353	0.621101	0	-0.003065	0.106568	0.000027	1.334636
223	53.333102		2.899128	1.214236	3220.210522	0.813512	0	0	0	0	3.133528
224	53.551806		3.113796	1.637466	2950.277346	0.745319	0	-0.105511	2.595029	0.000656	0.888978
225	53.663585		3.59184	1.86714	3870.510228	0.977795	0	0	0	0	1.805633
226	53.610998		3.14286	1.684454	3358.889239	0.848546	0	0	0	0	1.63528
227	53.335882		2.898924	1.208194	2600.346368	0.656917	0	0	0	0	0.905971
228	53.389987		2.79996	1.307666	2913.767694	0.736096	0	-0.000736	0.031093	0.000008	0.899752
229	53.53118		3.179592	1.51286	3041.523799	0.768371	0	0	0	0	0.900065
230	53.259638		2.539896	1.063982	2506.113833	0.633112	0	-0.002678	0.235094	0.000059	0.588038
231	53.327916		2.533356	1.16239	2367.149198	0.598006	0	-0.032488	1.0238	0.000259	0.873689
232	53.232159		2.535876	1.032589	2356.635461	0.595349	0	-0.003871	0.103648	0.000026	0.720458
233	53.190274		2.749986	0.920654	2874.886672	0.726274	0	-0.003907	0.041989	0.000011	2.344895
234	53.349416		2.747376	1.235176	2540.399675	0.641773	0	0	0	0	1.265656
235	53.347963		2.743104	1.191982	3194.900985	0.807118	0	0	0	0	0.92052
236	53.267575		2.654796	1.066647	2484.295317	0.6276	0	-0.00196	0.191281	0.000048	1.562669
237	53.310827		2.805864	1.123892	2838.48103	0.717077	0	0	0	0	1.356332
238	53.231187		2.992344	1.009051	2780.765854	0.702496	0	-0.014832	0.018013	0.000005	2.033185
239	53.289778		2.812812	1.112092	2884.420432	0.728682	0	-0.001486	0.014626	0.000004	1.573376
240	53.384797		3.234192	1.348547	2993.170149	0.756155	0	0	0	0	1.613928
241	53.475334		3.347178	1.489148	3102.701073	0.783826	0	0	0	0	1.018766
242	53.348439		3.111516	1.256052	3185.232319	0.804675	0	0	0	0	2.457215
243	53.41343		3.088296	1.438322	2457.633868	0.620864	0	0	0	0	1.348611
244	53.321062		2.771952	1.176081	2605.729656	0.658277	0	-0.0004	0.004761	0.000001	1.268802
245	53.400565		2.928252	1.330861	2656.366106	0.67107	0	-0.000155	0.008522	0.000002	1.414377
246	53.387518		2.7999	1.343058	2619.047468	0.661642	0	-0.056092	0.42181	0.000107	1.334545
247	53.467071		3.182688	1.460252	3212.054273	0.811451	0	0	0	0	2.107416
248	53.526719		3.18906	1.558648	2699.724632	0.682023	0	0	0	0	1.723568
249	53.357915		3.244128	1.222003	2608.25213	0.658915	0	-0.000827	0.032194	0.000008	1.939675

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250	53.322984		2.958444	1.168864	2511.005497	0.634348	0	0	0	0	1.419169
251	53.202639		2.545188	0.922428	2620.292365	0.661956	0	-0.016365	0.719295	0.000182	1.21691
252	53.174187		2.646144	0.903614	2032.377722	0.513433	0.007368	-0.003036	0.188303	0.000048	1.553668
253	53.316482		2.53572	1.152611	2586.330861	0.653377	0	-0.004558	0.104038	0.000026	0.985791
254	53.153613		2.139864	0.893043	2216.466888	0.559939	0	-0.001509	0.019962	0.000005	0.694898
255	53.101212		2.236764	0.773124	2095.101844	0.529279	0	-0.011302	0.831039	0.00021	0.630043
256	53.170501		2.432172	0.944756	2338.680512	0.590814	0	-0.005696	0.290846	0.000073	0.781524
257	53.221652		2.482452	1.044228	2473.088211	0.624769	0	-0.004537	0.354225	0.000089	1.55151
258	53.241864		2.82378	1.028802	2581.245402	0.652092	0	-0.001168	0.06353	0.000016	0.799417
259	53.265509		2.683452	1.066711	2731.079679	0.689944	0	-0.001347	0.006463	0.000002	0.578433
260	53.292784		2.853366	1.135229	2961.647679	0.748192	0	-0.000839	0.006332	0.000002	0.758523
261	53.322802		2.606508	1.170667	2306.667573	0.582726	0	0	0	0	0.72002
262	53.465198		3.372252	1.429498	3107.397973	0.785012	0	0	0	0	1.281573
263	53.49867		3.197616	1.488791	3274.323345	0.827182	0	0	0	0	1.035914
264	53.388964		2.947524	1.329989	2897.751047	0.73205	0	-0.116752	6.591109	0.001665	1.650508
265	53.347407		2.6421	1.205367	2521.388553	0.636971	0	0	0	0	2.759855
266	53.384392		2.694816	1.266382	2802.923666	0.708094	0	0	0	0	1.414135
267	53.294207		2.943378	1.113053	2699.131817	0.681873	0	-0.000645	0.008961	0.000002	1.159046
268	53.324834		2.808696	1.174616	2858.583825	0.722155	0	-0.000495	0.003801	0.000001	1.509566
269	53.318016		2.708736	1.142354	2498.202285	0.631113	0	0	0	0	2.437982
270	53.169408		2.7756	0.86641	2528.222758	0.638697	0	-0.00353	0.067105	0.000017	1.388119
271	53.151656		2.599056	0.87924	2257.886736	0.570403	0	-0.003726	0.118048	0.00003	1.516344
272	53.234771		2.672748	1.043435	2874.833759	0.72626	0	-0.006792	0.120358	0.00003	2.242666
273	53.054944		2.510916	0.675542	2225.773822	0.56229	0	-0.018692	1.595701	0.000403	1.469413
274	53.224116		2.594544	0.984034	2585.417986	0.653146	0	-0.005798	0.138378	0.000035	1.447414
275	53.109752		2.782488	0.807268	2343.862411	0.592123	0	-0.0032	0.107919	0.000027	1.545826
276	53.083729		2.358864	0.734056	2327.055387	0.587877	0	-0.013078	0.997214	0.000252	0.937861
277	53.127645		2.371704	0.865492	2115.390018	0.534404	0.1269	-0.007746	0.71059	0.00018	0.800086
278	53.197594		2.584872	0.961154	2270.082535	0.573484	0.017952	-0.008712	0.439601	0.000111	1.676018
279	53.191488		2.389194	0.966746	2464.249519	0.622536	0	-0.002373	0.302545	0.000076	0.76669
280	53.513131		2.815044	1.48991	2429.883714	0.613854	0	0	0	0	0.705969
281	53.479204		3.061644	1.432644	2864.826035	0.723732	0	0	0	0	1.274783
282	53.351796		2.64822	1.223912	2839.293252	0.717282	0	0	0	0	1.23766
283	53.28079		2.653368	1.111838	2440.312376	0.616489	0	-0.000304	0.012726	0.000003	1.41048
284	53.098266		2.554248	0.796932	2554.472781	0.645329	0	-0.008963	0.411209	0.000104	1.022747
285	53.137505		2.370828	0.838289	2018.442184	0.509913	0	-0.016582	0.185004	0.000047	1.590574
286	53.331641		2.680224	1.197048	2795.677663	0.706263	0	-0.016395	0.751429	0.00019	1.49736
287	53.509293		3.391068	1.593342	2644.951442	0.668186	0	-0.047316	5.764913	0.001456	1.855392
288	53.659009		3.358128	1.754528	2958.678689	0.747442	0	-0.001721	0.016819	0.000004	1.593862
289	53.202909		2.558268	0.92627	2347.077929	0.592935	0	-0.003696	0.013991	0.000004	2.351325
290	53.280796		2.348028	1.090774	2194.222123	0.55432	0	-0.000408	0.015902	0.000004	0.73602
291	53.121975		2.428662	0.837965	2145.64638	0.542048	0	-0.009484	1.598943	0.000404	0.720152
292	53.00667		2.179968	0.660236	1964.195099	0.496209	0.091224	-0.011741	1.869394	0.000472	1.059888
293	53.15124		2.157924	0.876034	2156.402438	0.544765	0.104784	-0.013514	0.768113	0.000194	0.767405
294	53.316238		2.823396	1.187241	2671.379255	0.674862	0	-0.000578	0.021392	0.000005	1.105401
295	53.374438		2.70978	1.249046	2834.495812	0.71607	0	0	0	0	0.835286
296	53.273606		2.458824	1.057305	2429.951748	0.613871	0	-0.000454	0.007343	0.000002	0.779278
297	53.280368		2.321976	1.076994	2325.108105	0.587385	0.005532	-0.002642	0.293511	0.000074	0.733997
298	53.372727		2.673036	1.244995	2294.388013	0.579624	0	-0.000617	0.020257	0.000005	1.017405
299	53.257828		2.554596	1.014065	2675.505719	0.675905	0	-0.000972	0.029432	0.000007	0.75235
300	53.259485		2.696976	1.032615	2625.676692	0.663317	0	-0.002054	0.04467	0.000011	0.973313

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301	53.331334		2.590572	1.153533	2566.945664	0.64848	0	-0.000267	0.004664	0.000001	0.595235
302	53.328088		2.519952	1.143755	2554.718085	0.64539	0	-0.000335	0.008102	0.000002	0.729127
303	53.272346		2.307204	1.068966	2573.162713	0.65005	0	-0.022138	0.63977	0.000162	0.858582
304	53.283902		2.594568	1.066197	2405.726588	0.607751	0	0	0	0	2.457922
305	53.497272		2.832336	1.456106	3136.609075	0.792392	0	0	0	0	1.540745
306	53.454858		2.839836	1.432432	3038.211417	0.767534	0	0	0	0	1.508541
307	53.458378		2.954304	1.42204	3236.848311	0.817715	0	0	0	0	1.148407
308	53.484432		2.795376	1.496896	2652.818729	0.670173	0	0	0	0	0.442845
309	53.559118		3.231588	1.705395	3188.2786	0.805445	0	0	0	0	1.186926
310	53.57021		3.254184	1.690651	2803.927827	0.708348	0	0	0	0	1.926749
311	53.341623		2.60496	1.194686	2804.668836	0.708535	0	-0.001537	0.080833	0.00002	0.583284
312	53.293214		2.690628	1.088582	2407.502621	0.6082	0	-0.036116	0.487371	0.000123	0.848822
313	53.069978		2.401656	0.726502	2335.638787	0.590045	0	-0.016661	0.878422	0.000222	1.176502
314	53.28361		2.94432	1.094978	2750.316354	0.694804	0	-0.006768	0.141108	0.000036	1.390477
315	53.428184		2.930724	1.294347	3062.145838	0.77358	0	0	0	0	2.278064
316	53.474228		3.222972	1.412242	2735.676535	0.691105	0	0	0	0	1.856686
317	53.497562		2.984712	1.475459	3044.958803	0.769238	0	0	0	0	0.773152
318	53.276776		2.601264	1.147248	2658.197149	0.671532	0	-0.002109	0.068049	0.000017	1.045537
319	53.102458		2.134272	0.815693	2142.956311	0.541368	0	-0.003749	0.218676	0.000055	2.732154
320	53.143018		2.508024	0.833894	2457.91479	0.620935	0	-0.008451	0.542863	0.000137	0.970545
321	53.117736		3.128172	1.012615	2498.08887	0.631084	0	-0.07908	36.194886	0.009144	3.287175
322	53.3002		2.821476	1.118057	2771.124338	0.700061	0	-0.001691	0.007964	0.000002	1.770387
323	53.230356		2.376384	0.975895	2463.546601	0.622358	0	-0.000636	0.00929	0.000002	0.648924
324	53.298469		2.6538	1.110272	2510.00799	0.634096	0	-0.000449	0.01171	0.000003	1.035451
325	53.144521		2.160936	0.863192	2097.641805	0.529921	0	-0.003395	0.068494	0.000017	0.902289
326	53.205153		2.26974	0.979662	2257.02079	0.570184	0	-0.002646	0.291619	0.000074	1.773361
327	53.104979		2.292564	0.813798	2220.082451	0.560853	0	-0.01294	0.711711	0.00018	1.413086
328	53.121623		2.466204	0.823863	2276.506842	0.575107	0	-0.017102	0.385203	0.000097	1.804167
329	53.124183		2.491284	0.830122	2326.284796	0.587682	0	-0.011881	0.728904	0.000184	2.171837
330	53.15833		2.134596	0.926481	2030.720812	0.513015	0	-0.002827	0.153984	0.000039	1.340167
331	53.252406		2.82552	1.09088	2264.032436	0.571955	0	-0.001997	0.074607	0.000019	1.149702
332	53.214654		2.772312	0.98731	2644.86642	0.668164	0	-0.005081	0.008753	0.000002	2.993878
333	53.343024		2.973252	1.264648	2390.003208	0.603779	0	0	0	0	1.12311
334	53.309712		2.70612	1.180152	2432.990874	0.614639	0	-0.000906	0.015341	0.000004	0.534662
335	53.364095		2.80638	1.272458	2580.142784	0.651813	0	-0.00084	0.043021	0.000011	1.227038
336	53.145951		2.39334	0.872084	2104.451873	0.531641	0	-0.01402	1.290254	0.000326	1.842186
337	53.255481		2.257248	1.047993	2435.10288	0.615172	0	-0.000017	0.001223	0	1.507337
338	53.268614		2.541672	1.024612	2232.250529	0.563927	0	-0.00007	0.00464	0.000001	1.273035
339	53.298929		2.322288	1.099792	2218.914943	0.560558	0	-0.000249	0.003932	0.000001	1.013563
340	53.249117		2.70024	1.020513	2355.408211	0.595039	0	-0.011037	0.047614	0.000012	1.114936
341	53.081489		2.263608	0.738862	2191.615902	0.553661	0	-0.035835	3.183612	0.000804	1.214364
342	53.072408		2.327388	0.729342	2240.159658	0.565925	0	-0.016728	0.448006	0.000113	1.292862
343	53.044109		2.337456	0.723551	2027.4106	0.512178	0.069936	-0.101858	3.45977	0.000874	2.528567
344	53.132191		2.348436	0.826403	2353.146584	0.594468	0	-0.013239	0.214052	0.000054	1.630658
345	53.115684		2.167464	0.842875	2105.738466	0.531966	0	-0.032431	0.437156	0.00011	1.664091
346	53.250693		2.614752	1.030329	2468.229257	0.623541	0	-0.003922	0.073849	0.000019	1.334279
347	53.293455		2.859204	1.131952	2629.491792	0.66428	0	-0.006428	0.314111	0.000079	1.417248
348	53.316885		2.99106	1.185939	2687.914382	0.679039	0	0	0	0	1.702784
349	53.423764		2.838972	1.324848	2266.076397	0.572472	0	0	0	0	0.819148
350	53.517367		3.544116	1.523501	2994.04237	0.756376	0	0	0	0	1.046142
351	53.494357		3.247836	1.460617	2841.252024	0.717777	0	0	0	0	1.138872

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352	53.624363		3.32106	1.770072	3197.453273	0.807763	0	0	0	0	1.325158
353	53.563159		3.18528	1.631254	3067.13888	0.774842	0	0	0	0	1.496641
354	53.409488		2.792196	1.31692	2677.163388	0.676323	0	0	0	0	1.159391
355	53.355065		3.019332	1.22379	2656.958595	0.671219	0	-0.000278	0.000924	0	1.183168
356	53.093192		2.721444	0.734115	2329.877965	0.58859	0	-0.014862	0.336261	0.000085	1.464067
357	53.10043		2.192532	0.757226	2162.684239	0.546352	0	-0.009593	0.517408	0.000131	0.839012
358	53.016249		2.254476	0.644118	2134.448332	0.539219	0	-0.040498	3.156634	0.000797	1.253077
359	53.146295		2.632776	0.82694	2326.285969	0.587682	0	-0.011941	0.158391	0.00004	1.113281
360	53.458666		3.179832	1.450449	2998.510464	0.757504	0	0	0	0	1.510554
361	53.522554		3.267684	1.515048	2958.563204	0.747413	0	0	0	0	2.687498
362	52.737684		3.427284	1.120222	2173.925606	0.549192	0	-0.407993	370.818668	0.093679	5.52125
363	53.587106		3.730788	1.67702	3320.502571	0.838848	0	0	0	0	1.968483
364	53.377951		3.132672	1.288497	2760.916532	0.697482	0	-0.001459	0.044014	0.000011	1.323194
365	53.633917		3.55128	1.740596	2952.418961	0.74586	0	0	0	0	1.269164
366	53.216427		3.139356	1.015384	2585.051271	0.653053	0	-0.053663	6.336497	0.001601	1.053961
367	53.664104		3.035268	1.770175	3191.34658	0.80622	0	-0.009337	0.097739	0.000025	0.805541
368	53.52209		3.049428	1.570906	2595.244106	0.655628	0	-0.004286	0.034563	0.000009	1.067103
369	53.452901		2.894076	1.395865	3014.98161	0.761665	0	-0.000437	0.00329	0.000001	0.970257
370	53.489062		2.927316	1.46022	2947.169845	0.744534	0	0	0	0	1.154058
371	53.464764		2.9388	1.405369	2764.010864	0.698263	0	0	0	0	0.762718
372	53.450505		2.797452	1.36281	2915.838497	0.736619	0	0	0	0	1.409383
373	53.473966		3.12336	1.41614	3054.976127	0.771769	0	0	0	0	1.161542
374	53.560857		3.836028	1.615321	3397.511662	0.858303	0	0	0	0	0.858092
375	53.490276		3.327012	1.466094	3110.277427	0.78574	0	0	0	0	1.074865
376	53.570982		3.1716	1.624221	3184.170606	0.804407	0	0	0	0	0.876485
377	53.502888		3.432648	1.503617	3110.751811	0.78586	0	0	0	0	1.494876
378	53.493599		3.152208	1.487327	2918.951365	0.737406	0	0	0	0	1.008579
379	53.553789		2.826984	1.566869	3224.858681	0.814686	0	0	0	0	0.866039
380	53.43009		2.707584	1.350725	2591.240709	0.654617	0	0	0	0	0.459303
381	53.484921		2.81556	1.434376	3150.43744	0.795885	0	0	0	0	0.67091
382	53.248807		2.729208	1.010274	2673.518962	0.675403	0	-0.001834	0.092888	0.000023	0.831372
383	53.342606		2.577624	1.214578	2610.801758	0.659559	0	0	0	0	0.710994
384	53.463988		2.842956	1.417858	3011.92514	0.760893	0	0	0	0	0.916625
385	53.302641		2.652252	1.098963	2442.896483	0.617141	0	-0.000101	0.000251	0	1.969244
386	53.394997		3.01026	1.279166	2956.084468	0.746786	0	0	0	0	1.295982
387	53.295927		3.046344	1.146634	2880.484311	0.727688	0	-0.00059	0.006521	0.000002	1.912201
388	53.335037		2.652384	1.165244	2509.209457	0.633894	0	0	0	0	1.263438
389	53.289957		2.668596	1.083932	2638.564303	0.666572	0	-0.006509	0.023617	0.000006	2.197327
390	53.543805		3.179772	1.569252	3289.01956	0.830895	0	0	0	0	1.273158
391	53.57795		2.982192	1.580586	2802.241116	0.707921	0	0	0	0	0.924351
392	53.534142		2.905296	1.531978	3068.680047	0.775231	0	0	0	0	0.986855
393	53.489602		2.997504	1.49553	3030.389186	0.765558	0	0	0	0	1.202074
394	53.579949		3.427488	1.615607	3196.212963	0.807449	0	-0.00024	0.001583	0	0.826959
395	53.629539		3.074448	1.711325	3045.262789	0.769315	0	0	0	0	1.328585
396	53.52937		3.017556	1.536431	2986.166142	0.754386	0	0	0	0	1.341353
397	53.672235		3.329214	1.748863	3349.258051	0.846113	0	-0.000006	0.000078	0	1.09484
398	53.741716		3.432756	1.88249	3578.414892	0.904004	0	0	0	0	1.201666
399	54.014752		4.701816	2.332391	2633.917103	0.665398	0	0	0	0	1.186645
400	53.417499		2.733636	1.355093	2767.487411	0.699142	0	0	0	0	1.034594
401	53.437486		3.095676	1.456346	2907.482929	0.734508	0	-0.00233	0.057868	0.000015	2.370929
402	53.344394		2.732904	1.195858	2395.678953	0.605213	0	-0.000295	0.007847	0.000002	0.814002

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403	53.389305		2.579772	1.290445	2770.386599	0.699874	0	-0.000209	0.005887	0.000001	0.898515
404	53.304295		2.860584	1.110013	2464.738486	0.622659	0	-0.000087	0.000568	0	0.78306
405	53.288183		2.540544	1.060958	2385.478989	0.602636	0	-0.000036	0.015581	0.000004	0.837279
406	53.392999		2.726352	1.238995	2825.430758	0.71378	0	-0.010546	0.282993	0.000071	1.387465
407	53.475247		3.165204	1.582256	2976.717774	0.751999	0	-0.113152	60.604127	0.01531	0.939965
408	53.534733		3.765444	1.529257	3047.182598	0.7698	0	-0.007586	0.263173	0.000066	0.973229
409	53.336408		2.516052	1.194005	2348.537476	0.593304	0	-0.00024	0.016705	0.000004	1.043122
410	53.290263		2.425236	1.157622	2463.128848	0.622253	0	-0.003165	0.324095	0.000082	0.891799
411	53.292189		2.457672	1.122464	2474.048444	0.625011	0	-0.001017	0.017644	0.000004	0.807566
412	53.186852		2.35152	0.926905	2332.656916	0.589292	0	-0.005644	0.473663	0.00012	0.711478
413	53.308481		2.550828	1.15207	2494.848688	0.630266	0	-0.002033	0.058882	0.000015	1.212983
414	53.442292		2.525364	1.351587	2536.417488	0.640767	0	0	0	0	0.906766
415	53.439442		2.634756	1.368201	2879.598656	0.727464	0	0	0	0	1.192194
416	53.404753		2.383476	1.256013	2674.29185	0.675598	0	0	0	0	0.595499
417	53.252002		2.33316	1.045872	2346.979292	0.59291	0	-0.002505	0.107385	0.000027	1.5602
418	53.214342		2.22564	0.945289	2454.266244	0.620014	0	-0.001062	0.024817	0.000006	0.779013
419	53.132882		2.341008	0.813184	2413.29649	0.609664	0	-0.002524	0.09938	0.000025	1.343952
420	53.112256		2.173752	0.776564	2110.075737	0.533062	0.0726	-0.013241	1.022321	0.000258	1.242972
421	53.037065		2.111028	0.682671	1943.808163	0.491058	0.079596	-0.035919	1.29934	0.000328	2.357948
422	53.008114		2.325804	0.642488	2131.909942	0.538578	0.0774	-0.04133	5.133245	0.001297	2.355979
423	53.054359		2.405784	0.686335	2146.869061	0.542357	0.005352	-0.027875	4.517584	0.001141	1.344467
424	53.168042		2.79732	0.863981	2477.703416	0.625935	0	-0.008648	0.42363	0.000107	1.363344
425	53.263553		2.548368	1.066023	2560.434078	0.646835	0	-0.007927	0.34098	0.000086	1.136464
426	53.33522		2.517864	1.156783	2566.784482	0.648439	0	-0.002072	0.104317	0.000026	0.91254
427	53.475189		3.153552	1.407979	3065.488863	0.774425	0	-0.000044	0.000606	0	0.571074
428	53.537903		2.917152	1.519193	2717.113276	0.686416	0	0	0	0	0.834492
429	53.585576		2.899812	1.620622	3021.243501	0.763247	0	0	0	0	1.786315
430	53.471824		2.720148	1.377936	3016.077945	0.761942	0	0	0	0	1.525253
431	53.669786		3.449064	1.740941	3127.936037	0.790201	0	-0.000171	0.000393	0	1.201541
432	53.652546		3.310716	1.714185	2956.064165	0.746781	0	0	0	0	1.592746
433	53.496567		3.027564	1.419506	3162.822557	0.799014	0	0	0	0	1.559421
434	53.608438		3.005112	1.629469	3311.195095	0.836497	0	0	0	0	1.770124
435	53.644002		3.162108	1.704459	2954.350408	0.746348	0	0	0	0	1.719033
436	53.48968		2.923368	1.416651	3112.166265	0.786217	0	-0.030891	0.312037	0.000079	0.934423
437	53.447037		3.119112	1.410572	2497.077308	0.630829	0	0	0	0	0.548154
438	53.472729		2.88264	1.405553	3028.840276	0.765167	0	-0.002097	0.011698	0.000003	1.104801
439	53.07447		2.747136	0.870244	2384.510756	0.602392	0	-0.075077	28.604546	0.007226	2.126698
440	53.403969		2.936136	1.269818	2919.856501	0.737634	0	-0.002631	0.064094	0.000016	1.218076
441	53.388059		2.978844	1.212256	2528.733026	0.638826	0	-0.000073	0.004155	0.000001	1.20731
442	53.119437		2.42526	0.786792	2454.847811	0.620161	0	-0.004286	0.324817	0.000082	1.193462
443	53.117236		2.293644	0.817888	2320.304602	0.586171	0.031488	-0.011668	0.598935	0.000151	1.017296
444	53.051554		2.18292	0.697809	2013.945807	0.508777	0	-0.017678	1.084985	0.000274	1.234339
445	52.974944		2.083548	0.569876	1884.574394	0.476094	0.23868	-0.032475	4.652762	0.001175	0.907053
446	52.986844		2.189916	0.617804	2100.842178	0.530729	0.140292	-0.023207	2.33204	0.000589	1.624583
447	52.955009		2.136672	0.565498	2149.092923	0.542919	0.08136	-0.036072	7.507232	0.001897	1.652636
448	53.045091		2.311548	0.652365	1963.617862	0.496063	0.1527	-0.01302	0.918193	0.000232	1.301177
449	53.097922		2.469276	0.761342	2359.562451	0.596089	0	-0.006588	0.637374	0.000161	1.351447
450	53.037527		2.15142	0.664692	2092.009991	0.528498	0.031152	-0.011711	1.211077	0.000306	0.634774
451	53.076846		2.149572	0.761538	1895.422146	0.478835	0	-0.007508	0.970451	0.000245	0.884248
452	53.212183		2.251656	0.962891	2398.640416	0.605961	0	-0.025784	0.656172	0.000166	1.03483
453	53.314653		2.439588	1.078441	2618.244565	0.661439	0	-0.000746	0.022641	0.000006	0.602115

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454	53.423624		2.746476	1.320419	2943.708609	0.74366	0	-0.001729	0.043064	0.000011	0.82069
455	53.580216		3.052776	1.590658	3134.275792	0.791802	0	0	0	0	0.625778
456	53.577324		3.082848	1.539423	3348.325715	0.845877	0	0	0	0	1.742348
457	53.633247		3.426744	1.715495	3341.659612	0.844193	0	0	0	0	1.981137
458	53.640968		3.300792	1.726343	3129.86346	0.790688	0	0	0	0	1.050792
459	53.514381		2.855064	1.45117	3054.013683	0.771526	0	0	0	0	0.884366
460	53.491758		3.189588	1.441775	3300.828935	0.833878	0	-0.032078	1.014069	0.000256	1.062608
461	53.585893		2.934396	1.624333	2852.107874	0.720519	0	0	0	0	0.422604
462	53.552553		3.25368	1.50493	3126.501723	0.789838	0	-0.000331	0.004083	0.000001	0.790079
463	53.507467		2.8674	1.440867	2718.712508	0.68682	0	0	0	0	1.358207
464	53.390372		3.039708	1.245944	3163.528869	0.799192	0	-0.000971	0.034684	0.000009	1.905159
465	53.409589		2.660904	1.280309	2593.405493	0.655164	0	-0.000016	0.000173	0	1.167831
466	53.1243		2.1567	0.857104	2187.356125	0.552585	0	-0.003544	0.402035	0.000102	0.933388
467	53.174924		2.177172	0.930772	2185.26905	0.552058	0.073608	-0.004604	0.311605	0.000079	0.92034
468	53.065258		2.39088	0.719397	2340.649594	0.591311	0	-0.030471	2.946964	0.000744	2.270391
469	53.047795		2.275164	0.686078	2266.087161	0.572475	0.093156	-0.013014	0.815842	0.000206	1.400537
470	53.398438		3.884448	1.270092	2414.102895	0.609867	0	-0.004219	0.301628	0.000076	1.722677
471	53.18794		3.630792	0.997692	1980.953753	0.500442	0	-0.01545	2.19765	0.000555	2.457877
472	53.165904		2.858796	0.938596	2486.696104	0.628206	0	-0.011491	1.39845	0.000353	2.346707
473	53.11621		2.3793	0.80955	1848.893472	0.46708	0	-0.013118	0.536212	0.000135	1.131491
474	53.089174		2.392272	0.849882	2555.053287	0.645475	0.061932	-0.012524	1.798229	0.000454	1.2811
475	53.27903		2.84256	1.103683	2645.650208	0.668362	0	-0.005443	0.158805	0.00004	1.734427
476	53.098532		2.391588	0.781759	2354.449366	0.594797	0.142104	-0.016651	1.724338	0.000436	1.081095
477	53.557023		4.003644	1.583587	2873.430412	0.725906	0	-0.004244	0.348032	0.000088	0.88875
478	53.196593		2.509116	0.969302	2674.811975	0.675729	0	-0.004639	0.215262	0.000054	0.907914
479	53.110717		2.690928	0.825775	2370.274275	0.598795	0	-0.006419	0.226797	0.000057	1.382513
480	53.374582		2.816424	1.241239	2627.355946	0.663741	0	-0.003358	0.210086	0.000053	0.807042
481	53.539358		2.975124	1.499038	3083.978973	0.779096	0	0	0	0	1.663387
482	53.51924		2.840748	1.474916	2953.13051	0.74604	0	0	0	0	0.901354
483	53.326908		2.672412	1.174757	2552.94408	0.644942	0	-0.001243	0.016275	0.000004	1.751427
484	53.280565		2.654604	1.080328	2497.513376	0.630939	0	-0.000407	0.006685	0.000002	1.006435
485	53.389118		2.619564	1.269909	3023.494934	0.763816	0	0	0	0	1.050076
486	53.417359		3.13866	1.357473	2537.771372	0.641109	0	-0.000327	0.003351	0.000001	1.159873
487	53.129354		2.988204	1.074819	2260.715211	0.571117	0	-0.139517	70.979906	0.017931	2.709168
488	53.445948		3.126888	1.359612	3265.945502	0.825066	0	0	0	0	3.191581
489	53.184679		2.52306	0.913001	2367.585555	0.598116	0	-0.002266	0.028345	0.000007	1.590746
490	53.032953		2.554788	0.701974	2295.14814	0.579816	0.165426	-0.017161	2.578544	0.000651	0.800572
491	53.406346		2.610972	1.324911	3126.028085	0.789719	0	-0.00124	0.029347	0.000007	0.870479
492	53.489336		2.833128	1.408672	2780.745801	0.702491	0	0	0	0	1.513403
493	53.552849		3.1596	1.538122	3202.098115	0.808936	0	0	0	0	1.502588
494	53.135914		2.6028	0.851549	2369.649086	0.598637	0	-0.009424	1.11302	0.000281	0.794365
495	53.108681		1.987428	0.838452	2024.228368	0.511375	0.088272	-0.011203	1.866386	0.000471	1.602985
496	53.155568		2.345736	0.855529	2315.368197	0.584924	0	-0.002716	0.116523	0.000029	0.768121
497	53.231399		2.339616	0.98	2507.257616	0.633401	0	-0.002808	0.096571	0.000024	1.034198
498	53.259007		2.554656	1.030893	2369.839619	0.598685	0	-0.002889	0.112165	0.000028	1.89829
499	53.3835		2.661708	1.23939	3115.634071	0.787093	0	-0.000118	0.003809	0.000001	1.080116
500	53.342383		2.542404	1.181195	2671.040357	0.674777	0	-0.001299	0.055915	0.000014	0.576913
501	53.368536		2.704668	1.231486	2947.966386	0.744736	0	-0.001004	0.03524	0.000009	0.753767
502	53.564777		3.008256	1.575047	3214.731452	0.812128	0	0	0	0	0.545629
503	53.471441		2.87328	1.431447	3059.077354	0.772805	0	-0.000439	0.002407	0.000001	1.235468
504	53.723897		3.547104	1.876155	3595.712365	0.908374	0	0	0	0	1.381277

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505	53.903976		4.750548	2.125878	3121.301812	0.788525	0	0	0	0	1.423045
506	53.719237		3.578688	1.874758	3610.807044	0.912187	0	0	0	0	1.13993
507	53.791972		3.387588	1.930466	3114.505175	0.786808	0	0	0	0	1.119094
508	53.873267		3.347652	2.050573	3732.372582	0.942898	0	0	0	0	0.851561
509	53.877541		3.433788	2.078961	3742.306627	0.945407	0	0	0	0	0.9899
510	53.734751		3.24918	1.842694	3349.686923	0.846221	0	0	0	0	0.505214
511	53.651808		3.249012	1.690488	3269.120389	0.825868	0	0	0	0	0.789358
512	53.791968		3.286296	1.925246	3482.730052	0.879831	0	0	0	0	0.837784
513	53.52879		2.903316	1.507595	3186.495201	0.804994	0	0	0	0	0.907832
514	53.376984		2.69232	1.246085	2754.621287	0.695891	0	-0.00097	0.007272	0.000002	0.627222
515	53.390121		2.955372	1.258278	2888.377258	0.729682	0	-0.008935	0.266507	0.000067	1.098424
516	53.525238		3.23454	1.508357	2996.548669	0.757009	0	-0.004333	0.037195	0.000009	1.421022
517	53.510585		2.867004	1.446718	2975.734135	0.75175	0	0	0	0	1.401081
518	53.47859		2.87328	1.397191	2871.091751	0.725315	0	0	0	0	1.551955
519	53.348263		2.69058	1.172861	2788.833167	0.704534	0	-0.000624	0.007964	0.000002	1.149609
520	53.341821		2.385408	1.177099	2599.92676	0.656811	0	-0.000719	0.014993	0.000004	0.746381
521	53.402548		2.716776	1.278988	2752.770167	0.695424	0	-0.000744	0.025381	0.000006	0.670499
522	53.359017		2.673204	1.213532	2707.566189	0.684004	0	-0.002391	0.135049	0.000034	1.744148
523	53.250807		2.616276	1.065702	2476.746688	0.625693	0	-0.004726	0.340397	0.000086	0.8744
524	53.277099		2.327808	1.080416	2466.420821	0.623084	0	-0.003109	0.237648	0.00006	0.76422
525	53.408006		2.729028	1.261826	2817.251776	0.711714	0	-0.000987	0.036512	0.000009	1.034531
526	53.342767		2.722488	1.198089	2449.54913	0.618822	0	-0.001197	0.045156	0.000011	0.966439
527	53.403205		2.838756	1.291982	3107.409322	0.785015	0	-0.000231	0.002407	0.000001	1.092257
528	53.456392		2.724636	1.372698	2709.643523	0.684529	0	-0.001871	0.02555	0.000006	0.802918
529	53.419237		3.041352	1.358985	3057.942068	0.772518	0	-0.000253	0.003631	0.000001	1.372593
530	53.478043		2.861724	1.409364	3044.218476	0.769051	0	0	0	0	0.897063
531	53.450858		2.718684	1.337138	2588.487364	0.653922	0	-0.000933	0.04877	0.000012	0.609615
532	53.499663		2.862492	1.466877	3021.234296	0.763245	0	-0.000664	0.038931	0.00001	0.842769
533	53.419263		2.728296	1.349556	2582.141672	0.652318	0	-0.005419	0.351156	0.000089	0.742845
534	53.456227		3.001476	1.393987	3127.803835	0.790167	0	-0.001421	0.046402	0.000012	0.825791
535	53.227085		2.601684	0.995784	2509.279245	0.633911	0	-0.00395	0.408959	0.000103	0.911846
536	53.333024		2.75916	1.175225	2991.988404	0.755857	0	-0.018111	0.87769	0.000222	0.640974
537	53.373406		2.680224	1.203061	2909.943927	0.73513	0	-0.001652	0.063893	0.000016	0.89316
538	53.310802		2.653896	1.142459	2551.469042	0.64457	0	-0.00053	0.015583	0.000004	1.774558
539	53.369981		2.745732	1.224712	2926.740333	0.739373	0	-0.001977	0.13304	0.000034	1.298111
540	53.293409		2.80686	1.06798	2750.225359	0.694781	0	-0.002383	0.171746	0.000043	0.834612
541	53.260015		2.638824	1.025476	2877.483798	0.72693	0.007896	-0.235688	5.122936	0.001294	1.05413
542	53.390653		2.863032	1.264001	2922.944395	0.738414	0	-0.001812	0.031222	0.000008	0.816387
543	53.245389		2.706828	1.021938	2734.008432	0.690684	0	-0.008157	0.547572	0.000138	1.005834
544	53.412008		2.766276	1.26756	2950.491193	0.745373	0	-0.000419	0.015978	0.000004	1.250366
545	53.456485		2.976072	1.359856	3216.933872	0.812684	0	0	0	0	2.287692
546	53.386966		2.6907	1.26254	2924.588055	0.73883	0	0	0	0	1.717898
547	53.410089		2.830812	1.330713	3054.909679	0.771752	0	-0.000291	0.008402	0.000002	1.27359
548	53.378965		3.015024	1.22219	2958.664952	0.747438	0	-0.000163	0.001212	0	2.528499
549	53.467987		3.105912	1.404836	3114.88421	0.786904	0	0	0	0	2.500276
550	53.451005		3.00162	1.388172	3209.336152	0.810765	0	0	0	0	2.461977
551	53.569593		2.905068	1.585548	3208.564972	0.81057	0	0	0	0	0.858707
552	53.765245		3.455712	1.912694	3519.867925	0.889213	0	0	0	0	0.667799
553	53.774874		3.270072	1.934292	3623.260211	0.915333	0	-0.071284	1.898581	0.00048	0.906428
554	53.669748		3.125556	1.754515	3316.680659	0.837883	0	0	0	0	0.851458
555	53.658213		3.066084	1.742098	3287.147309	0.830422	0	0	0	0	0.579575

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556	53.407461		2.989044	1.317293	2972.138731	0.750842	0	-0.001872	0.030894	0.000008	0.774621
557	53.405644		2.93718	1.296309	2957.704303	0.747196	0	-0.002148	0.118005	0.00003	0.750478
558	53.322636		2.787912	1.152716	2761.427441	0.697611	0	-0.002403	0.366187	0.000093	0.659043
559	53.146673		2.662332	0.867987	2646.636119	0.668611	0.172812	-0.009912	1.057899	0.000267	1.60057
560	53.091656		2.613072	0.988516	2302.478586	0.581668	0	-0.095729	60.705232	0.015336	1.905664
561	53.558292		3.042696	1.528563	3339.664238	0.843689	0	0	0	0	1.803824
562	53.434509		2.822292	1.380618	2988.438757	0.75496	0	-0.000999	0.012639	0.000003	0.600281
563	53.372733		3.013284	1.235201	2796.713029	0.706525	0	-0.005003	0.231388	0.000058	1.703681
564	53.265371		2.801484	1.056736	2804.876984	0.708587	0	-0.004785	0.630228	0.000159	1.150802
565	53.253042		2.501172	1.045702	2695.068519	0.680847	0.034788	-0.010308	0.660167	0.000167	0.550831
566	53.372787		2.761536	1.236864	2882.27034	0.728139	0	-0.004553	0.86617	0.000219	1.064713
567	53.499339		3.746532	1.682256	3039.985623	0.767982	0	-0.16038	49.150918	0.012417	1.502619
568	53.807665		3.516564	1.970571	3433.395792	0.867368	0	-0.006259	0.153103	0.000039	1.727351
569	53.670782		3.212172	1.715901	2786.750405	0.704008	0	0	0	0	1.491871
570	53.550616		3.30462	1.594917	2960.825624	0.747984	0	-0.000151	0.000866	0	1.793414
571	53.472651		2.883156	1.392648	2982.619121	0.75349	0	-0.040664	0.481718	0.000122	1.144174
572	53.382162		2.703528	1.226256	2657.640796	0.671392	0	-0.00332	0.03897	0.00001	1.244748
573	53.474466		2.996916	1.391349	2892.822523	0.730805	0	-0.000715	0.009504	0.000002	1.103328
574	53.659691		3.29622	1.727346	3479.086541	0.878911	0	0	0	0	1.834586
575	53.739307		3.20142	1.872691	2819.812866	0.712361	0	0	0	0	2.027594
576	53.727944		3.373572	1.828344	3588.989673	0.906675	0	0	0	0	2.244687
577	53.647595		3.404352	1.662472	3315.476763	0.837579	0	0	0	0	1.658296
578	53.802701		3.710676	1.91203	3598.498008	0.909077	0	0	0	0	1.698211
579	53.829005		3.614676	1.985734	3075.849807	0.777042	0	0	0	0	1.017011
580	53.657384		3.094644	1.690626	3175.322261	0.802172	0	0	0	0	0.50371
581	53.593054		3.029868	1.606793	3310.741623	0.836382	0	0	0	0	1.756248
582	53.46944		3.1026	1.422617	3033.502113	0.766344	0	-0.000195	0.003809	0.000001	0.853691
583	53.425211		2.911476	1.323747	2649.628807	0.669367	0	0	0	0	0.716159
584	53.666618		3.07932	1.796161	3372.550611	0.851997	0	0	0	0	0.876908
585	53.629516		3.072432	1.647875	3288.58291	0.830784	0	0	0	0	1.446458
586	53.363008		2.863092	1.182613	3058.060494	0.772548	0	-0.001234	0.030968	0.000008	0.781607
587	53.412055		2.795016	1.271043	2720.195552	0.687195	0	-0.000137	0.001454	0	0.672079
588	53.455949		2.870148	1.374134	3276.828728	0.827815	0	-0.000504	0.010643	0.000003	0.749963
589	53.418707		2.971356	1.304056	2795.330498	0.706176	0	-0.000236	0.002965	0.000001	1.65
590	53.385981		2.694096	1.258682	3006.585539	0.759544	0	-0.01879	1.247475	0.000315	0.893073
591	53.366887		2.617824	1.21344	2603.912357	0.657818	0	-0.003348	0.070135	0.000018	0.940989
592	53.406381		3.0084	1.27869	2973.81171	0.751265	0	-0.001401	0.023475	0.000006	1.472489
593	53.534698		3.048468	1.488686	3627.389565	0.916376	0	0	0	0	1.265898
594	53.408489		2.985456	1.269247	2727.070942	0.688931	0	-0.001301	0.041207	0.00001	0.723506
595	53.604064		3.02892	1.58571	3330.527487	0.841381	0	-0.004306	0.085515	0.000022	0.878081
596	53.566353		3.082356	1.542189	3264.779872	0.824771	0	0	0	0	1.113773
597	53.676081		3.15036	1.739173	3564.540796	0.900499	0	0	0	0	1.785062
598	53.779004		3.302976	1.912193	3995.88768	1.009469	0	-0.002734	0.079298	0.00002	1.595818
599	53.505064		3.102636	1.513577	3105.444282	0.784519	0	-0.001299	0.044843	0.000011	2.001502
600	53.380792		2.818368	1.244372	2952.427501	0.745863	0	-0.00202	0.072543	0.000018	1.061054
601	53.423685		3.045216	1.288228	2961.442235	0.74814	0	-0.001893	0.036186	0.000009	0.926701
602	53.257145		2.468712	1.049568	2387.205024	0.603072	0.04914	-0.005064	0.689845	0.000174	1.037854
603	53.266635		2.45124	1.047401	2396.000492	0.605294	0	-0.007321	0.36086	0.000091	0.919844
604	53.199995		2.297328	0.959356	2358.99838	0.595946	0.096192	-0.007339	1.02007	0.000258	0.624909
605	53.236147		2.707776	1.039022	2577.132935	0.651053	0	-0.004307	0.445845	0.000113	1.112336
606	53.144709		2.695356	0.830244	2521.51527	0.637003	0	-0.010503	0.647191	0.000163	1.378205

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607	53.239584		2.30724	1.009233	2190.606576	0.553406	0.125352	-0.019704	1.149253	0.00029	0.895402
608	53.277726		2.590236	1.098686	2705.106379	0.683383	0	-0.006617	0.736775	0.000186	1.017428
609	53.265499		2.517648	1.054072	2509.669017	0.63401	0.063288	-0.008056	0.667806	0.000169	0.538424
610	53.336844		2.577828	1.196348	2714.611494	0.685784	0	-0.006653	0.50233	0.000127	0.92923
611	53.285658		2.592516	1.07336	2687.544841	0.678946	0	-0.004284	0.225199	0.000057	0.704535
612	53.312284		2.71962	1.138845	2276.478732	0.5751	0	-0.001714	0.248092	0.000063	0.612748
613	53.586805		3.062964	1.655742	2948.884325	0.744967	0	-0.000125	0.002251	0.000001	1.793754
614	53.690664		3.703848	1.898857	3388.634583	0.85606	0	0	0	0	1.874661
615	53.525874		2.718468	1.496505	2774.879168	0.701009	0	-0.000192	0.004484	0.000001	1.056787
616	53.473406		2.734224	1.429726	2743.205424	0.693007	0	-0.019813	0.986889	0.000249	0.83354
617	53.431477		2.516172	1.353112	2874.370331	0.726143	0	-0.00079	0.01946	0.000005	0.787087
618	53.357787		2.658348	1.225046	2777.578834	0.701691	0	-0.000837	0.023624	0.000006	0.820449
619	53.360637		2.65014	1.237138	2502.34766	0.63216	0	-0.008667	0.287572	0.000073	0.84447
620	53.410958		2.76222	1.332478	3059.430475	0.772894	0	-0.001532	0.042531	0.000011	0.75747
621	53.523837		2.907384	1.487479	2931.324918	0.740532	0	-0.002784	0.007251	0.000002	0.821971
622	53.553115		3.478932	1.564854	2821.915555	0.712892	0	-0.00583	0.08693	0.000022	0.935443
623	53.59061		3.13668	1.598417	2945.315956	0.744066	0	0	0	0	0.853882
624	53.598165		3.071112	1.640531	3220.951177	0.813699	0	0	0	0	0.658918
625	53.546902		2.595396	1.542226	2531.986209	0.639648	0	-0.000518	0.004181	0.000001	0.412001
626	53.327182		2.362728	1.166171	2512.137034	0.634633	0	-0.022712	0.509855	0.000129	1.090645
627	53.361169		2.492616	1.231703	2559.402153	0.646574	0	-0.00203	0.045096	0.000011	0.527184
628	53.270997		2.348832	1.10592	2392.016325	0.604288	0	-0.006164	0.595812	0.000151	0.817655
629	53.415642		2.467128	1.348786	2219.978299	0.560826	0	-0.000168	0.005877	0.000001	1.087087
630	53.338222		2.363256	1.238821	2527.349459	0.638476	0	-0.001658	0.090152	0.000023	0.892413
631	53.313126		2.740392	1.137235	2538.696697	0.641343	0	-0.001627	0.205627	0.000052	0.761836
632	53.3234		2.649672	1.213425	2382.029604	0.601765	0	-0.0039	0.442957	0.000112	0.742706
633	53.26618		2.560404	1.129197	2271.221175	0.573772	0.052116	-0.003383	0.597988	0.000151	1.419832
634	53.144136		2.35824	0.87663	2352.824186	0.594387	0.012132	-0.004687	0.526755	0.000133	1.19988
635	53.087532		2.456088	0.81196	2300.76721	0.581236	0.09558	-0.019801	1.945488	0.000491	0.735974
636	53.142273		2.292372	0.878079	2288.599615	0.578162	0	-0.013044	0.885895	0.000224	1.331222
637	53.200997		2.15964	0.975603	1986.441912	0.501829	0	-0.004659	0.482481	0.000122	0.993932
638	53.154178		2.207148	0.877181	2340.590387	0.591296	0	-0.002288	0.311194	0.000079	1.08006
639	53.371586		2.395932	1.267178	2476.754956	0.625695	0	-0.00089	0.052443	0.000013	0.429237
640	53.180073		2.553144	0.88853	1996.026931	0.50425	0	-0.001714	0.209792	0.000053	0.962918
641	53.290466		2.508012	1.11862	2430.337773	0.613969	0	-0.00378	0.315693	0.00008	0.556348
642	53.206824		2.13588	0.996452	2185.01242	0.551993	0.096732	-0.007453	1.413713	0.000357	1.872893
643	53.355977		2.435508	1.227348	2722.543893	0.687788	0	0	0	0	1.27163
644	53.268132		2.716524	1.065994	2244.356019	0.566985	0	-0.00502	0.331874	0.000084	1.005784
645	53.287556		2.400228	1.123522	2618.41363	0.661482	0.007512	-0.006721	0.647003	0.000163	0.697157
646	53.201124		2.260116	1.019529	2094.068662	0.529018	0.112008	-0.0059	0.969074	0.000245	0.97236
647	53.341284		3.266556	1.220253	2750.41178	0.694828	0	-0.000337	0.08309	0.000021	3.845968
648	53.159354		2.253108	0.912778	2342.088466	0.591675	0	-0.012277	0.289207	0.000073	1.41726
649	53.10543		2.38542	0.842812	2334.132735	0.589665	0.008436	-0.011124	1.267835	0.00032	0.666577
650	53.120196		2.503548	0.847961	2400.590729	0.606454	0	-0.002547	0.072251	0.000018	1.398369
651	53.092753		2.354412	0.804489	2276.976154	0.575225	0.027456	-0.011293	1.204061	0.000304	0.697193
652	53.013938		2.391612	0.676584	2205.623949	0.5572	0.101592	-0.021194	2.373923	0.0006	0.573341
653	53.142837		2.3859	0.90886	2518.569282	0.636258	0	-0.007517	0.647511	0.000164	0.782242
654	53.210966		2.579364	0.973623	2558.202042	0.646271	0	-0.000518	0.00927	0.000002	1.008457
655	53.246556		2.608836	1.062144	2650.905232	0.66969	0	-0.028419	0.690661	0.000174	2.122602
656	53.179454		2.708748	0.925475	2387.800922	0.603223	0	-0.003353	0.089047	0.000022	2.816136
657	53.138671		2.730348	0.878959	2611.747555	0.659798	0	-0.01897	0.961729	0.000243	1.629164

Segment S47S481

658	53.267168		2.4288	1.063174	2454.418242	0.620052	0	0	0	0	1.7496
659	53.143493		2.455992	0.892418	2455.420082	0.620305	0	-0.012724	0.194845	0.000049	1.67444
660	53.231426		2.739336	1.051775	2823.772216	0.713361	0	-0.00298	0.003117	0.000001	1.55562
661	53.332666		2.450628	1.137089	2242.952453	0.56663	0	0	0	0	0.853878
662	53.260486		2.396028	1.053859	2544.623077	0.64284	0	-0.007565	0.122011	0.000031	1.175483
663	53.379001		2.881692	1.268055	2958.347366	0.747358	0	-0.001764	0.034637	0.000009	1.376216
664	53.211348		2.403588	1.013575	2454.388749	0.620045	0	-0.002698	0.131916	0.000033	2.412131
665	53.06181		2.239992	0.731762	2028.331479	0.512411	0	-0.01501	1.192315	0.000301	2.472003
666	53.389954		2.607732	1.292817	2803.193815	0.708162	0	0	0	0	0.767773
667	53.44011		2.626896	1.403435	2849.536407	0.71987	0	-0.000598	0.000558	0	1.215143
668	53.44706		2.814192	1.44167	2558.4757	0.64634	0	0	0	0	0.672371
669	53.510532		2.846568	1.468968	3159.30276	0.798125	0	0	0	0	2.007549
670	53.533816		3.298176	1.651348	3068.335023	0.775144	0	-0.00226	0.029562	0.000007	1.117179
671	53.74554		3.40176	2.044659	3376.927607	0.853103	0	0	0	0	2.658971
672	53.790998		3.730356	2.176671	3630.16873	0.917078	0	0	0	0	2.141603
673	53.758919		3.667692	2.045365	3311.873829	0.836668	0	0	0	0	1.199118
674	53.610852		3.235464	1.732247	2798.243268	0.706912	0	0	0	0	1.47535
675	53.495157		2.860068	1.499861	2949.520604	0.745128	0	0	0	0	0.955022
676	53.566718		2.768724	1.649079	2959.82522	0.747731	0	0	0	0	1.276806
677	53.505816		2.817828	1.549256	2953.662398	0.746175	0	0	0	0	1.324652
678	53.362271		2.691996	1.248941	2424.779778	0.612565	0	-0.003033	0.011105	0.000003	1.529353
679	53.337597		2.619684	1.27091	2583.273811	0.652604	0	-0.002928	0.21131	0.000053	0.613151
680	53.507345		3.008904	1.568808	2947.307037	0.744569	0	-0.000914	0.058018	0.000015	0.686287
681	53.459135		2.887164	1.456068	2595.777195	0.655763	0	-0.000031	0.006779	0.000002	2.042973
682	53.532886		2.96718	1.614081	2887.435524	0.729444	0	0	0	0	1.580877
683	53.392409		3.158712	1.424681	2584.229032	0.652846	0	-0.000144	0.02978	0.000008	1.638452
684	53.335859		2.56932	1.240125	2495.883234	0.630527	0	-0.000921	0.036359	0.000009	1.092616
685	53.484364		2.706288	1.494819	2965.533794	0.749174	0	-0.000342	0.005004	0.000001	0.915215
686	53.143203		2.423004	0.868754	2373.343151	0.59957	0	-0.009744	1.212114	0.000306	1.039746
687	53.158927		2.462088	0.921667	2394.409647	0.604892	0	-0.013409	0.364936	0.000092	1.567791
688	53.245141		2.409756	1.062704	2264.794739	0.572148	0	-0.002473	0.165435	0.000042	0.781188
689	53.258396		2.599932	1.113912	2591.449733	0.65467	0	-0.061238	2.672563	0.000675	1.396597
690	53.390376		3.020964	1.331545	2355.295611	0.595011	0	0	0	0	0.566823
691	53.355408		3.351	1.291763	2861.925716	0.722999	0	0	0	0	2.108251
692	53.720329		3.502092	1.962083	3222.230248	0.814022	0	-0.242756	2.520496	0.000637	3.981899
693	53.544022		2.616192	1.572639	2695.497282	0.680955	0	0.002922	0.018207	0.000005	1.539324
694	53.497917		2.601072	1.485075	3107.356659	0.785002	0	0	0	0	0.781951
695	53.567287		3.12018	1.616803	3340.524145	0.843906	0	0	0	0	1.008493
696	53.576882		3.121776	1.643203	3138.400776	0.792844	0	0.009797	0.263642	0.000067	0.752593
697	53.527681		2.926104	1.546322	2675.770647	0.675972	0	0.008441	0.134716	0.000034	0.774237
698	53.545157		2.757816	1.585176	3118.748359	0.78788	0	0.002059	0.015687	0.000004	0.60386
699	53.421193		2.719008	1.357466	2978.887499	0.752547	0	0.014577	0.31643	0.00008	0.877178
700	53.53812		2.692536	1.590478	2624.480975	0.663014	0	0.00206	0.019756	0.000005	1.237394
701	53.6371		2.913564	1.7338	3290.079503	0.831163	0	0.011734	0.230223	0.000058	0.743175
702	53.72974		3.281712	1.92624	3672.095247	0.92767	0	0.015997	0.424189	0.000107	0.964824
703	53.72934		3.042012	1.948914	2932.444883	0.740814	0	0	0	0	0.969269
704	53.582724		2.77086	1.612752	23.526721	0.005943	0.48408	0.058464	0.008597	0.000002	0.974284
AVERAGE DIAMETER	**106.7528146**	**MAXIMUM**	**5.852496**	**3.425991**	**4256.513804**	**1.07531**	**0.48408**	**15.030138**	**1310.751727**	**0.331131**	**13.55779**

Segment S47S481

AVERAGE	2.957991046	1.335145519	2743.616199	0.69311124	0.007094518	0.012438044	3.860436145	0.00097523	1.601057

MAXIMUM MEASUREMENTS HIGHLIGHTED IN PEACH

LEGEND:

MAXIMUM CORROSION: MAXIMUM DEPTH OF CORROSION IN THE ONE FOOT SECTION OF PIPE.
AVERAGE CORROSION: THE AVERAGE CORROSION FOR EACH ONE FOOT SECTION.
INTEGRATED CORROSION: CORROSION OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED CORROSION: INTEGRATED CORROSION DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE TO COMPARE THE EXTENT OF CORROSION IN EACH ONE FOOT SECTION OF PIPE
MAXIMUM BUILDUP: MAXIMUM BUILDUP IN THE ONE FOOT SECTION OF PIPE.
AVERAGE BUILDUP: THE AVERAGE BUILDUP FOR EACH ONE FOOT SECTION.
INTEGRATED BUILDUP: BUILDUP OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED BULDUP: INTEGRATED BUILDUP DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE TO COMPARE THE EXTENT OF BUILDUP IN EACH ONE FOOT SECTION OF PIPE
OVALITY: CHANGE IN CIRCULARITY; THE AMOUNT OF OUT-OF-ROUNDNESS

Segment S47S481

EBMUD
MULTI-SENSOR INSPECTION PROJECT

MULTI-SENSOR INSPECTION SUMMARY REPORT FOR: S53 S54, 105" HORSESHOE RCP, 973.7 LF INSPECTED LENGTH

INSPECTION PROCEEDED DOWNSTREAM FROM S53 TO S54. THE FLOATING PONTOON WAS USED FOR THIS INSPECTION. WATER LEVEL WAS AT 40% DURING THIS INSPECTION.

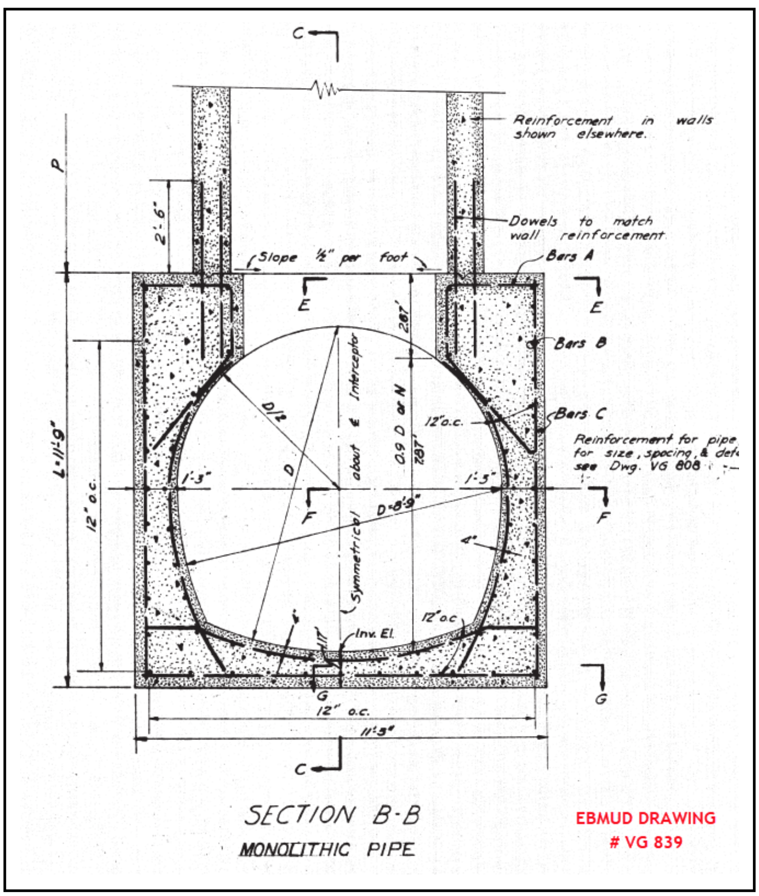
SURFACE AGGREGATE PROJECTING AND SURFACE SPALLING THROUGHOUT INSPECTION. SURFACE REINFORCEMENT VISIBLE AND CORRODED AT 945 FEET. MAXIMUM CORROSION/MEASUREMENT OUTSIDE REFERENCE CIRCLE TO 5.18 INCHES AT 471 FEET. AVERAGE CORROSION OVER ENTIRE LENGTH OF PIPE IS 1.76 INCHES.

SONAR SCANS INDICATE THAT 6,534 CF OF DEBRIS IS PRESENT.

ADDITIONAL GO PRO VIDEO WAS ALSO OBTAINED, WITH IMAGES SHOWN HEREIN.

AS-BUILT DIMENSIONS

The dimensions available from the EBMUD as-built reference drawings were recreated in NPS' 3D modeling software so that a comparison of 3D laser measured values vs. as-built dimensions could be compared in order to produce the 3D virtual model of the pipe interior.

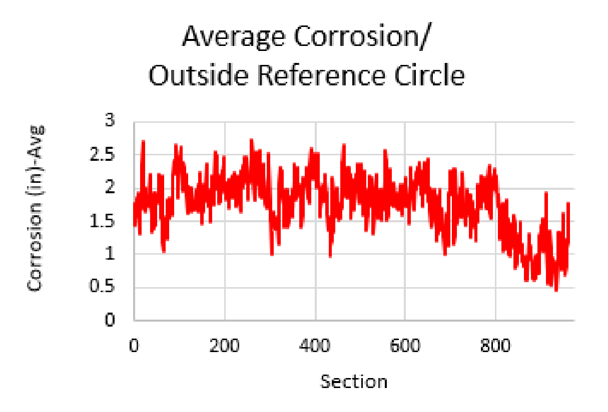


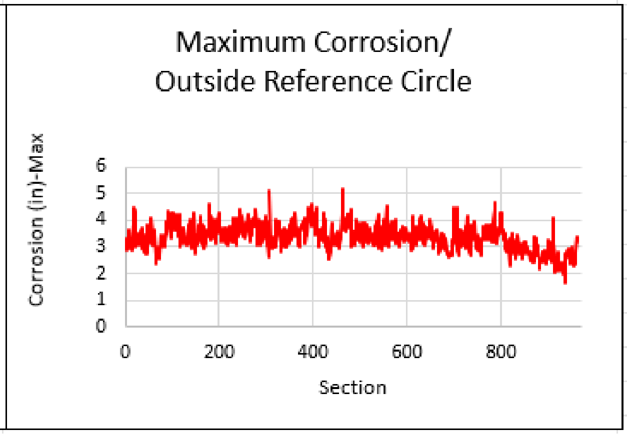
Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

LASER SCAN SUMMARY RESULTS

Measurement	*Measurement From Pipe Center (Inches)*
Average Corrosion/Outside Reference Circle	1.76
Maximum Average Corrosion/Outside Reference Circle	2.72
Maximum Corrosion/Outside Reference Circle	5.18





PACP SCORING REPORT

PACP v7.0 Inspections and Scoring

General Information:

Surveyed by:	F MORENO/NPS
Certificate number:	U-913-19012
Reviewed by:	
Reviewer certificate no.	
Owner:	
Customer:	
P/O number:	
Work order no.:	
Media label:	
Project name:	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022
Start date/time:	20220517 12:05
Sheet number:	
Weather:	1
Pre-cleaning:	N
Date cleaned:	
Flow control:	N
Purpose:	F
Direction:	D
Technology used:	
Inspection status:	CI
Consequence of failure:	
Pressure value:	

Location:

Drainage area:	
Pipe segment ref.:	S53S541
Street:	2ND ST/MLK
City:	OAKLAND
Location code:	C
Location details:	

Pipe:

Pipe use:	SS
Height:	105 in.
Width:	105 in.
Shape:	H
Material:	RCP
Lining method:	
Coating method:	
Pipe joint length:	
Total length:	973.700 ft.
Length surveyed:	973.700 ft.
Year constructed:	1950
Year renewed:	

Measurements:

	Rim to invert:	Rim to grade:	Grade to invert:	Northing:	Easting:	Elevation:
Upstream MH No: S53						
Downstream MH No: S54						

MH coordinate system:
MH vertical datum:
GPS accuracy:

Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

Pipe Ratings

Grade	Structural: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	O&M: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	Overall: Pipe Rating	Pipe Rating Index	LoF	Risk
1	193	193	777	513Z	2.0	0	0	0	0000	0.0	777	2.0	5.1	
2	0	0				0	0							
3	193	579				0	0							
4	0	0				0	0							
5	1	5				0	0							

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
0.0 ft.		AMH					☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 0.0 ft_1.JPG	S53
0.0 ft.		MWL				40	☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---MWL at 0.0 ft.JPG	
10.0 ft.	00:00:58	SAP	S01				☐	8 / 4		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 10.0 ft.JPG	
10.0 ft.	00:01:50	SSC	S02				☐	9 / 3		1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 10.0 ft.JPG	
314.0 ft.	00:17:13	TBA		8.000			☐	3 /				
945.0 ft.	00:47:05	SRC					☐	8 / 1		5		

Observations

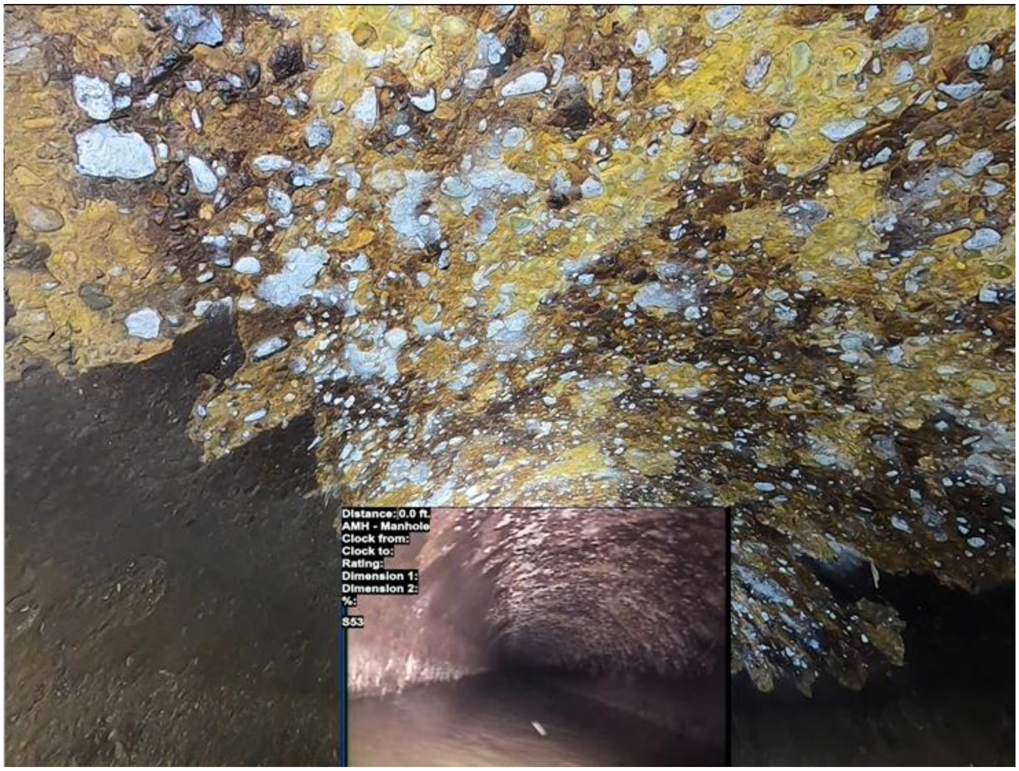
Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
973.7 ft.	00:48:57	SSC	F02				☐	9 / 3		1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 973.7 ft.JPG	
973.7 ft.	00:49:01	SAP	F01				☐	8 / 4		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 973.7 ft.JPG	
973.7 ft.	00:49:11	AMH					☐	/			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 973.7 ft.JPG	S54

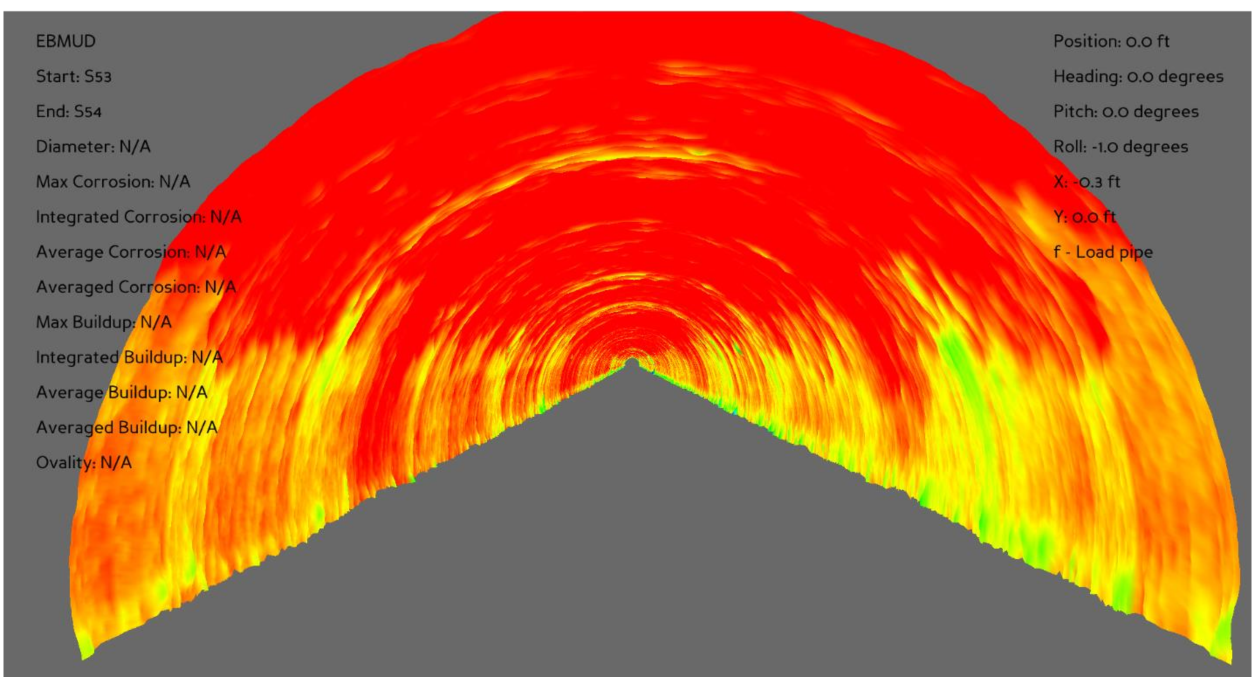
Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

IMAGE REPORT

SURFACE AGGREGATE PROJECTING AND SURFACE SPALLING THROUGHOUT. GO PRO VIDEO WAS ALSO OBTAINED ON THIS SEGMENT TO PROVIDE HIGHER QUALITY VIDEO TO EBMUD. MAXIMUM CORROSION AT OR ABOVE 3 INCHES IS TYPICAL

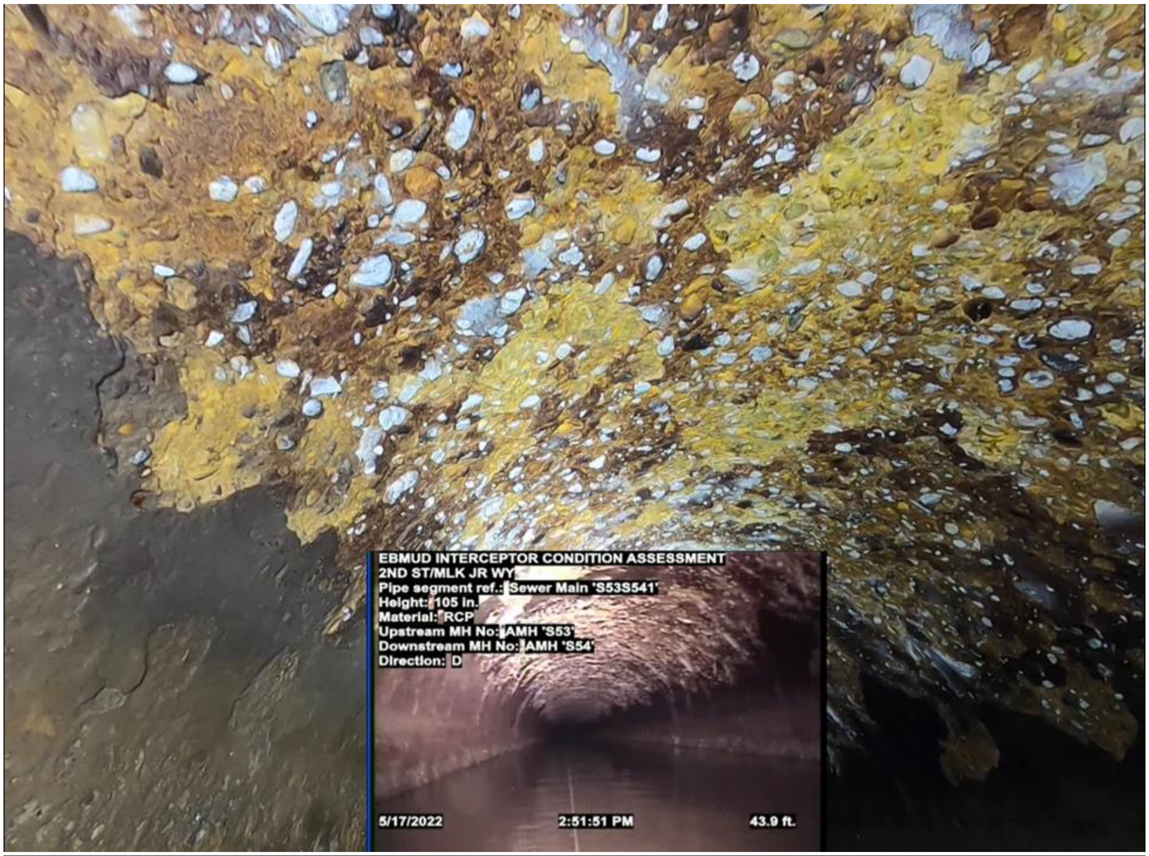


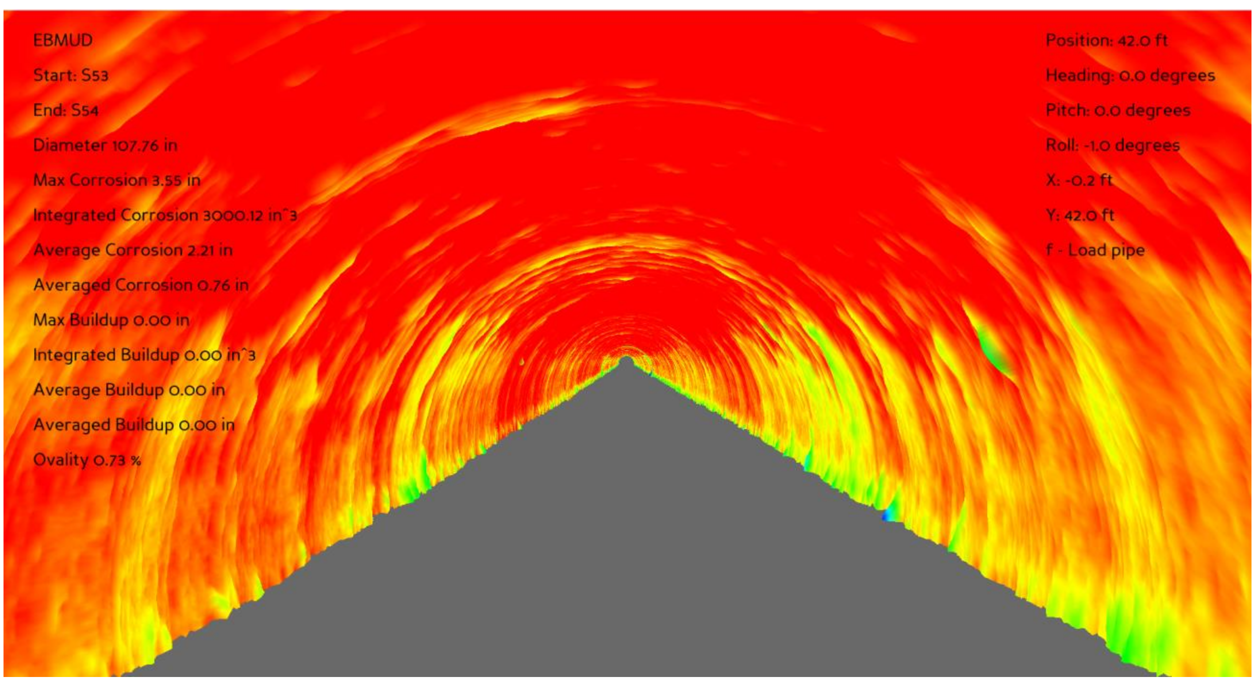


Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

TYPICAL VIEW 44 FEET

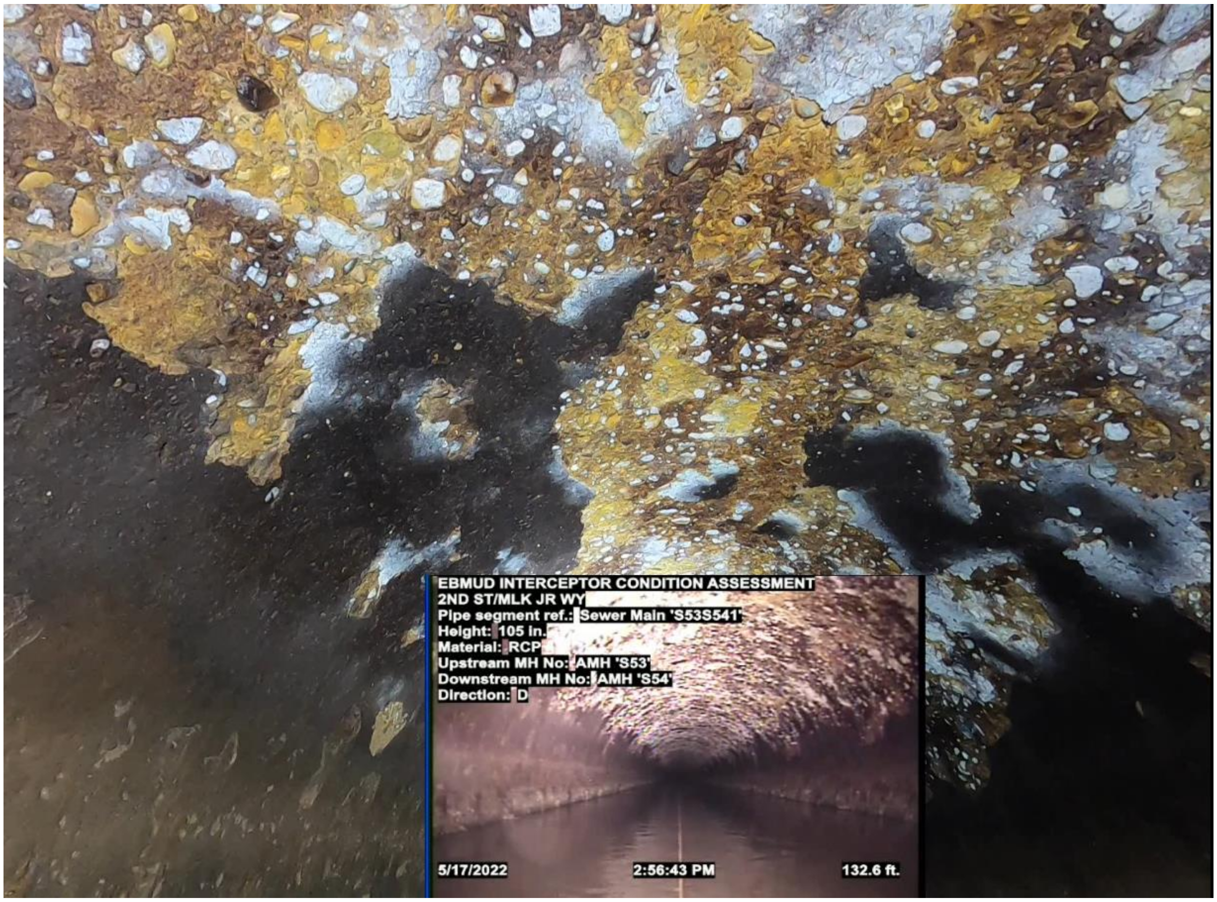


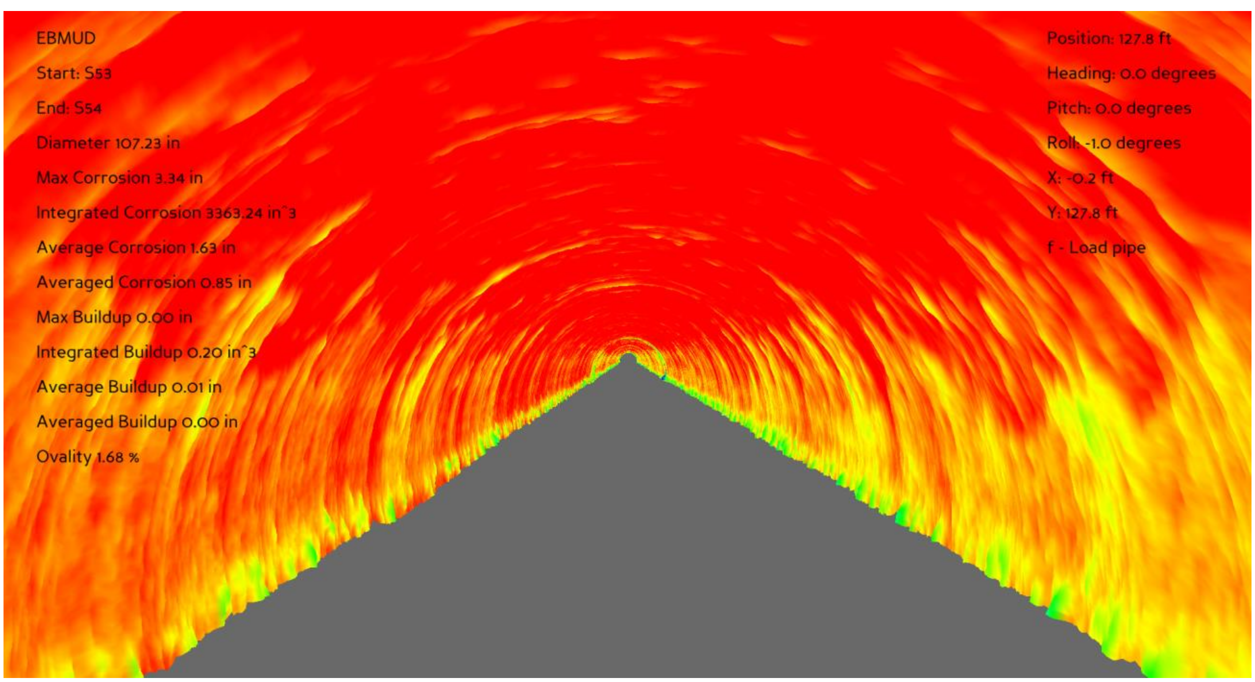


Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

TYPICAL INTERIOR VIEW, 133 FEET, MAXIMUM CORROSION TO 3.72 INCHES

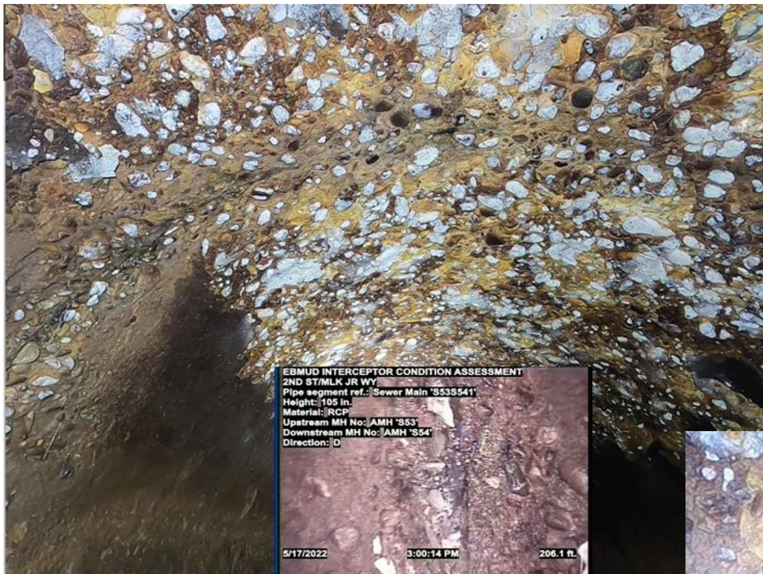


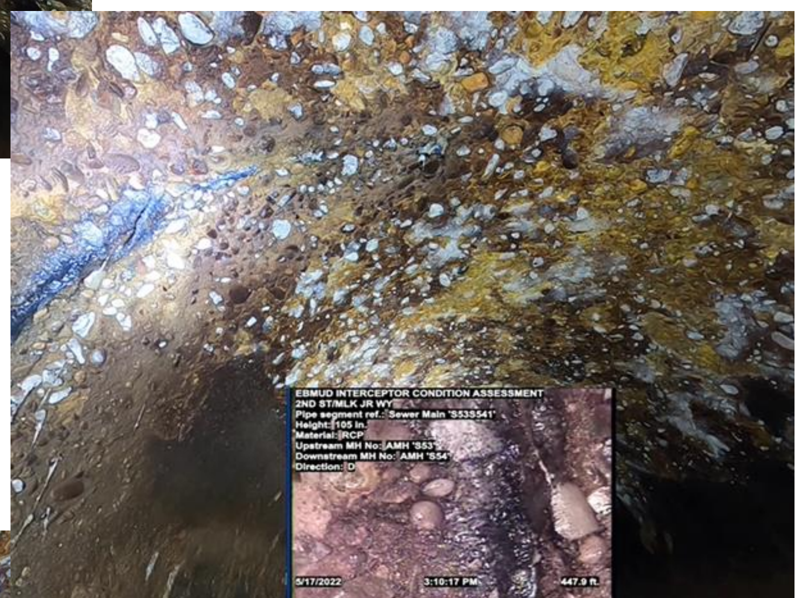


Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

SOME JOINTS APPEAR TO HAVE A SEALING RING VISIBLE, BUT IT'S HARD TO TELL EXACTLY. THERE IS ALSO INFILTRATION PRESENT. EXAMPLES FROM 206.1, 447.9, AND 488 FEET.

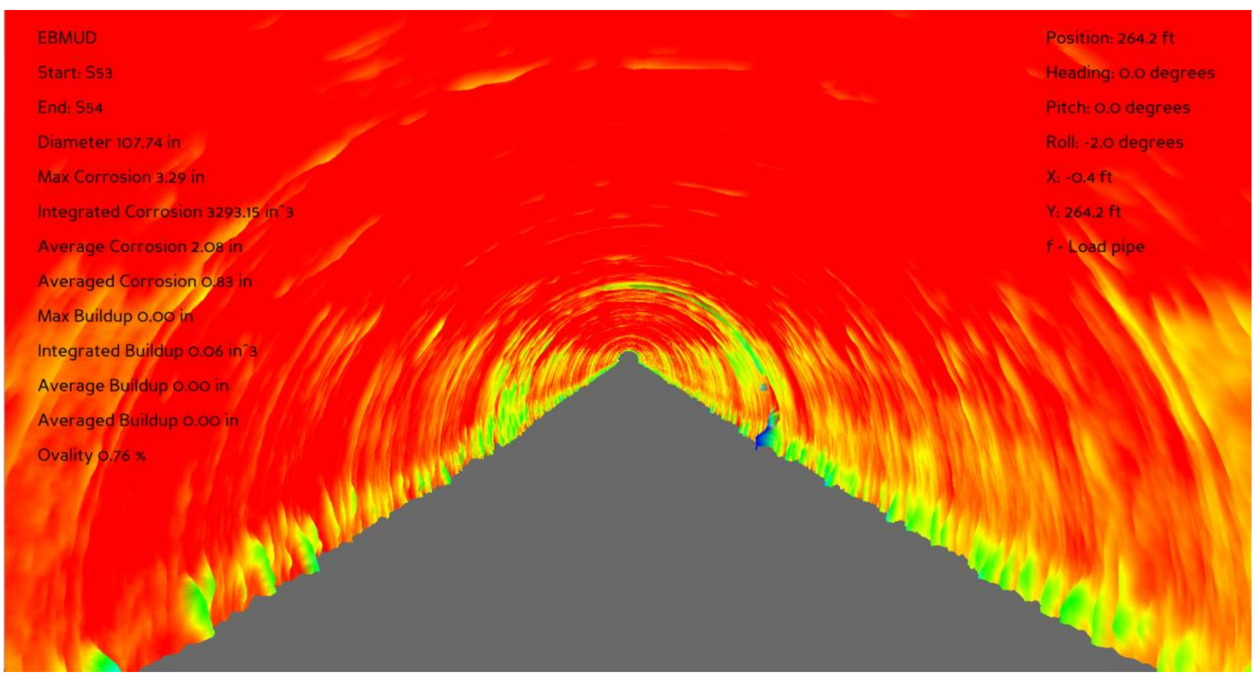




Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

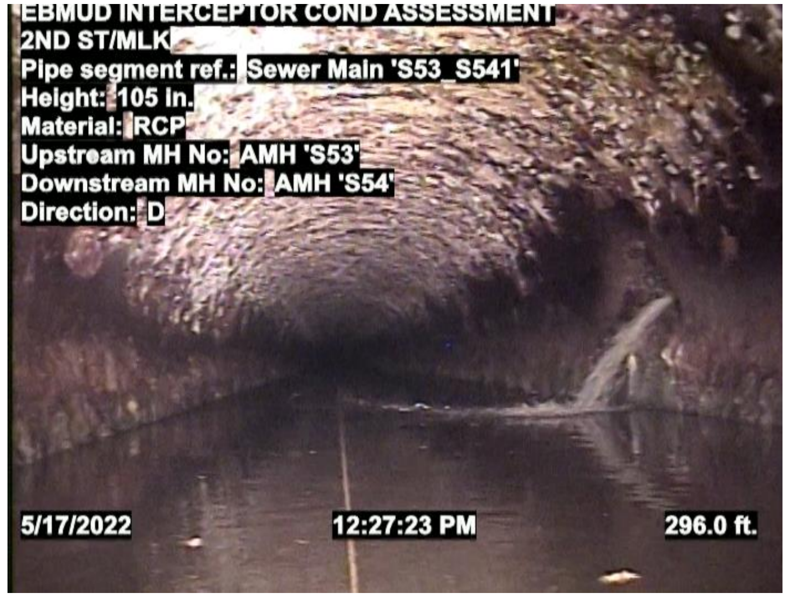
MAXIMUM AVERAGE CORROSION OF 2.72 INCHES AT 269 FEET

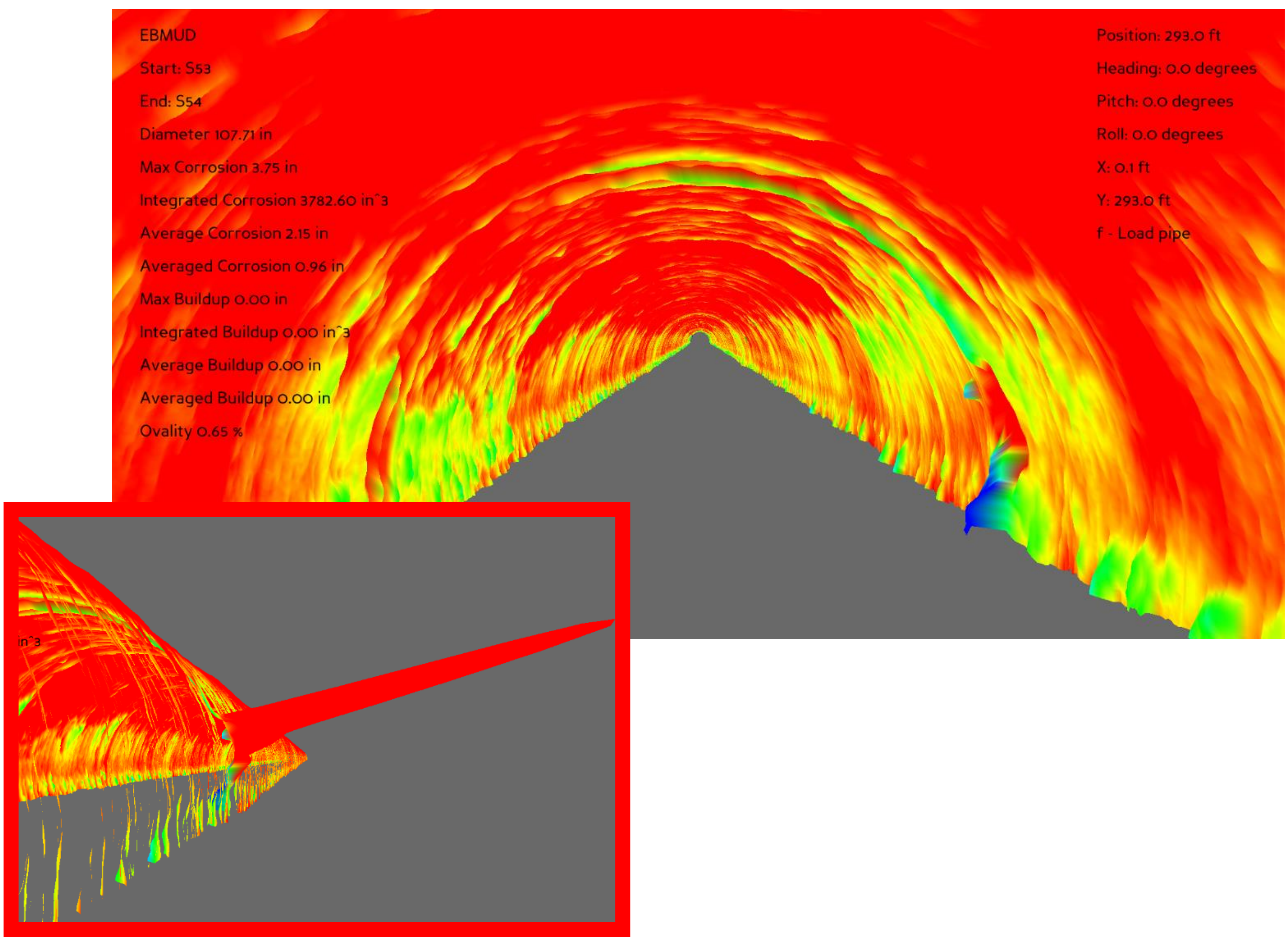


Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

ACTIVE TAP AT 314 FEET

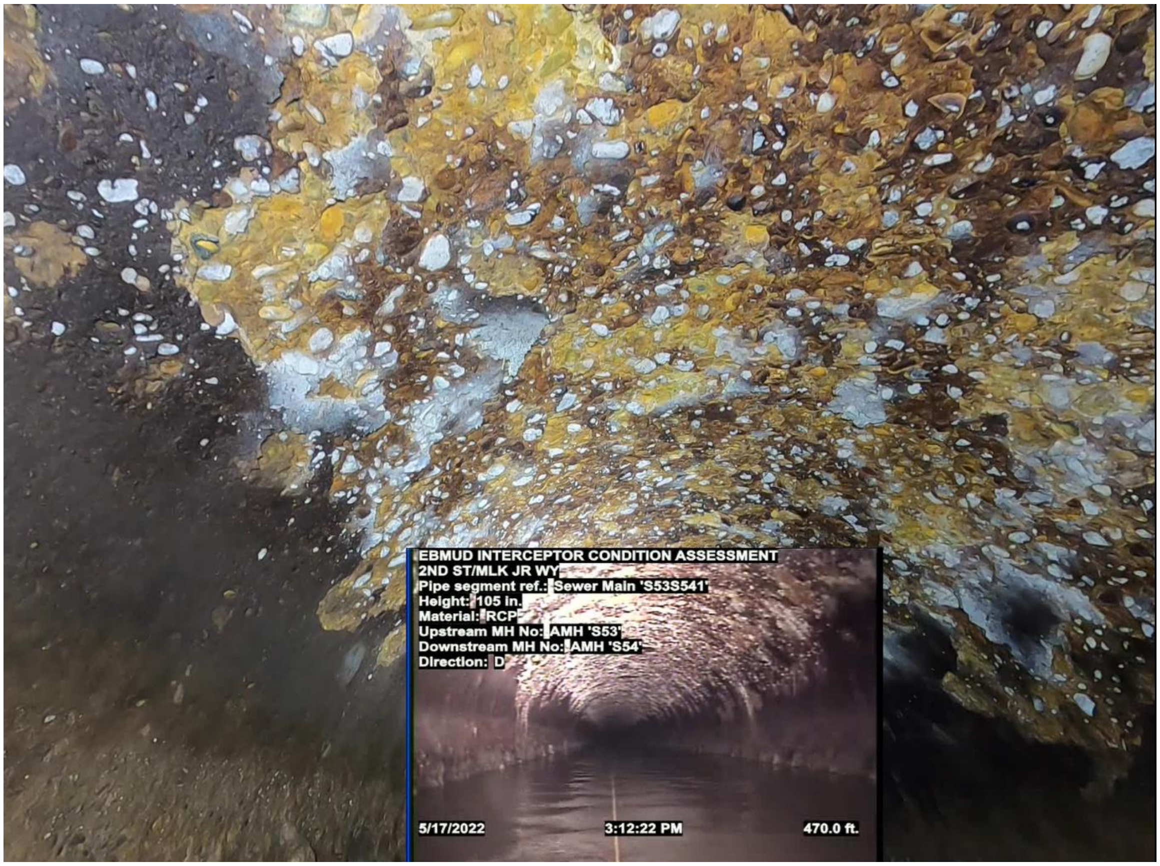


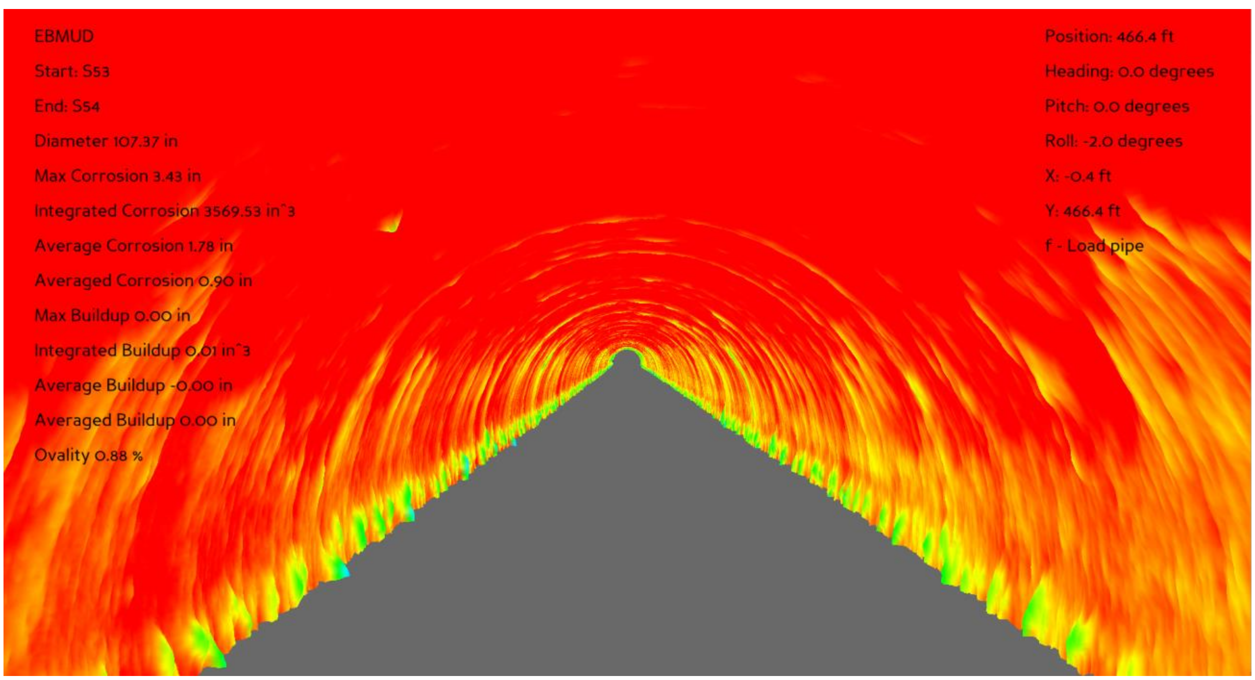


Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

MAXIMUM CORROSION OF 5.18 INCHES AT 471 FEET. AVERAGE CORROSION TO 2.64 INCHES.

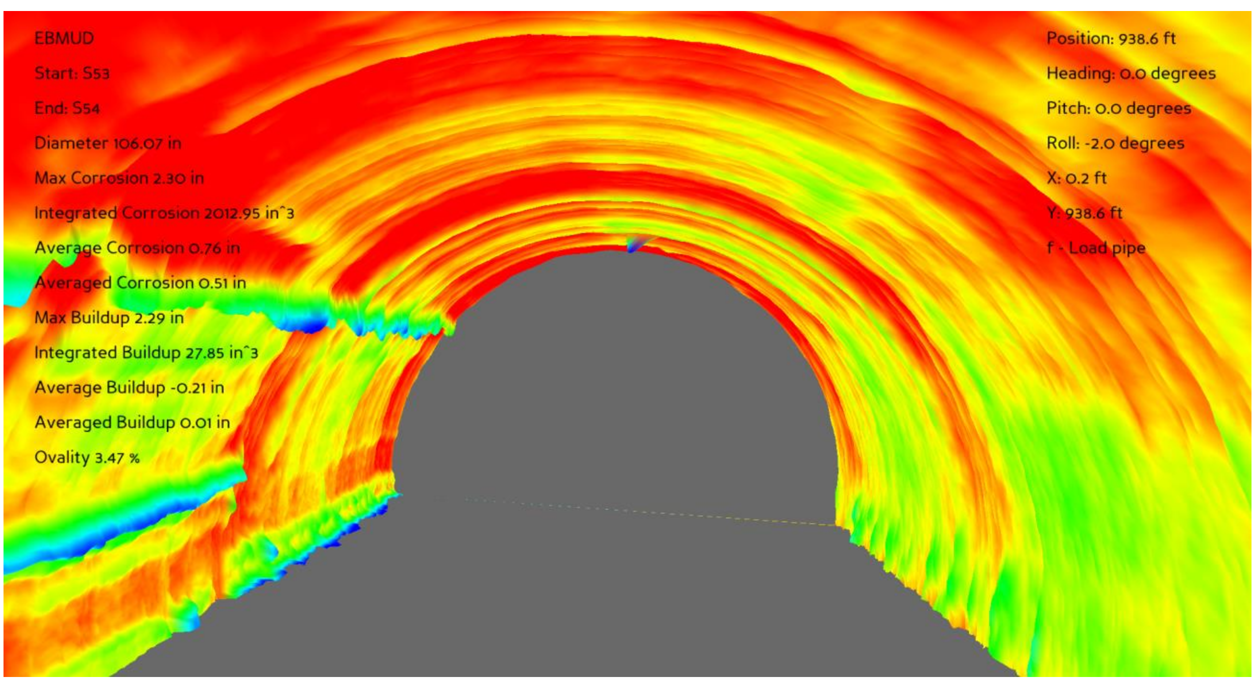




Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

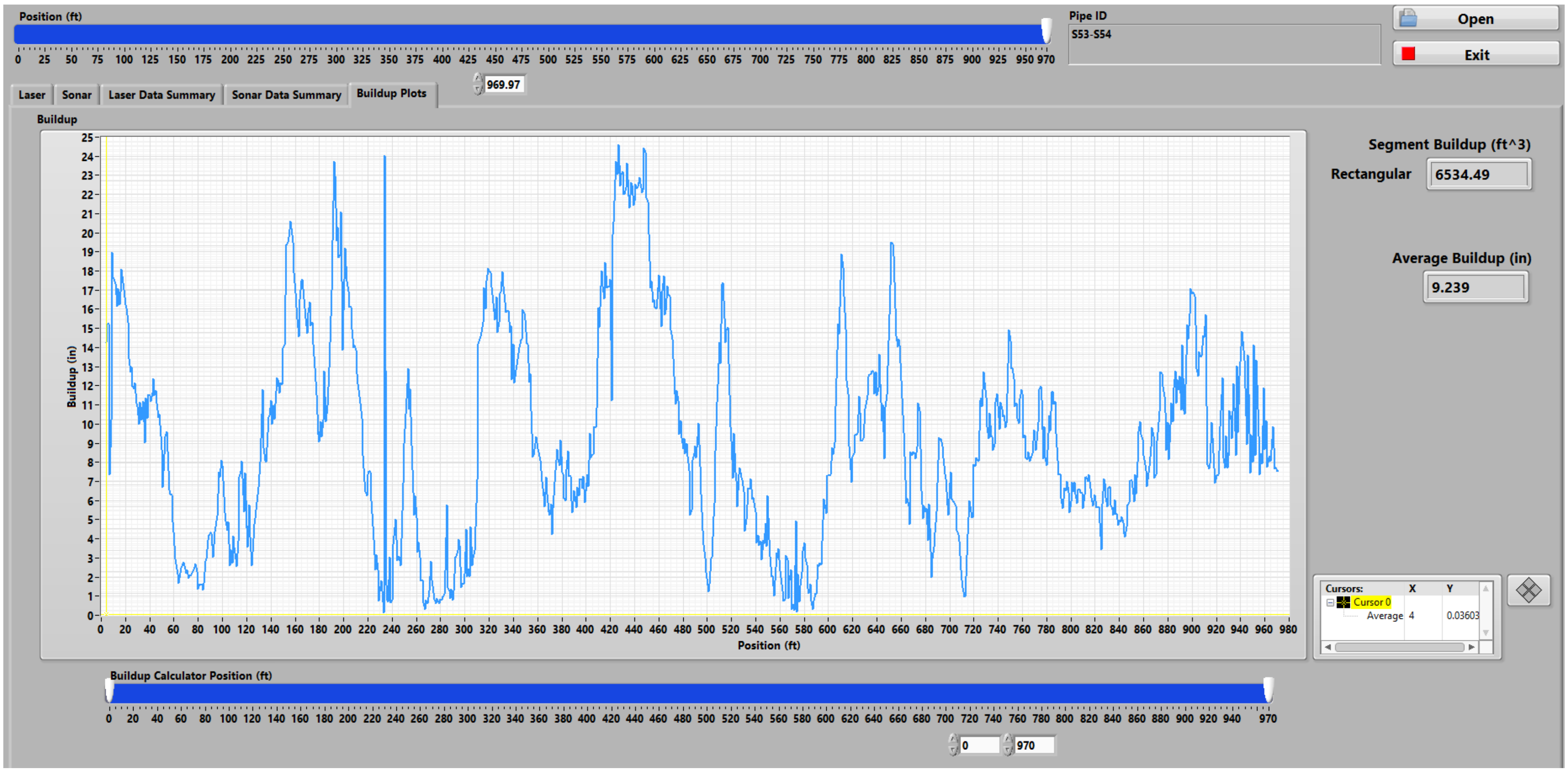
SURFACE REINFORCEMENT CORRODED AT 945 FEET. NOTE THAT WATER OR DEBRIS GOT ON LASER LENS AT 920 FEET AND CONTINUES TO END OF INSPECTION, CAUSING ARTIFICIAL BUILDUP RIDGES BETWEEN THE 8 TO 9 O'CLOCK POSITIONS.



Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

SONAR RESULTS: 6,534 CF (242 CY)



Segment S53S541

EBMUD
MULTI-SENSOR INSPECTION PROJECT

LASER RESULTS BY 1 FOOT SCAN

Segment S53S541

Title 1	Title 2	Title 3	Minimum Position (ft)	Maximum Position (ft)	Surface Area(in2)/ft
EBMUD	Start: S53	End: S54	12	975	3958.406744

Position (ft)	Circular Radius (in)		Maximum Corrosion (in)	Average Corrosion (in)	Integrated Corrosion (in3)	Averaged Corrosion (in)	Maximum Buildup (in)	Average Buildup (in)	Integrated Buildup (in3)	Averaged Buildup (in)	Ovality (%)
9	53.611773		3.30138	1.758366	2550.618453	0.644355	0	0	0	0	1.808977
10	53.606912		2.996724	1.656344	2912.573218	0.735794	0	0	0	0	1.607157
11	53.4983		2.84322	1.441248	2680.211637	0.677094	0	0.000824	0.015625	0.000004	1.124399
12	53.643445		2.937492	1.684594	3090.269497	0.780685	0	0	0	0	0.724764
13	53.711184		3.007608	1.838143	3281.405371	0.828971	0	0	0	0	1.603953
14	53.708247		3.15744	1.836571	3545.291914	0.895636	0	0	0	0	1.486727
15	53.564219		2.994996	1.566097	3377.777661	0.853317	0	-0.000018	0.013731	0.000003	0.665804
16	53.692201		3.412732	1.83735	3552.775921	0.897527	0	0	0	0	0.912589
17	53.750049		3.6246	1.9365	3182.97198	0.804104	0	0	0	0	0.322164
18	53.622456		2.985396	1.68697	3447.993145	0.871056	0	0.003096	0.034896	0.000009	1.029568
19	53.609536		3.316276	1.727943	2977.331753	0.752154	0	0	0	0	1.233778
20	53.453966		2.948424	1.337373	2833.848842	0.715906	0	0	0	0	1.211036
21	53.408301		2.841	1.301744	2728.917319	0.689398	0	0	0	0	1.00946
22	53.537026		2.924028	1.580608	3216.300761	0.812524	0	0.002217	0.018629	0.000005	0.529
23	53.565872		3.013572	1.61226	3096.057942	0.782148	0	0	0	0	0.68007
24	53.704817		3.286608	1.810626	3332.466093	0.841871	0	0	0	0	0.910912
25	53.923542		3.844164	2.229952	3781.672073	0.955352	0	0.007123	0.098186	0.000025	1.84501
26	53.945863		4.21812	2.335121	3100.475586	0.783264	0	0	0	0	1.203252
27	54.090961		4.441608	2.701772	4434.818769	1.120354	0	0	0	0	1.266845
28	53.941773		4.317768	2.456497	3628.914922	0.916762	0	0	0	0	1.637692
29	53.827078		3.58497	2.024323	3494.135144	0.882713	0	0	0	0	2.267093
30	53.646124		3.009828	1.682352	2747.141804	0.694002	0	0	0	0	2.389752
31	53.618036		3.102508	1.670959	3200.945955	0.808645	0	0	0	0	1.098772
32	53.768399		3.476928	2.007357	3460.745189	0.874277	0	0	0	0	0.737769
33	53.572532		3.184668	1.635352	2929.884109	0.740168	0	0	0	0	1.592323
34	53.598474		3.071796	1.676516	3379.315333	0.853706	0	0	0	0	0.917011
35	53.690364		3.09636	1.877494	3051.898592	0.770992	0	0	0	0	0.94635
36	53.681635		3.343416	1.770197	3277.630085	0.828018	0	0	0	0	1.183909
37	53.762004		3.436656	1.870828	3431.70002	0.86694	0	0	0	0	1.311074
38	53.707022		3.292956	1.82731	3702.918971	0.935457	0	0	0	0	2.168402
39	53.713764		3.252288	1.871122	2905.345774	0.733968	0	0	0	0	1.837072
40	53.682031		3.08328	1.72293	3473.216167	0.877428	0	0	0	0	2.084704
41	53.744124		3.410904	1.861764	3607.149108	0.911263	0	0	0	0	1.015868
42	53.878863		3.545844	2.214912	3000.115813	0.75791	0	0	0	0	0.725931
43	53.815122		3.717396	2.203722	3651.657117	0.922507	0	0.00994	0.247314	0.000062	1.50728
44	53.747951		3.450132	1.895427	3573.661679	0.902803	0	0.002323	0.029424	0.000007	1.080535
45	53.670059		3.080418	1.747267	3360.596128	0.848977	0	0	0	0	2.490976
46	53.590697		2.95254	1.621114	3065.172614	0.774345	0	0.007714	0.196873	0.00005	1.586022
47	53.564071		2.842428	1.582671	3081.151322	0.778382	0	0	0	0	1.850533
48	53.42909		2.791326	1.333681	3170.719791	0.801009	0	0.024589	0.535254	0.000135	1.999983
49	53.461045		2.909976	1.451232	2611.350086	0.659697	0	0.000096	0.000413	0	0.918265
50	53.447008		2.748732	1.396896	3205.08179	0.80969	0	0.022498	0.767522	0.000194	1.405569
51	53.459139		2.97216	1.540706	2693.34664	0.680412	0	0.002451	0.038234	0.00001	1.160353
52	53.638964		3.256332	1.724043	3200.941694	0.808644	0	0.015408	0.663269	0.000168	1.300305

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53	53.762773		3.43368	1.928565	3491.003862	0.881921	0	0	0	0	2.983474
54	53.719949		3.48084	1.929768	3421.948756	0.864476	0	0.005124	0.054025	0.000014	1.434274
55	53.720754		3.473112	1.833358	3032.269402	0.766033	0	0	0	0	1.234954
56	53.475077		2.76888	1.436666	3065.185506	0.774348	0	0.012431	0.389178	0.000098	0.914674
57	53.702137		3.835008	1.882032	3302.632813	0.834334	0	0.002929	0.011785	0.000003	0.567638
58	53.74511		3.306972	1.905228	3324.902362	0.83996	0	0	0	0	0.738789
59	53.718001		3.336768	1.844477	3227.666388	0.815395	0	-0.02277	0.58398	0.000148	1.545356
60	53.762715		3.48246	1.89311	3501.543469	0.884584	0	0	0	0	1.52139
61	53.751788		3.502716	1.881846	3390.29601	0.85648	0	0	0	0	1.761404
62	53.70624		3.150924	1.766787	2833.813728	0.715898	0	0	0	0	1.945409
63	53.76813		3.411756	1.931416	3505.204778	0.885509	0	0	0	0	1.721044
64	53.899765		4.081404	2.199685	3997.574484	1.009895	0	0.00529	0.155778	0.000039	1.485054
65	53.838958		3.493512	2.060424	3338.460496	0.843385	0	0	0	0	0.711451
66	53.614173		3.142452	1.68933	2964.397566	0.748887	0	0	0	0	1.32421
67	53.562636		3.059704	1.536897	3186.249607	0.804932	0	0	0	0	1.856906
68	53.668224		3.133476	1.747436	3615.44859	0.91336	0	0.030651	3.603808	0.00091	1.129165
69	53.872784		3.623808	2.17264	2534.183855	0.640203	0	0.023836	0.425506	0.000107	0.548948
70	53.737666		3.512088	1.893017	3569.584401	0.901773	0	0.005837	0.049713	0.000013	1.072501
71	53.572862		3.499668	1.598033	2847.247421	0.719291	0	0.001164	0.024318	0.000006	1.027657
72	53.367373		2.700144	1.186353	2899.627623	0.732524	0	0.000171	0.071471	0.000018	0.619901
73	53.252534		2.377728	1.038876	2437.866771	0.615871	0	0.010133	1.341824	0.000339	0.734823
74	53.540818		2.83398	1.569886	2679.800724	0.67699	0	0.001589	0.725375	0.000183	1.367873
75	53.416021		2.846772	1.378561	2981.691109	0.753255	0.001296	-0.0002	3.566287	0.000901	2.257275
76	53.527589		2.76846	1.485568	3110.519386	0.785801	0	0.030943	0.937059	0.000237	1.227801
77	53.5227		2.99118	1.45104	2479.82023	0.626469	0	0	0	0	1.786873
78	53.428952		2.70252	1.339526	3176.200333	0.802394	0	0.012144	0.541537	0.000137	1.900122
79	53.485067		2.81319	1.441532	2681.354446	0.677382	0	0	0	0	1.404144
80	53.528414		2.601348	1.491466	2951.271543	0.745571	0	0	0	0	1.689192
81	53.4081		2.530404	1.24038	2290.355	0.578605	0	0.094635	4.257768	0.001076	1.949372
82	53.583632		2.705592	1.570281	3182.140242	0.803894	0	0.000027	0.000295	0	1.352068
83	53.70861		3.426102	1.827755	3339.704078	0.843699	0	0.000321	0.006371	0.000002	1.524842
84	53.606594		2.987796	1.607697	3264.499258	0.8247	0	0	0	0	1.65714
85	53.662279		3.107568	1.836158	3302.698512	0.83435	0	0.007224	0.062312	0.000016	1.386133
86	53.544735		3.06204	1.547924	2748.733266	0.694404	0	0.059203	1.196281	0.000302	1.29275
87	53.694013		3.036414	1.774292	3673.259477	0.927964	0	0	0	0	1.884987
88	53.656065		3.045192	1.718104	3284.172162	0.82967	0	0.000204	0.042965	0.000011	2.314262
89	53.617611		3.18072	1.701921	2825.296131	0.713746	0	0.036534	1.393069	0.000352	1.420044
90	53.704154		3.469704	1.801014	3313.370329	0.837046	0	0	0	0	2.450723
91	53.661724		3.061776	1.712443	3516.006142	0.888238	0	0	0	0	1.389359
92	53.59823		3.013548	1.612178	2882.382356	0.728167	0	0.003153	0.025308	0.000006	1.989004
93	53.625624		3.193176	1.593002	2986.162871	0.754385	0	0.000458	0.009426	0.000002	2.329667
94	53.793334		3.492396	1.932416	2867.729052	0.724465	0	0	0	0	2.158669
95	53.924171		3.968892	2.177366	3751.277291	0.947674	0	0	0	0	2.499501
96	54.06396		3.936924	2.416643	4074.125392	1.029234	0	0.000954	0.008029	0.000002	1.689862
97	54.013089		3.537648	2.25888	3129.954736	0.790711	0	0	0	0	1.615704
98	54.019051		3.782772	2.335148	4139.53912	1.045759	0	0	0	0	2.51456
99	53.944932		4.059096	2.207933	3963.089396	1.001183	0	0.001628	0.028222	0.000007	1.261405
100	54.139623		4.33092	2.582067	4169.103828	1.053228	0	0	0	0	1.474091
101	54.184809		4.004676	2.643267	3493.534528	0.882561	0	0	0	0	1.081905
102	54.150312		4.149456	2.568853	3949.560594	0.997765	0	0.017047	0.456531	0.000115	1.323085

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103	53.908866		3.725616	2.120937	3744.775601	0.946031	0	0	0	0	2.466228
104	53.906488		3.80544	2.146529	4080.11167	1.030746	0	0	0	0	3.593689
105	53.729502		3.290124	1.854786	3331.904321	0.841729	0	0.004191	0.127797	0.000032	1.964335
106	54.028742		4.18668	2.456703	3485.539922	0.880541	0	0	0	0	1.889905
107	53.995502		4.245684	2.268479	4178.563768	1.055618	0	0.001446	0.01766	0.000004	1.785613
108	54.003302		3.654456	2.332782	3790.650385	0.95762	0	0.002748	0.033455	0.000008	1.281864
109	54.009177		3.922536	2.356122	3853.022652	0.973377	0	0	0	0	1.937415
110	54.091783		4.20846	2.413801	3899.451381	0.985106	0	0	0	0	1.90688
111	54.153732		4.257192	2.630886	4070.038307	1.028201	0	0	0	0	1.001297
112	54.004488		3.661944	2.287364	3401.432648	0.859293	0	0	0	0	1.394959
113	53.949708		3.879684	2.250079	4067.695644	1.027609	0	0	0	0	0.438746
114	53.826723		3.65748	1.962287	3593.646941	0.907852	0	0.02786	0.728832	0.000184	1.434199
115	53.910301		3.610608	2.21699	4045.056196	1.02189	0	0	0	0	0.965972
116	54.023105		3.64914	2.332413	3530.819143	0.89198	0	0	0	0	1.516424
117	54.018762		4.229016	2.380016	4093.910215	1.034232	0	0	0	0	1.867368
118	53.980307		4.115136	2.30717	3365.808392	0.850294	0	0.005256	0.059976	0.000015	1.415514
119	53.940445		3.646716	2.181293	3736.727749	0.943998	0	0.003884	0.020756	0.000005	1.423628
120	53.883665		3.446172	2.069537	3658.321643	0.92419	0	0	0	0	0.740367
121	53.885925		3.37086	2.172483	2899.862131	0.732583	0	0	0	0	1.042207
122	53.855672		3.794052	2.122383	3980.417646	1.005561	0	0	0	0	1.545702
123	53.799108		4.2381	2.080742	3637.591521	0.918953	0	0.033703	1.31139	0.000331	2.156338
124	53.920246		3.97098	2.207431	3408.936254	0.861189	0	0	0	0	1.684132
125	53.761574		3.447996	1.899713	3548.932608	0.896556	0	0	0	0	1.21322
126	53.583545		3.000168	1.622803	2741.872667	0.692671	0	0	0	0	0.996618
127	53.616966		3.336504	1.628544	3363.236393	0.849644	0	0.005463	0.198419	0.00005	1.677194
128	53.75394		3.223752	1.878348	3365.824365	0.850298	0	0.016282	0.277136	0.00007	1.023862
129	53.830497		3.397572	2.016096	3028.599468	0.765106	0	0	0	0	0.969024
130	53.797322		3.669588	2.009929	2967.633397	0.749704	0	0.002596	0.072644	0.000018	0.878594
131	53.704689		3.461856	1.864518	3435.714108	0.867954	0	0.000342	0.013511	0.000003	0.868583
132	53.75689		3.145452	1.843928	3758.46541	0.949489	0	0.005212	0.29181	0.000074	1.44964
133	53.780121		3.723372	1.99101	2985.339575	0.754177	0	0.001224	0.325317	0.000082	0.695773
134	53.810938		3.374076	1.982645	3528.433667	0.891377	0	0.016291	0.858393	0.000217	2.131282
135	53.603068		3.328056	1.631437	3199.218736	0.808209	0	0	0	0	2.025183
136	53.715463		3.340368	1.878115	3765.351594	0.951229	0	0	0	0	1.217199
137	53.659794		3.345276	1.750935	2329.812407	0.588573	0	0.021258	0.337055	0.000085	1.973686
138	53.675244		3.114696	1.726457	3035.40355	0.766825	0	0	0	0	2.017739
139	53.676851		3.090504	1.714925	3530.543637	0.89191	0	0.000624	0.006608	0.000002	1.577172
140	53.639654		3.080256	1.677678	3324.222383	0.839788	0	0.001788	0.032614	0.000008	1.171526
141	53.696181		3.165204	1.784655	2871.4218	0.725398	0	0.012822	0.174054	0.000044	0.674128
142	53.622486		3.811476	1.659265	3474.802672	0.877829	0	0.000683	0.011231	0.000003	3.017601
143	53.616375		3.33696	1.672689	3151.770746	0.796222	0	0.005282	0.118081	0.00003	1.844099
144	53.698882		3.310992	1.789313	3235.209743	0.817301	0	0.008534	0.362066	0.000091	1.331485
145	53.76969		4.036248	1.96978	3637.424971	0.918911	0	0.003156	0.019677	0.000005	0.576281
146	53.765682		3.486204	1.900199	3084.34986	0.77919	0	0.001613	0.01173	0.000003	1.016901
147	53.650254		3.132624	1.699339	3276.976452	0.827852	0	0.000221	0.001039	0	0.878504
148	53.689272		3.249468	1.74924	3309.636842	0.836103	0	0.00117	0.008455	0.000002	0.865323
149	53.622548		2.905896	1.632212	3071.243033	0.775879	0	0.001902	0.210967	0.000053	0.626944
150	53.746844		3.163674	1.81394	3419.505953	0.863859	0	0	0	0	1.579864
151	53.861361		3.443964	2.062146	3787.733477	0.956883	0	0.006457	0.203353	0.000051	0.911718
152	53.783627		3.376968	1.88279	3419.185216	0.863778	0	0	0	0	0.693668

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153	53.699972		3.196884	1.696158	2716.237116	0.686195	0	0.011232	0.147589	0.000037	1.408595
154	53.969874		4.097148	2.221567	3591.166647	0.907225	0	0.02818	1.617716	0.000409	1.200354
155	53.886075		4.260294	2.15727	3856.082913	0.97415	0	0.00003	0.000151	0	0.599877
156	53.582556		3.05676	1.649695	3278.698101	0.828287	0	0.008662	0.520351	0.000131	1.181988
157	53.508286		2.722188	1.455331	2644.608947	0.668099	0	0.014741	0.269337	0.000068	2.423915
158	53.495715		3.031476	1.465268	3182.477564	0.803979	0	0.024184	0.849041	0.000214	2.033657
159	53.722467		3.459168	1.856296	3322.632087	0.839386	0	0.000165	0.001905	0	1.610582
160	53.767899		3.440856	1.877375	3039.474659	0.767853	0	0	0	0	1.267016
161	53.659186		3.050868	1.647435	3479.039241	0.878899	0	0.038849	1.154501	0.000292	1.017191
162	53.669374		3.133506	1.780867	3004.683297	0.759064	0	0	0	0	1.760474
163	53.806592		3.813222	2.04774	3600.020289	0.909462	0	0	0	0	1.164276
164	53.814657		3.187308	1.935909	3205.216891	0.809724	0	0	0	0	1.639111
165	53.786616		3.333864	1.894999	3406.580605	0.860594	0	0.000259	0.031238	0.000008	0.991901
166	53.713305		3.27678	1.795475	3422.594689	0.864639	0	0.012555	0.184687	0.000047	1.549992
167	53.80238		3.455184	1.94721	3635.338122	0.918384	0	0.003207	0.032544	0.000008	0.940819
168	54.046065		4.130508	2.37211	3655.18436	0.923398	0	0.000127	0.000693	0	1.410426
169	53.901214		3.947748	2.202331	3472.517813	0.877251	0	0	0	0	0.449461
170	53.731117		3.726348	1.861685	3309.55385	0.836082	0	0	0	0	0.893816
171	53.79632		3.824784	1.911095	3799.548381	0.959868	0	0.018437	0.579153	0.000146	1.385993
172	53.733901		3.358752	1.822175	3721.682626	0.940197	0	0.007597	0.227957	0.000058	0.705601
173	53.622372		3.112932	1.712385	2507.318398	0.633416	0	0.024399	0.683289	0.000173	0.777845
174	53.663229		3.025248	1.725455	3542.471422	0.894924	0	0.029126	0.966937	0.000244	1.021322
175	53.760414		3.780984	1.978044	3570.326979	0.901961	0	0.003706	0.098391	0.000025	1.667455
176	53.621205		3.0108	1.576726	2866.219915	0.724084	0	0.000357	0.011375	0.000003	0.537897
177	53.471208		2.908056	1.492797	2854.598336	0.721148	0.048576	0.040959	1.96463	0.000496	1.716074
178	53.652233		3.109404	1.719383	3341.532298	0.844161	0	0.003679	1.927963	0.000487	1.306134
179	53.747648		3.394272	1.867791	3510.809702	0.886925	0	0.001115	0.469556	0.000119	2.073764
180	53.849299		3.628284	2.117028	3542.693423	0.89498	0	0.05287	1.877597	0.000474	1.732915
181	53.940845		3.533376	2.182956	3421.576557	0.864382	0	0	0	0	0.754938
182	53.834435		3.517644	2.009028	3092.106547	0.781149	0	0	0	0	1.476547
183	53.699385		3.365724	1.755691	3318.170673	0.838259	0	0.012144	0.464908	0.000117	2.298459
184	53.786217		3.40566	1.858227	3610.672848	0.912153	0	0	0	0	1.348955
185	53.830277		3.422148	2.028761	2908.758156	0.734831	0	0.034478	0.652321	0.000165	2.076776
186	54.040787		4.5021	2.537626	3499.480409	0.884063	0	0.006475	0.071336	0.000018	2.115216
187	53.993243		4.589196	2.555353	4204.272278	1.062112	0	0.019062	0.511251	0.000129	2.308898
188	53.884519		3.91362	2.22679	3698.056453	0.934229	0	0	0	0	0.865019
189	53.802926		3.227628	1.981752	3529.395161	0.89162	0	0.008618	0.190158	0.000048	1.05186
190	53.868243		3.366576	2.062987	3102.583437	0.783796	0	0.007619	0.137477	0.000035	0.524429
191	54.045239		4.151886	2.461944	4255.363692	1.075019	0	-0.000369	0.015968	0.000004	0.428821
192	54.059805		4.025544	2.486279	4191.137672	1.058794	0	0	0	0	0.737133
193	53.949922		3.764952	2.224344	3401.539686	0.85932	0	0	0	0	1.107141
194	53.973074		3.438078	2.186366	3484.59143	0.880302	0	0.018703	0.787004	0.000199	1.232904
195	53.895411		3.929604	2.12443	3543.317051	0.895137	0	0.000386	0.00028	0	0.924428
196	53.72226		3.30822	1.801224	3077.598852	0.777484	0	0.008643	0.147705	0.000037	2.448503
197	53.70133		3.45342	1.774104	3461.091388	0.874365	0	0.024688	1.300714	0.000329	2.199398
198	53.748311		3.355872	1.809138	3342.508727	0.844408	0	0	0	0	2.645563
199	53.881205		3.6345	2.077694	3799.890072	0.959954	0	0.00119	0.014362	0.000004	1.923572
200	53.897034		3.428952	2.090036	3354.088666	0.847333	0	0	0	0	0.872083
201	53.770123		3.108936	1.901805	3653.457186	0.922962	0	0	0	0	0.975385
202	53.80795		4.022016	1.956337	3586.049066	0.905932	0	0.01623	0.655249	0.000166	1.767838

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203	53.971425		3.846192	2.265548	3824.559129	0.966186	0	0.004327	0.426935	0.000108	0.782186
204	53.965275		3.888972	2.183827	3861.325887	0.975475	0	0	0	0	1.026427
205	54.004042		3.866412	2.350785	3918.149633	0.98983	0	0	0	0	1.338162
206	53.988821		3.907992	2.303199	3928.723381	0.992501	0	0.002646	0.024057	0.000006	1.633368
207	54.095948		4.29192	2.47687	4158.485229	1.050545	0	0	0	0	1.945941
208	53.872606		3.662616	2.07145	3234.25427	0.81706	0	0.01842	1.910306	0.000483	1.872223
209	53.871837		3.492912	2.071332	3485.541912	0.880542	0	0	0	0	1.614507
210	53.861305		3.682602	2.059598	3696.413737	0.933814	0	0.01456	0.440434	0.000111	0.918543
211	53.736356		3.199956	1.823671	3438.00688	0.868533	0	0.013729	0.600338	0.000152	1.517088
212	53.86481		3.520272	2.081172	3507.262485	0.886029	0	0.001178	0.153349	0.000039	0.878942
213	53.831642		3.289188	2.020005	3564.282953	0.900434	0	0.006592	0.207948	0.000053	1.317096
214	53.781428		3.261696	1.927791	3697.562375	0.934104	0	0.001188	0.243609	0.000062	1.465828
215	53.813175		3.576204	1.953172	3487.635513	0.881071	0	0.002573	0.104456	0.000026	1.831742
216	53.774904		3.364128	1.914374	3257.803279	0.823009	0	0.012782	0.77804	0.000197	0.82851
217	53.886307		3.616992	2.122601	3846.12563	0.971635	0	0	0	0	0.4413
218	53.873369		3.681852	2.08449	3678.50243	0.929289	0	0.016365	0.809483	0.000204	0.803725
219	53.675689		3.204672	1.704555	2951.548607	0.745641	0	0.060283	2.049486	0.000518	1.765918
220	53.689274		3.418008	1.8485	3298.500706	0.83329	0	0	0	0	0.645421
221	53.784597		3.109344	1.910472	3123.12889	0.788986	0	0.005917	0.234619	0.000059	0.792932
222	53.774888		3.40674	1.875656	3437.565988	0.868422	0	0.00481	0.376578	0.000095	1.181973
223	53.866346		3.556692	2.060434	3599.012363	0.909207	0	0.017061	0.498344	0.000126	1.280174
224	53.928852		3.702624	2.17896	3285.232275	0.829938	0	0	0	0	0.642113
225	53.905549		3.57786	2.112901	4165.312292	1.05227	0	0.018374	0.982417	0.000248	1.080183
226	53.816379		3.528702	1.98162	3714.965072	0.9385	0	0.005142	0.319874	0.000081	1.101654
227	53.749856		3.071244	1.846967	3501.456465	0.884562	0	0.000575	0.072917	0.000018	0.386683
228	53.84155		3.539532	2.040382	3299.723532	0.833599	0	0.011923	1.248052	0.000315	0.700765
229	53.795461		3.625188	2.015325	3165.726488	0.799748	0	0.003932	0.338198	0.000085	1.282502
230	53.955963		3.719952	2.240836	3752.087659	0.947878	0	0.011971	0.133265	0.000034	0.818163
231	53.940894		3.752328	2.183125	3595.259171	0.908259	0	0.001672	0.02193	0.000006	1.00255
232	53.836582		3.657876	2.11182	3207.364382	0.810267	0	0	0	0	0.938801
233	53.829997		3.579552	2.001882	3517.441591	0.8886	0	0.000389	0.005245	0.000001	1.397186
234	53.776563		3.162048	1.902812	3527.844794	0.891228	0	0.018032	0.709895	0.000179	1.293127
235	53.657733		3.222024	1.72046	3670.723337	0.927323	0	0.004804	1.722747	0.000435	0.971122
236	53.764531		3.18414	1.914653	2972.44395	0.750919	0	0	0	0	1.280529
237	53.88087		4.079844	2.184465	3672.582596	0.927793	0	0.008771	0.449385	0.000114	1.320541
238	53.773712		3.385398	1.891905	3612.856128	0.912705	0	0.042688	1.533913	0.000388	1.119777
239	53.847821		3.900216	2.127895	3929.796278	0.992772	0	0	0	0	0.578705
240	53.863548		3.311064	1.941833	3355.199659	0.847614	0	0	0	0	1.303594
241	53.706107		3.216492	1.78132	3514.483553	0.887853	0	0	0	0	1.523109
242	53.717432		3.355092	1.792193	3407.978653	0.860947	0	0.019688	1.023863	0.000259	1.315804
243	53.658948		3.07566	1.649719	3374.823017	0.852571	0	0.004401	0.2478	0.000063	1.112518
244	53.808761		3.345588	1.913501	3130.24794	0.790785	0	0.003389	0.062167	0.000016	2.078331
245	53.985752		4.082442	2.251352	3805.913854	0.961476	0	0.005621	0.08525	0.000022	2.136247
246	53.92179		3.651324	2.122786	3903.631629	0.986162	0	0.055471	2.155909	0.000545	1.340481
247	53.830363		3.38862	1.992938	3490.588156	0.881816	0	0	0	0	1.676433
248	53.993382		3.7737	2.331561	3179.920015	0.803333	0	0	0	0	3.399156
249	53.956915		3.919464	2.238422	3937.516775	0.994723	0	0.00461	0.020509	0.000005	1.365921
250	53.911459		3.798564	2.133484	3873.693503	0.978599	0	0	0	0	1.44837
251	53.9229		3.529632	2.210808	3524.326854	0.89034	0	0.014237	0.186861	0.000047	1.269444
252	53.825222		3.811704	2.082617	3474.17014	0.877669	0	0.000624	0.018759	0.000005	1.250669

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253	54.014652		4.429704	2.468723	4167.012715	1.052699	0	0.001235	0.015495	0.000004	1.115011
254	53.973014		3.543948	2.255677	3870.851084	0.977881	0	0	0	0	1.015799
255	53.933409		3.814884	2.211267	4120.197653	1.040873	0	0.000891	0.129454	0.000033	1.297676
256	54.055458		3.882672	2.405262	3316.731344	0.837896	0	0.016192	0.43375	0.00011	1.487076
257	54.004006		4.128474	2.472816	3835.383207	0.968921	0	0.001418	0.049518	0.000013	2.094265
258	53.923485		3.698064	2.177396	3368.560774	0.850989	0	0.024335	0.69458	0.000175	1.634159
259	53.838578		3.536688	2.086006	3422.679385	0.864661	0	0.022994	0.759049	0.000192	2.642961
260	53.710519		3.371688	1.819857	3079.127889	0.777871	0	0.053926	2.098868	0.00053	2.24469
261	53.922241		3.855284	2.187677	3904.32426	0.986337	0	0.003289	0.266915	0.000067	1.110739
262	53.937015		3.876636	2.16612	3455.451733	0.87294	0	0	0	0	1.662736
263	53.930488		3.37128	2.167706	4085.680786	1.032153	0	0.00644	0.121329	0.000031	0.496897
264	53.870386		3.289464	2.078732	3293.148121	0.831938	0	0.001049	0.063075	0.000016	0.762369
265	53.927624		3.558462	2.174206	3976.505057	1.004572	0	0.000797	0.010651	0.000003	0.721011
266	54.036057		3.613992	2.338231	3832.047133	0.968078	0	0	0	0	0.750483
267	54.089793		3.885696	2.477112	3000.98572	0.75813	0	0.002895	0.012401	0.000003	1.151578
268	53.959776		3.714972	2.236228	4005.144767	1.011807	0	0.003084	0.150994	0.000038	0.697491
269	54.269727		4.205184	2.717723	4418.195302	1.116155	0	0	0	0	1.170848
270	54.133286		4.158984	2.510851	3726.344806	0.941375	0	0	0	0	1.01973
271	54.100592		3.989352	2.398644	4017.848361	1.015017	0	0	0	0	1.344196
272	53.944471		3.734256	2.199034	3591.449271	0.907297	0	0.000291	0.092921	0.000023	0.95546
273	53.873906		3.556584	2.09497	3775.785553	0.953865	0	0.003546	0.611737	0.000155	1.181538
274	53.71021		3.213552	1.811914	3015.310391	0.761748	0	0.016142	0.396727	0.0001	1.07138
275	53.777801		3.384012	1.922786	3400.575357	0.859077	0	0	0	0	2.772514
276	53.711427		3.416016	1.820957	3463.011449	0.87485	0	0.034241	3.560857	0.0009	2.244257
277	54.029715		3.890676	2.275152	3893.296453	0.983551	0	0.003016	1.986494	0.000502	1.726217
278	54.09322		4.04238	2.54982	3600.203018	0.909508	0	0	0	0	1.438759
279	53.969042		3.8733	2.181559	3108.249055	0.785227	0	-0.002642	0.269522	0.000068	1.474571
280	53.901774		3.792588	2.13629	3974.475021	1.004059	0	0.000393	0.221492	0.000056	1.372968
281	54.004665		4.106706	2.339307	3703.846398	0.935691	0	0.005176	0.20673	0.000052	0.945175
282	53.851205		3.83676	2.223141	3720.491989	0.939896	0	-0.003583	0.408969	0.000103	1.070568
283	53.900499		3.733536	2.103525	3654.558906	0.92324	0	0.003463	0.047224	0.000012	1.195693
284	53.846303		3.794562	2.062911	3660.643511	0.924777	0	0.015082	0.711604	0.00018	1.82418
285	53.838023		3.978516	2.1106	3864.290904	0.976224	0	0.004869	0.96266	0.000243	2.186663
286	54.123804		4.390416	2.557788	3933.646583	0.993745	0	0	0	0	1.285607
287	54.029955		3.742476	2.357485	4035.715349	1.01953	0	0	0	0	1.178419
288	53.705076		3.69906	1.866313	3495.183323	0.882977	0	0.000262	0.060023	0.000015	0.880658
289	53.819622		3.706308	2.035443	3109.384264	0.785514	0	0	0	0	1.834596
290	53.766494		3.086712	1.853446	3425.185564	0.865294	0	0.014206	0.361687	0.000091	1.733919
291	53.798654		3.34284	1.938538	3531.269217	0.892094	0	0.00288	0.091272	0.000023	0.98073
292	53.89819		4.046148	2.152411	3910.970728	0.988016	0	0.004816	0.262315	0.000066	1.260539
293	53.855163		3.75414	2.150597	3782.602613	0.955587	0	0	0	0	0.649641
294	53.979654		3.952872	2.366856	3812.593944	0.963164	0	0	0	0	1.286371
295	53.932688		3.969408	2.145785	3757.464653	0.949237	0	0	0	0	2.044441
296	53.789467		3.398358	1.962219	3559.99821	0.899351	0	0.015406	0.507331	0.000128	1.463626
297	53.703906		3.082572	1.79281	2896.457218	0.731723	0	0.000851	0.006198	0.000002	0.767415
298	53.701983		3.322116	1.788343	3363.945171	0.849823	0	0	0	0	1.784807
299	53.660306		3.350304	1.768697	3311.665138	0.836616	0	0.030013	1.802856	0.000455	1.730817
300	53.605391		3.157896	1.690472	3474.585188	0.877774	0.340032	0.058167	3.543631	0.000895	1.166265
301	53.77511		3.28308	1.927731	3504.084534	0.885226	0	0.013042	0.315585	0.00008	2.196135
302	53.755772		3.305364	1.809488	3666.728324	0.926314	0	0.004524	0.052157	0.000013	1.492606

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303	53.72297		3.67017	1.864071	3402.650065	0.859601	0	-0.000241	0.288279	0.000073	1.403523
304	53.936988		3.934644	2.21614	4011.419044	1.013392	0	0	0	0	1.759945
305	53.935334		3.460428	2.123198	3658.93623	0.924346	0	0	0	0	0.964287
306	54.104102		4.144812	2.526789	4005.468997	1.011889	0	0.01461	0.626659	0.000158	2.214806
307	53.990557		3.926196	2.376357	3956.487675	0.999515	0	0.015064	0.364256	0.000092	2.297774
308	53.649683		3.502248	1.787162	3778.023792	0.95443	0.26772	0.016298	3.159038	0.000798	1.764816
309	53.489491		3.132948	1.515691	2553.747898	0.645145	0	0.052495	3.596062	0.000908	1.91032
310	53.56091		3.06168	1.5716	3442.867589	0.869761	0	0.000343	0.273755	0.000069	2.498451
311	53.588094		3.25587	1.635184	3179.278112	0.803171	0	-0.011799	2.327217	0.000588	2.009387
312	53.23338		2.605896	0.999786	2411.138972	0.609119	0.336528	0.021795	4.460334	0.001127	1.636643
313	53.45064		3.942456	1.332924	2210.388987	0.558404	0	0.007206	0.254866	0.000064	1.402298
314	TAP HERE - VALUES PLACED AT BOTTOM OF PAGE TO PREVENT SKEWING OF DATA AVERAGES										
315	53.570411		5.135832	1.629999	3077.464372	0.77745	0	0.008882	2.799227	0.000707	2.752059
316	53.57045		3.25014	1.499702	3469.421404	0.876469	0.022344	-0.022546	2.267715	0.000573	3.311344
317	53.572318		3.389064	1.502603	3455.95547	0.873067	0	-0.003363	0.24836	0.000063	2.525648
318	53.487844		3.130488	1.39758	3231.816573	0.816444	0	0.003554	0.849857	0.000215	2.54525
319	53.481114		3.192144	1.38349	3571.090251	0.902153	0.073248	0.000368	2.274877	0.000575	2.46315
320	53.537847		3.40439	1.502186	3564.048649	0.900375	0	0.006952	2.019574	0.00051	3.360584
321	53.59154		3.201672	1.51311	3507.387317	0.88606	0	-0.003319	0.565786	0.000143	1.882191
322	53.464885		2.907342	1.384877	3178.246249	0.80291	0	0.000371	1.128082	0.000285	1.930272
323	53.585932		3.328584	1.563235	3741.079589	0.945097	0	-0.000529	0.120383	0.00003	2.328531
324	53.506454		3.022896	1.440672	2382.022879	0.601763	0	-0.022901	2.108699	0.000533	1.746639
325	53.484024		3.133452	1.435366	3423.848449	0.864956	0	0.035336	7.616493	0.001924	2.381682
326	53.5462		3.003768	1.498263	3278.653445	0.828276	0	-0.000392	0.120949	0.000031	2.909596
327	53.318949		2.979276	1.154155	3242.667862	0.819185	0	-0.006797	3.235397	0.000817	3.654285
328	53.517588		3.422736	1.587106	2992.726163	0.756043	0	-0.007664	5.14273	0.001299	2.609925
329	53.811679		3.809268	2.052264	3806.234108	0.961557	0	0.003173	0.042415	0.000011	1.244845
330	53.912628		4.04616	2.314301	4022.875985	1.016287	0	0	0	0	1.003849
331	53.920683		3.549048	2.154549	2910.752153	0.735334	0	0	0	0	1.89357
332	53.878553		3.962016	2.194171	4354.333097	1.100022	0	-0.000019	0.001937	0	1.01254
333	53.933079		3.831882	2.234911	4092.353638	1.033839	0	0.008398	0.392905	0.000099	1.325213
334	53.896826		3.9486	2.266096	3915.923302	0.989268	0	0	0	0	1.1616
335	53.775912		3.981276	2.076639	3116.240831	0.787246	0	0.000501	0.009941	0.000003	1.232682
336	53.821213		3.702144	2.069066	3820.235513	0.965094	0	0.013617	1.691654	0.000427	1.163703
337	53.751208		3.43128	1.853932	3566.436098	0.900978	0	0	0	0	2.054517
338	53.662304		3.125616	1.73559	3651.972407	0.922586	0	0.010032	0.288474	0.000073	2.742628
339	53.490703		2.776272	1.409402	2882.453414	0.728185	0	0	0	0	3.351398
340	53.50317		2.86254	1.43705	3120.38934	0.788294	0	0.000109	0.427522	0.000108	2.35779
341	53.632385		3.03774	1.684145	3014.958967	0.76166	0	0.0112	0.306459	0.000077	1.288195
342	53.735105		3.612756	1.978702	3771.003169	0.952657	0	0	0	0	0.513198
343	53.702538		3.377568	1.949814	2134.526468	0.539239	0	0	0	0	1.036952
344	53.656437		3.509496	1.874834	3475.081633	0.877899	0	0	0	0	1.641003
345	53.484687		3.01938	1.464522	2978.190014	0.752371	0	0.01239	0.835407	0.000211	2.157227
346	53.561308		3.194328	1.550626	2964.771309	0.748981	0	0	0	0	3.040242
347	53.763477		3.68022	1.985541	3768.942889	0.952136	0	0	0	0	2.251185
348	53.513895		3.322452	1.403571	3188.197725	0.805424	0	-0.000856	0.02353	0.000006	2.795435
349	53.520284		3.08718	1.483803	2917.994441	0.737164	0	0.147601	7.652226	0.001933	2.270122
350	53.66273		3.02376	1.667716	3264.082809	0.824595	0	-0.003426	0.432146	0.000109	2.14936
351	53.723516		3.542688	1.784309	3330.754662	0.841438	0	0.002931	0.039389	0.00001	2.580762
352	53.653976		3.021864	1.703668	3334.32868	0.842341	0	0	0	0	2.216237

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353	53.536457		3.157992	1.648908	2908.3341	0.734723	0	0.004359	1.574976	0.000398	1.713653
354	53.658389		3.62286	1.869302	3052.666363	0.771186	0	0.0018	0.198393	0.00005	0.9884
355	53.597095		3.374388	1.644421	3490.518547	0.881799	0	0.003233	0.045638	0.000012	1.994734
356	53.600528		3.575172	1.675996	3581.461074	0.904773	0	0.000237	0.056025	0.000014	2.198864
357	53.57171		3.186888	1.57663	3314.169762	0.837248	0	0.00556	0.091613	0.000023	2.138683
358	53.595378		3.112644	1.655374	3372.925452	0.852092	0.012204	0.005038	2.116467	0.000535	1.73677
359	53.694543		3.828024	1.981207	3733.948962	0.943296	0	0.008223	2.295887	0.00058	1.099835
360	53.591429		3.28158	1.654263	3172.986413	0.801582	0	-0.000012	0.002465	0.000001	2.045346
361	53.798621		4.032744	2.098649	3509.903323	0.886696	0	0.005194	0.208981	0.000053	0.726547
362	53.721396		3.307752	1.820544	3666.098427	0.926155	0	-0.000196	0.086275	0.000022	1.318469
363	53.896276		4.0827	2.354129	4068.751877	1.027876	0	0.004549	0.463832	0.000117	1.276126
364	53.822544		3.60486	2.013305	3780.443046	0.955042	0	0.000067	0.004474	0.000001	0.391071
365	53.92937		3.634704	2.196114	3814.165131	0.963561	0	0	0	0	0.532938
366	53.722972		3.406764	1.825964	3655.723817	0.923534	0	0.005988	0.513223	0.00013	1.521106
367	53.810758		3.73038	2.078924	3322.157621	0.839266	0	0.033582	0.977985	0.000247	1.698355
368	53.750426		3.817656	1.930735	3539.127707	0.894079	0	0.001949	0.84565	0.000214	0.882581
369	53.932518		4.057236	2.298702	3337.292278	0.84309	0	0.002594	0.031145	0.000008	0.863666
370	53.815193		4.246668	2.123669	4186.262444	1.057562	0	0	0	0	1.767924
371	53.695569		3.555864	1.895673	3131.026411	0.790981	0	0	0	0	0.841851
372	53.750422		3.378564	1.933238	3185.019612	0.804622	0	0	0	0	1.669969
373	53.726031		3.463776	1.86841	3774.011219	0.953417	0	0	0	0	1.937373
374	53.787504		3.702864	1.928152	3721.119827	0.940055	0	0.006663	1.20298	0.000304	1.446181
375	53.773171		3.668292	2.056323	3644.144167	0.920609	0	0	0	0	1.491652
376	53.764558		3.33678	1.985465	3462.099164	0.874619	0	0	0	0	0.768779
377	53.595851		3.087432	1.612726	3474.896438	0.877852	0	0.031032	1.360241	0.000344	0.825697
378	53.608084		3.25728	1.580517	3566.598718	0.901019	0	0	0	0	2.261468
379	53.519147		3.018336	1.419753	3104.739866	0.784341	0	0	0	0	1.955092
380	53.558616		3.089124	1.591501	3030.719599	0.765641	0	-0.000174	0.277236	0.00007	1.885825
381	53.763912		3.635988	1.858291	3645.09332	0.920849	0	0.004946	0.848014	0.000214	2.235389
382	53.764219		3.645672	1.906424	3403.846166	0.859903	0	0.021434	0.657844	0.000166	1.897167
383	53.883961		3.797484	2.14435	3625.857718	0.915989	0	0	0	0	2.897687
384	53.85062		3.736488	2.026748	4072.03213	1.028705	0	0	0	0	3.332889
385	53.889707		3.92022	2.117872	3691.238004	0.932506	0	0	0	0	3.07927
386	53.830415		3.853806	2.042763	3787.754771	0.956889	0	0	0	0	3.076824
387	53.847813		3.781788	2.102282	3835.177898	0.968869	0	0.004407	0.109968	0.000028	1.805182
388	53.935435		3.957576	2.307372	3730.618699	0.942455	0	0.008056	0.133857	0.000034	0.902244
389	53.895486		3.958536	2.225016	4004.766012	1.011712	0	0	0	0	0.603317
390	53.864998		3.642732	2.05863	3836.528344	0.96921	0	0.022537	1.937666	0.00049	1.835656
391	53.755024		4.075428	1.869757	3581.584573	0.904805	0	0.005865	1.913887	0.000483	2.225673
392	53.733242		3.135588	1.837738	3410.452476	0.861572	0	0	0	0	2.549596
393	53.789643		3.505434	2.005822	3775.171195	0.95371	0	0	0	0	1.774565
394	53.692149		3.686256	1.914086	3660.990106	0.924865	0	0.015433	0.496845	0.000126	1.653471
395	53.704124		3.42318	1.77373	3858.075545	0.974654	0	0.00151	0.087436	0.000022	2.666641
396	53.877685		4.053936	2.251957	3559.080306	0.899119	0	0	0	0	1.337223
397	53.913591		3.977256	2.228052	4359.673354	1.101371	0	0	0	0	1.823879
398	54.011354		4.094052	2.349792	4057.058456	1.024922	0	0	0	0	2.603281
399	54.119427		4.468032	2.588358	4288.672087	1.083434	0	0	0	0	0.97751
400	54.04953		4.289796	2.508707	4236.175632	1.070172	0	0	0	0	1.804182
401	53.961441		4.212174	2.293986	4067.410252	1.027537	0	0	0	0	1.618428
402	53.95385		4.162704	2.303224	3816.607109	0.964178	0	0	0	0	2.034801

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403	53.892564		3.848112	2.229461	3881.766022	0.980638	0	0.001269	0.009948	0.000003	1.317899
404	53.860955		3.731364	2.139568	3755.890963	0.948839	0	0.01015	0.299377	0.000076	1.01194
405	53.946258		3.967104	2.282925	4062.43203	1.02628	0	0.000918	0.021123	0.000005	0.445041
406	54.118402		4.59702	2.520104	4010.871563	1.013254	0	0	0	0	1.264242
407	53.942184		3.952536	2.177322	4181.14824	1.05627	0	0	0	0	1.583806
408	53.926536		3.969828	2.206537	3948.19028	0.997419	0	0	0	0	1.90979
409	53.882026		3.892068	2.150158	3810.881045	0.962731	0	-0.000028	0.010215	0.000003	0.606631
410	53.859547		3.910164	2.141465	3857.442374	0.974494	0	0.000641	0.072718	0.000018	0.481843
411	53.781089		4.002084	2.059032	3393.557989	0.857304	0	0.024929	0.623143	0.000157	0.445309
412	53.804407		3.448512	2.003647	3648.222113	0.921639	0	0.00158	0.072026	0.000018	0.893271
413	53.948313		4.278828	2.433004	3942.208085	0.995908	0	0	0	0	1.356693
414	54.005121		4.028232	2.437688	3920.209243	0.99035	0	0	0	0	1.125093
415	54.161217		4.469556	2.528618	4173.365918	1.054304	0	0	0	0	1.121309
416	54.03159		3.928068	2.329546	4107.610341	1.037693	0	0.004725	0.149332	0.000038	0.999165
417	53.90515		3.692904	2.107111	3705.996528	0.936234	0	-0.009639	0.440296	0.000111	1.591099
418	53.837789		3.614784	2.009375	3802.785689	0.960686	0	0.007185	0.168244	0.000043	0.79052
419	53.574786		3.014748	1.566812	3058.570044	0.772677	0	0	0	0	2.127756
420	53.633016		3.067134	1.660239	3057.67294	0.77245	0	0.000678	0.039585	0.00001	0.762463
421	53.698725		3.299988	1.819881	3404.577481	0.860088	0	0.016465	0.507403	0.000128	0.54932
422	53.70008		3.24138	1.859709	3334.669828	0.842427	0	0	0	0	0.735537
423	53.75968		3.418344	1.935726	3290.143541	0.831179	0	0	0	0	0.490313
424	53.672126		3.608184	1.860791	3481.151451	0.879432	0	0.012301	0.939938	0.000237	1.182608
425	53.680456		3.584268	1.818636	3391.259908	0.856723	0	0.001256	0.075705	0.000019	0.820975
426	53.788014		3.71616	2.064092	3805.71478	0.961426	0	0	0	0	0.647956
427	53.704039		3.511836	1.824244	3556.48627	0.898464	0	0.00283	0.180716	0.000046	1.159937
428	53.689342		3.346008	1.787754	3414.890157	0.862693	0	0	0	0	3.303068
429	53.710972		3.210552	1.810337	3421.312272	0.864315	0	0	0	0	2.056215
430	53.779634		4.051956	1.996354	3607.08606	0.911247	0	0.005514	0.464534	0.000117	0.963682
431	53.904232		4.298808	2.218292	4062.453288	1.026285	0	0	0	0	1.82654
432	53.841158		4.13448	2.101841	3674.409033	0.928255	0	0.002324	0.045092	0.000011	1.100891
433	53.681478		3.378528	1.885017	3400.325109	0.859014	0.234576	0.009879	3.53819	0.000894	1.471274
434	53.785711		4.044756	1.933631	3686.30965	0.931261	0	0	0	0	0.899287
435	53.606574		3.013908	1.610433	3212.046718	0.811449	0	0.005326	0.066134	0.000017	0.618145
436	53.604659		2.964012	1.617047	3042.43202	0.7686	0	0.024646	0.567835	0.000143	0.602998
437	53.475763		2.816292	1.352163	2919.733942	0.737603	0	0.000275	0.132932	0.000034	1.268282
438	53.438473		2.95368	1.354543	2933.690013	0.741129	0	0.000047	0.000917	0	0.929669
439	53.535443		3.349764	1.575907	3077.408613	0.777436	0	-0.000352	0.080032	0.00002	1.293996
440	53.375606		3.04122	1.405961	3256.667943	0.822722	0	0.0022	1.833436	0.000463	1.552766
441	53.221743		2.527056	0.977942	2184.649508	0.551901	0	0.021528	1.650518	0.000417	0.987491
442	53.362106		2.7882	1.192133	2903.31548	0.733456	0	0.000666	0.027713	0.000007	1.647486
443	53.325981		2.568948	1.138672	2805.21088	0.708672	0	0.002636	0.737575	0.000186	2.99898
444	53.361364		2.785968	1.211257	2825.217146	0.713726	0	0.002857	0.043408	0.000011	3.782177
445	53.447724		2.961504	1.341693	3468.530118	0.876244	0	0.000881	0.207443	0.000052	3.662416
446	53.512148		3.209592	1.487024	3368.411273	0.850951	0	0.035886	5.690289	0.001438	1.143423
447	53.909157		3.874164	2.160102	3904.916547	0.986487	0	0	0	0	1.042635
448	53.797903		3.510828	1.938392	3556.077448	0.898361	0	0	0	0	0.924748
449	53.440396		3.060564	1.340731	2875.42139	0.726409	0	0.018488	4.411873	0.001115	0.924391
450	53.542841		3.094908	1.479643	3185.215428	0.804671	0	0.000357	0.311641	0.000079	2.294456
451	53.636686		3.387912	1.78076	3376.346979	0.852956	0	0.003866	0.099493	0.000025	2.599104
452	53.663435		3.149064	1.645218	3750.977358	0.947598	0	0.004842	0.171563	0.000043	2.295957

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453	53.700372		3.223524	1.756274	3134.986385	0.791982	0	0	0	0	1.380056
454	53.704778		3.249102	1.718725	3438.413418	0.868636	0	0	0	0	1.902062
455	53.653693		3.088992	1.668231	3335.947089	0.84275	0	0	0	0	2.02897
456	53.580479		3.154872	1.573467	3396.925809	0.858155	0	0.036667	3.894937	0.000984	2.5466
457	53.82102		3.448584	1.95263	3731.871456	0.942771	0	0.000135	0.019105	0.000005	1.446184
458	53.810985		3.592836	2.007687	3656.649669	0.923768	0	0	0	0	1.707284
459	53.522534		3.10818	1.517933	3125.964069	0.789703	0	-0.002499	0.290673	0.000073	1.082518
460	53.559652		3.087228	1.516327	3429.622237	0.866415	0	0	0	0	2.054463
461	53.680337		3.142944	1.72158	3467.778062	0.876054	0	0.000518	0.012731	0.000003	2.053706
462	53.650415		2.972076	1.664485	3295.054328	0.832419	0	0.006449	1.479986	0.000374	0.754396
463	53.568023		2.943384	1.546733	3328.501781	0.840869	0	0.0213	0.747873	0.000189	0.537261
464	53.570964		3.032796	1.540759	3130.520262	0.790854	0	0	0	0	2.323247
465	53.616905		3.327212	1.664888	3318.884459	0.838439	0	0.002333	0.529618	0.000134	0.903554
466	53.686333		3.428856	1.777212	3569.533119	0.90176	0	-0.000047	0.010173	0.000003	0.884067
467	53.630489		3.388632	1.684741	3369.500747	0.851227	0	-0.0001	0.294009	0.000074	0.926781
468	53.783445		3.484364	1.896598	3499.547683	0.88408	0	0.002932	0.112111	0.000028	1.124516
469	54.060106		4.182684	2.387948	3908.513069	0.987396	0	0	0	0	2.545823
470	54.04379		4.281288	2.304755	4048.126202	1.022666	0	0	0	0	1.955567
471	54.165404		5.181132	2.644942	4236.592186	1.070277	0	0.000069	0.000693	0	1.212465
472	53.829908		3.627972	1.967316	3630.805719	0.917239	0	-0.002118	2.962156	0.000748	0.851599
473	53.936852		3.735072	2.167342	3880.955006	0.980434	0	0	0	0	1.603038
474	53.969913		4.070628	2.273999	3979.821778	1.00541	0	0	0	0	1.387721
475	53.909644		3.703616	2.112741	3882.391245	0.980796	0	0	0	0	2.127551
476	53.822337		3.596802	2.006325	3733.410769	0.94316	0	0.003482	0.057759	0.000015	1.885307
477	53.746033		3.571056	1.860979	3447.744772	0.870993	0	-0.000249	0.031393	0.000008	1.504847
478	53.764138		3.542316	1.859066	3565.624665	0.900773	0	0	0	0	2.767578
479	53.820083		3.581592	1.934075	3620.724859	0.914692	0	0	0	0	1.465535
480	54.027109		4.233768	2.305631	3886.453375	0.981823	0	0.005083	0.104923	0.000027	2.697654
481	53.932644		3.86088	2.212462	3792.941386	0.958199	0	0	0	0	1.324238
482	53.858649		3.80094	2.048271	3867.767612	0.977102	0	0.00749	0.480205	0.000121	1.587103
483	53.911607		4.19604	2.310073	3978.574824	1.005095	0	0.000345	0.007849	0.000002	0.627689
484	53.860945		4.134264	2.227657	3848.092691	0.972132	0	0.005256	0.278841	0.00007	0.94333
485	53.909178		3.76788	2.160592	3966.701297	1.002095	0	0	0	0	1.08389
486	53.818081		3.708024	1.980226	3834.512876	0.968701	0	0.00137	0.143166	0.000036	1.192989
487	53.942459		4.38684	2.207622	3409.415825	0.86131	0	0	0	0	0.879282
488	53.881342		3.475272	2.073157	3883.733608	0.981136	0	0.00099	0.007861	0.000002	0.556243
489	53.536088		2.991132	1.532649	2937.202014	0.742016	0	0.036986	4.659966	0.001177	1.162121
490	53.779181		3.531372	1.925334	3528.913076	0.891498	0	0	0	0	0.680317
491	53.813609		3.583782	2.133253	3636.349935	0.91864	0	-0.000233	1.890261	0.000478	3.049562
492	53.821639		3.368868	1.977315	3332.689839	0.841927	0	0	0	0	0.862971
493	53.607883		3.238668	1.680515	3396.921299	0.858154	0	0.006991	1.57823	0.000399	0.903951
494	53.743725		3.590664	1.854149	3576.391434	0.903493	0	-0.001005	0.424514	0.000107	0.874427
495	53.733133		3.21102	1.885019	3480.254957	0.879206	0	0.003847	0.076874	0.000019	0.730469
496	53.631108		3.056112	1.714035	3326.98822	0.840487	0	0.003967	4.610525	0.001165	1.54936
497	53.782742		3.559044	2.017972	3224.590335	0.814618	0	-0.000067	0.006926	0.000002	0.950358
498	53.803698		3.577908	2.016366	3921.819493	0.990757	0	0.000159	0.001905	0	0.86329
499	53.815181		3.2337	1.959503	3592.113203	0.907464	0	0.011145	0.348274	0.000088	0.882807
500	53.978145		4.00392	2.196804	4170.604738	1.053607	0	0	0	0	0.92933
501	53.90696		3.595284	2.118389	3825.140791	0.966333	0	0.003042	0.39629	0.0001	0.903817
502	53.829412		3.340752	2.001062	3633.622075	0.917951	0	-0.000005	0.001905	0	0.909587

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503	53.99936		3.903504	2.370642	3911.595363	0.988174	0	0.001341	0.059915	0.000015	1.216584
504	53.806281		3.390648	1.984803	3574.061849	0.902904	0	0	0	0	1.199491
505	53.688126		3.203994	1.76014	3666.381228	0.926227	0	0	0	0	1.292133
506	53.920458		3.693348	2.182804	3860.294073	0.975214	0	0	0	0	0.451334
507	53.67577		3.281256	1.800643	3429.774325	0.866453	0	0.007927	7.736738	0.001955	2.671321
508	53.821703		3.498468	1.980123	3694.361377	0.933295	0	0.009479	0.417678	0.000106	0.849922
509	53.716785		3.482268	1.788744	3478.58006	0.878783	0	0	0	0	1.365075
510	53.784076		3.8742	1.89586	3446.888053	0.870777	0	0.000399	0.00277	0.000001	2.096798
511	54.042108		3.876648	2.361502	4024.71449	1.016751	0	0	0	0	2.205447
512	53.745683		3.247824	1.865058	3682.679431	0.930344	0	0.04108	2.399076	0.000606	1.004309
513	53.586676		3.023316	1.58152	3383.632665	0.854797	0	-0.008266	1.729233	0.000437	1.414084
514	53.83755		3.6417	2.024246	3539.626246	0.894205	0	-0.002109	0.631266	0.000159	1.522139
515	53.921076		3.862752	2.102253	3710.579457	0.937392	0	0.001767	0.05679	0.000014	1.281067
516	53.784874		3.19152	1.888837	3651.882745	0.922564	0	0.014872	3.059134	0.000773	1.289662
517	53.988727		3.69948	2.267763	4033.694867	1.01902	0	0	0	0	1.485724
518	53.939697		3.851568	2.223622	3906.657623	0.986927	0	0	0	0	1.002106
519	53.777331		3.898236	1.957618	3508.365541	0.886307	0	-0.000176	0.233137	0.000059	2.155225
520	53.804662		3.816792	1.95979	3676.22235	0.928713	0	0.021804	1.415813	0.000358	1.359579
521	53.83946		3.79764	1.976227	3639.637134	0.91947	0	0	0	0	1.798
522	53.678511		3.207216	1.695293	2909.659682	0.735058	0	0.016893	0.750041	0.000189	1.042845
523	53.447232		3.596952	1.352568	2840.451327	0.717574	0	0.052464	6.128997	0.001548	1.884239
524	53.615949		3.179508	1.615757	3480.550276	0.879281	0	0.007345	0.275446	0.00007	3.381618
525	53.582889		3.128808	1.586337	3235.673488	0.817418	0.002004	0.029244	1.07999	0.000273	2.572632
526	53.734859		3.411024	1.803933	3507.092156	0.885986	0	0.010355	0.56825	0.000144	2.26769
527	53.807592		3.479508	1.940212	3711.739094	0.937685	0	0.006313	0.145351	0.000037	1.185219
528	53.784789		3.70791	1.983051	3746.713409	0.946521	0	0.006123	0.998053	0.000252	0.937656
529	53.947548		3.724788	2.18808	3518.863143	0.888959	0	0	0	0	1.697079
530	53.708285		3.50286	1.830884	3990.173673	1.008025	0	0.007004	1.107184	0.00028	1.476083
531	53.684876		3.162978	1.773707	3583.807009	0.905366	0	0.015995	0.736614	0.000186	1.07571
532	53.951077		3.47646	2.162323	4105.744606	1.037222	0	0	0	0	1.406743
533	53.768125		3.47988	1.912754	3605.710674	0.910899	0	0.015319	0.902242	0.000228	1.167909
534	53.663723		3.394212	1.731395	3405.699271	0.860371	0	0.012047	1.092602	0.000276	0.884436
535	53.750274		3.387312	1.867207	3779.329133	0.95476	0	0	0	0	2.078453
536	53.676617		3.080808	1.709438	3243.839021	0.819481	0	0.001973	0.029261	0.000007	2.193108
537	53.420256		3.089196	1.296054	3153.443684	0.796645	0	0.006667	0.245041	0.000062	3.135471
538	53.43103		3.033924	1.313667	2937.33329	0.742049	0	0.058479	4.590118	0.00116	2.611376
539	53.552962		3.36402	1.586171	3223.506369	0.814344	0	0.017919	1.699955	0.000429	1.642289
540	53.643454		3.664704	1.747971	3068.181421	0.775105	0	0.019646	1.317435	0.000333	1.393124
541	53.754877		3.767568	1.886419	3181.876815	0.803828	0	0.034187	2.809884	0.00071	2.788487
542	53.794854		3.891738	2.000481	3832.240822	0.968127	0	0.002853	1.964127	0.000496	2.246998
543	53.958917		3.9642	2.178418	3924.281889	0.991379	0	0	0	0	3.514773
544	53.815579		3.656772	2.041426	4072.42338	1.028804	0	-0.000411	0.491452	0.000124	3.376106
545	53.94668		4.230288	2.211531	3695.799666	0.933658	0	0	0	0	1.632414
546	53.840074		3.754032	2.004861	3759.480213	0.949746	0	0	0	0	2.385147
547	53.601675		3.240828	1.601007	3379.209426	0.853679	0	-0.000504	0.186495	0.000047	2.682934
548	53.532305		2.951076	1.534756	3003.159799	0.758679	0	0.061652	2.136854	0.00054	2.949893
549	53.629322		3.310224	1.656197	3250.075242	0.821056	0	-0.000173	0.401166	0.000101	3.840443
550	53.789029		3.735432	1.963859	3732.460854	0.94292	0	0	0	0	2.756216
551	53.704291		3.489144	1.713694	3348.12268	0.845826	0	-0.00001	0.017	0.000004	2.346428
552	53.689329		3.441504	1.778084	3630.274004	0.917105	0	0.000399	0.002338	0.000001	1.608135

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553	53.742056		3.485436	1.848126	3550.618934	0.896982	0	0.000323	0.030096	0.000008	1.275245
554	53.555148		2.89596	1.504376	3314.588026	0.837354	0	0.003208	0.076958	0.000019	0.845392
555	53.585203		3.122952	1.565571	3297.383703	0.833008	0	0.014281	1.995148	0.000504	1.810553
556	53.637961		3.662196	1.673096	3446.011952	0.870555	0	0.004366	1.353524	0.000342	1.704694
557	53.791733		4.034448	1.988198	3655.100418	0.923377	0	0	0	0	2.780564
558	53.641236		3.616416	1.708614	3295.93357	0.832641	0	0	0	0	2.77871
559	53.679118		3.201048	1.782095	3358.54866	0.84846	0	0.004521	1.780861	0.00045	1.420445
560	53.646346		3.085796	1.662559	3285.04634	0.829891	0	0	0	0	2.631798
561	53.691056		3.190404	1.745192	3409.408073	0.861308	0	0.020884	1.190471	0.000301	0.793821
562	53.89007		3.757776	2.102598	3752.655865	0.948022	0	0.038921	1.041953	0.000263	1.067466
563	53.88111		3.717384	2.057403	3773.393958	0.953261	0	0.002061	0.065779	0.000017	0.966769
564	54.13759		4.517028	2.574008	3905.540761	0.986645	0	0.034132	0.671584	0.00017	1.596156
565	54.008153		4.114032	2.355801	3967.443326	1.002283	0	0.012825	0.235125	0.000059	1.337075
566	54.103989		4.041612	2.422334	3989.023047	1.007735	0	0	0	0	1.207037
567	53.849787		3.797424	2.062202	3592.814407	0.907642	0	0	0	0	1.522623
568	53.549692		3.11982	1.508827	3172.447615	0.801446	0	0.015448	3.85957	0.000975	1.430551
569	53.600441		2.975484	1.590243	3352.161212	0.846846	0	-0.000137	0.016516	0.000004	1.101248
570	53.67286		3.359408	1.738589	3495.134537	0.882965	0	0.003437	0.068982	0.000017	1.43571
571	53.689353		3.41844	1.824886	3504.285339	0.885277	0	0.003024	1.004051	0.000254	1.032848
572	53.876038		3.723612	2.104686	3381.234041	0.854191	0	0	0	0	2.118889
573	53.861119		3.664248	2.05008	3937.960919	0.994835	0	0.003645	0.10146	0.000026	2.337462
574	53.926759		3.434832	2.111217	3957.703824	0.999822	0	0.00246	0.137993	0.000035	1.241314
575	54.006011		3.9537	2.290968	4032.793947	1.018792	0	0.001699	0.085396	0.000022	0.870731
576	53.759296		3.549312	1.879362	3135.599888	0.792137	0	0.00022	0.001121	0	2.326098
577	53.685295		3.253098	1.76331	3529.097589	0.891545	0	0.005475	0.083835	0.000021	3.094666
578	53.755717		3.864096	1.852071	3475.888036	0.878103	0	0	0	0	2.925424
579	53.702964		3.327084	1.75729	3301.000576	0.833922	0	0.002724	0.028547	0.000007	1.264185
580	53.715673		3.381456	1.814685	3431.364288	0.866855	0	0.036518	0.497475	0.000126	1.871518
581	53.679255		3.635724	1.717153	3321.102177	0.839	0	0	0	0	2.400985
582	53.743349		4.007964	1.856211	3332.467414	0.841871	0	0	0	0	1.91329
583	53.869959		3.560472	2.074656	3955.906989	0.999368	0	0	0	0	1.794711
584	53.756243		3.2847	1.860096	3785.110714	0.956221	0	0.010373	0.667247	0.000169	2.205056
585	53.716713		3.107424	1.829148	3538.220072	0.89385	0	0.011467	0.496274	0.000125	0.935035
586	53.776152		3.21588	1.920512	2822.820016	0.71312	0	0	0	0	1.068566
587	53.689614		3.212916	1.762707	3468.126764	0.876142	0	0.004873	0.947644	0.000239	1.459578
588	53.638208		3.52578	1.681063	3271.450786	0.826456	0	0	0	0	1.695315
589	53.632702		3.502068	1.735339	3003.201255	0.758689	0	0.039566	1.53313	0.000387	1.234402
590	53.760204		3.19302	1.870437	2915.823666	0.736615	0	0.013911	0.427929	0.000108	0.938659
591	53.7585		3.499296	1.865925	3444.930863	0.870282	0	-0.001361	0.106741	0.000027	1.780866
592	53.63755		3.013698	1.664966	3407.663199	0.860867	0	0.003962	1.321421	0.000334	1.660269
593	53.770252		3.621828	1.925328	3316.696789	0.837887	0	0	0	0	2.805512
594	53.698442		3.37653	1.841397	3565.453113	0.900729	0	0	0	0	2.921244
595	53.674991		3.294312	1.74293	3840.484311	0.97021	0	0.031348	1.15371	0.000291	2.390266
596	53.843763		3.503664	2.041217	3462.689493	0.874768	0	0.011628	0.422138	0.000107	2.864088
597	53.881764		3.742068	2.058862	3629.770891	0.916978	0	0.001547	0.023879	0.000006	2.633371
598	53.717341		3.512356	1.798955	3595.126166	0.908226	0	0.007503	0.234662	0.000059	1.045521
599	53.6735		3.311208	1.754249	3324.800217	0.839934	0	0	0	0	2.359447
600	53.712752		3.177504	1.83016	3289.537007	0.831026	0	0.000066	0.036655	0.000009	2.071678
601	53.594433		3.320664	1.600865	3297.474168	0.833031	0	0.020633	1.197148	0.000302	1.287
602	53.683526		3.67398	1.812983	3612.004321	0.912489	0	0.00621	1.000833	0.000253	2.09289

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603	53.698116		3.383736	1.83533	3490.558386	0.881809	0	0	0	0	2.341626
604	53.717754		3.383652	1.877167	3600.253114	0.909521	0	-0.000353	0.131635	0.000033	2.421553
605	53.671613		3.235194	1.725492	3844.064328	0.971114	0	0.000392	0.401086	0.000101	2.268555
606	53.854001		3.687252	2.048859	3970.864384	1.003147	0	0	0	0	1.709647
607	53.863306		3.343908	2.026828	3597.970736	0.908944	0	0.00546	0.052107	0.000013	0.931167
608	53.817967		3.28935	2.01032	3638.228338	0.919114	0	0.068553	2.538092	0.000641	0.988263
609	53.93688		3.525744	2.149017	3955.791515	0.999339	0	-0.000219	0.056414	0.000014	0.537076
610	53.847214		3.371724	2.051216	3262.112741	0.824097	0	-0.000246	0.248626	0.000063	0.861571
611	53.745113		3.171756	1.909649	3336.446348	0.842876	0	0.001416	0.087781	0.000022	0.516114
612	53.692322		3.224658	1.725276	3356.939755	0.848053	0	0.002797	0.18903	0.000048	0.75872
613	53.736101		3.332508	1.840485	3441.905795	0.869518	0	0.003835	0.143013	0.000036	0.907408
614	53.63028		3.341352	1.716069	3336.647654	0.842927	0	0.012408	0.249336	0.000063	0.969488
615	53.678205		3.523716	1.856156	3501.477047	0.884567	0	0.006768	0.437734	0.000111	1.276438
616	53.504615		3.137436	1.460883	3146.601295	0.794916	0	0.007732	1.078916	0.000273	2.327594
617	53.607842		2.869416	1.580266	3026.351466	0.764538	0	0.005859	0.097925	0.000025	0.894686
618	53.601039		2.908356	1.633465	3302.247601	0.834237	0	0.000385	0.009886	0.000002	0.317762
619	53.760552		3.130944	1.841996	3448.871979	0.871278	0	0.001665	0.102239	0.000026	0.790795
620	53.915698		4.149768	2.301448	3508.13725	0.88625	0	0	0	0	0.804486
621	53.834825		3.252792	1.969395	3451.998584	0.872068	0	0.040281	1.957507	0.000495	1.099754
622	53.860038		3.577092	2.117578	4010.012327	1.013037	0	0.001549	1.030953	0.00026	1.224715
623	53.811742		3.426648	1.986582	3604.430592	0.910576	0	0	0	0	1.401395
624	53.647635		3.752916	1.845552	2989.985752	0.755351	0	0.020311	4.200722	0.001061	1.020097
625	53.847246		3.680184	2.088903	3837.950273	0.969569	0	-0.000062	0.004502	0.000001	1.277754
626	53.788268		3.394368	1.958899	3565.04843	0.900627	0	0	0	0	1.382463
627	53.625951		3.05634	1.657403	3162.906189	0.799035	0	0.01367	0.373369	0.000094	0.63279
628	53.796266		3.5691	2.028295	3645.63252	0.920985	0	0	0	0	0.999971
629	53.636157		3.317916	1.716201	3058.710855	0.772713	0	-0.000131	0.004935	0.000001	1.213068
630	53.935653		3.743454	2.233597	4083.633839	1.031636	0	0	0	0	0.560859
631	53.866604		3.436716	2.032773	3700.305421	0.934797	0	0	0	0	0.988144
632	53.832024		3.489564	2.038284	3349.62725	0.846206	0	0.001862	0.191071	0.000048	0.999672
633	53.833805		3.231096	1.979786	3589.47832	0.906799	0	-0.000016	0.003975	0.000001	1.513175
634	54.00148		3.569964	2.320783	3666.601841	0.926282	0	0	0	0	0.917906
635	53.967679		3.619308	2.205538	3884.913059	0.981434	0	0.008784	0.101194	0.000026	1.212955
636	53.912237		4.023528	2.051328	4089.944276	1.03323	0	0	0	0	1.124655
637	54.000999		4.14972	2.381214	4060.841276	1.025878	0	-0.000708	1.04981	0.000265	0.994866
638	54.070656		3.991152	2.360972	4054.823392	1.024357	0	0.003619	0.123275	0.000031	0.475691
639	53.93117		3.677856	2.171032	3251.313961	0.821369	0	0	0	0	0.645774
640	53.927367		3.766236	2.266345	4116.552762	1.039952	0	0.005234	0.756855	0.000191	1.316947
641	53.916054		3.863676	2.189355	4071.16928	1.028487	0	0.034648	1.358329	0.000343	1.468214
642	53.891421		3.50142	2.085765	3692.152877	0.932737	0	0	0	0	0.733269
643	53.781547		3.11196	1.888759	2842.628313	0.718124	0	0.000912	0.003908	0.000001	1.008662
644	53.985834		3.755316	2.252524	3946.027947	0.996873	0	0	0	0	0.818485
645	53.892524		3.530124	2.09393	3721.157109	0.940064	0	0.000017	0.202309	0.000051	0.67577
646	53.634254		3.084096	1.72302	2790.45705	0.704944	0	0.00228	0.867873	0.000219	0.904549
647	53.785303		3.3663	1.99366	3306.304244	0.835261	0	0	0	0	0.865286
648	53.810009		3.711312	2.074784	3582.319089	0.90499	0	-0.000113	0.046109	0.000012	1.094502
649	54.037305		3.589632	2.394294	4186.936703	1.057733	0	0	0	0	1.320563
650	53.910848		3.385224	2.12993	3472.431554	0.87723	0	0	0	0	1.061469
651	53.809743		3.428868	1.932249	3365.48505	0.850212	0	0.009975	2.659297	0.000672	1.484325
652	53.851899		3.555684	2.045416	3809.833688	0.962466	0	0.040257	1.238497	0.000313	1.016406

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653	53.847957		3.312192	2.036565	3756.982103	0.949115	0	0.003032	0.021406	0.000005	1.535413
654	53.843011		3.66864	2.074118	3714.145328	0.938293	0	0	0	0	1.012096
655	53.875123		3.517884	2.05634	3723.694688	0.940705	0	0.010746	2.660548	0.000672	1.827827
656	54.016455		3.660744	2.324884	4099.512935	1.035647	0	0.000013	0.001624	0	0.63356
657	54.067436		4.000716	2.433066	3874.80223	0.978879	0	0	0	0	0.88335
658	53.867609		3.72084	2.041619	3688.711011	0.931868	0	0.001265	0.024686	0.000006	0.984938
659	53.745523		3.223608	1.784601	3594.421901	0.908048	0	0	0	0	1.112179
660	53.833201		3.724668	2.011844	3614.067266	0.913011	0	0.016027	0.428894	0.000108	0.851162
661	53.798368		3.499164	1.943583	3630.274106	0.917105	0	0.023484	0.632444	0.00016	0.675618
662	53.680636		3.45888	1.811887	3447.938893	0.871042	0	0.000308	0.250325	0.000063	0.672199
663	53.621967		3.499752	1.657606	3155.588431	0.797187	0	0.002003	0.114828	0.000029	1.424721
664	53.476793		2.9499	1.410468	2594.660475	0.655481	0	0.000684	0.003463	0.000001	1.470913
665	53.586465		3.258078	1.548346	3221.561292	0.813853	0	0.001691	0.124188	0.000031	1.75325
666	53.789917		3.562056	1.967852	3609.481533	0.911852	0	0	0	0	0.651373
667	53.707077		3.269964	1.768697	3481.120178	0.879425	0	-0.000043	0.003636	0.000001	1.831264
668	53.748078		3.224772	1.816069	3516.76456	0.888429	0	0	0	0	2.359124
669	53.692305		3.291876	1.806378	3575.962334	0.903384	0	0.057552	4.931303	0.001246	1.168215
670	53.784209		3.201492	1.919483	3533.366426	0.892623	0	0.00786	0.211641	0.000053	1.430805
671	53.721712		3.228396	1.810508	3471.890495	0.877093	0	0.002525	0.554545	0.00014	1.010227
672	53.822021		3.60636	1.977319	3476.207082	0.878183	0	0	0	0	2.782647
673	53.692518		3.290304	1.730193	3404.193574	0.859991	0	-0.000676	0.641267	0.000162	1.272676
674	53.570204		2.799696	1.522816	3055.191485	0.771824	0	0	0	0	1.721382
675	53.475988		2.773668	1.383815	3161.151432	0.798592	0	-0.000003	0.103977	0.000026	1.339689
676	53.36219		2.766108	1.209896	2951.340751	0.745588	0	0.006674	1.686307	0.000426	1.154794
677	53.422439		2.879112	1.375769	3086.691743	0.779781	0	0.018391	3.354423	0.000847	1.414155
678	53.630243		2.976096	1.688317	3419.988605	0.863981	0	0.010095	0.368615	0.000093	0.631422
679	53.487816		2.945652	1.427896	2983.401813	0.753688	0	-0.00182	0.222639	0.000056	0.942691
680	53.425478		3.287952	1.317738	2774.087389	0.700809	0	0.015102	0.394828	0.0001	1.386593
681	53.674484		3.422676	1.742073	3162.003366	0.798807	0	0.003053	0.039822	0.00001	0.858574
682	53.721225		3.381312	1.878327	3531.528516	0.892159	0	0	0	0	1.268556
683	53.781964		3.502884	1.930131	3608.785739	0.911676	0	0.000043	0.006501	0.000002	1.441712
684	53.815136		3.45552	1.984238	3492.212699	0.882227	0	0.002827	2.605668	0.000658	1.195225
685	53.664476		3.033816	1.688094	3205.064313	0.809685	0	0	0	0	3.23812
686	53.619318		2.943948	1.621122	3384.141119	0.854925	0	0.008576	0.354313	0.00009	2.014748
687	53.475709		2.993136	1.421541	3277.714931	0.828039	0	0.008108	1.49434	0.000378	2.389785
688	53.593693		3.209988	1.601965	3407.706169	0.860878	0	0.001717	0.025625	0.000006	3.371052
689	53.450073		2.849136	1.348507	3177.548573	0.802734	0	0.062961	3.683022	0.00093	2.22843
690	53.660915		3.295872	1.703282	3337.645258	0.843179	0	0.001524	0.394324	0.0001	3.077267
691	53.498605		2.907624	1.429979	2837.877822	0.716924	0	0.012506	0.230005	0.000058	3.101262
692	53.441676		2.954316	1.35954	3098.726827	0.782822	0	0.004899	0.423628	0.000107	2.869952
693	53.405483		2.875428	1.274123	3130.464052	0.790839	0	0.001266	0.331999	0.000084	2.682183
694	53.278112		2.763564	1.024075	2914.834281	0.736366	0	0.00712	1.776973	0.000449	2.079946
695	53.221287		2.671824	0.987069	2367.068985	0.597985	0.223224	0.018456	2.757192	0.000697	1.094471
696	53.431226		2.763684	1.276154	2955.27363	0.746582	0	-0.000116	0.010878	0.000003	3.476507
697	53.387243		2.638932	1.235004	2960.496182	0.747901	0	0.009657	0.306637	0.000077	3.270876
698	53.40818		2.805948	1.245369	3092.265636	0.781189	0	0.012449	0.196432	0.00005	2.906393
699	53.371608		2.744532	1.245381	2828.287349	0.714501	0.86232	0.113493	4.337025	0.001096	1.777549
700	53.400824		2.696124	1.286281	2864.036322	0.723533	0	0.006855	4.038574	0.00102	1.287542
701	53.620318		2.742576	1.615231	3209.460562	0.810796	0	0	0	0	2.006264
702	53.309927		2.669526	1.137412	2524.077494	0.63765	0	0.038622	6.301426	0.001592	1.547414

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703	53.344416		2.717976	1.159587	2398.71096	0.605979	0	0.039714	1.83892	0.000465	1.352512
704	53.563705		3.19808	1.589445	3297.113968	0.83294	0	0.033748	3.207097	0.00081	2.058592
705	53.755887		3.262476	1.924887	3299.638175	0.833577	0	0.024894	0.879866	0.000222	3.002595
706	53.812689		3.153216	1.901439	3475.291461	0.877952	0	0.000018	0.018897	0.000005	0.619168
707	53.917421		4.325712	2.25879	3441.571006	0.869433	0	0.003003	0.127605	0.000032	1.021855
708	53.841916		4.483908	2.131584	3857.784344	0.97458	0	-0.000088	0.30732	0.000078	1.036629
709	53.75523		3.52542	1.90959	3696.37114	0.933803	0.179352	0.010308	3.215719	0.000812	1.785386
710	53.803279		3.73968	1.969619	3113.264032	0.786494	0	-0.00012	0.03153	0.000008	1.540308
711	53.904953		3.642488	2.112419	3915.264195	0.989101	0	0.003095	0.072629	0.000018	1.483425
712	53.736025		4.100988	1.949829	3289.480472	0.831011	0	-0.000737	0.20386	0.000052	0.748538
713	54.003645		4.456344	2.294281	3437.481092	0.8684	0	0	0	0	1.452734
714	54.035604		3.66786	2.282576	3253.977528	0.822042	0	0	0	0	3.144079
715	53.687945		3.547572	1.748494	3646.770054	0.921272	0	0.000133	0.004931	0.000001	2.333539
716	53.313319		2.839488	1.162041	2848.094128	0.719505	0	0.029749	10.049126	0.002539	1.471479
717	53.439117		2.68116	1.286259	2827.513617	0.714306	0	0.042455	1.386001	0.00035	2.798712
718	53.52075		3.166074	1.467442	3208.192004	0.810476	0	0.000019	0.222114	0.000056	4.869299
719	53.786966		3.621192	1.942867	3351.526161	0.846686	0	0.026364	0.548841	0.000139	2.785608
720	53.964132		3.6171	2.273058	2659.429218	0.671843	0	0	0	0	1.639313
721	53.614651		3.060288	1.653938	2741.550641	0.692589	0	0.083357	7.625485	0.001926	2.184295
722	53.745776		3.175	1.851461	3632.988698	0.917791	0	0.002511	0.013159	0.000003	1.417855
723	53.665672		2.971224	1.670564	2583.766394	0.652729	0	-0.003084	0.227493	0.000057	2.507207
724	53.5115		3.11052	1.461796	2699.714654	0.682021	0	-0.009268	6.486974	0.001639	3.047537
725	53.663662		3.256632	1.721802	3203.798112	0.809366	0	0.001326	0.047367	0.000012	2.248787
726	53.620697		3.058296	1.653024	3647.702836	0.921508	0	0.030396	1.407885	0.000356	2.231228
727	53.751134		3.37404	1.87342	3304.214353	0.834733	0	-0.00016	0.041688	0.000011	1.84363
728	53.801049		3.56382	1.943212	3664.533904	0.92576	0	0.017288	0.2906	0.000073	2.175404
729	53.82285		3.541884	1.997673	3771.456654	0.952771	0	-0.022364	0.787793	0.000199	0.86172
730	53.751336		3.283548	1.907064	3173.845597	0.801799	0	0	0	0	1.208349
731	53.563173		3.108072	1.577323	3278.166512	0.828153	0	0.000621	0.459551	0.000116	2.177701
732	53.577866		2.928264	1.574762	3607.052198	0.911238	0	0.006363	0.253475	0.000064	0.859346
733	53.885087		3.781548	2.09005	3373.386154	0.852208	0	0	0	0	1.266976
734	53.830587		3.404736	1.975179	3803.238533	0.9608	0	0.002484	0.014014	0.000004	0.597232
735	53.959943		4.145556	2.246422	3894.990473	0.983979	0	0.024304	0.308156	0.000078	1.281866
736	53.693001		3.324348	1.765491	3461.295787	0.874416	0	0.019758	0.963697	0.000243	2.403896
737	53.693122		3.459348	1.745055	3053.972911	0.771516	0	0	0	0	3.412347
738	53.669738		3.340956	1.690111	3677.991872	0.92916	0	0.004035	0.810618	0.000205	2.91803
739	53.631596		2.997942	1.655965	3362.730466	0.849516	0	0.005107	0.255921	0.000065	3.711174
740	53.474113		2.859708	1.431026	3092.726028	0.781306	0.028404	0.031607	4.664228	0.001178	1.330817
741	53.549011		2.79822	1.549668	2658.845151	0.671696	0.252408	0.145502	4.689123	0.001185	0.966958
742	53.554987		2.694072	1.511069	2957.762604	0.74721	0	0.003033	0.135937	0.000034	1.37451
743	53.533681		2.876856	1.501489	3463.280786	0.874918	0	0.038676	2.678627	0.000677	0.679593
744	53.665363		3.116544	1.702392	2977.84326	0.752283	0	0.008765	0.081922	0.000021	0.723826
745	53.771268		3.803904	1.97617	3288.950285	0.830877	0	0.036018	1.446488	0.000365	1.054357
746	53.759342		3.59934	1.937583	3888.549438	0.982352	0	0.000983	0.011192	0.000003	2.135477
747	53.665954		3.29976	1.712472	3671.689643	0.927568	0	0	0	0	2.637978
748	53.600062		3.306696	1.600383	3483.193905	0.879948	0	0.007341	0.264645	0.000067	2.446509
749	53.77401		3.558292	1.911637	3649.007818	0.921838	0	0.020737	0.684304	0.000173	1.739899
750	53.599542		3.362694	1.623553	3496.833725	0.883394	0	0.020529	4.200469	0.001061	0.858807
751	53.67073		3.263676	1.710873	3213.262508	0.811757	0	0.013548	0.210937	0.000053	1.188797
752	53.738633		3.96924	1.897469	3503.655604	0.885118	0	0	0	0	1.363752

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753	53.642141		2.921928	1.650212	3353.920127	0.84729	0	0.000067	0.002943	0.000001	0.782162
754	53.390348		2.949636	1.267929	2983.519994	0.753717	0.174402	0.085602	9.778733	0.00247	2.056233
755	53.666444		3.360864	1.763506	3508.400048	0.886316	0	0	0	0	1.215565
756	53.570852		3.058968	1.552402	3207.217899	0.810229	0	0.005644	0.129045	0.000033	1.249709
757	53.700227		3.4677	1.805731	3361.654179	0.849244	0	0.001283	0.093335	0.000024	1.595102
758	53.612892		3.0378	1.647746	3756.948297	0.949106	0	0.03989	1.652266	0.000417	1.692844
759	53.5362		2.878044	1.488944	2647.562359	0.668845	0	0.004278	0.553876	0.00014	2.87985
760	53.483626		2.957224	1.407646	3180.371182	0.803447	0	0.008915	0.242477	0.000061	2.862948
761	53.577015		3.163056	1.605117	2962.765683	0.748474	0	0.001841	0.534484	0.000135	3.186194
762	53.633763		2.85672	1.676165	3250.883564	0.821261	0	0.012837	2.939689	0.000743	1.059942
763	53.469536		2.989656	1.372214	3343.760956	0.844724	0	0.012103	1.158815	0.000293	1.150463
764	53.356051		2.673012	1.19492	2900.222448	0.732674	0.1449	0.075425	5.608126	0.001417	0.793937
765	53.573883		3.332844	1.536092	3219.041549	0.813216	0	0.040011	1.78744	0.000452	1.045315
766	53.538503		3.10992	1.476567	2885.053923	0.728842	0	0.002191	0.421412	0.000106	1.59698
767	53.59708		3.275076	1.613383	3431.709961	0.866942	0	0.001652	0.110896	0.000028	2.107237
768	53.680688		3.31668	1.710727	3425.176074	0.865292	0	0.009812	0.540101	0.000136	1.959994
769	53.85673		3.623796	2.050608	3654.400196	0.9232	0	0	0	0	1.237913
770	53.783049		3.785388	1.973382	3634.872234	0.918266	0	0.022481	0.513287	0.00013	0.635506
771	53.771127		3.577068	1.970111	3875.325536	0.979011	0	0.000032	0.007012	0.000002	1.103845
772	53.734481		3.437064	1.865395	3102.466489	0.783766	0	0	0	0	0.90118
773	53.641697		3.254064	1.721689	3140.846233	0.793462	0	0.00122	0.052203	0.000013	1.217438
774	53.615149		3.4788	1.710099	3368.985835	0.851096	0	0.0021	0.233247	0.000059	2.218124
775	53.636488		3.287544	1.702274	2869.904321	0.725015	0	0.007168	0.916816	0.000232	2.095164
776	53.816088		3.424044	1.920306	2969.661654	0.750216	0	0.008634	0.173363	0.000044	1.581917
777	53.922441		3.847756	2.169907	4167.627695	1.052855	0	0.002232	0.030992	0.000008	1.682835
778	53.850781		3.83322	2.104764	3951.504184	0.998256	0	0.000046	0.000122	0	0.974207
779	53.766336		3.619848	1.983204	3281.693641	0.829044	0	0.041959	5.40768	0.001366	1.909033
780	53.871739		3.234516	2.018484	3729.447535	0.942159	0	0.000576	0.090262	0.000023	0.825321
781	53.845626		3.363048	1.987265	3526.947137	0.891002	0	0.016632	0.841904	0.000213	0.970763
782	53.928754		3.830748	2.147792	3575.676783	0.903312	0	0	0	0	2.299746
783	53.699078		3.560628	1.810812	3701.977889	0.935219	0	0.031039	1.658511	0.000419	0.500011
784	53.708322		3.52911	1.803059	3656.242473	0.923665	0	0.045397	3.80417	0.000961	2.181811
785	53.791415		3.694284	1.875201	3689.526889	0.932074	0	0.000034	0.000693	0	1.526267
786	53.876347		3.616836	2.031434	3806.862165	0.961716	0	0	0	0	2.342709
787	53.843919		3.813	2.033844	3648.52944	0.921717	0	0.012896	1.488899	0.000376	2.20714
788	53.671458		3.167232	1.704231	3252.168081	0.821585	0	0	0	0	2.624856
789	53.699645		3.240828	1.705334	3250.844509	0.821251	0	0	0	0	1.653302
790	53.687784		3.216708	1.809418	3537.256224	0.893606	0	0	0	0	0.811141
791	53.881758		3.55314	2.070349	3745.813632	0.946293	0	0.01453	0.789928	0.0002	1.07489
792	53.940555		3.964332	2.161265	3779.404895	0.954779	0	0.001469	0.161714	0.000041	1.564332
793	53.985666		4.409244	2.332068	3552.674659	0.897501	0	0.063262	1.694545	0.000428	1.375547
794	53.895919		4.685196	2.221159	3924.039657	0.991318	0	-0.000496	0.116024	0.000029	0.863621
795	53.769909		3.599472	1.897336	3442.377905	0.869637	0	-0.00057	0.189372	0.000048	0.68251
796	53.59951		3.183708	1.64484	3356.191092	0.847864	0	0	0	0	0.81952
797	53.486451		3.093252	1.539279	2967.159081	0.749584	0	0.027438	1.043857	0.000264	0.940811
798	53.676768		3.168192	1.700395	3702.758096	0.935416	0	0.003933	0.084513	0.000021	1.071457
799	53.744324		3.215376	1.855538	3831.314271	0.967893	0	0.005452	0.987444	0.000249	1.151357
800	53.845778		3.544164	2.102193	3543.249118	0.89512	0	0.000009	0.01918	0.000005	1.442978
801	53.812454		3.518856	1.974973	3438.038655	0.868541	0	0.005149	0.572534	0.000145	1.490164
802	53.831776		3.417936	1.999586	3923.822609	0.991263	0	0.016109	0.561999	0.000142	1.959616

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803	53.91726		3.687132	2.15148	3205.251903	0.809733	0	0	0	0	1.2304
804	54.000708		3.741564	2.22743	3848.436688	0.972219	0	0.005226	0.617241	0.000156	1.73686
805	53.873647		3.86118	2.091154	3836.477966	0.969198	0	0.006927	0.389886	0.000098	0.977723
806	54.012821		4.281168	2.275017	4192.360559	1.059103	0	0	0	0	1.701865
807	53.874774		4.158768	2.036125	3482.357046	0.879737	0	0	0	0	1.96471
808	53.941425		4.252404	2.174778	4023.432155	1.016427	0	0	0	0	2.516086
809	53.812196		3.582612	1.975584	3553.663383	0.897751	0	0.000816	0.037348	0.000009	1.597065
810	53.806389		3.521892	1.950338	3896.07339	0.984253	0	0.000268	0.02889	0.000007	1.098239
811	53.920096		3.615924	2.151095	3911.538832	0.98816	0	0.004793	0.094267	0.000024	0.78947
812	53.681313		3.407676	1.717021	3207.164774	0.810216	0	0.002688	0.051076	0.000013	0.799505
813	53.753438		3.35754	1.90468	3679.902416	0.929642	0	0	0	0	0.597988
814	53.674461		3.279156	1.857242	3510.637071	0.886881	0	0.016367	1.801254	0.000455	1.179952
815	53.733199		3.485472	1.891495	3722.653567	0.940442	0	0.001192	0.011697	0.000003	0.860022
816	53.566164		3.213732	1.644646	3343.593827	0.844682	0	0	0	0	1.987243
817	53.539982		3.139104	1.42584	2919.390684	0.737517	0	0.000808	0.026627	0.000007	2.120531
818	53.392239		2.938968	1.231454	3080.690928	0.778265	0	0.013892	2.984115	0.000754	1.844843
819	53.590661		2.808312	1.592028	2778.560001	0.701939	0	0	0	0	2.229557
820	53.53261		2.93682	1.511481	3441.087266	0.869311	0	0.00571	0.146691	0.000037	0.892519
821	53.673168		3.260064	1.744204	3751.721108	0.947786	0	0.022233	3.625393	0.000916	1.524413
822	53.588206		2.941464	1.59708	3157.301394	0.797619	0	0.003444	0.489538	0.000124	0.763112
823	53.466166		2.774988	1.391974	3113.636583	0.786588	0	0.000614	0.389651	0.000098	0.785158
824	53.536112		2.879628	1.526308	3135.790477	0.792185	0	0.009014	2.452297	0.00062	1.573343
825	53.688614		2.996652	1.77091	3553.407037	0.897686	0	0	0	0	1.066337
826	53.251346		2.316	1.048183	2447.608545	0.618332	0	0.026083	7.454627	0.001883	1.434945
827	53.477246		3.286464	1.396788	2949.647665	0.74516	0	0.00489	0.570123	0.000144	0.854264
828	53.561672		3.04824	1.613893	3279.590624	0.828513	0	0.00344	0.310192	0.000078	1.641697
829	53.232444		2.69514	1.082028	2455.159171	0.620239	0.424752	0.046518	15.146438	0.003826	4.077878
830	53.438518		3.510696	1.358026	3149.058223	0.795537	0	-0.0001	0.015775	0.000004	0.644922
831	53.527083		3.059748	1.584704	2847.551023	0.719368	0	0.000197	0.103365	0.000026	0.330962
832	53.390683		2.907564	1.383985	2858.754822	0.722198	0	0.004152	2.754891	0.000696	0.753433
833	53.664287		3.279072	1.827498	3356.013042	0.847819	0	0.015833	0.497732	0.000126	1.930958
834	53.527638		3.258108	1.468944	3009.621671	0.760311	0	0.002022	0.059973	0.000015	1.021474
835	53.42226		2.71944	1.285937	2887.969005	0.729579	0.27042	0.050702	4.753171	0.001201	1.588796
836	53.603352		3.102264	1.543242	3265.012402	0.82483	0	0.00019	0.005923	0.000001	1.562795
837	53.247236		2.72706	1.007901	2626.391775	0.663497	0	0.012805	2.727269	0.000689	1.304591
838	53.331837		2.644524	1.165648	2928.235342	0.739751	0	0.010077	0.666447	0.000168	1.517922
839	53.247518		2.577408	0.964824	2078.865902	0.525177	0.255408	0.032909	1.67688	0.000424	1.132407
840	53.332655		2.978724	1.226889	3120.911711	0.788426	0	0.002732	0.113073	0.000029	1.732058
841	53.471503		2.85036	1.468712	3110.892192	0.785895	0	0.022485	2.055634	0.000519	1.523275
842	53.406575		2.972976	1.427037	3410.899305	0.861685	0	0.004413	3.719537	0.00094	1.589043
843	53.286947		3.436296	1.159552	2746.244829	0.693775	0	-0.007504	3.239231	0.000818	2.623775
844	53.304445		3.046068	1.101557	3150.934434	0.796011	0.123612	0.00029	2.114542	0.000534	2.367664
845	53.292416		2.723088	1.332486	2467.909147	0.62346	0.877236	0.02985	8.107989	0.002048	3.006095
846	53.34675		2.71032	1.22946	3155.518083	0.797169	0.02064	0.007387	1.69283	0.000428	1.546549
847	53.517712		3.044676	1.465671	3132.196441	0.791277	0	0.005351	1.529554	0.000386	1.574203
848	53.492167		2.766708	1.465403	3378.648359	0.853537	0	0.01007	0.861352	0.000218	1.314573
849	53.57378		3.062592	1.591248	3427.02338	0.865758	0	0.003139	0.240423	0.000061	1.232896
850	53.510913		3.139824	1.452012	3297.796619	0.833112	0	0.016412	0.604254	0.000153	2.185401
851	53.243703		2.787336	0.993543	2602.577003	0.657481	0	0.000976	3.023835	0.000764	2.020354
852	53.179731		2.536992	0.794647	2618.685525	0.66155	0.077016	-0.027204	4.334128	0.001095	2.360054

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853	53.156742		2.754822	0.864677	2705.449481	0.683469	0.25278	-0.004042	5.856263	0.001479	1.76287
854	53.312733		3.0804	1.157562	2954.476901	0.74638	0	0.015756	2.227443	0.000563	2.067171
855	53.424033		3.05532	1.236667	3178.184734	0.802895	0	0.000292	0.073695	0.000019	2.028657
856	53.319899		2.987868	1.028856	2807.965047	0.709367	0	0.008713	2.357553	0.000596	1.669011
857	53.373401		2.897586	1.178773	2923.626074	0.738587	0.140742	0.022707	2.529812	0.000639	2.034074
858	53.44762		3.175092	1.316947	2882.817298	0.728277	0	0.00599	0.440203	0.000111	2.217065
859	53.346447		2.725824	1.034328	2754.753222	0.695925	0	-0.009771	0.799178	0.000202	1.842127
860	53.459873		3.185736	1.267522	3189.985491	0.805876	0	0	0	0	2.782283
861	53.339891		2.936508	1.127737	2969.095606	0.750073	0	0.014679	1.058009	0.000267	1.748713
862	53.504169		2.987904	1.475517	2941.193349	0.743025	0	0.000485	0.037918	0.00001	0.969702
863	53.404084		3.005376	1.120925	2862.220406	0.723074	0	-0.000423	0.181113	0.000046	1.249795
864	53.368102		2.857752	1.122276	2822.608161	0.713067	0	0.002726	0.975761	0.000247	3.305569
865	53.428472		2.961204	1.160229	2990.121708	0.755385	0	0.004703	0.159082	0.00004	3.135479
866	53.242325		2.712792	0.900557	2806.758112	0.709063	0	-0.004721	3.022895	0.000764	3.629296
867	53.27213		2.829048	0.908622	2786.628427	0.703977	0	-0.027225	0.694138	0.000175	3.087999
868	53.318602		2.706468	0.962665	2496.518952	0.630688	0	0.008728	1.538058	0.000389	2.740579
869	53.298709		2.811696	0.861645	2877.048261	0.72682	0	-0.028999	1.506225	0.000381	3.289158
870	53.205064		2.502672	0.820474	2589.502722	0.654178	0	-0.004786	1.084409	0.000274	2.072346
871	53.139928		2.60567	0.816376	2382.889039	0.601982	0	0.003128	2.62699	0.000664	2.277415
872	53.211034		2.575872	0.908559	2449.520885	0.618815	0	-0.027249	2.245454	0.000567	2.381426
873	53.007449		2.449404	0.605993	2050.194881	0.517934	0.315408	-0.072368	16.891299	0.004267	2.99741
874	53.117138		2.436528	0.648418	2304.660438	0.582219	0.24084	-0.08353	9.66825	0.002442	3.379294
875	53.245449		2.592408	0.960153	2544.134395	0.642717	0	-0.000969	0.011982	0.000003	3.980744
876	53.202578		2.78106	0.913201	2669.469829	0.67438	0	-0.015889	3.651276	0.000922	2.901391
877	53.041647		2.416128	0.613828	2465.206736	0.622778	0.193632	-0.082693	23.104883	0.005837	2.316551
878	53.149419		2.522364	0.826989	2310.658169	0.583734	0.096768	-0.054509	1.974291	0.000499	2.27777
879	53.055407		2.523084	0.692097	2600.798776	0.657032	0.04968	-0.049656	16.477479	0.004163	2.133681
880	53.383499		3.403926	1.21292	2740.15525	0.692237	0	-0.000635	0.002377	0.000001	2.798906
881	53.402046		3.307164	1.29471	3187.091531	0.805145	0	0.002569	0.403202	0.000102	2.391638
882	53.384775		2.861016	1.16203	2938.186697	0.742265	0	-0.00047	0.353603	0.000089	2.879671
883	53.318346		2.691252	1.116154	2889.384846	0.729936	0	0.007909	1.324099	0.000335	1.65059
884	53.386521		3.083052	1.132842	3127.022742	0.78997	0	0.000161	0.005418	0.000001	3.348487
885	53.326901		2.762592	1.0934	2616.165277	0.660914	0	-0.013408	0.85423	0.000216	3.281232
886	53.229691		2.70336	0.920374	2825.404593	0.713773	0	-0.006452	2.210684	0.000558	2.010687
887	53.247504		2.819988	0.994468	2776.839335	0.701504	0	-0.017688	1.906016	0.000482	2.226221
888	53.183344		2.527944	0.886261	2577.89517	0.651246	0	-0.046343	4.793253	0.001211	2.749343
889	53.033577		2.16846	0.674403	2126.415308	0.53719	0.297324	-0.076313	17.855306	0.004511	4.075432
890	53.018555		2.373486	0.634945	2446.705761	0.618104	0.129204	-0.092257	14.809823	0.003741	4.397852
891	53.071757		2.496408	0.658887	2408.694622	0.608501	0.135396	-0.034337	5.250024	0.001326	2.624969
892	52.982212		2.43024	0.613345	2388.749226	0.603462	0.228216	-0.026821	11.098312	0.002804	1.856377
893	52.9818		2.42508	0.629823	2430.188035	0.613931	0.33684	-0.031248	10.051911	0.002539	1.950644
894	53.07747		2.569572	0.700068	2304.424897	0.58216	0.197892	-0.089016	10.154346	0.002565	2.419817
895	53.079771		2.604228	0.65072	2367.654382	0.598133	0.323052	-0.088656	14.794405	0.003737	2.251199
896	53.151468		2.795676	0.802407	2807.537928	0.70926	0	-0.015584	5.514855	0.001393	2.806444
897	53.282841		2.759484	0.971776	3055.143244	0.771811	0	0.003497	1.154792	0.000292	3.627039
898	53.295407		2.823828	0.973018	2679.118867	0.676817	0	-0.002836	0.026456	0.000007	3.049817
899	53.243735		2.613036	1.009672	2836.641126	0.716612	0	0.01302	0.561705	0.000142	1.815609
900	53.246916		2.386596	0.942088	2325.661546	0.587525	0	0.026606	1.457337	0.000368	1.841678
901	53.191371		2.855124	0.873023	2594.136859	0.655349	0	-0.028076	3.483191	0.00088	3.181046
902	53.097559		2.445684	0.719807	2611.212474	0.659662	0.227232	-0.069871	6.89712	0.001742	3.984906

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903	53.020173		2.351016	0.707707	2161.895212	0.546153	0.352956	-0.07806	14.967345	0.003781	4.008437
904	53.131721		2.490444	0.804937	2428.04909	0.61339	0.184524	-0.059932	7.074743	0.001787	5.036391
905	53.278948		2.64066	1.034079	2635.170582	0.665715	0	-0.014092	1.009741	0.000255	3.35142
906	53.440022		2.57928	1.281293	2442.55423	0.617055	0	0.004402	0.054388	0.000014	1.904364
907	53.467756		2.548164	1.323851	2843.02	0.718223	0	0.007692	0.191851	0.000048	1.818125
908	53.517519		2.858676	1.428724	2974.557749	0.751453	0	0.00017	0.005224	0.000001	1.587477
909	53.472698		3.236844	1.317288	2806.818446	0.709078	0	0.001825	0.187857	0.000047	1.213962
910	53.36814		2.884044	1.059612	2293.774794	0.579469	0	0	0	0	1.19877
911	53.404825		2.836956	1.226692	2868.672428	0.724704	0	0.024696	1.469791	0.000371	1.264371
912	53.482712		2.999628	1.352058	2868.824577	0.724742	0	0.001529	0.069142	0.000017	1.36494
913	53.595879		3.094608	1.548245	3031.12631	0.765744	0	0	0	0	1.661097
914	53.561081		3.17742	1.476686	3070.655467	0.77573	0	0.001853	0.020199	0.000005	1.422951
915	53.375453		2.550912	1.162436	2630.275325	0.664478	0	0.006853	0.898214	0.000227	1.298875
916	53.36805		2.40888	1.060368	1620.215719	0.40931	0.039768	0.020568	0.519174	0.000131	1.429888
917	53.444478		2.655732	1.231356	2350.889679	0.593898	0	0.075486	3.901696	0.000986	2.05856
918	53.53214		2.844936	1.498664	2463.802165	0.622423	0.145968	0.056128	3.123366	0.000789	0.733625
919	53.706428		4.100148	1.922472	3164.079382	0.799332	0	-0.065798	1.421343	0.000359	0.813128
920	53.380848		3.101364	1.580016	2322.012147	0.586603	3.479052	-0.408816	19.211226	0.004853	0.875825
921	53.1486		2.69916	1.183696	2207.762264	0.55774	4.162692	-0.582032	46.294757	0.011695	1.126617
922	52.880681		2.019312	0.74172	1708.177733	0.431532	4.603224	-0.478073	66.558406	0.016814	3.613398
923	52.857928		2.058936	0.702604	1624.479243	0.410387	4.897884	-0.432676	50.618166	0.012788	3.68165
924	52.723416		2.227464	0.564612	2064.74027	0.521609	4.622208	-0.291914	106.688622	0.026952	3.925574
925	52.882834		2.109756	0.665553	1934.276702	0.48865	4.446576	-0.275277	60.576869	0.015303	4.849374
926	52.9208		2.300616	0.690998	2114.540839	0.53419	4.58688	-0.400388	50.134725	0.012665	3.796789
927	53.098725		2.352204	0.929553	2384.480873	0.602384	2.769804	-0.38742	30.665095	0.007747	3.168136
928	53.369202		2.77584	1.362079	2587.593619	0.653696	2.730156	-0.402053	20.904354	0.005281	2.812153
929	53.201068		2.484912	1.11393	2155.970034	0.544656	2.920104	-0.355442	22.232789	0.005617	2.38039
930	53.030333		2.31378	0.814559	2364.691532	0.597385	2.866584	-0.282517	39.531292	0.009987	2.733153
931	52.956278		2.175924	0.688255	2133.430911	0.538962	2.77806	-0.278725	32.364032	0.008176	3.364533
932	52.820364		2.103492	0.524603	1808.788342	0.456949	3.023316	-0.188052	50.350101	0.01272	2.688953
933	52.992001		2.0892	0.740525	2134.225423	0.539163	2.94636	-0.277927	27.37048	0.006915	3.96975
934	53.034094		2.218692	0.81999	2281.733556	0.576427	2.465244	-0.261298	22.359207	0.005649	3.635269
935	53.158589		2.367	0.942168	2219.165373	0.560621	2.341812	-0.259517	18.034016	0.004556	2.934536
936	53.146571		2.390868	0.903632	2518.088132	0.636137	2.20104	-0.226683	19.918249	0.005032	2.45259
937	53.101064		2.179368	0.893833	2287.635505	0.577918	2.344224	-0.271769	19.277245	0.00487	4.087658
938	53.034592		2.300544	0.761188	2012.952951	0.508526	2.294424	-0.208914	27.849185	0.007035	3.469447
939	53.072292		2.146236	0.87354	1569.796716	0.396573	2.238768	-0.239952	14.621365	0.003694	4.178242
940	52.959246		1.9842	0.744936	1633.281095	0.412611	2.28624	-0.297936	25.35508	0.006405	3.626318
941	53.05317		2.309556	0.852903	2209.894865	0.558279	2.113572	-0.311865	35.315871	0.008922	3.862292
942	52.915649		1.921416	0.668561	1789.544779	0.452087	2.15316	-0.30072	36.576173	0.00924	4.181166
943	52.774344		1.67838	0.460692	1000.335319	0.252712	2.486064	-0.200028	37.19799	0.009397	2.895593
944	53.062281		2.318088	0.856821	2066.055789	0.521941	1.851708	-0.320562	29.070771	0.007344	5.688593
945	53.270865		2.737776	1.147845	2167.568069	0.547586	2.034564	-0.319968	10.568872	0.00267	3.491648
946	53.340576		2.690604	1.345336	2414.227342	0.609899	1.950456	-0.255276	12.759591	0.003223	1.170948
947	53.311544		2.638032	1.197988	2082.461412	0.526086	1.650612	-0.237808	8.181597	0.002067	2.076826
948	53.304589		2.806836	1.181573	2364.388083	0.597308	1.681968	-0.315856	12.295255	0.003106	1.794302
949	53.419095		2.811384	1.339636	2575.433485	0.650624	1.979544	-0.314123	12.350486	0.00312	2.467552
950	53.40008		2.938788	1.27846	2646.773454	0.668646	1.603836	-0.249188	8.819017	0.002228	3.072579
951	53.191834		2.673408	0.932502	2550.091019	0.644222	1.733952	-0.216161	12.242121	0.003093	1.641137
952	53.196483		2.711676	0.929488	2197.830921	0.555231	1.731492	-0.220472	10.206834	0.002579	1.689327

Segment S53S541

953	53.074902		2.485512	0.779474	2004.861238	0.506482	2.064852	-0.208442	16.072836	0.00406	1.950172
954	53.163175		2.399424	0.930962	2028.295385	0.512402	1.815386	-0.2615	13.614618	0.003439	2.401617
955	53.11638		2.360832	0.892984	2335.594512	0.590034	1.590516	-0.288404	22.376393	0.005653	1.860321
956	53.371285		2.836956	1.300833	2744.251927	0.693272	1.060968	-0.37152	22.208827	0.005611	1.662282
957	53.583389		2.971344	1.61782	3123.497479	0.789079	1.060692	-0.183347	6.593838	0.001666	1.192001
958	53.454574		2.88822	1.457844	2820.399932	0.712509	1.866984	-0.03333	6.961394	0.001759	2.378646
959	53.261796		2.64408	1.064829	2415.148645	0.610132	1.535748	-0.20994	15.061306	0.003805	1.310201
960	53.172455		2.448816	0.91874	2453.166316	0.619736	1.894416	-0.167956	11.197549	0.002829	0.486052
961	53.27769		2.458932	1.055168	2557.847888	0.646181	1.498668	-0.154254	6.678379	0.001687	1.365422
962	53.021578		2.275344	0.691708	2100.728593	0.530701	2.450856	-0.129206	17.664175	0.004462	1.33583
963	53.125327		2.308572	0.828209	2380.802246	0.601455	1.979316	-0.105999	12.626022	0.00319	0.603865
964	53.193603		2.333784	0.955335	2525.10393	0.637909	1.994772	-0.100682	10.293061	0.0026	1.25038
965	53.373308		2.6028	1.223951	2733.770423	0.690624	1.255824	-0.226525	12.603782	0.003184	0.639893
966	53.320192		2.634828	1.104476	2751.676801	0.695148	1.736592	-0.100308	9.42321	0.002381	1.050329
967	53.344247		2.793252	1.179799	2933.956991	0.741196	1.836312	-0.064519	12.593723	0.003182	1.772514
968	53.690232		3.395736	1.775952	3298.407493	0.833266	1.483644	0.003164	1.858371	0.000469	0.661297
969	53.670336		3.177168	1.703782	2919.549326	0.737557	1.484808	0.008324	2.103232	0.000531	0.816293
970	53.590442		3.29208	1.608442	1345.43222	0.339892	0.814776	-0.00431	0.689101	0.000174	1.462341
AVERAGE DIAMETER	**107.3542067**	**MAXIMUM**	**5.181132**	**2.717723**	**4434.818769**	**1.120354**	**4.897884**	**0.147601**	**106.688622**	**0.026952**	**5.688593**
		AVERAGE	**3.350147041**	**1.764445858**	**3325.688135**	**0.840158258**	**0.133758121**	**-0.00784283**	**2.072258471**	**0.000523504**	**1.647961138**

MAXIMUM MEASUREMENTS HIGHLIGHTED IN PEACH

LEGEND:

MAXIMUM CORROSION: MAXIMUM DEPTH OF CORROSION IN THE ONE FOOT SECTION OF PIPE
AVERAGE CORROSION: THE AVERAGE CORROSION FOR EACH ONE FOOT SECTION
INTEGRATED CORROSION: CORROSION OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED CORROSION: INTEGRATED CORROSION DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE TO COMPARE THE EXTENT OF CORROSION IN EACH ONE FOOT SECTION OF PIPE
MAXIMUM BUILDUP: MAXIMUM BUILDUP IN THE ONE FOOT SECTION OF PIPE
AVERAGE BUILDUP: THE AVERAGE BUILDUP FOR EACH ONE FOOT SECTION
INTEGRATED BUILDUP: BUILDUP OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED BULDUP: INTEGRATED BUILDUP DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE TO COMPARE THE EXTENT OF BUILDUP IN EACH ONE FOOT SECTION OF PIPE
OVALITY: CHANGE IN CIRCULARITY; THE AMOUNT OF OUT-OF-ROUNDNESS

ONE TAP LOCATED AT 314 FEET. DATA INCLUDED HERE TO NOT SKEW THE ABOVE RESULTS

Position (ft)	Circular Radius (in)		Maximum Corrosion (in)	Average Corrosion (in)	Integrated Corrosion (in3)	Averaged Corrosion (in)	Maximum Buildup (in)	Average Buildup (in)	Integrated Buildup (in3)	Averaged Buildup (in)	Ovality
314	54.258138		118.768704	3.777228	1987.591293	0.502119	6.427908	0.076398	109.375921	0.027631	31.844192

Segment S53S541

MULTI-SENSOR INSPECTION SUMMARY REPORT FOR: S54 S55, 105" HORSESHOE RCP, 282 LF INSPECTED LENGTH

INSPECTION PROCEEDED DOWNSTREAM FROM S54 TO S55. THE FLOATING PONTOON WAS USED FOR THIS INSPECTION. WATER LEVEL WAS AT 40%.

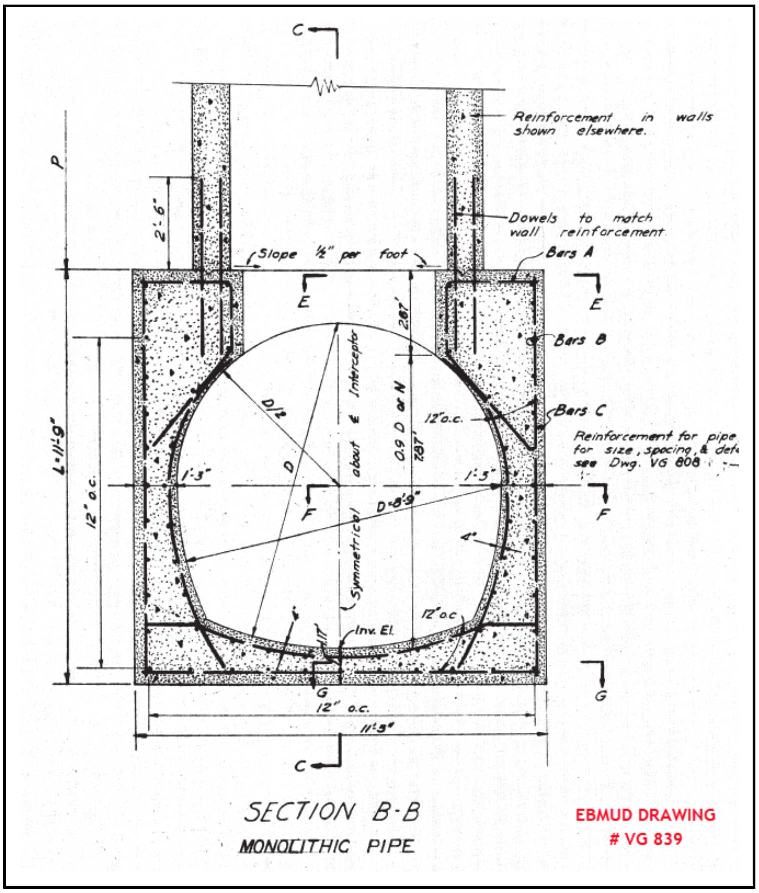
SURFACE AGGREGATE PROJECTING AND SURFACE SPALLING THROUGHOUT INSPECTION.

MAXIMUM CORROSION/MEASUREMENT OUTSIDE REFERENCE CIRCLE TO 4.34 INCHES. AVERAGE CORROSION OVER ENTIRE LENGTH OF PIPE IS 1.03 INCHES.

SONAR PROFILED DEBRIS OF 2,953 CF (109 CY).

AS-BUILT DIMENSIONS

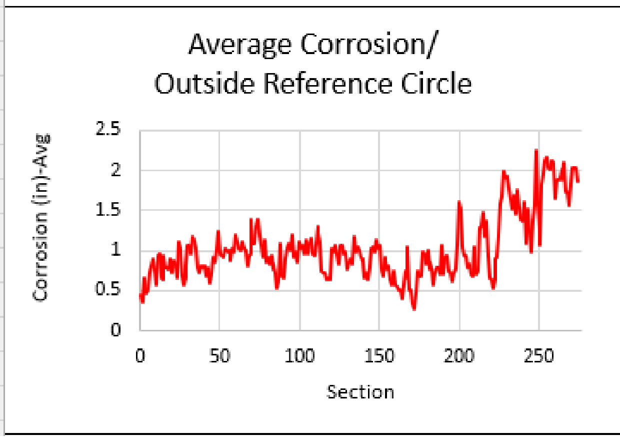
The dimensions available from the EBMUD as-built reference drawings were recreated in NPS' 3D modeling software so that a comparison of 3D laser measured values vs. as-built dimensions could be compared in order to produce the 3D virtual model of the pipe interior.

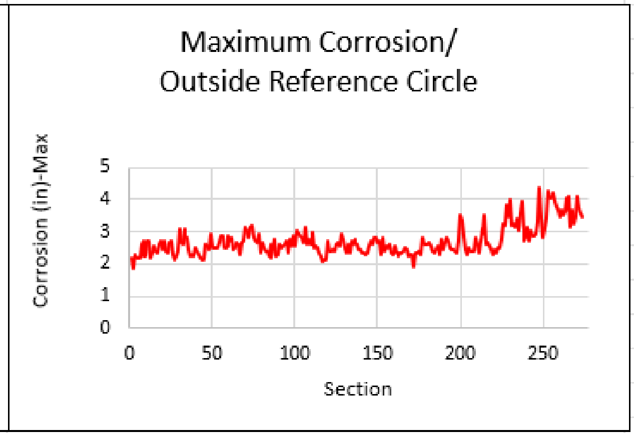


EBMUD
MULTI-SENSOR INSPECTION PROJECT

LASER SCAN SUMMARY RESULTS

Measurement	Measurement From Pipe Center (Inches)
Average Corrosion/Outside Reference Circle	1.03
Maximum Average Corrosion/Outside Reference Circle	2.24
Maximum Corrosion/Outside Reference Circle	4.34





PACP SCORING REPORT

PACP v7.0 Inspections and Scoring

General Information:

Surveyed by:	Certificate number:	Reviewed by:	Reviewer certificate no.	Owner:	Customer:
F MORENO/NPS	U-913-19012				
P/O number:	**Work order no.:**	**Media label:**	**Project name:**		**Start date/time:**
			EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022		20220517 13:04
Sheet number:	**Weather:**	**Pre-cleaning:**	**Date cleaned:**	**Flow control:**	**Purpose:**
	1	N		N	F
Direction:	**Technology used:**		**Inspection status:**	**Consequence of failure:**	**Pressure value:**
D			CI		

Location:

Drainage area:	Pipe segment ref.:		Street:		
	S54S551		MARKET ST/S. OF 3RD ST		
City:		**Location code:**	**Location details:**		
OAKLAND		D			

Pipe:

Pipe use:	Height:	Width:	Shape:	Material:	Lining method:
SS	105 in.	105 in.	H	RCP	
Coating method:	**Pipe joint length:**	**Total length:**	**Length surveyed:**	**Year constructed:**	**Year renewed:**
		282.000 ft.	282.000 ft.	1950	

Measurements:

Upstream MH No:	Rim to invert:	Rim to grade:	Grade to invert:	Northing:	Easting:	Elevation:
S54						
Downstream MH No:	**Rim to invert:**	**Rim to grade:**	**Grade to invert:**	**Northing:**	**Easting:**	**Elevation:**
S55						
MH coordinate system:	**MH vertical datum:**		**GPS accuracy:**			

Segment S54S551

EBMUD
MULTI-SENSOR INSPECTION PROJECT

Pipe Ratings

Grade	Structural: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	O&M: Amount of Defects	Segment Grade	Pipe Rating	Quick Rating	Pipe Rating Index	Overall: Pipe Rating	Pipe Rating Index	LoF	Risk
1	56	56	224	3J1J	2.0	4	4	7	3114	1.4	231	2.0	4.0	
2	0	0				0	0							
3	56	168				1	3							
4	0	0				0	0							
5	0	0				0	0							

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
0.0 ft.		AMH					☐				EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 0.0 ft_2.JPG	S54
0.0 ft.		MWL				40	☐				EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---MWL at 0.0 ft_1.JPG	
0.0 ft.	00:00:22	SAP	S01				☑	8	4	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 0.0 ft_2.JPG	
0.0 ft.	00:00:50	SSC	S02				☐	9	3	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 0.0 ft.JPG	
36.9 ft.	00:02:50	LL	S03			5	☐			1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---LL at 36.9 ft.JPG	

Observations

Distance	Video Ref.	PACP Code	Continuous	Value Inches (mm) 1st	2nd	%	Joint	Circumferential Location At/From	To	Rating	Image Ref.	Remarks
58.8 ft.	00:03:48	LL	F03			5	☐			1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---LL at 58.8 ft.JPG	
95.1 ft.	00:05:29	MGO					☐				EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S54'-AMH 'S55'-MGO at 95.1 ft.JPG	Possibly Hole
258.0 ft.	00:11:50	MGO					☐				EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S54'-AMH 'S55'-MGO at 258.0 ft.JPG	Possibly Holes
276.0 ft.	00:12:49	ID					☐	9		3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022-AMH 'S54'-AMH 'S55'-ID at 276.0 ft.JPG	
282.0 ft.	00:13:20	SSC	F02				☐	9	3	1	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SSC at 282.0 ft.JPG	
282.0 ft.	00:13:23	SAP	F01				☑	8	4	3	EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---SAP at 282.0 ft.JPG	
282.0 ft.	00:13:26	AMH					☐				EBMUD INTERCEPTOR COND_ASSESSMENT EMBARCADERO W.MAY 2022---AMH at 282.0 ft.JPG	S55

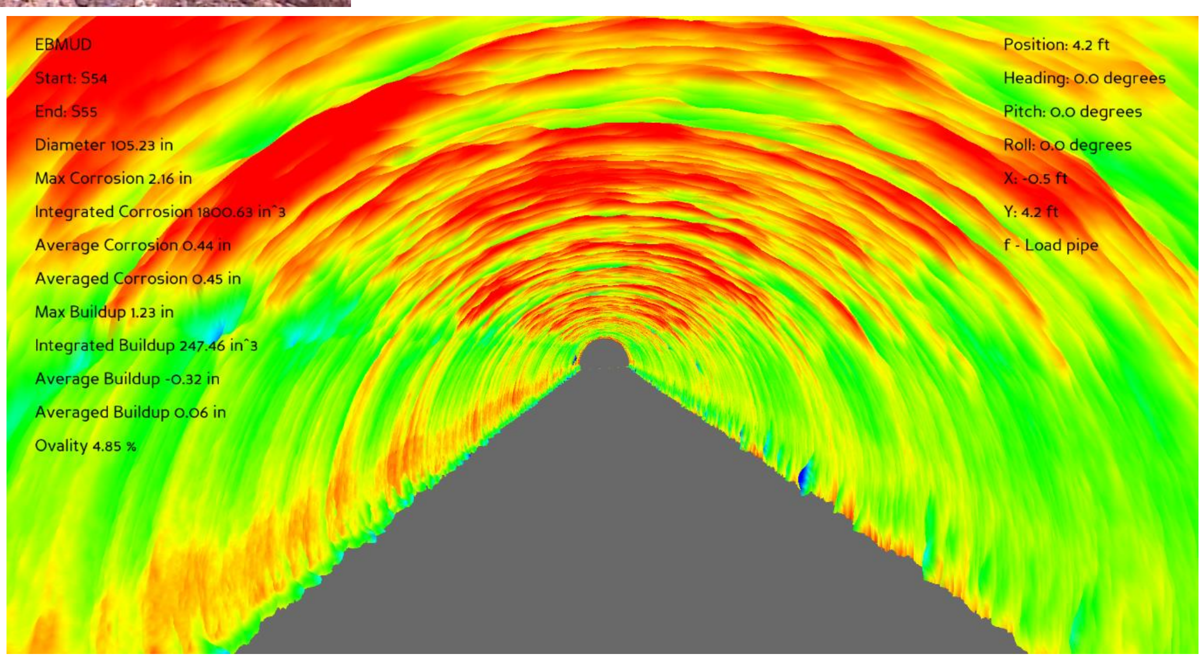
Segment S54S551

EBMUD
MULTI-SENSOR INSPECTION PROJECT

IMAGE REPORT

0 FEET. GENERAL OBSERVATION: THIS PIPE HAS A LEFT ALIGNMENT CHANGE FROM 37-59 FEET SO THE FLOAT HUGGED THE LEFT SIDE OF THE PIPE.

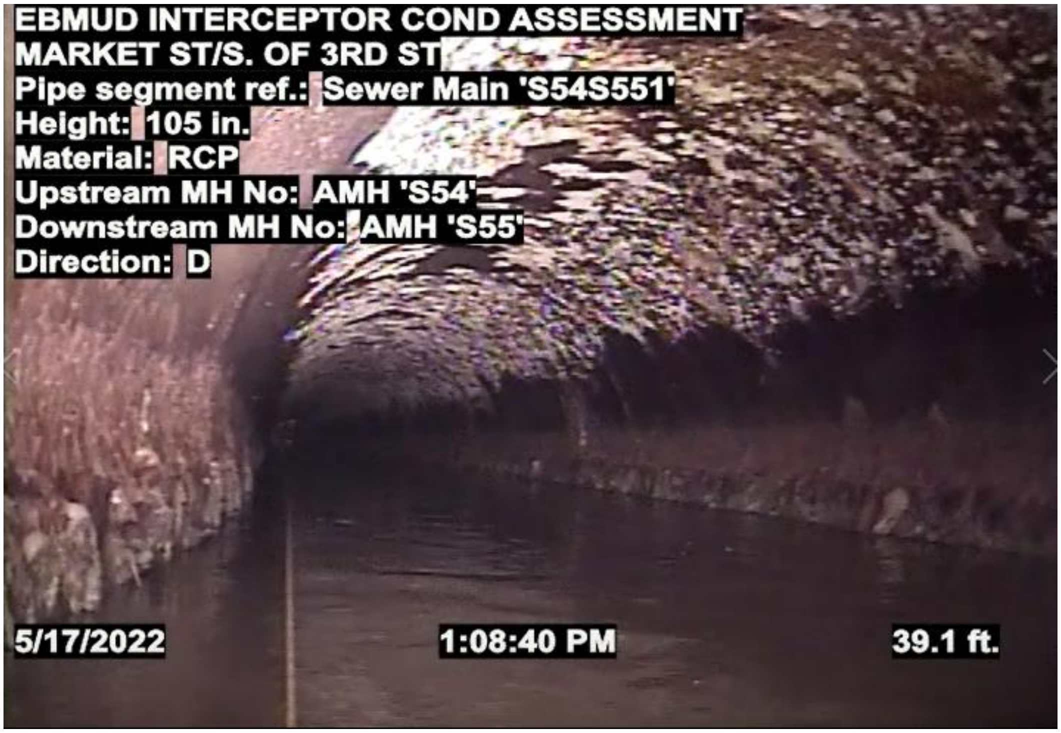
SURFACE AGGREGATE PROJECTING AND SURFACE SPALLING THROUGHOUT. CORROSION AT 4 FEET TO 2.16 INCHES.

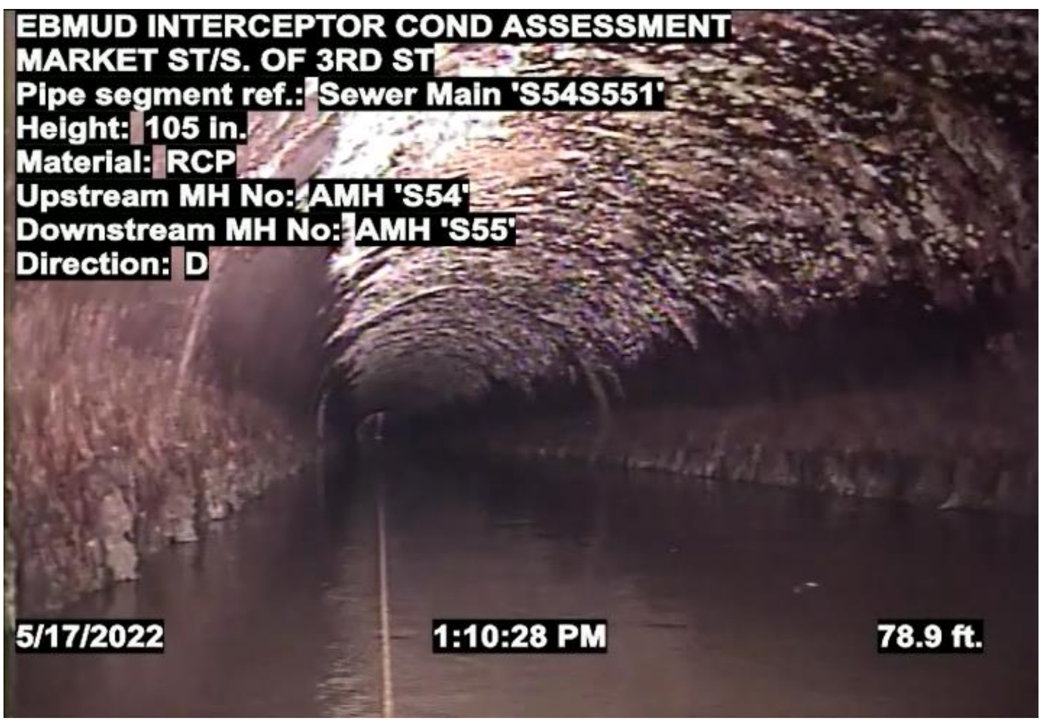


Segment S54S551

EBMUD
MULTI-SENSOR INSPECTION PROJECT

TYPICAL INTERIOR VIEWS

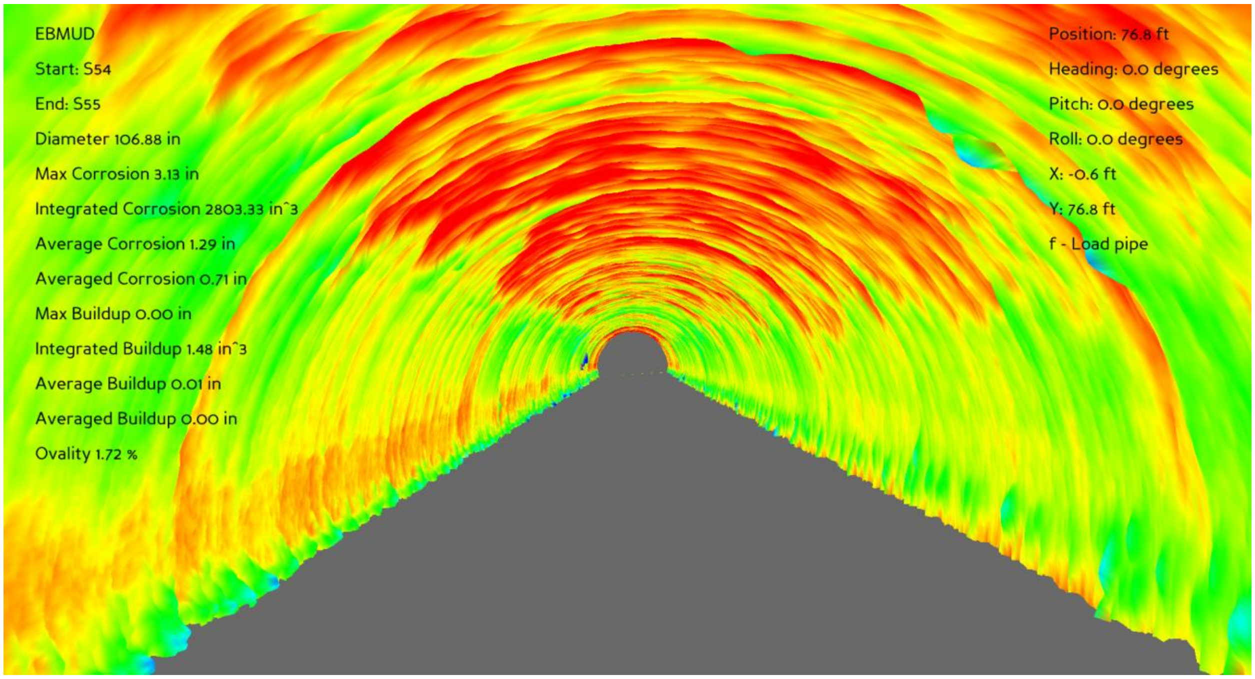




Segment S54S551

EBMUD
MULTI-SENSOR INSPECTION PROJECT

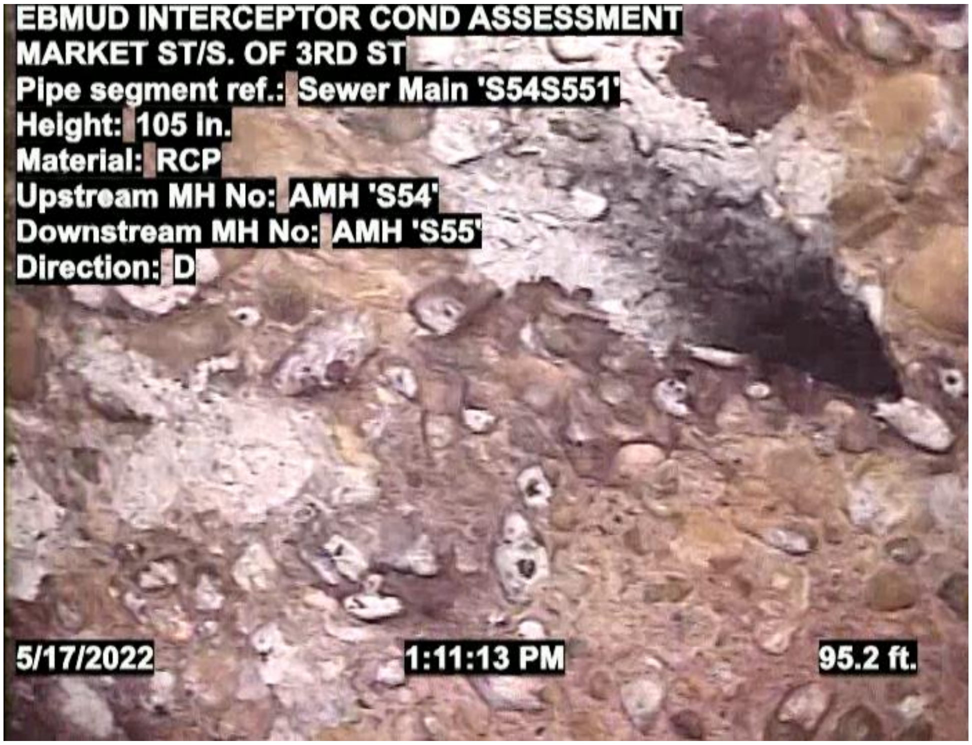
TYPICAL INTERIOR VIEW, 87.5 FEET

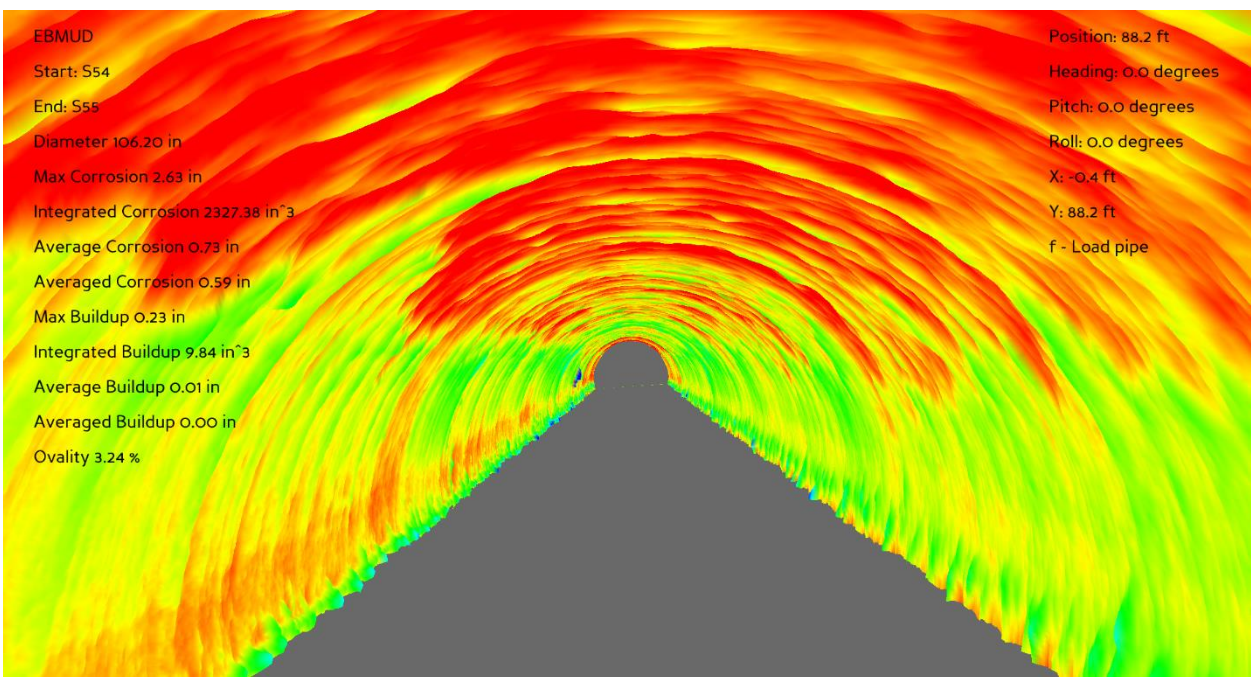


Segment S54S551

EBMUD
MULTI-SENSOR INSPECTION PROJECT

POSSIBLE SMALL HOLE AT 95.2 FEET. THE LASER DIDN'T PICK UP THE HOLE DUE THE ANGLE OF THE HOLE. CODED AS AN MGO IN THE PACP REPORT.

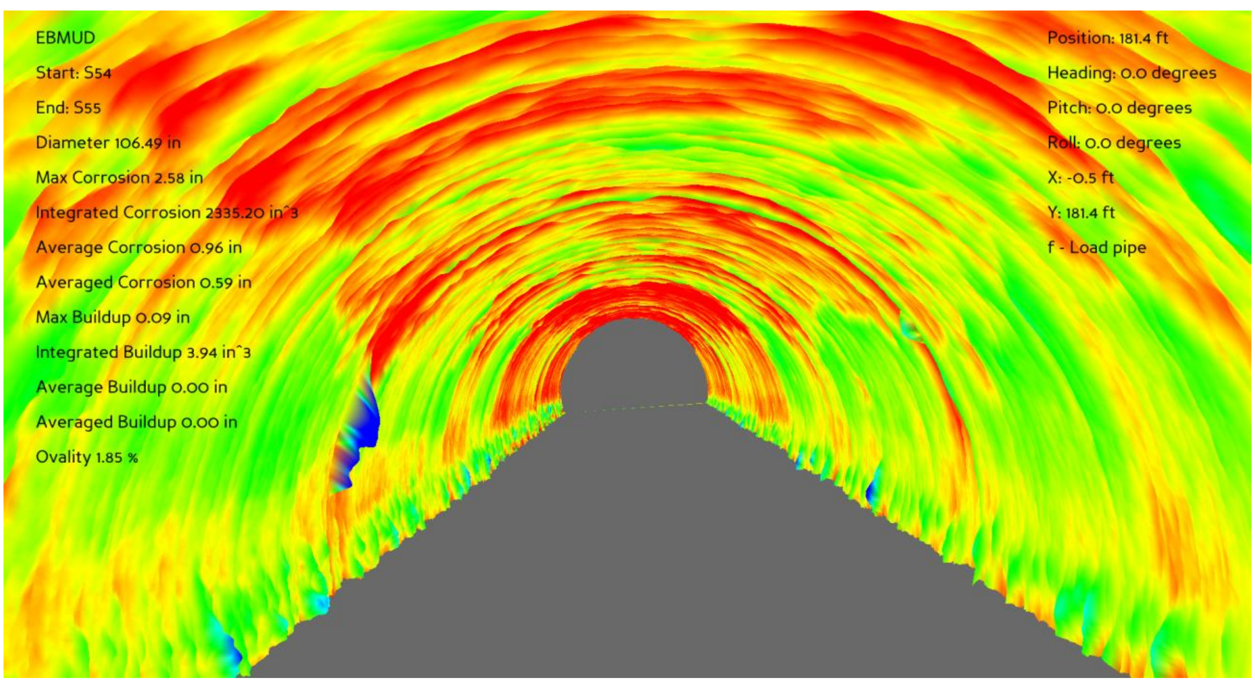




Segment S54S551

EBMUD
MULTI-SENSOR INSPECTION PROJECT

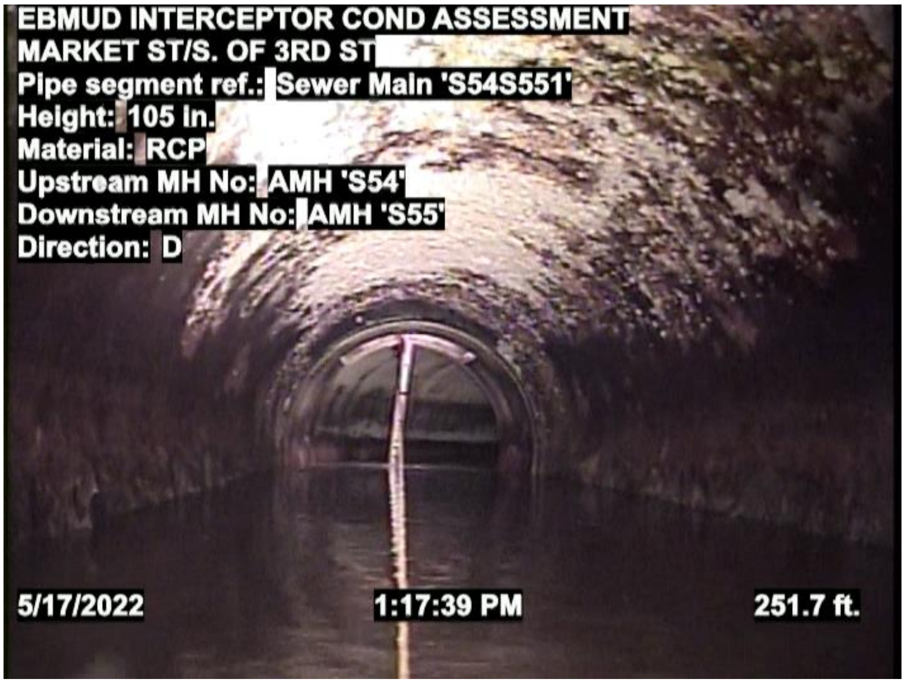
INTERIOR VIEW, TOWARD 187 FEET

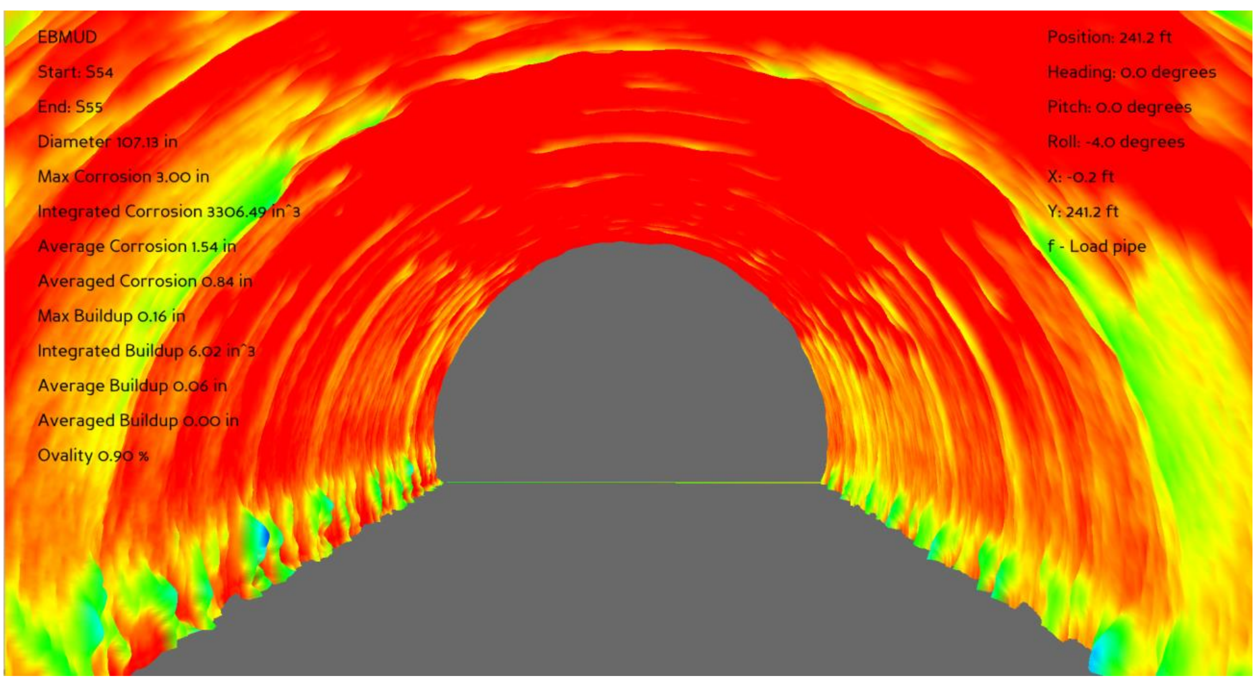


Segment S54S551

EBMUD
MULTI-SENSOR INSPECTION PROJECT

LOOKING TOWARD AREA OF MAXIMUM CORROSION. CONSISTENTLY HIGH LEVEL OF CORROSION FROM 251 FEET TO 277 FEET. MAXIMUM CORROSION TO 4.34 INCHES AT 251 FEET. POSSIBLY SOME MISSING AGGREGATE OR SMALL HOLES AROUND 258 FEET (CODED AS AN MGO).

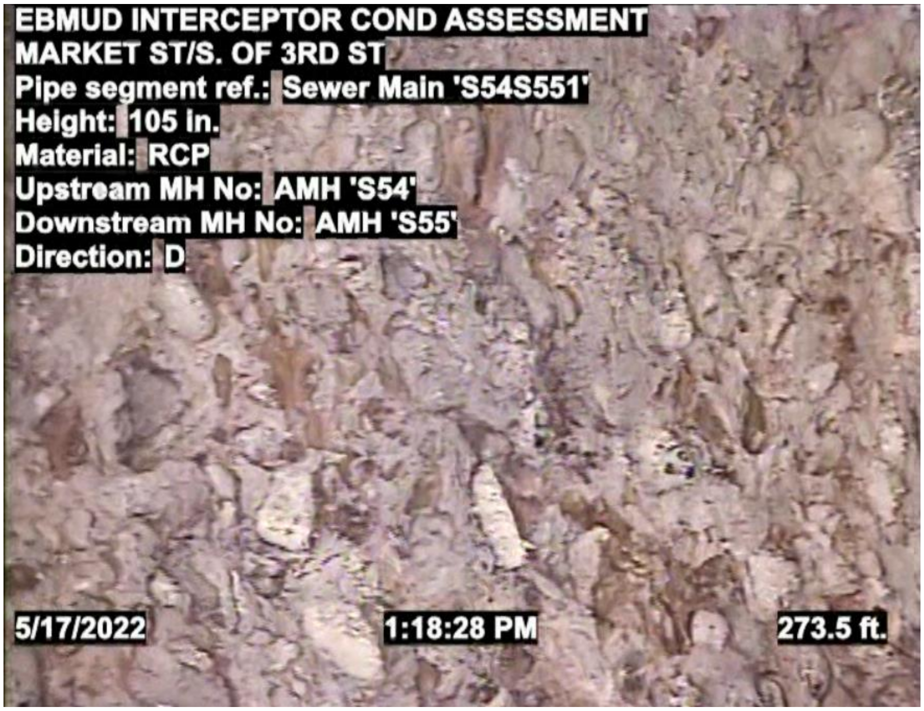




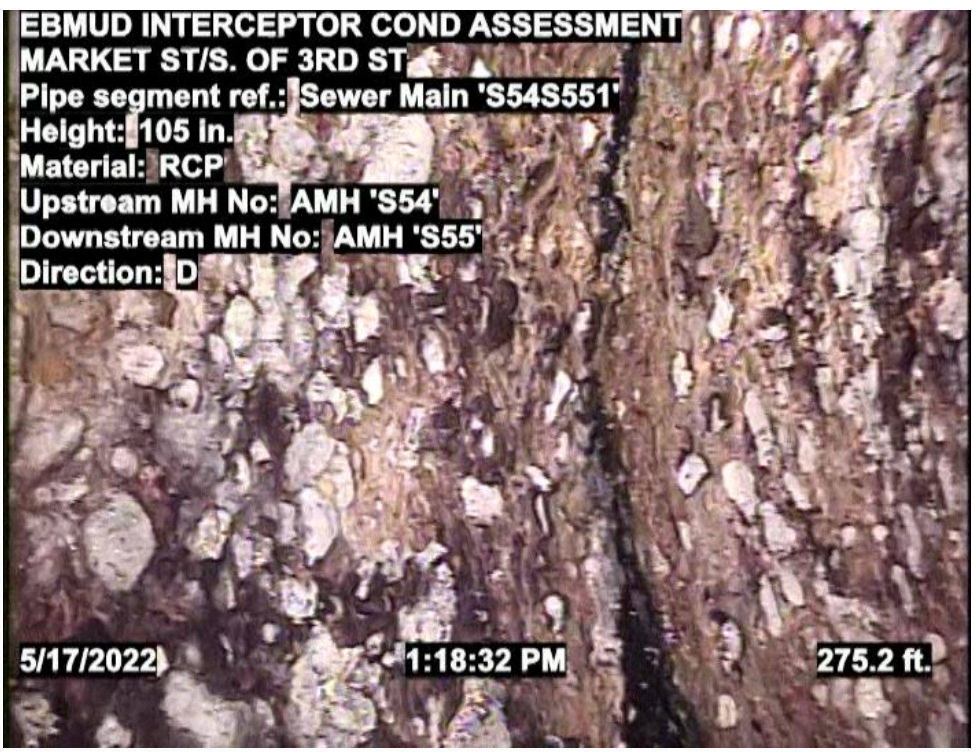
Segment S54S551

EBMUD
MULTI-SENSOR INSPECTION PROJECT

CROWN OF PIPE NEAR S55, 273 FEET FROM S54, MAXIMUM CORROSION TO 3.47 INCHES.



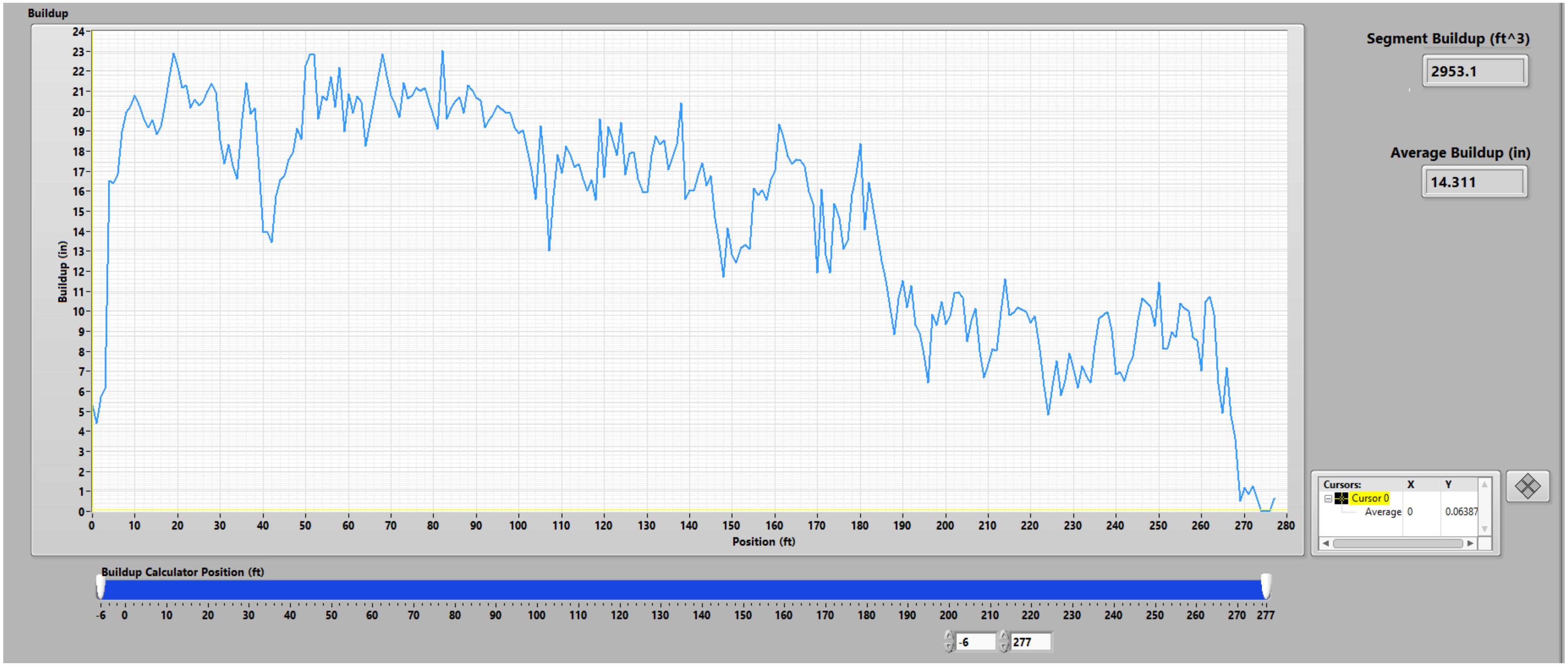
INFILTRATION DRIPPER AT 276 FEET



Segment S54S551

EBMUD
MULTI-SENSOR INSPECTION PROJECT

SONAR RESULTS, 2,953 CUBIC FEET OF DEBRIS



Segment S54S551

LASER RESULTS BY 1 FOOT SCAN

Segment S54S551

Title 1 EBMUD	Title 2 Start: S54	Title 3 End: S55	Minimum Position (ft) 5	Maximum Position (ft) 282	Surface Area(in2)/ft 3958.406744						
Position (ft)	Circular Radius (in)		Maximum Corrosion (in)	Average Corrosion (in)	Integrated Corrosion (in3)	Averaged Corrosion (in)	Maximum Buildup (in)	Average Buildup (in)	Integrated Buildup (in3)	Averaged Buildup (in)	Ovality (%)
4	52.616253		2.16348	0.43585	1800.627372	0.454887	1.231536	-0.320983	247.464482	0.062516	4.848525
5	52.65781		1.858008	0.363129	1658.743518	0.419043	0.791712	-0.153485	97.562776	0.024647	2.827378
6	53.005161		2.282212	0.663898	2249.725205	0.568341	0.367548	-0.007114	13.664408	0.003452	1.497058
7	52.837826		2.165466	0.46599	2026.68049	0.511994	1.324584	-0.035385	37.912443	0.009578	1.213556
8	52.848489		2.1915	0.512311	1943.198251	0.490904	0.742332	-0.027461	27.282338	0.006892	1.592228
9	53.096474		2.190972	0.721196	2317.57069	0.585481	0.210348	-0.025543	6.022516	0.001521	4.530802
10	53.113987		2.587596	0.801856	2321.568068	0.586491	0.235512	0.003976	9.65312	0.002439	3.806326
11	53.237685		2.7333	0.887184	2369.19058	0.598521	0.027468	-0.018433	4.010512	0.001013	3.473701
12	53.097641		2.231328	0.771359	2185.838309	0.552202	0.14856	-0.045646	8.033081	0.002029	4.59618
13	52.915856		2.247144	0.567961	2060.261796	0.520478	0.31944	-0.055291	31.82577	0.00804	3.151122
14	53.274224		2.731572	0.9353	2310.446743	0.583681	0	-0.04257	2.540454	0.000642	3.70617
15	53.314524		2.68656	0.970735	2645.132903	0.668232	0	-0.003984	0.725791	0.000183	2.355248
16	53.009106		2.1948	0.653153	2225.458584	0.562211	0.481104	-0.088631	24.647263	0.006227	2.998073
17	52.978721		2.327724	0.63927	2192.147968	0.553796	0.343992	-0.011697	13.358318	0.003375	2.054488
18	53.242576		2.562204	0.942042	2425.780188	0.612817	0.0486	-0.002851	1.052846	0.000266	3.918199
19	53.054095		2.412696	0.78165	2174.691623	0.549386	0.375564	-0.069095	15.738526	0.003976	4.238011
20	53.008442		2.347416	0.787567	2185.936184	0.552226	0.512712	-0.089993	28.244256	0.007135	6.331124
21	53.006188		2.58546	0.759485	2165.103912	0.546963	0.576108	-0.09682	22.934509	0.005794	5.838336
22	53.150171		2.688492	0.898924	2265.740279	0.572387	0.041964	-0.011668	4.993152	0.001261	5.421041
23	53.06396		2.434422	0.722745	2186.974497	0.552489	0.202788	-0.032522	7.763826	0.001961	5.261089
24	53.233861		2.696472	0.866863	2395.579383	0.605188	0.108456	0.018264	2.24664	0.000568	3.89134
25	53.201403		2.376312	0.829319	2392.854995	0.6045	0.02658	0.018293	2.548809	0.000644	4.143722
26	53.055234		2.310024	0.670322	2172.339763	0.548791	0.2391	0.003432	18.016165	0.004551	2.378219
27	53.3317		2.630892	1.100303	2508.575465	0.633734	0	0.013476	0.703147	0.000178	1.907751
28	53.274786		2.727528	1.029908	2481.158075	0.626807	0	0.004978	0.527728	0.000133	2.543987
29	53.049983		2.307228	0.678737	2139.206334	0.540421	0.273348	-0.000691	5.180523	0.001309	3.049706
30	52.94602		2.097816	0.568437	2085.150647	0.526765	0.164832	-0.041784	17.314915	0.004374	4.206338
31	53.048074		2.25294	0.658522	2232.150587	0.563901	0.222036	-0.03979	7.41185	0.001872	4.084679
32	53.080138		2.371104	0.804865	2485.701404	0.627955	0.035892	-0.036544	12.457979	0.003147	4.031915
33	53.326952		3.089352	1.06647	2635.327574	0.665755	0	0.007797	0.894867	0.000226	4.53842
34	53.308699		2.632236	1.07561	2571.195281	0.649553	0.261156	0.013416	4.394743	0.00111	3.718438
35	53.216515		2.627328	0.969526	2483.989995	0.627523	0.393936	0.017251	6.93163	0.001751	1.319047
36	53.437332		3.061896	1.181505	2745.486564	0.693584	0	0.008798	0.09274	0.000023	1.404298
37	53.3653		2.888376	1.123608	2694.700218	0.680754	0	0.013441	1.053761	0.000266	0.962807
38	53.20965		2.813976	1.022988	2569.198365	0.649049	0.56022	0.097935	16.904286	0.00427	1.834939
39	53.101568		2.450436	0.790026	2302.39387	0.581647	0.049416	-0.001256	25.988245	0.006565	3.359807
40	53.110776		2.217336	0.729701	2387.86638	0.603239	0.126372	-0.018953	6.884197	0.001739	3.630198
41	53.175312		2.291508	0.820665	2203.882524	0.55676	0.054936	-0.020666	1.474241	0.000372	5.402038
42	53.079032		2.234052	0.781879	2048.097751	0.517405	0.035628	-0.075208	15.630787	0.003949	5.745634
43	53.085265		2.477052	0.803366	2028.078976	0.512347	0.524892	-0.145044	12.17067	0.003075	5.146078
44	52.988887		2.385936	0.682412	2263.529288	0.571828	0.495264	-0.027389	21.960467	0.005548	4.438581
45	53.083888		2.27898	0.737413	2081.548001	0.525855	0.300432	-0.020127	11.106551	0.002806	3.515885
46	53.14595		2.188548	0.787716	2125.047179	0.536844	0.07098	-0.005595	5.508143	0.001392	3.239006
47	52.941038		2.120388	0.600576	1963.921271	0.496139	0.691704	-0.02353	32.850316	0.008299	2.23269

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48	53.116305		2.125074	0.70978	1938.095959	0.489615	0.211212	0.003383	4.212259	0.001064	3.015983
49	53.225688		2.57574	0.907426	2395.11541	0.605071	0.078744	0.008081	0.822814	0.000208	2.911858
50	53.189191		2.561112	0.858662	2367.834991	0.598179	0	-0.003543	2.747408	0.000694	3.649601
51	53.304121		2.46234	1.008881	2554.033355	0.645218	0	0.003612	1.0774	0.000272	4.643633
52	53.459924		2.933598	1.23329	2714.329132	0.685713	0	0.007973	0.217798	0.000055	4.729397
53	53.256275		2.488392	0.959654	2626.723111	0.663581	0	0.013068	6.425151	0.001623	2.972435
54	53.239225		2.494164	0.937202	2551.516535	0.644582	0	0.023968	3.044557	0.000769	2.927145
55	53.188637		2.490312	0.915208	2544.980393	0.64293	0.1881	0.016138	17.975149	0.004541	1.367443
56	53.26991		2.48088	1.022382	2479.10982	0.62629	0.234348	0.023502	2.876201	0.000727	1.144825
57	53.265757		2.658732	1.009929	2499.3696	0.631408	0.095208	0.008707	0.882482	0.000223	1.21819
58	53.287887		2.853852	0.978128	2441.356393	0.616752	0	0.011074	2.91017	0.000735	1.102629
59	53.254407		2.890476	0.996096	2596.078709	0.655839	0.009504	0.009337	1.991492	0.000503	1.704213
60	53.168171		2.489832	0.872392	2337.047884	0.590401	0.231336	0.045894	7.835512	0.001979	1.861363
61	53.276183		2.47836	1.030048	2609.826237	0.659312	0.039024	0.013194	1.122142	0.000283	2.8751
62	53.230612		2.524152	0.989691	2448.655761	0.618596	0.21696	0.021581	2.848733	0.00072	1.443147
63	53.325755		2.875368	1.18995	2537.316394	0.640994	0.01578	0.007856	0.798279	0.000202	1.256279
64	53.304037		2.701344	1.119139	2705.716838	0.683537	0	0.016301	2.635479	0.000666	0.805536
65	53.287575		2.792262	1.022247	2552.872447	0.644924	0.000162	0.066213	7.505338	0.001896	1.411497
66	53.301409		2.4273	1.01064	2498.763997	0.631255	0.010884	0.013496	1.570936	0.000397	0.777571
67	53.330813		2.502612	1.10788	2689.264465	0.679381	0.155538	0.022542	3.998829	0.00101	0.855492
68	53.256201		2.674128	1.024592	2620.553039	0.662022	0.399288	0.036099	3.539355	0.000894	0.875579
69	53.25697		2.610972	1.001903	2591.409473	0.65466	0	0.013665	2.824233	0.000713	2.01258
70	53.151373		2.255856	0.806551	2282.55692	0.576635	0.103608	0.017905	6.100848	0.001541	1.918406
71	53.213041		2.650968	0.941471	2668.3149	0.674088	0.285144	0.02111	5.827046	0.001472	3.085785
72	53.230178		2.682696	0.958523	2658.664276	0.67165	0.309636	0.017473	17.513631	0.004424	3.126608
73	53.527026		3.149136	1.383513	3005.336221	0.759229	0	0.012855	0.88714	0.000224	4.05057
74	53.348243		3.011964	1.088455	2697.494495	0.68146	0.034116	0.068867	9.056192	0.002288	2.262184
75	53.324753		2.818512	1.089556	2704.147687	0.68314	0.123384	0.064381	4.528772	0.001144	3.286402
76	53.439942		3.130776	1.294112	2803.328279	0.708196	0	0.011473	1.476066	0.000373	1.716818
77	53.488929		3.167472	1.379579	2910.317827	0.735225	0	0.015839	1.885339	0.000476	0.969145
78	53.389137		2.835144	1.193686	2953.762083	0.7462	0.001692	0.054074	5.996526	0.001515	1.507272
79	53.319987		2.712432	1.078756	2370.162756	0.598767	0	0.017288	2.490735	0.000629	1.762455
80	53.253576		2.672652	0.926371	2744.045665	0.69322	0	-0.000875	1.35867	0.000343	3.180885
81	53.348581		2.904024	1.141082	2801.718513	0.707789	0	0.004443	0.94149	0.000238	2.588343
82	53.17192		2.359956	0.852886	2362.914047	0.596936	0.47646	0.031964	5.40556	0.001366	1.816745
83	53.201931		2.64456	0.913392	2609.715012	0.659284	0.124932	0.043665	4.008749	0.001013	4.121226
84	53.141566		2.48988	0.825392	2785.0462	0.703578	0.343368	0.016789	4.079954	0.001031	2.872215
85	53.23087		2.410992	0.937897	2152.726485	0.543837	0.190296	0.044616	3.572955	0.000903	1.567302
86	53.097467		2.413296	0.762862	2196.778743	0.554965	0.258936	0.042158	12.497679	0.003157	1.701609
87	53.158265		2.220756	0.822525	2299.378408	0.580885	0.17328	-0.007487	10.900668	0.002754	2.35309
88	53.101548		2.627532	0.733373	2327.378574	0.587958	0.230148	0.01463	9.838973	0.002486	3.240219
89	52.937371		2.173464	0.536384	2004.04503	0.506276	0.599628	-0.010502	20.26066	0.005118	2.012695
90	52.954939		2.436336	0.607271	2138.759664	0.540308	0.344412	-0.020656	18.361502	0.004639	1.06471
91	53.299975		2.782644	1.099489	2543.530633	0.642564	0.176772	-0.115516	5.25546	0.001328	1.464602
92	53.037182		2.217636	0.672932	2124.720754	0.536762	0.320736	0.020999	13.569103	0.003428	0.840547
93	53.029768		2.294568	0.664188	2228.601809	0.563005	0.509148	0.013095	15.118411	0.003819	1.02517
94	53.208712		2.603868	0.887669	2463.353571	0.622309	0	0.013084	1.304132	0.000329	2.252642
95	53.279634		2.517072	1.026265	2503.797417	0.632527	0	0.016209	2.493892	0.00063	2.000096
96	53.320519		2.573148	1.081083	2562.675644	0.647401	0	0.021522	1.431041	0.000362	2.580583
97	53.29146		2.592	1.008226	2675.418139	0.675883	0	0.028618	4.721697	0.001193	1.480516

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98	53.409098		2.707788	1.205603	2666.2162	0.673558	0	0.004336	0.145122	0.000037	2.40492
99	53.212959		2.3361	0.909053	2350.63868	0.593835	0.070416	0.029934	2.470577	0.000624	2.546061
100	53.270911		2.780688	0.983548	2534.795316	0.640357	0	0.016149	1.100671	0.000278	3.647091
101	53.242542		2.52912	0.95905	2307.266556	0.582878	0.064704	0.013391	1.45177	0.000367	2.889392
102	53.207656		2.851632	0.85924	2427.278056	0.613196	0.123096	0.033507	4.23575	0.00107	2.23482
103	53.325188		2.572452	1.106895	2289.993089	0.578514	0.088428	0.026004	2.345182	0.000592	2.662951
104	53.302855		3.048078	1.028837	2595.921348	0.6558	0.156588	0.07714	6.406736	0.001619	2.677498
105	53.306229		2.9358	1.066822	2449.033098	0.618692	0.14964	0.033651	3.064821	0.000774	2.834745
106	53.240117		2.891388	0.970234	2613.582484	0.660261	0	0.032554	4.677303	0.001182	2.899934
107	53.355082		2.82462	1.128913	2609.39518	0.659203	0	0.02899	2.357591	0.000596	2.818393
108	53.269613		2.647284	0.963877	2637.484306	0.666299	0	0.014635	1.828839	0.000462	3.355586
109	53.310519		3.118116	1.089881	2703.775957	0.683047	0	0.023984	2.083392	0.000526	2.897474
110	53.358238		2.600376	1.151193	2757.430223	0.696601	0.01014	0.040409	3.176714	0.000803	1.882984
111	53.265132		2.740884	0.963952	2674.0549	0.675538	0	0.034767	7.794002	0.001969	1.161852
112	53.23262		2.608296	0.931175	2454.105363	0.619973	0	0.022425	3.054993	0.000772	1.427353
113	53.330863		2.582832	1.079187	2549.397548	0.644046	0	0.031533	2.637752	0.000666	1.413686
114	53.472244		2.965224	1.31008	2752.954578	0.69547	0.030336	0.037096	2.266864	0.000573	1.793861
115	53.395499		2.521428	1.210099	2360.331246	0.596283	0.2151	0.042928	3.63142	0.000917	1.328211
116	53.327152		2.55894	1.114751	2739.561886	0.692087	0.003972	0.029162	3.542199	0.000895	1.665377
117	53.100579		2.470356	0.742	2654.728896	0.670656	0.516012	0.061566	11.382853	0.002876	1.552969
118	53.090747		2.309988	0.734481	2364.533681	0.597345	0.191016	-0.000133	5.651256	0.001428	1.739446
119	53.104011		2.255112	0.726686	2338.541694	0.590779	0.185484	0.026828	7.547545	0.001907	1.758531
120	53.019309		2.091324	0.631666	1986.005664	0.501718	0.373596	0.000772	8.002755	0.002022	1.917397
121	53.033493		2.101584	0.661172	2201.748037	0.556221	0.088416	-0.007734	7.161155	0.001809	2.926926
122	52.984068		2.145672	0.63684	2137.878361	0.540086	0.14352	-0.054452	20.350733	0.005141	3.55907
123	53.310861		2.707644	1.027157	2620.311678	0.661961	0	0.022937	3.235695	0.000817	3.779732
124	53.28031		2.369016	0.97904	2577.87716	0.651241	0	0.01211	1.292457	0.000327	2.160383
125	53.351874		2.385516	1.070388	2339.350504	0.590983	0.142356	0.04339	2.805557	0.000709	3.026636
126	53.243512		2.435148	0.9522	2646.393242	0.66855	0	0.023427	4.632551	0.00117	2.026963
127	53.174471		2.373672	0.83171	2476.534007	0.625639	0	0.035714	16.08129	0.004063	3.063834
128	53.289395		2.57778	1.038033	2232.214213	0.563917	0.206892	0.02462	2.997401	0.000757	2.113612
129	53.328999		2.640876	1.062566	2705.73559	0.683542	0.022404	0.024387	2.710571	0.000685	2.545107
130	53.341673		2.556852	1.067668	2214.567406	0.559459	0	0.028885	3.079021	0.000778	2.956683
131	53.208328		2.939076	0.963958	2704.508843	0.683232	0	0.017427	18.518023	0.004678	2.745151
132	53.267087		2.781696	0.981768	2658.821319	0.67169	0	0.00601	2.069071	0.000523	2.999752
133	53.162137		2.508408	0.766989	2608.721372	0.659033	0.221628	0.010886	4.147936	0.001048	2.028192
134	53.173638		2.317032	0.847383	2221.598402	0.561236	0	0.017598	6.845675	0.001729	2.167294
135	53.208806		2.585796	0.890738	2586.91959	0.653525	0	0.021637	5.42157	0.00137	2.596093
136	53.165619		2.360568	0.824953	2542.869119	0.642397	0	0.03111	6.437618	0.001626	1.874485
137	53.39664		2.721924	1.170382	2501.477532	0.63194	0	0.032263	1.703249	0.00043	1.92535
138	53.21475		2.584932	0.991508	2556.143048	0.64575	0.053916	0.013738	2.714975	0.000686	1.066313
139	53.293522		2.754348	1.049773	2723.633467	0.688063	0	0.024771	2.609886	0.000659	1.490331
140	53.258335		2.671332	0.999636	2719.706886	0.687071	0	0.025272	4.173284	0.001054	1.320708
141	53.200281		2.606412	0.909739	2218.468043	0.560445	0.019476	0.018323	6.443468	0.001628	1.334218
142	53.20401		2.462328	0.884687	2454.888972	0.620171	0.167028	-0.009651	5.631063	0.001423	2.238056
143	53.154508		2.449824	0.888533	2550.842303	0.644411	0	-0.007766	6.082299	0.001537	3.384031
144	53.002384		2.324568	0.662166	2161.111485	0.545955	0.390444	-0.025962	12.082323	0.003052	3.329433
145	53.090364		2.3178	0.724659	2450.029638	0.618943	0.086892	-0.012747	10.890671	0.002751	4.167833
146	52.994652		2.291892	0.63224	2163.475895	0.546552	0.010332	-0.010509	13.756822	0.003475	2.369165
147	53.153881		2.35812	0.783129	2436.961152	0.615642	0	0.006975	1.430803	0.000361	3.418444

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148	53.293219		2.569728	1.026426	2692.209262	0.680124	0.176712	0.038433	3.259611	0.000823	1.864326
149	53.28678		2.702064	1.042672	2594.253945	0.655378	0.241752	0.021932	3.120563	0.000788	2.112537
150	53.273647		2.589144	0.971947	2592.953526	0.65505	0	0.028383	3.73309	0.000943	1.599729
151	53.367797		2.836656	1.134429	2790.884037	0.705052	0.039108	0.025069	3.951306	0.000998	1.927044
152	53.298864		2.817828	1.022917	2323.564743	0.586995	0	0.020092	3.082766	0.000779	1.722781
153	53.309494		2.674644	1.071194	2699.723211	0.682023	0	0.007774	1.763283	0.000445	2.701261
154	53.074256		2.704128	0.759803	2287.204879	0.577809	0	-0.021661	16.369566	0.004135	2.17131
155	53.048055		2.2773	0.671869	2255.0013	0.569674	0.310776	-0.016677	7.800418	0.001971	1.32492
156	53.257962		2.820864	0.925993	2650.096105	0.669486	0	0.00646	3.254397	0.000822	2.061221
157	53.202848		2.404404	0.876077	2379.71528	0.60118	0.248988	0.023372	3.22949	0.000816	2.312483
158	53.10757		2.547216	0.76541	2432.080106	0.614409	0	-0.017361	9.951237	0.002514	3.987037
159	53.142359		2.474976	0.81272	2620.67823	0.662054	0.1281	0.001615	3.908929	0.000988	3.725993
160	52.985977		2.585268	0.631242	2411.23713	0.609143	0.3081	-0.085854	23.068026	0.005828	4.702338
161	52.950564		2.353464	0.575417	2170.742922	0.548388	0.377856	-0.071861	19.934513	0.005036	3.643311
162	53.116768		2.303868	0.746731	2343.016292	0.591909	0.159444	-0.037863	2.789275	0.000705	4.787999
163	52.923766		2.542812	0.57314	2377.531164	0.600628	0.351084	-0.029602	38.872925	0.00982	1.853914
164	52.956718		2.323056	0.553641	2128.431046	0.537699	0.561024	0.004431	6.694853	0.001691	1.653381
165	52.949021		2.354496	0.514723	2073.622851	0.523853	0.490152	-0.00541	7.266484	0.001836	1.693742
166	52.904284		2.214156	0.517705	2243.29049	0.566716	0.586728	-0.014327	22.227359	0.005615	1.295602
167	52.718271		2.327076	0.406949	2033.1915	0.513639	0.87816	-0.120341	89.922161	0.022717	1.968562
168	52.954959		2.3514	0.572128	2173.709154	0.549137	0.713292	0.003188	13.209816	0.003337	1.265914
169	53.102043		2.39718	0.745971	2373.927627	0.599718	0.19608	0.035336	5.753872	0.001454	1.265191
170	53.027654		2.469432	0.65645	2462.845049	0.622181	0.374868	0.046713	13.862193	0.003502	2.175465
171	53.261804		2.465016	1.043304	2478.072217	0.626028	0.17502	0.041471	4.36772	0.001103	1.834551
172	52.875527		2.230836	0.510692	2083.133816	0.526256	0.63324	-0.057967	28.815044	0.007279	1.036127
173	52.848137		2.279352	0.512308	1886.63674	0.476615	0.675792	-0.109948	47.727847	0.012057	2.282111
174	52.703783		2.305356	0.339258	1778.643501	0.449333	0.528132	-0.158332	101.771307	0.02571	3.265509
175	52.571335		1.892088	0.283368	1597.140946	0.403481	1.455804	-0.212157	164.176047	0.041475	1.866316
176	52.858972		2.340156	0.477134	1924.453083	0.486169	0.554916	-0.021082	28.957369	0.007315	1.562554
177	53.099949		2.351724	0.740017	2438.884278	0.616128	0.367068	0.023604	6.215537	0.00157	1.619326
178	53.060973		2.366652	0.684487	2352.882373	0.594401	0.20448	0.021626	5.784515	0.001461	1.504803
179	53.058992		2.308548	0.686399	2373.721838	0.599666	0.011784	-0.001871	7.076265	0.001788	1.030229
180	53.2532		2.828832	0.989287	2639.564594	0.666825	0	0.014612	1.477831	0.000373	2.619424
181	53.245525		2.576916	0.960485	2335.204408	0.589935	0.086988	0.000947	3.942603	0.000996	1.847518
182	53.157189		2.61984	0.836853	2856.800509	0.721705	0.035208	0.028162	8.978168	0.002268	2.029512
183	53.246478		2.582244	0.995787	2437.834665	0.615863	0.198504	0.037936	2.812486	0.000711	2.300947
184	53.117048		2.644764	0.764288	2562.328799	0.647313	0	0.019991	10.17113	0.00257	1.906448
185	53.167816		2.539332	0.853116	2567.944655	0.648732	0	0.018634	3.773304	0.000953	2.808827
186	53.156293		2.409696	0.79572	2535.810706	0.640614	0	-0.012371	2.864259	0.000724	4.5954
187	52.992381		2.340192	0.578573	2198.860224	0.555491	0.319212	-0.057689	11.608249	0.002933	3.046196
188	53.097486		2.445612	0.719456	2511.792778	0.634546	0.17316	-0.076487	5.558639	0.001404	4.73107
189	53.108257		2.56074	0.783035	2515.365224	0.635449	0.312936	-0.077929	13.760474	0.003476	3.369052
190	53.141095		2.372988	0.782873	2366.9458	0.597954	0	-0.025193	4.269277	0.001079	2.97946
191	53.061525		2.260764	0.698897	2444.505848	0.617548	0	-0.007642	12.442256	0.003143	1.249524
192	53.266335		2.761476	1.061221	2345.582471	0.592557	0	0.009919	0.638962	0.000161	1.998818
193	53.031764		2.431794	0.710973	2421.010917	0.611612	0	0.020735	10.374156	0.002621	1.334831
194	53.220515		2.639808	0.926565	2917.874965	0.737134	0	0.004183	0.471705	0.000119	3.271626
195	53.23183		2.824008	0.948336	2684.908524	0.67828	0	0.015983	0.894715	0.000226	3.263121
196	53.062709		2.7021	0.73644	2532.712425	0.639831	0.14802	-0.016619	6.227632	0.001573	3.046316
197	53.002043		2.485296	0.718939	2406.074508	0.607839	0.237204	-0.004217	15.968572	0.004034	0.900271

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198	52.978318		2.451756	0.618362	2389.538327	0.603662	0.409428	-0.027974	14.06791	0.003554	1.394388
199	53.006049		2.465364	0.628154	2331.705338	0.589051	0.220332	-0.020625	11.377321	0.002874	1.344937
200	53.087166		2.4111	0.717113	2382.51918	0.601888	0	-0.014596	4.052892	0.001024	2.032863
201	53.089447		2.352888	0.777374	2473.677915	0.624918	0.947988	0.065731	14.382264	0.003633	1.634646
202	53.27583		2.708352	1.062551	2661.284836	0.672312	0	0.037077	3.259554	0.000823	1.195265
203	53.489975		3.51792	1.612876	3052.607068	0.771171	0	-0.258258	25.154977	0.006355	1.288685
204	53.541228		3.358236	1.509541	3083.947174	0.779088	0	0.024918	2.383871	0.000602	0.75744
205	53.255976		2.888952	1.039852	2805.972274	0.708864	0	0.015671	4.908113	0.00124	2.637111
206	53.235763		2.441412	0.942401	2552.163299	0.644745	0	0.005862	1.38416	0.00035	1.659424
207	53.225696		2.298612	0.934575	2471.798393	0.624443	0.19188	0.023157	3.218732	0.000813	1.601138
208	53.122205		2.49282	0.794716	2379.727736	0.601183	0.02994	0.007541	3.231079	0.000816	2.78794
209	53.153418		2.38164	0.829158	2509.161946	0.633882	0	0.010132	2.491591	0.000629	3.047805
210	53.078649		2.406624	0.71324	2287.974228	0.578004	0.428388	0.028335	8.970075	0.002266	0.743231
211	53.026159		2.389596	0.682946	2318.573541	0.585734	0.143064	0.011452	18.595388	0.004698	1.961281
212	53.286019		2.800584	1.049056	2753.314402	0.695561	0	0.024256	1.357669	0.000343	3.131941
213	53.119929		2.598624	0.805465	2552.032968	0.644712	0.119352	-0.04356	7.68284	0.001941	2.413155
214	53.088944		2.315616	0.709495	2333.70712	0.589557	0.165636	-0.037208	3.379236	0.000854	3.498721
215	53.08557		2.704596	0.743399	2532.380339	0.639747	0.185784	0.005221	6.340868	0.001602	2.56716
216	53.391349		3.089664	1.277731	2872.961721	0.725787	0	0.019736	0.737555	0.000186	1.599633
217	53.425546		2.93832	1.296792	3066.715793	0.774735	0	0.059131	3.007887	0.00076	1.345307
218	53.551801		3.513276	1.48488	3098.724337	0.782821	0	0.02492	1.808084	0.000457	1.489108
219	53.319388		2.610492	1.165868	2732.245878	0.690239	0.22926	0.067644	17.672196	0.004464	3.294666
220	53.495573		2.651724	1.367843	3002.38153	0.758482	0	0.002101	0.039494	0.00001	1.638153
221	53.234629		2.557872	0.94586	2655.047853	0.670736	0.014904	0.061104	4.782016	0.001208	2.023681
222	53.041268		2.451804	0.656319	2525.503545	0.63801	0.180408	-0.003116	9.044476	0.002285	1.911016
223	53.026884		2.286312	0.636938	2099.831355	0.530474	0.164724	-0.020446	5.379675	0.001359	2.706596
224	52.895453		2.434608	0.52801	2356.83759	0.595401	0.238104	-0.040853	39.842351	0.010065	2.895099
225	52.989149		2.360916	0.641705	2282.727905	0.576678	0.080892	-0.015269	16.071753	0.00406	2.692426
226	53.189081		2.475144	0.895263	2539.708122	0.641599	0	-0.022616	3.269163	0.000826	4.629618
227	53.16933		2.497812	0.918414	2543.808914	0.642635	0	0.007272	3.985852	0.001007	3.650893
228	53.34253		2.776764	1.171433	2841.686063	0.717886	0.049164	0.024984	1.703436	0.00043	1.054989
229	53.541272		3.252492	1.584305	2998.454594	0.75749	0	-0.000252	1.686305	0.000426	1.027168
230	53.604009		3.214572	1.661198	3448.212359	0.871111	0	0.019265	1.430916	0.000361	0.483887
231	53.719086		3.842556	1.997214	3352.39824	0.846906	0	0.056739	2.276177	0.000575	1.405175
232	53.646413		3.445008	1.896504	3061.499719	0.773417	0	0.012015	1.568086	0.000396	0.902618
233	53.759332		3.988464	1.934781	3898.375029	0.984834	0	0.009762	0.73497	0.000186	1.274991
234	53.71395		3.209496	1.773048	3685.253575	0.930994	0.072756	0.020894	1.511123	0.000382	0.679473
235	53.64388		3.225864	1.647839	3382.938603	0.854621	0	0.021703	2.254679	0.00057	1.359981
236	53.557605		3.146688	1.512804	3516.138893	0.888271	0	0.05056	5.124644	0.001295	1.815841
237	53.688826		3.388188	1.685202	3381.239901	0.854192	0	0	0	0	3.227453
238	53.552038		3.040908	1.447543	3672.889348	0.927871	0	0.014091	1.428789	0.000361	2.295208
239	53.674597		3.550644	1.654873	3353.454357	0.847173	0	0.01229	1.270224	0.000321	2.880179
240	53.696336		3.919872	1.750667	3607.563949	0.911368	0	-0.003083	0.565396	0.000143	2.945401
241	53.56402		3.00258	1.54408	3306.492045	0.835309	0.155868	0.060255	6.024665	0.001522	0.897441
242	53.495048		2.704236	1.381309	2870.318067	0.72512	0	0.003029	0.945047	0.000239	2.308336
243	53.48713		2.80026	1.358962	3059.796406	0.772987	0	0.022366	2.197139	0.000555	1.532031
244	53.621244		3.1395	1.59714	3218.15355	0.812992	0	0.005835	0.252581	0.000064	2.506314
245	53.323169		2.711412	1.090016	2852.531528	0.720626	0.284892	0.031348	6.175297	0.00156	0.716422
246	53.565317		3.02862	1.528956	3144.579805	0.794405	0	0.076332	4.800003	0.001213	2.093595
247	53.39926		2.850984	1.232802	3248.269583	0.8206	0	0.040271	2.617842	0.000661	2.58035

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248	53.235207		2.880924	0.972547	2499.324507	0.631397	0	0.008386	4.620403	0.001167	2.285286
249	53.492979		2.914704	1.372656	3352.200296	0.846856	0	0.000837	0.244752	0.000062	3.627338
250	53.591411		3.296448	1.571027	3145.858675	0.794729	0	0.076761	4.598414	0.001162	2.936619
251	54.039953		4.339728	2.239824	3871.213658	0.977973	0	0.002573	0.06881	0.000017	3.237049
252	53.623977		3.432012	1.581969	3277.713087	0.828038	0	0.001071	0.241104	0.000061	3.262693
253	53.418984		2.814168	1.255679	3035.210629	0.766776	0	0.022482	2.286203	0.000578	3.462563
254	53.287576		3.067464	1.073177	2861.843341	0.722979	0	-0.010977	6.42671	0.001624	2.509026
255	53.728626		3.387756	1.818214	3662.811738	0.925325	0	0.035406	3.274716	0.000827	1.626369
256	53.755991		4.237008	1.954332	3679.757616	0.929606	0	0.043023	7.363324	0.00186	0.76724
257	53.791502		4.061808	2.113428	3808.632825	0.962163	0	0.020033	1.849147	0.000467	1.088069
258	53.856636		4.049616	2.156184	3720.743126	0.93996	0	0.000249	0.001558	0	0.898152
259	53.753688		4.195992	2.034295	3555.738129	0.898275	0	0.00444	7.967362	0.002013	1.520398
260	53.839922		3.916044	2.02137	3762.990904	0.950633	0	0.033853	2.258012	0.00057	1.44678
261	53.901793		3.780564	2.109901	3943.006839	0.99611	0	0.033752	1.827979	0.000462	1.891745
262	53.916767		3.673368	2.089874	3942.348325	0.995943	0	0.006098	0.070332	0.000018	2.246232
263	53.654557		3.47346	1.637778	3261.124367	0.823848	0	0.004789	2.139505	0.00054	0.943206
264	53.76652		3.670848	1.872849	3783.986357	0.955937	0	0.012832	3.792018	0.000958	1.536811
265	53.778329		3.517392	1.875111	3639.410226	0.919413	0	0.034786	1.440188	0.000364	2.021046
266	53.800592		3.619212	1.908194	3622.913829	0.915245	0	0	0	0	3.391199
267	53.838887		4.037124	2.020074	3474.797335	0.877827	0	0.044466	2.047911	0.000517	2.518034
268	53.785891		3.65112	1.89266	3687.681668	0.931608	0	0.015877	1.546965	0.000391	1.634973
269	53.896677		4.070148	2.106999	3624.792025	0.91572	0	0.01209	0.198592	0.00005	2.076281
270	53.697003		3.152088	1.735482	3159.696848	0.798224	0	0.023391	1.802088	0.000455	1.182491
271	53.691061		3.661116	1.722543	3288.00659	0.830639	0	0.030461	2.192503	0.000554	1.319336
272	53.584837		3.225312	1.560838	2849.304908	0.719811	0	0.020194	3.873327	0.000979	1.641262
273	53.7489		3.47154	1.826768	3950.918739	0.998108	0	0.032248	1.22574	0.00031	4.021198
274	53.886383		4.119156	2.040877	4036.702851	1.01978	0	0.006583	0.046228	0.000012	4.519409
275	53.870427		3.72174	2.029702	3791.487381	0.957832	0	0.026401	1.109548	0.00028	3.207017
276	53.899114		3.57408	2.038662	3880.780772	0.98039	0	0	0	0	4.12183
277	53.796848		3.434058	1.856304	1260.774713	0.318506	0	0.03888	0.133058	0.000034	3.207648
AVERAGE DIAMETER	**106.5241605**	**MAXIMUM**	**4.339728**	**2.239824**	**4036.702851**	**1.01978**	**1.455804**	**0.097935**	**247.464482**	**0.062516**	**6.331124**
		AVERAGE	**2.706617095**	**1.029512573**	**2613.509012**	**0.660242682**	**0.143843518**	**0.002759219**	**9.276769084**	**0.002343551**	**2.440665215**

MAXIMUM MEASUREMENTS HIGHLIGHTED IN PEACH

LEGEND:

MAXIMUM CORROSION: MAXIMUM DEPTH OF CORROSION IN THE ONE FOOT SECTION OF PIPE.
AVERAGE CORROSION: THE AVERAGE CORROSION FOR EACH ONE FOOT SECTION.
INTEGRATED CORROSION: CORROSION OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED CORROSION: INTEGRATED CORROSION DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE TO COMPARE THE EXTENT OF CORROSION IN EACH ONE FOOT SECTION OF PIPE
MAXIMUM BUILDUP: MAXIMUM BUILDUP IN THE ONE FOOT SECTION OF PIPE.
AVERAGE BUILDUP: THE AVERAGE BUILDUP FOR EACH ONE FOOT SECTION.
INTEGRATED BUILDUP: BUILDUP OVER A 1 FOOT WIDE SECTION OF PIPE IN CUBIC INCHES
AVERAGED BULDUP: INTEGRATED BUILDUP DIVIDED BY SURFACE AREA OF 1FT WIDE SECTION OF THE PIPE. USE TO COMPARE THE EXTENT OF BUILDUP IN EACH ONE FOOT SECTION OF PIPE
OVALITY: CHANGE IN CIRCULARITY; THE AMOUNT OF OUT-OF-ROUNDNESS

Segment S54S551

Appendix C Manhole Drop-down Reports

Manhole ID: A32

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	June 6, 2022	Segment:	Alameda Interceptor
Location Description:	Buena Vista Avenue & Ohlone Street		

Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	57 inches	Structure Lined?	Yes
Pipe Lined?	Upstream only	Penetration Depth:	--
Penetration Depth:	½-inch	Surface pH:	--
Surface pH:	1	Depth pH:	--
Depth pH:	4 @ ½-inch	VANDA Condition:	3
VANDA Condition:	4		

Assessment Summary: The surface of the downstream pipe was in VANDA Level 4 condition. The pipe had large, loose aggregate on the surface, as seen in Photo A32 - 1. The remaining mortar was a soft paste that would scrape away easily, revealing reinforcement underneath. Beneath the mortar, the reinforcement was corroded and damaged.

The surface of the upstream pipe was in VANDA Level 1 condition. The pipe was lined and in good condition. Slight discoloration was observed at the crown of the pipe and near the waterline, as seen in Photo A32 - 2. The coating of the pipe was intact, and no aggregate or reinforcement was exposed.

The walls around the manhole were in VANDA Level 3 condition. Through sounding, it was found that the walls had a soft surface layer. The walls were coated in a black material that would crumble when pressure was applied. Beyond this, there were no visible spalls, aggregate, or exposed rebar on the walls. Slight discoloration was observed in the manhole structure, as seen in Photo A32 - 4.


Photo A32 - 1. Downstream pipe, efflorescence and exposed aggregate on walls.


Photo A32 - 2. Upstream pipe, no visible aggregate or exposed rebar.


Photo A32 - 3. Side lateral pipe, showing signs of coating damage.


Photo A32 - 4. Efflorescence and discoloration on bench walls.

Manhole ID: A34

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	June 7, 2022	Segment:	Alameda Interceptor
Location Description:	Buena Vista Avenue & Jay Street		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	57 inches	Structure Lined?	Yes
Pipe Lined?	No	Penetration Depth:	1/2inch
Penetration Depth:	½-inch	Surface pH:	--
Surface pH:	1	Depth pH:	--
Depth pH:	4 @ ½-inch	VANDA Condition:	3
VANDA Condition:	5		

Assessment Summary: In general, the concrete surfaces of the upstream and downstream pipe walls were in VANDA Level 5 condition. The remaining mortar on these pipes was a soft paste that would scrape off easily. The soft mortar was about 1/2 of an inch deep; beyond this, hard concrete was present. Both pipes had large aggregate exposed and missing in some areas. No cracks were present; however, bands of circumferential reinforcement were exposed in both pipes, as seen in Photo A34 - 1 and Photo A34 - 2.

The manhole structure was in VANDA Level 3 condition. The top layer of concrete was soft, but hard concrete was found below 1/2 of an inch. The coating was intact, but slight discoloration was observed, as seen in Photo A34 - 5. The interceptor opening at the manhole structure was in fair condition with some coating remaining, as seen in Photo A34 - 6.


Photo A34 - 1. Downstream pipe, circumferential rebar and aggregate exposed.


Photo A34 - 2. Upstream pipe, circumferential rebar and aggregate exposed.


Photo A34 - 3. Coating damage and exposed circumferential rebar in downstream pipe.


Photo A34 - 4. Exposed circumferential rebar and large aggregate in upstream pipe.


Photo A34 - 5. Manhole conditions on upper bench.


Photo A34 - 6. Manhole condition above upstream pipe.

Manhole ID: A35

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	June 8, 2022	Segment:	Alameda Interceptor
Location Description:	Buena Vista Avenue & Benton Street		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	57 inches	Structure Lined?	Yes
Pipe Lined?	No	Penetration Depth:	--
Penetration Depth:	1-inch	Surface pH:	--
Surface pH:	1	Depth pH:	--
Depth pH:	4 @ 1-inch	VANDA Condition:	4
VANDA Condition:	5		

Assessment Summary: The concrete surface of the downstream pipe was in VANDA Level 5 condition. The surface of the pipe was a soft paste with solid concrete being found beyond 1-inch deep. Large pieces of aggregate were exposed. Circumferential, as well as longitudinal rebar, was exposed; see Photo A35 - 1. The exposed rebar was corroded and missing in some areas. At the 12:00 position of the downstream pipe, some circumferential rebar was missing. The remaining rebar was observed to be sagging into the headspace of the pipe, as seen in Photo A35 - 3.

The surface of the upstream pipe was in VANDA Level 4 condition. The surface of the pipe was a soft mush, with solid concrete being found about ½-inches deep. Efflorescence and exposed large aggregate were seen on the pipe's surface; see Photo A35 - 2. The circumferential rebar was partially exposed; scraping away the surface mortar revealed additional reinforcement. Longitudinal reinforcement was not visible in the upstream pipe. The exposed reinforcement in the upstream pipe was observed to be corroded.

The walls were in VANDA Level 4 condition. There was no visible aggregate or cracks on the walls. The walls were covered in a yellow lining. On the roof of the structure, below the manhole opening, transverse and longitudinal reinforcement was exposed; see Photo A35 - 5. The exposed reinforcement was observed to be corroded and was causing discoloration to the surrounding concrete.

Photo A35 - 1. Downstream pipe, exposed circumferential and longitudinal rebar, rebar is corroded, remaining mortar is soft and mushy.

Photo A35 - 2. Upstream pipe, exposed circumferential rebar, exposed rebar is corroded, surface mortar scrapes away easily revealing rebar.

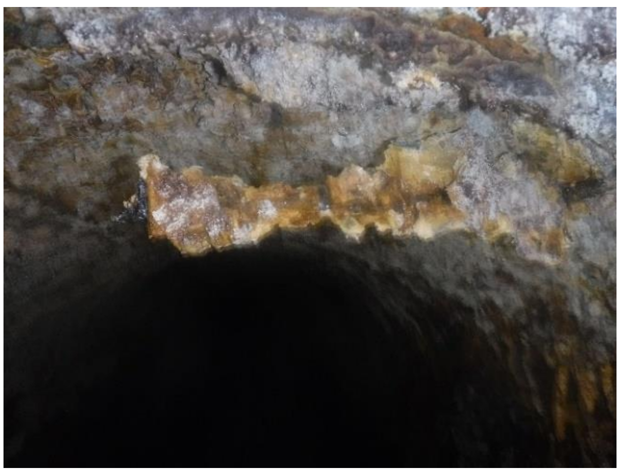

Photo A35 - 3. Rebar sagging into pipe headspace at crown of downstream pipe.

Photo A35 - 4. Broken circumferential rebar in upstream pipe.

Photo A35 - 5. Bottom of manhole access, exposed rebar is corroded.

Manhole ID: A37

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	June 8, 2022	Segment:	Alameda Interceptor
Location Description:	Buena Vista Avenue & St. Charles Street		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	60 inches	Structure Lined?	Yes
Pipe Lined?	Upstream only	Penetration Depth:	--
Penetration Depth:	1/2-inch	Surface pH:	--
Surface pH:	2	Depth pH:	--
Depth pH:	4 @ ½-inch	VANDA Condition:	3
VANDA Condition:	4		

Assessment Summary: The concrete surface of the downstream pipe was in VANDA Level 4 condition. The surface of the pipe was a soft yellow paste. Solid concrete was found at a depth of 7/16-inch. Large aggregate was exposed and missing in some locations; see Photo A37 - 1. Circumferential rebar was observed to be exposed down the length of the pipe. The exposed rebar was corroded but still providing some support; see Photo A37 - 3. The corrosion from the rebar caused the nearby mortar and aggregate to become discolored.

The upstream pipe was lined and in good condition; see Photo A37 - 2.

The manhole structure was in VANDA Level 3 condition. The walls around the upstream pipe had large aggregate protruding but not completely exposed on the surface as seen in Photo A37 - 4. The walls were discolored and had a surface layer of efflorescence. Through sounding, the concrete on the bench would crumble; see Photo A37 – 5. The lining on the upper wall was in good condition. No exposed reinforcement was observed along the walls of the structure.

Photo A37 - 1. Downstream pipe, exposed circumferential rebar and aggregate.

Photo A37 - 2. Upstream pipe, no exposed rebar or aggregate.

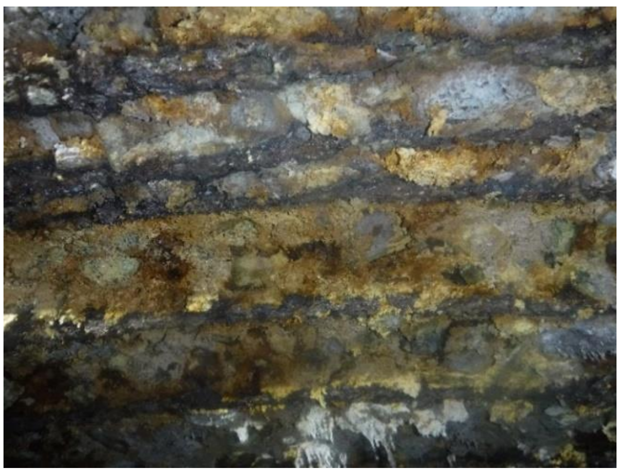

Photo A37 - 3. Exposed and corroded circumferential rebar in downstream pipe.

Photo A37 - 4. Exposed aggregate on manhole structure above upstream pipe.

Photo A37 - 5. Concrete spalling on manhole structure wall.

Photo A37 - 6. Soft mushy yellow concrete in manhole structure.

Manhole ID: A39

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	June 9, 2022	Segment:	Alameda Interceptor
Location Description:	Buena Vista Avenue & Woods Street		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	60 inches	Structure Lined?	Yes
Pipe Lined?	No	Penetration Depth:	--
Penetration Depth:	1-inch	Surface pH:	--
Surface pH:	1	Depth pH:	--
Depth pH:	4 @ 1-inch	VANDA Condition:	3
VANDA Condition:	5		

Assessment Summary: In general, both concrete surfaces of the upstream and downstream pipe were in VANDA Level 5 condition. Both pipes had soft yellow mortar on the surface, with solid concrete being found at a depth beyond 1-inch. Exposed large aggregate and efflorescence were observed on the exposed portions of the pipes; see Photo A39 - 1 and Photo A39 - 2.

The downstream pipe had exposed longitudinal and circumferential rebar. The rebar was corroded and consumed in some sections. A 2-inches deep, a 12-inch by 9-inch hole was found at the 12:00 position of the downstream pipe; see Photo A39 - 3. Circumferential rebar was missing at this location. The remaining rebar was corroded. Discoloration of the nearby concrete can be attributed to corrosion of the reinforcement. Large cracking with black tar was found around the rim of the pipe near the manhole opening; see Photo A39 - 5. Large aggregate and efflorescence were observed near the large cracks.

The upstream pipe only had circumferential rebar exposed. The rebar was heavily corroded with some portions near the roof of the pipe consumed. The remaining rebar was sagging into the pipe headspace; see Photo A39 - 6. Delamination was also present in the upstream pipe near the water level; see Photo A39 - 4. Soft yellow mortar and large aggregate was seen at the delamination.

The lining on the manhole wall was rough and was crumbly like some of the other manholes along Buena Vista.

Photo A39 - 1. Downstream pipe, exposed circumferential and longitudinal rebar, exposed rebar and walls are corroded.

Photo A39 - 2. Upstream pipe exposed circumferential rebar and aggregate. Concrete is soft and scrapes away easily revealing rebar.

Photo A39 - 3. 12-inch x 9-inch hole at crown of downstream pipe, 2-inches deep.

Photo A39 - 4. Delamination in upstream pipe.

Photo A39 - 5. Crack above downstream pipe, black tar inside crack.

Photo A39 - 6. Exposed circumferential and longitudinal rebar in upstream pipe. Walls and rebar are corroded.

Manhole ID: A40

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	June 9, 2022	Segment:	Alameda Interceptor
Location Description:	Buena Vista Avenue & 8th Street		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	60 inches	Structure Lined?	Yes
Pipe Lined?	No	Penetration Depth:	--
Penetration Depth:	--	Surface pH:	--
Surface pH:	--	Depth pH:	--
Depth pH:	--	VANDA Condition:	--
VANDA Condition:	3		

Assessment Summary: Confined space entry was not conducted at A40 due to the drop inlet discharging water into the force main. Photos were collected from the topside of the manhole and analyzed for visible defects. The lining on the wall was rough and may be crumbly like some of the other manholes along Buena Vista; see Photo A40-1. The drop inlet and upstream pipe also showed signs of concrete deterioration. From the top of the manhole, the crown and 6:00 of the drop inlet looked to have a light gray color and soft texture; see Photo A40-2. The crown of the upstream pipe had a section of missing concrete. The corrosive environment may have corroded the concrete resulting in spalling of that section; see Photo A40-3.

Photo A40 -1. Manhole, discoloration, and degradation observed on walls.

Photo A40 -2. Drop inlet, surface damage on crown and 6:00 of pipe.

Photo A40 -3. Upstream pipe, loss of concrete on crown of pipe.

Manhole ID: A46A

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	June 9, 2022	Segment:	Alameda Interceptor
Location Description:	Parking lot next to 2148 Mariner Square Drive		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	60 inches	Structure Lined?	Yes
Pipe Lined?	Downstream only	Penetration Depth:	--
Penetration Depth:	1/8-inch	Surface pH:	--
Surface pH:	2	Depth pH:	--
Depth pH:	10 @ 1/8-inch	VANDA Condition:	3
VANDA Condition:	3		

Assessment Summary: The downstream pipe was lined and in good condition. Through sounding, the surface of the pipe was found to be hard, and the lining was intact. The sides of the pipe were grey, while the roof of the pipe was dark grey to black in color. There was no visible aggregate or rebar exposed on the downstream pipe; see Photo A46A - 1. No cracks were observed in the pipe.

The upstream pipe was in VANDA Level 3 condition. The walls of the pipe had large aggregate protruding from the surface. The surface mortar still provided support holding the large aggregate together; see Photo A46A -2. The surface mortar was soft, with solid concrete being found at a depth of ¼-inches. The crown of the upstream pipe appeared smooth and did not have any visible aggregate; see Photo A46A - 3. There was no visible reinforcement exposed inside the pipe.

The manhole structure was in VANDA Level 2 condition. Soft blisters were observed on the walls of the manhole structure. These blisters were soft and crumbled easily when force was applied; see Photo A46A – 5. The surface of the walls was hard, and no large aggregate was observed. The walls around the top of the structure, near the manhole were in good condition; see Photo A46A – 6. The coating along the top of the manhole structure was intact. No exposed reinforcement was observed along the walls of the structure.

Photo A46A - 1. Downstream pipe, no visible rebar or aggregate.

Photo A46A - 2. Upstream pipe, lining is sagging into pipe and aggregate is exposed.

Photo A46A - 3. Crown of upstream pipe, top portion of pipe does not have exposed aggregate.

Photo A46A - 4. Detail of exposed aggregate in upstream pipe.

Photo A46A - 5. Pitting on walls of manhole structure.

Photo A46A - 6. Green lining on upper section of manhole structure.

Manhole ID: A47

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	June 6, 2022	Segment:	Alameda Interceptor
Location Description:	Parking lot next to 2238 Mariner Square Drive		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	60 inches	Structure Lined?	Yes
Pipe Lined?	Upstream only	Penetration Depth:	--
Penetration Depth:	¼-inch	Surface pH:	--
Surface pH:	1	Depth pH:	--
Depth pH:	4 @ 1/4-inch	VANDA Condition:	3
VANDA Condition:	4		

Assessment Summary: The downstream pipe at manhole A47 was in VANDA Level 4 condition. The surface concrete was a soft paste and yellow in color. Exposed large aggregate was observed on the upper portion of the pipe; see Photo A47 - 1. The aggregate was held loosely together by the surface concrete, see Photo A47 - 3, and would come off easily when scraped. There were hollow black bubbles on the walls of the downstream pipe that would crack easily when touched. These bubbles may be remnants of a previous pipe coating. Exposed circumferential reinforcement was also observed on the crown of the downstream pipe. The reinforcement was corroded, leading to discoloration of the nearby concrete; see Photo A47 - 4. The exposed reinforcement was moderately consumed by corrosion but still provided some structural support.

The upstream pipe was lined and in good condition. The surface lining was still intact; see Photo A47 - 2. The surface was smooth, with no exposed aggregate or reinforcement. Through sounding, no spalls were detected, nor were any visible cracks observed.

The manhole structure was in VANDA Level 3 condition. The coating along the walls of the upper segments were intact, but a clear divide was observed near the interceptor-manhole joint where the coating was no longer present; see Photo A47 - 5. Below the interceptor-manhole joint, large aggregate was observed protruding from the walls. No reinforcement was observed to be exposed on the walls of the structure. The walls of the upper segments of the manhole structure had a hard surface and were stained green; see Photo A47 – 6.

Photo A47 - 1. Downstream pipe, exposed aggregate and discoloration at joints.

Photo A47 - 2. Upstream pipe, no visible aggregate or exposed reinforcement.

Photo A47 - 3. Left wall of downstream pipe, exposed aggregate protruding from wall.

Photo A47 - 4. Crown of downstream pipe, exposed circumferential rebar is corroded.

Photo A47 - 5. Exposed aggregate on interceptor-manhole joint.

Photo A47 - 6. Green discoloration on upper manhole structure.

Manhole ID: A48

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	June 6, 2022	Segment:	Alameda Interceptor
Location Description:	Grass lawn next to Marina Village Parkway		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	60 inches	Structure Lined?	Yes
Pipe Lined?	Downstream only	Penetration Depth:	--
Penetration Depth:	1/8-inch	Surface pH:	--
Surface pH:	5	Depth pH:	--
Depth pH:	10 @ 1/8 -inch	VANDA Condition:	2
VANDA Condition:	4		

Assessment Summary: The downstream pipe was lined and in good condition; see Photo A48 - 1. No aggregate or rebar were exposed. There were no visible spalls or cracks within the pipe.

The concrete surface of the upstream pipe was in VANDA Level 4 condition. Large aggregate was exposed, and the surface mortar was soft, with solid concrete being found at a depth of ¼-inches. The exposed aggregate was protruding from the wall; see Photo A48 - 2 and Photo A48 - 4. Some sections near the 12:00 position of the pipe had corrosion staining and partial rebar exposure; see Photo A48 - 5.

The manhole structure was in VANDA Level 2 condition. The walls were soft with solid concrete being found at a depth of ¼-inches. The soft surface layer had some brown stained concrete beneath the surface; see Photo A48 – 6. No large cracks or large aggregate was observed along the walls of the structure.

Photo A48 - 1. Downstream pipe, no visible aggregate or reinforcement.

Photo A48 - 2. Upstream pipe, exposed aggregate, damaged coating, and exposed rebar.

Photo A48 - 3. Damaged coating in upstream pipe, coating missing in areas.

Photo A48 - 4. Exposed aggregate in upstream pipe.

Photo A48 - 5. Exposed rebar in upstream pipe, reinforcement is corroded.

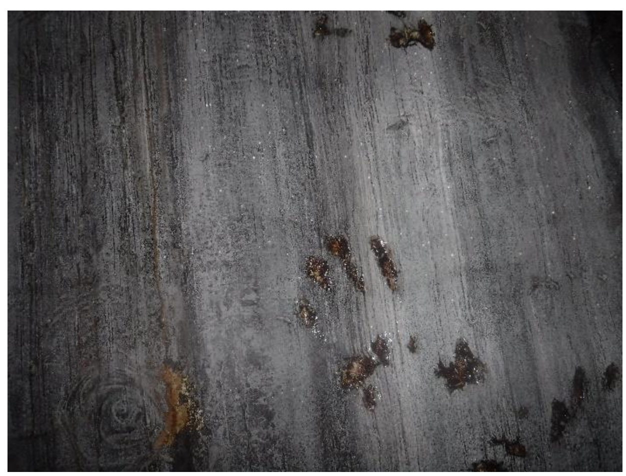

Photo A48 - 6. Soft walls of the manhole structure.

Manhole ID: N19

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	September 30, 2022	Segment:	North Interceptor
Location Description:	Intersection of University Ave and Second St		

Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	66 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	1/8-inch
Penetration Depth:	1/8-inch	Surface pH:	4
Surface pH:	3	Depth pH:	10 @ 1/8 inch
Depth pH:	10 @ 1/8-inch	VANDA Condition:	2
VANDA Condition:	3		

Assessment Summary: The upstream pipe was in VANDA Level 2 condition, while the downstream siphons were in VANDA level 3. Surface damage was observed on the crown of the upstream pipe, see Photo N19-1. The pipe had a soft layer of concrete on the surface. When scraped away, a hard layer of concrete was observed 1/8 of an inch underneath. No exposed reinforcement was observed along the pipe, although pH measurements indicate a severely corrosive environment for the concrete. There were two siphons that water flowed through when exiting the manhole. The downstream siphons had moderate surface damage, see Photo N19-2. Exposed aggregate was seen on the crown of the siphons near the siphons wall penetration.

The manhole structure was in VANDA Level 2 condition. The ceiling of the structure was in relatively good condition with minor signs of surface damage; see Photo N19-3. The manhole walls and bench experienced moderate surface damage resulting in sections of exposed aggregate; see Photo N19-4. No large cracks or spalls were observed along the walls.

Photo N19-1. Upstream pipe in good condition, minor surface damage on crown of pipe.

Photo N19-2. Downstream siphon, exposed aggregate on crown and near siphon entrance.

Photo N19-3. Manhole ceiling in good condition.

Photo N19-4. Manhole walls and bench, exposed aggregate on surfaces.

Manhole ID: N22

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	September 30, 2022	Segment:	North Interceptor
Location Description:	In Berkley Aquatic Park		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	66 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	1/16-inch
Penetration Depth:	1/8-inch	Surface pH:	4
Surface pH:	3	Depth pH:	10 @ 1/16-inch
Depth pH:	10 @ 1/8-inch	VANDA Condition:	3
VANDA Condition:	3		

Assessment Summary: Overall, the upstream and downstream pipes were in VANDA Level 3 condition. The crown of the pipe experienced moderate surface damage to the concrete. Signs of surface mortar delamination were observed on the crown of both pipes; see Photo N22 - 1. Multiple areas of mortar failure were observed on the crown, see Photo N22 - 2. The surface layer of the pipe was soft with a hard layer of concrete at 1/8 of an inch below the surface. No exposed reinforcement was observed along the pipe, although pH measurements indicate a severely corrosive environment for the concrete.

The manhole structure was in VANDA Level 3 condition. The manhole walls and bench showed signs of moderate surface damage. Multiple areas of large aggregate were visible on the walls, bench, and ceiling; see Photo N22 - 3. The manhole's rim had also experienced moderate surface damage and corrosion; see Photo N22 - 4.

Photo N22-1. Upstream pipe, surface damage along crown of pipe.

Photo N22-2. Downstream pipe, surface damage and delamination of surface mortar lining.

Photo N22-3. Exposed large aggregate on manhole ceiling.

Photo N22-4. Moderate corrosion observed on manhole rim.

Manhole ID: N26

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	July 14, 2022	Segment:	North Interceptor
Location Description:	W. Bolivar Drive near 2851 Bolivar Drive		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	66 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	--
Penetration Depth:	1/16-inches	Surface pH:	--
Surface pH:	4	Depth pH:	--
Depth pH:	10 @ 1/16-inches	VANDA Condition:	2
VANDA Condition:	3		

Assessment Summary: The upstream and downstream pipes were in VANDA Level 3 condition. Surface damage was observed on the crown of the pipes, see Photo N26 - 1 and Photo N26 - 2. A soft surface layer of concrete and signs of surface mortar delamination were observed on the crown; see Photo N26 - 3 and Photo N26 - 5. The surface of the pipes were found to be soft and would crumble easily. Solid concrete was found at a depth of 1/16 of an inch. No exposed reinforcement was observed within the pipe. pH measurements were taken in the craters of the downstream pipe and indicated a minorly corrosive environment for the concrete below the surface.

The manhole structure was in VANDA Level 2 condition. Through sounding, the walls were found to have a hard layer of concrete with fine aggregate exposed on the walls and bench; see Photo N26 - 5 and Photo N26 - 6. No large cracks or exposed reinforcements were observed along the walls of the structure.

Photo N26 - 1. Upstream pipe, surface damage on crown of pipe.

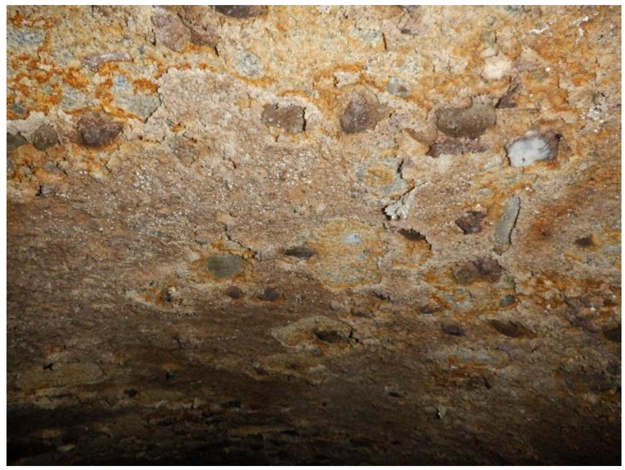

Photo N26 - 2. Upstream pipe, moderate surface damage and delamination of surface mortar lining on crown.

Photo N26 - 3. Downstream pipe, exposed aggregate on crown of pipe.

Photo N26 - 4. Downstream pipe, moderate surface damage and delamination of surface mortar lining on crown.

Photo N26 - 5. Manhole wall near upstream, fine exposed aggregate on surface.

Photo N26 - 6. Fine exposed aggregate around drop inlet on bench.

Manhole ID: N31

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	July 14, 2022	Segment:	North Interceptor
Location Description:	La Coste Street & 64th Street		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	66 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	--
Penetration Depth:	1/16-inch	Surface pH:	--
Surface pH:	4	Depth pH:	--
Depth pH:	10 @ 1/16-inch	VANDA Condition:	2
VANDA Condition:	3		

Assessment Summary: The upstream and downstream pipes were in VANDA Level 3 condition. Surface damage was observed on the crown of the pipes; see Photo N31 - 1 and Photo N31 - 2. A soft surface layer of concrete and signs of surface mortar delamination were observed on the crown; see Photo N31 - 3 and Photo N31 - 4. A hard layer of concrete was found at a depth of 1/16 of an inch below the surface. No exposed reinforcement was observed along the pipe. pH measurements were taken in the cavities inside the pipe and indicated a severely corrosive environment for the concrete below the surface.

The manhole structure was in VANDA Level 2 condition. Through sounding, the surface concrete was found to be hard. No large aggregate or exposed reinforcement were observed on the walls of the structure, see Photo N31 - 5. Along the bench of the manhole, fine aggregate was exposed, and the surface layer of mortar was no longer present; see Photo N31 - 6. No cracks or delaminations were observed inside the structure.

Photo N31 - 1. Upstream pipe, sections of exposed aggregate along crown of pipe.

Photo N31 - 2. Upstream pipe, moderate surface damage and delamination of surface mortar lining.

Photo N31 - 3. Downstream pipe, surface damage on crown of pipe.

Photo N31 - 4. Downstream pipe, moderate surface damage and delamination of surface mortar lining.

Photo N31 - 5. Manhole wall, in good condition.

Photo N31 - 6. Manhole bench, fine exposed aggregate below drop inlet.

Manhole ID: N35

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	July 14, 2022	Segment:	North Interceptor
Location Description:	Alley behind 5791 Christie Avenue		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	66 inches	Structure Lined?	Yes
Pipe Lined?	Downstream only	Penetration Depth:	--
Penetration Depth:	1/8-inch	Surface pH:	--
Surface pH:	2	Depth pH:	--
Depth pH:	10 @ 1/8-inches	VANDA Condition:	1
VANDA Condition:	3		

Assessment Summary: The upstream pipe was in VANDA Level 3 condition. Surface damage was observed on the crown of the pipes; see Photo N35 - 1. A soft surface layer of concrete and signs of surface mortar delamination were observed on the crown of each line. Multiple sites of mortar failure were observed on the crown; see Photo N35 - 2. A hard layer of concrete was revealed 1/10 of an inch below the surface. No exposed reinforcement was observed along the pipes. pH measurements indicate a severely corrosive environment for concrete below the surface.

The downstream pipe was in VANDA Level 1 condition. The lining inside the pipe was intact with slight discoloration below the typical waterline. A buildup of efflorescence was observed inside the pipe along the crown sections; see Photo N35 - 3. As the lining was still present, no reinforcement or large aggregate was exposed.

The manhole was in VANDA level 1 condition. The PVC lining on the walls of the manhole and along the bench was intact with no sections of visible concrete; see Photo N35 - 4.

Photo N35 - 1. Upstream pipe, surface damage along crown of pipe.

Photo N35 - 2. Upstream pipe, moderate surface damage and delamination of surface mortar lining.

Photo N35 - 3. Lined downstream pipe in good condition

Photo N35 - 4. PVC lining in manhole in good condition.

Manhole ID: S14

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 19, 2022	Segment:	South Interceptor
Location Description:	Coliseum Way North of Kevin Court		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	63 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	3/4-inch
Penetration Depth:	1/16-inch	Surface pH:	5
Surface pH:	4	Depth pH:	10 @ ¾-inch
Depth pH:	10 @ 1/16-inches	VANDA Condition:	3
VANDA Condition:	3		

Assessment Summary: In general, both the concrete surface of the upstream and downstream pipes were in VANDA Level 3 condition. The surface coating was intact and through sounding the surface was hard; see Photo S14 - 1and Photo S14 - 2. No cracks or spalls were observed in either of the pipes. The coating system was intact and no exposed aggregate or reinforcement were observed.

The manhole structure walls were in VANDA Level 3 condition. The crown above the upstream pipe opening had a protruding piece of rebar that was covered in sludge; see Photo S14 - 4. The surrounding bench walls were hard but had aggregate exposed; see Photo S14 - 5 and Photo S14 - 6. The exposed aggregate was still held together by the surrounding mortar; however, some penetrations and spalls were found. The penetrations exposed more aggregate but were shallow enough that rebar was not protruding. The penetrations were discolored which may indicate corrosion of the covered reinforcement.

Photo S14 - 1. Downstream pipe.

Photo S14 - 2. Upstream pipe.

Photo S14 - 3. Downstream pipe and manhole headspace as seen from the top bench.

Photo S14 - 4. Upstream pipe and manhole headspace as seen from the bench.

Photo S14 - 5. Bench wall, some exposed aggregate and discoloration.

Photo S14 - 6. Exposed aggregate on manhole structure wall, ¾" deep.

Manhole ID: S15

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 31, 2022	Segment:	South Interceptor
Location Description:	Coliseum Way North of Julie Ann Way		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	63 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	1-inch
Penetration Depth:	--	Surface pH:	1
Surface pH:	--	Depth pH:	8 @ 1-inch
Depth pH:	--	VANDA Condition:	4
VANDA Condition:	5		

Assessment Summary: Access to the lower portion of manhole S15 was not possible due to flow from a large inlet from the east that sprayed over the pipe opening; see Photo S15 - 1. Due to this the assessment of the manhole was conducted from the bench.

The manhole structure walls were in VANDA Level 4 condition. Each wall of the manhole had experience spalling which revealed large aggregate beneath; see Photo S15 - 2 and Photo S15 - 3. These spalls were about 1.5-inches to 3-inches thick. The underlying concrete was soft and mushy. The north and west walls had exposed reinforcement that was observed to be corroded; see Photo S15 - 4. Through sounding it was found that there were more hollow areas on the walls that may lead to further delamination.

Photo S15 - 1. Lateral inlet, spraying into interceptor pipe opening.

Photo S15 - 2. Bench wall, large spall with exposed aggregate beneath.

Photo S15 - 3. Roof of the manhole access, large aggregate exposed.

Photo S15 - 4. Bench wall, corroded reinforcement partially exposed.

Manhole ID: S16

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 31, 2022	Segment:	South Interceptor
Location Description:	Coliseum Way South of 50th Avenue		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	63 inches	Structure Lined?	No
Pipe Lined?	Yes	Penetration Depth:	1
Penetration Depth:	--	Surface pH:	2
Surface pH:	--	Depth pH:	10 @ 1-inch
Depth pH:	--	VANDA Condition:	3
VANDA Condition:	3		

Assessment Summary: In general, both the surfaces of the downstream and upstream pipes were in VANDA Level 3 condition. The downstream pipe had soft chalky concrete 3 feet from the manhole opening that would scrape away easily. The coatings for both pipes appeared to be intact, with only minor discoloration observed at the crown of both pipes; see Photo S16 – 1 and Photo S16 – 2. No cracks, spalls, or circumferential rebar were observed.

The manhole structure was in VANDA Level 3 condition. The lower box walls around the downstream pipe had a soft chalky surface and exposed large aggregate. The surface mortar and aggregate could be scraped away easily. Sounding indicated areas of concrete delaminating near these soft sections. The upper bench walls were in better condition, with no visible exposed reinforcement. No signs of delamination were detected through sounding in the upper box. The walls had slight discoloration and shallow surface spalling with medium-sized aggregate exposed; see Photo S16 – 4. A few small spalls were observed on the ceiling, The spalls had a chalky surface layer that crumble when pressure was applied.

Photo S16 – 1. Downstream pipe S16.

Photo S16 – 2. Upstream pipe S16

Photo S16 – 3. Crown of downstream pipe, exposed longitudinal reinforcement ends.

Photo S16 – 4. Bench walls, small spalls exposing aggregate.

Manhole ID: S38

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 20, 2022	Segment:	South Interceptor
Location Description:	Embarcadero South of 1363 Embarcadero		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	78 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	1-inch
Penetration Depth:	--	Surface pH:	1
Surface pH:	--	Depth pH:	9 @ 1-inch
Depth pH:	--	VANDA Condition:	3
VANDA Condition:	2		

Assessment Summary: The surface of the downstream pipe was in VANDA Level 2 condition. The coating inside the pipe was intact, protecting the concrete beneath; see Photo S38 - 1. No large aggregate or reinforcement was exposed inside the pipe. Through sounding, the surface was observed to have a hard surface. Slight discoloration was observed on the sides of the pipe below the typical waterline. No cracks were detected in the pipe.

The surface of the upstream pipe was in VANDA Level 2 condition. The mortar around the exposed aggregate on the sides of the pipe was semi-soft but still held the aggregate together; see Photo S38 - 2. The surface of crown of the pipe was hard and did not have aggregate exposed. No reinforcement was observed to be exposed in the pipe.

The walls around the manhole were in VANDA Level 3 condition. Sticks of reinforcement were observed to be protruding from the walls below the lateral line; see Photo S38 - 4. The exposed reinforcement was corroded and was staining the concrete near the wall penetrations. Large aggregate was also exposed around the pipe openings and near the roof around the manhole opening; see Photo S38 - 5 and Photo S38 - 6.

Photo S38 - 1. Downstream pipe.

Photo S38 - 2. Upstream pipe.

Photo S38 - 3. Large side lateral line.

Photo S38 - 4. Exposed rebar protruding from manhole structure wall.

Photo S38 - 5. Exposed aggregate on manhole structure wall above upstream pipe opening.

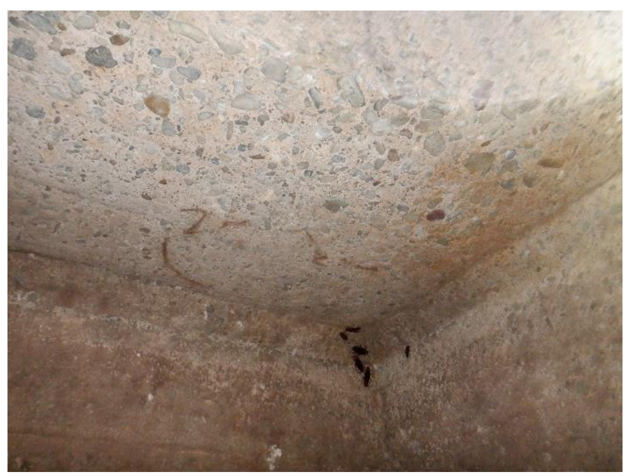

Photo S38 - 6. Exposed aggregate on roof of manhole structure.

Manhole ID: S39

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 20, 2022	Segment:	South Interceptor
Location Description:	Embarcadero South of 1363 Embarcadero		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	78 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	1-inch
Penetration Depth:	1/4-inch	Surface pH:	2
Surface pH:	3	Depth pH:	11 @ 1-inch
Depth pH:	11 @ 1/4-inch	VANDA Condition:	3
VANDA Condition:	2		

Assessment Summary: The surface of the upstream pipe was in VANDA Level 2 condition. The coating inside the pipe was largely intact with some deterioration observed on the sides below the typical waterline; see Photo S39 - 1. No reinforcement or large aggregate were observed inside the pipe.

The surface of the downstream pipe was in VANDA Level 2 condition. The pipe did not appear to be lined, and exposed aggregate was observed on the surface; see Photo S39 - 2. No cracks or delaminations were found on the downstream pipe.

The manhole structure was in VANDA Level 3 condition. The structure did not have a coating present and had large aggregate exposed throughout; see Photo S39 - 5 and Photo S39 - 6. The surface concrete was a soft paste and would scrape away easily. Solid concrete was found at a depth of 1-inch; see Photo S39 - 4. No reinforcement was exposed.

Photo S39 - 1. Upstream pipe.

Photo S39 - 2. Downstream pipe.

Photo S39 - 3. Large side lateral line.

Photo S39 - 4. Exposed aggregate and pit on manhole structure wall.

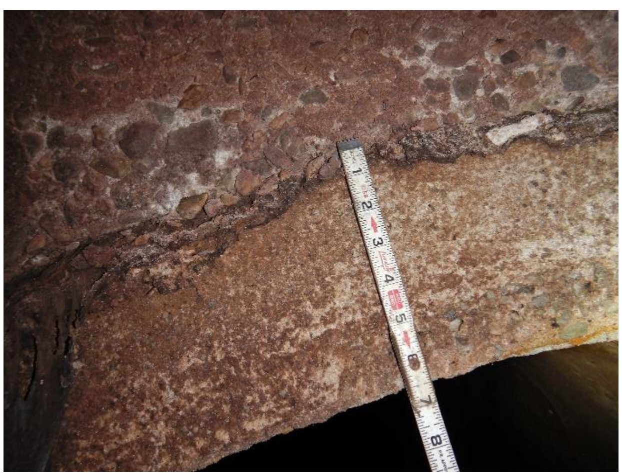

Photo S39 - 5. Exposed aggregate on manhole structure wall above upstream pipe opening

Photo S39 - 6. Exposed aggregate on roof of manhole structure.

Manhole ID: S47

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 19, 2022	Segment:	South Interceptor
Location Description:	Embarcadero West & Alice Street		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	105 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	1-inch
Penetration Depth:	0.5-inches	Surface pH:	2
Surface pH:	3	Depth pH:	10 @ 1-inch
Depth pH:	11	VANDA Condition:	4
VANDA Condition:	4		

Assessment Summary: Access to the lower portion of manhole S47 was not possible due to the high flow rate. Assessment of this manhole was conducted from the bench. From the bench, it was observed that the downstream pipe had exposed large aggregate and reinforcement. The exposed reinforcement was corroding. Around the crown of the interceptor pipes, discoloration, and efflorescence were observed; see Photo S47 – 1 and Photo S47 – 2.

In general, the manhole structure walls were in VANDA Level 4 condition. The walls were discolored and had multiple delamination; see Photo S47 - 3. The spalls exposed the mortar and large aggregate beneath. The delaminations were between one (1) and two (2) inches in depth, with soft mortar being found 0.5 to 1-inches below (total of 3 inches of concrete loss). There was large delamination on the roof near the manway access; see Photo S47 - 4. Due to the high flow and the large side lateral, high levels of Hydrogen Sulfide gases were present in the bench headspace.

Photo S47 - 1. Downstream pipe and manhole headspace as seen from the top bench

Photo S47 - 2. Side lateral line, surface coating corrosion on pipe bench.

Photo S47 - 3. Spall on west wall, aggregate exposed beneath delamination.

Photo S47 - 4. Delamination exposing aggregate on roof of manhole headspace.

Manhole ID: S48

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 19, 2022	Segment:	South Interceptor
Location Description:	Embarcadero West & Webster Street		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	105 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	1-inch
Penetration Depth:	1-inch	Surface pH:	2
Surface pH:	2	Depth pH:	12 @ 1-inch
Depth pH:	4 @ 1-inch	VANDA Condition:	4
VANDA Condition:	4		

Assessment Summary: The concrete surface of the downstream pipe was in VANDA Level 4 condition. Through sounding, the surface was found to be a soft layer of mortar. This mortar was less than ¼-inch deep and flaked off easily. Large aggregate was exposed and would come off easily as the mortar did not provide much support. The crown of the pipe was covered in a layer of efflorescence; see Photo S48 - 1. No cracks, spalls, or exposed reinforcement were observed.

The upstream pipe's concrete surface was also in VANDA Level 3 condition. The surface of the pipe was a chalky layer of mortar and exposed large aggregate; see Photo S48 - 2. About ¼-inch of the surface layer would flake off easily. Minor penetrations and holes about ¾ inches deep were observed. Below this 3/4-inches of mortar, solid concrete was found. No exposed reinforcement was observed; however, the walls were discolored, which may indicate corroded reinforcement beneath.

The walls of the manhole structure were in VANDA Level 4 condition as well. These walls also had a chalky layer of surface mortar with exposed large aggregate; see Photo S48 - 3 and Photo S48 - 4. The mortar and aggregate would flake off easily. No reinforcement was observed; however, corrosion stains were observed on the mortar.

Photo S48 - 1. Downstream pipe, exposed aggregate and soft mushy mortar, mineral deposit on crown of pipe.

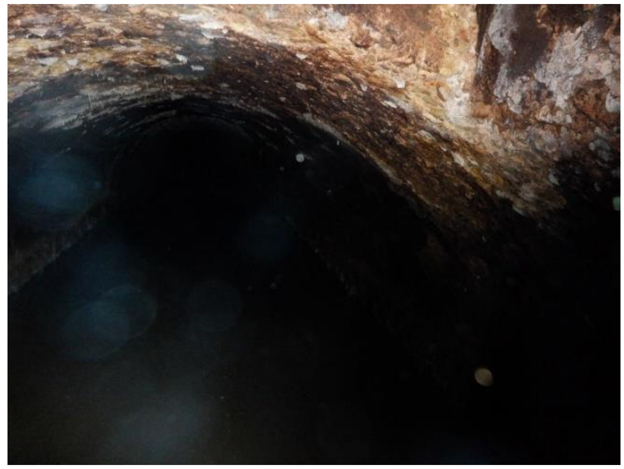

Photo S48 - 2. Upstream pipe, exposed aggregate and soft mortar.

Photo S48 - 3. Top bench of downstream pipe, corroded and some exposed aggregate.

Photo S48 - 4. Exposed aggregate on top of upstream pipe.

Photo S48 - 5. Upper walls of pipe in fair condition.

Manhole ID: S49

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	July 18, 2022	Segment:	South Interceptor
Location Description:	Embarcadero West & Franklin Street		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	105 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	1-inch
Penetration Depth:	2-inches	Surface pH:	--
Surface pH:	2	Depth pH:	--
Depth pH:	6 @ 2-inches	VANDA Condition:	4
VANDA Condition:	4		

Assessment Summary: The concrete surfaces of the upstream and downstream pipes were in VANDA Level 4 condition. The surface of both pipes was a soft paste and would scrape away easily. The subsurface concrete was a brown-yellowish color. Exposed aggregate was seen on the surface of both pipes with some pits or holes also visible; as seen in Photo S49 - 1 and Photo S49 - 2. The pits in the pipe ranged from one (1) to two (2) inch in depth. Reinforcement was also observed around the crown sections of both pipes. The exposed reinforcement was corroded but the circumferential bands still provided some structural support to the pipe.

The manhole structure was in VANDA Level 4 condition. The top surface of the walls appeared to be intact. Closer inspection revealed that the top 1-inch was soft and would crumble when light force was applied.

Photo S49 - 1. Downstream pipe.

Photo S49 - 2. Upstream pipe.

Photo S49 - 3. Wall near manhole dropdown, discoloration, and exposed aggregate.

Photo S49 - 4. Wall penetration with discolored soft mortar exposed.

Manhole ID: S50

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	July 18, 2022	Segment:	South Interceptor
Location Description:	Embarcadero West & Broadway		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	105 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	2-inches
Penetration Depth:	--	Surface pH:	1
Surface pH:	--	Depth pH:	3 @ 2 inches
Depth pH:	--	VANDA Condition:	4
VANDA Condition:	4		

Assessment Summary: Access to the lower portion of manhole S50 was not possible due to the large flow from a lateral line spraying into the pipe headspace. The lateral pipe can be seen in Photo S50 - 5. Visual assessment and respective tests for this site were conducted from the upper bench.

Overall, the concrete surface of S50 was in VANDA Level 3 condition. The concrete walls were hard but flakey. Chunks of the wall would flake away when very little force was applied, exposing the aggregate beneath; see Photo S50 - 6. Along each of the walls, multiple craters and pits were observed. Chalky, powdery white concrete was observed in these pits, as seen in Photo S50 - 4. These pits ranged in size from 0.5-inches to 2-inches in depth. No exposed reinforcement was observed. The upper portions of the walls did not have exposed aggregate visible; however, multiple pits were observed. The walls were soft, and the top 1-inch would crumble when light force was applied.

Photo S50 - 1. Large aggregate exposed on crown of downstream pipe.

Photo S50 - 2. Interceptor pipe as seen from the manhole structure.

Photo S50 - 3. Walls near manhole opening, multiple small pits and craters.

Photo S50 - 4. Chalky, white surface mortar exposed.

Photo S50 - 5. Lateral drop inlet pipe.

Photo S50 - 6. Large aggregate exposed on upper bench wall.

Manhole ID: S51

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	July 18, 2022	Segment:	South Interceptor
Location Description:	2nd Street & Broadway		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	105 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	2-inches
Penetration Depth:	--	Surface pH:	1
Surface pH:	--	Depth pH:	5 @ 2-inches
Depth pH:	--	VANDA Condition:	4
VANDA Condition:	4		

Assessment Summary: Access to the lower portion of Manhole S51 was not possible due to flow from a lateral pipe spraying into the headspace of the interceptor pipe. Due to this, visual assessment and associated tests were conducted from the upper bench. The concrete surface of the upper bench was in VANDA Level 4 condition. The surface concrete was very soft, and chunks of the wall would scrape away easily exposing aggregate and discolored concrete below. The soft concrete continued until a depth of approximately 4-inches. Multiple deep pits were also observed on the walls; see Photo S51 – 1. Inside these deep pits, discolored concrete, and large aggregate were observed. Some of these pits had reinforcement exposed; see Photo S51 – 4. The exposed reinforcement in these pits was corroded.

Photo S51 - 1. Crater in wall of upper bench.

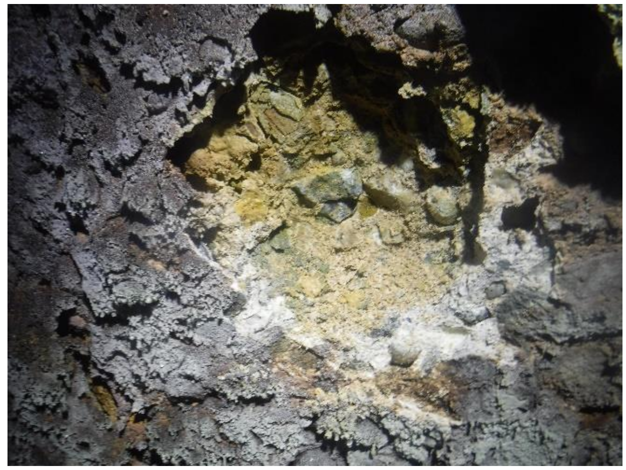

Photo S51 - 2. Large crater in wall exposing yellow surface mortar and aggregate.

Photo S51 - 3. Wall deterioration on upper bench.

Photo S51 - 4. Exposed corroded rebar in crater in upper bench.

Manhole ID: S53

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 17, 2022	Segment:	South Interceptor
Location Description:	2nd Street & Martin Luther King Jr, Way		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	105 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	--
Penetration Depth:	2 inches	Surface pH:	--
Surface pH:	1	Depth pH:	--
Depth pH:	3 @ 2 inches	VANDA Condition:	4
VANDA Condition:	4		

Assessment Summary: The concrete on the interior of the downstream and upstream pipes were in VANDA Level 4 condition. The pipes were corroded with damage to the crown; see Photo S53-1 and Photo S53-2 Large aggregate was exposed with discoloration and efflorescence on both pipes. The upstream pipe had dark circumferential rings around the joints. The pipe walls above the water level were in better condition with no visible, exposed aggregate. No exposed reinforcement was observed in either pipe.

The surface of the bench and upper box were in VANDA Level 4 condition. The walls above the downstream and upstream pipe openings had a mushy, soft surface with solid concrete found ½ of an inch below. These walls also had large aggregate exposed; see Photo S53-3 and Photo S53-4. Multiple small craters and pits were observed in the bench walls. In these craters, remnants of consumed reinforcement were observed. The surrounding concrete where the reinforcement was completely consumed took on an orange color.

Photo S53 - 1. Downstream pipe, exposed aggregate and discoloration on top portion of pipe.

Photo S53 - 2. Upstream pipe, exposed aggregate and discoloration at joint.

Photo S53 - 3. Exposed aggregate on manhole walls and ceiling.

Photo S53 - 4. Exposed aggregate on top of upstream pipe.

Manhole ID: S54

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 31, 2022	Segment:	South Interceptor
Location Description:	Market Street South of 3rd Street		
Pipe Condition		**Manhole Structure Condition**	
Pipe Diameter:	105 inches	Structure Lined?	No
Pipe Lined?	No	Penetration Depth:	1
Penetration Depth:	1	Surface pH:	1
Surface pH:	1	Depth pH:	4 @ 1-inch
Depth pH:	11	VANDA Condition:	4
VANDA Condition:	3 to 4		

Assessment Summary: The concrete surface of the downstream pipe was in VANDA Level 3 condition. The downstream pipe had some exposed medium aggregate near the manhole opening with discoloration and efflorescence around the crown. The surface had a flakey layer of concrete that would scrape off easily. Through sounding, multiple spalls were observed in areas with a soft surface layer of concrete. Dark circumferential rings were observed around the joints of the pipe; see Photo S54-1. No cracks or exposed reinforcement were observed in the pipe. The bench walls near the opening of the pipe were also corroded with exposed large aggregate; see Photo S54-2.

The upstream pipe's concrete surface was in VANDA Level 4 condition. The crown of the upstream pipe was more discolored with higher amounts of efflorescence and exposed aggregate; see Photo S54-3. The aggregate was loosely held together and would come off easily when scrapped. Some craters and pits were found on the side walls of the pipe; see Photo S54-4. These craters ranged from 0.5-inches to two (2) inches deep penetrations. The yellow concrete around these penetrations was soft and flaked off easily. No exposed reinforcement or cracks were observed.

The surfaces of the manhole were in VANDA Level 4 condition. The walls and ceiling had exposed aggregate and 1-inch of deteriorated concrete. The drop inlet had spalled concrete surrounding its wall penetration site; see Photo S54-5.


Photo S54 - 1. Downstream pipe, some exposed aggregate and discoloration at joints.


Photo S54 - 2. Upstream pipe, exposed aggregate on crown of pipe.

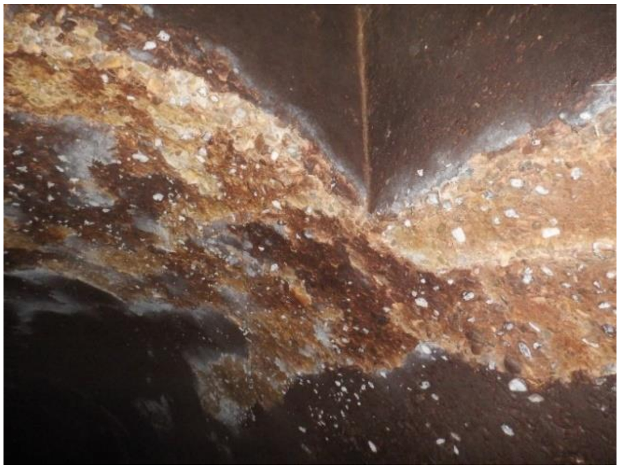
Photo S54 - 3. Exposed aggregate and wall corrosion on bench at downstream pipe opening.


Photo S54 - 4. 2-inch-deep hole in soft mortar.


Photo S54 - 5. Exposed aggregate on manhole wall and saplled concrete near drop inlet.

Manhole ID: S55

Assessed by:	V&A	Owner:	EBMUD
Date of Assessment:	May 31, 2022	Segment:	South Interceptor
Location Description:	Myrtle Street South of 3rd Street		

Pipe Condition		Manhole Structure Condition	
Pipe Diameter:	105 inches	Structure Lined?	Yes
Penetration Depth:	--	Penetration Depth:	--
Pipe Lined?	No	Surface pH:	--
Surface pH:	--	Depth pH:	--
Depth pH:	--	VANDA Condition:	1
VANDA Condition:	4		

Assessment Summary: The manhole was lined and was in good condition. There were no major signs of lining failure, as shown in Photo S55-1. Minor lining defects were observed at the weld seam above the inlet pipe, as shown in Photo S55-2. Confined space entry was not conducted at this site since the structure was lined and in good condition.

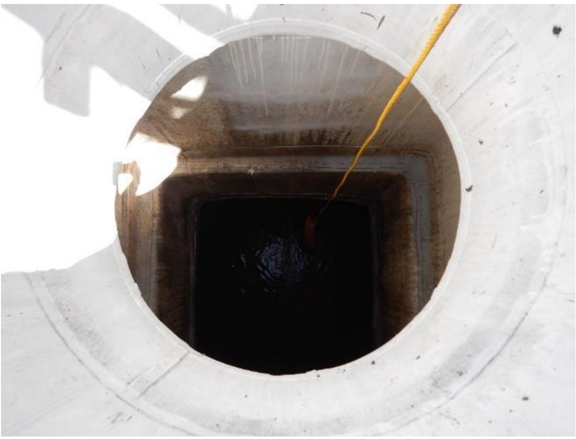

Photo S55 - 1. Manhole, lined throughout the structure.

Photo S55 - 2. Lining degradation above inlet pipe.

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Appendix D
SPR Data

Table D-1. SPR Data for Alameda Interceptor Scans

Manhole	Location	Bar Direction	Depth Max (Inch)	Depth Avg (Inch)	Depth Min (Inch)	Space Max (Inch)	Space Avg (Inch)	Space Min (Inch)
A32	Downstream Pipe	Longitudinal	3.8	3.8	3.7	-	19.1	-
A32	Downstream Pipe	Circumferential	-	3.6	-	-	-	-
A32	Upstream Pipe	Longitudinal	-	1.5	-	-	8.7	-
A32	Upstream Pipe	Circumferential	3.6	3.6	3.5	-	5.8	-
A34	Downstream Pipe	Longitudinal	-	1.1	-	-	10.0	-
A34	Downstream Pipe	Circumferential	0.9	0.8	0.7	-	5.0	-
A34	Upstream Pipe	Circumferential	-	0.7	-	-	-	-
A35	Downstream Pipe	Circumferential	-	0.6	-	-	-	-
A35	Downstream Pipe	Circumferential	-	1.6	-	-	-	-
A35	Upstream Pipe	Circumferential	-	3.6	-	-	-	-
A35	Upstream Pipe	Longitudinal	2.3	1.9	1.5	-	7.6	-
A37	Downstream Pipe	Longitudinal	1.4	1.0	0.7	9.7	8.3	7.5
A37	Downstream Pipe	Circumferential	0.9	0.6	0.3	4.4	3.1	2.2
A37	Upstream Pipe	Longitudinal	4.7	3.0	1.2	-	46.4	-
A37	Upstream Pipe	Circumferential	1.6	1.4	1.2	-	-	-
A39	Downstream Pipe	Longitudinal	0.6	0.5	0.4	-	4.7	-
A39	Downstream Pipe	Circumferential	0.6	0.5	0.4	-	2.1	-
A39	Upstream Pipe	Longitudinal	1.6	1.2	0.9	-	7.4	-
A39	Upstream Pipe	Circumferential	0.6	0.5	0.4	-	6.4	-
A46A	Upstream Pipe	Longitudinal	2.4	1.8	1.4	13.5	10.1	4.1
A46A	Upstream Pipe	Circumferential	2.1	1.8	1.4	5.2	3.2	1.8
A47	Downstream Pipe	Longitudinal	1.8	1.6	1.4	10.4	6.1	2.8
A47	Downstream Pipe	Circumferential	2.7	2.5	2.4	-	-	-
A47	Upstream Pipe	Longitudinal	4.3	4.1	3.8	13.0	12.3	11.7
A47	Upstream Pipe	Circumferential	-	5.3	-	-	-	-
A48	Downstream Pipe	Longitudinal	2.2	1.6	1.4	11	10.1	4.1
A48	Downstream Pipe	Circumferential	-	2.3	-	-	8.4	-
A48	Downstream Pipe	Circumferential	-	1.9	-	-	10.2	-
A48	North Wall	Vertical	1.61	1.3	0.9		11.3	

Manhole	Location	Bar Direction	Depth Max (Inch)	Depth Avg (Inch)	Depth Min (Inch)	Space Max (Inch)	Space Avg (Inch)	Space Min (Inch)
A48	West Wall	Vertical	2.72	2.69	2.41	11.3	10.9	10.7
A48	North Wall	Horizontal	2.9	2.5	1.9		16.2	
A48	West Wall	Horizontal	3.52	3.27	3.15	8.4	8.2	8.1

Table D-2. SPR Data for South Interceptor Scans

Manhole	Location	Bar Direction	Depth Max (inch)	Depth Avg (inch)	Depth Min (inch)	Space Max (inch)	Space Avg (inch)	Space Min (inch)
S14	Downstream Pipe	Longitudinal	1.8	1.6	1.4	12.2	7.9	4.4
S14	Downstream Pipe	Circumferential	1.6	1.4	1.3	3.5	3.1	2.6
S14	East Wall	Vertical	5.7	5.4	5.2	11.7	11.0	10.4
S14	East Wall	Horizontal	4.5	4.3	4.1	7.7	7.2	6.3
S15	West Wall	Horizontal	1.8	1.1	0.7	7.7	6.5	4.7
S15	West Wall	Vertical	0.5	0.4	0.3	-	3.3	-
S16	Downstream Pipe	Longitudinal	3.5	2.0	1.1	24.2	16.7	9.2
S16	Downstream Pipe	Circumferential	1.3	1.2	1.0	3.8	3.3	3.1
S16	East Wall	Vertical	3.7	3.5	3.5	12.7	12.0	11.5
S16	East Wall	Horizontal	5.3	4.8	4.4	9.0	7.6	5.8
S38	Downstream Pipe	Longitudinal	1.7	1.5	1.4	16.9	11.8	7.0
S38	Downstream Pipe	Circumferential	0.5	0.4	0.2	3.5	2.7	2.0
S38	East Wall	Horizontal	3.7	3.2	3.0	30.6	14.5	5.9
S38	East Wall	Vertical	-	4.2	-	-	-	-
S39	East Wall	Vertical	5.5	5.3	5.0	-	11.0	-
S39	East Wall	Horizontal	2.0	1.8	1.5	6.5	5.2	3.0
S39	Upstream Pipe	Circumferential	1.2	0.9	0.7	3.2	2.7	2.4
S39	Upstream Pipe	Longitudinal	2.1	1.8	1.5	19.4	11.5	3.2
S39	Ceiling	North - South	4.7	4.6	4.5	18.2	12.5	6.9
S39	Ceiling	East - West	3.5	3.3	3.0	18.7	9.9	4.3
S47	North Wall	Vertical	3.1	3.0	2.9	5.9	4.9	3.8
S47	North Wall	Horizontal	4.5	4.4	4.3	8.6	8.5	8.5
S47	Ceiling	North to South	3.7	3.5	3.2	11.1	10.9	10.8
S47	Ceiling	East to West	5.2	4.7	4.4	14.3	9.6	4.9
S47	Downstream Pipe	Longitudinal	3.0	2.7	2.4	11.7	10.4	9.1
S47	Downstream Pipe	Circumferential	1.3	1.1	0.8	8.2	6.7	5.3
S48	Upstream Pipe	Circumferential	1.3	1.1	0.8	8.2	6.7	5.3
S48	Upstream Pipe	Longitudinal	2.3	2.2	2.0	4.0	3.6	2.9

Manhole	Location	Bar Direction	Depth Max (inch)	Depth Avg (inch)	Depth Min (inch)	Space Max (inch)	Space Avg (inch)	Space Min (inch)
S48	West Wall	Vertical	3.0	2.8	2.7	-	11.2	-
S48	West Wall	Horizontal	2.3	2.3	2.2	5.6	4.2	2.8
S53	East Wall	Vertical	1.4	1.3	1.3	6.8	4.1	2.8
S53	Downstream Pipe	Longitudinal	6.8	5.0	2.0	11.2	8.2	4.8
S53	Downstream Pipe	Circumferential	4.5	4.2	4.1	13.4	11.9	9.4
S54	North wall lower box	Horizontal	7.0	6.3	5.7	13.1	10.0	8.2
S54	North wall lower box	Vertical	5.3	4.9	4.5	11.8	10.7	9.6
S54	Downstream Pipe	Longitudinal	-	-	-	11.5	8.9	6.4
S54	Downstream Pipe	Circumferential	2.0	1.9	1.8	-	-	-

Table D-3. SPR Data for North Interceptor Scans

Manhole	Location	Bar Direction	Depth Max (inch)	Depth Avg (inch)	Depth Min (inch)	Space Max (inch)	Space Avg (inch)	Space Min (inch)
N26	Downstream Pipe	Longitudinal	1.8	1.6	1.4	12.2	7.9	4.4
N26	Downstream Pipe	Circumferential	1.6	1.4	1.3	3.5	3.1	2.6
N31	Downstream Pipe	Longitudinal	4.0	2.7	2.0	15.5	11.6	4.6
N31	Downstream Pipe	Circumferential	4.0	2.9	1.8	6.9	3.3	2.0
N31	Upstream Pipe	Longitudinal	5.0	3.0	2.3	16.3	9.6	3.8
N31	Upstream Pipe	Circumferential	2.6	2.4	2.3	2.8	2.1	1.4
N35	Upstream Pipe	Longitudinal	4.2	2.6	1.1	22.7	13.9	7.0
N35	Upstream Pipe	Circumferential	3.4	2.7	1.5	3.4	2.8	2.1

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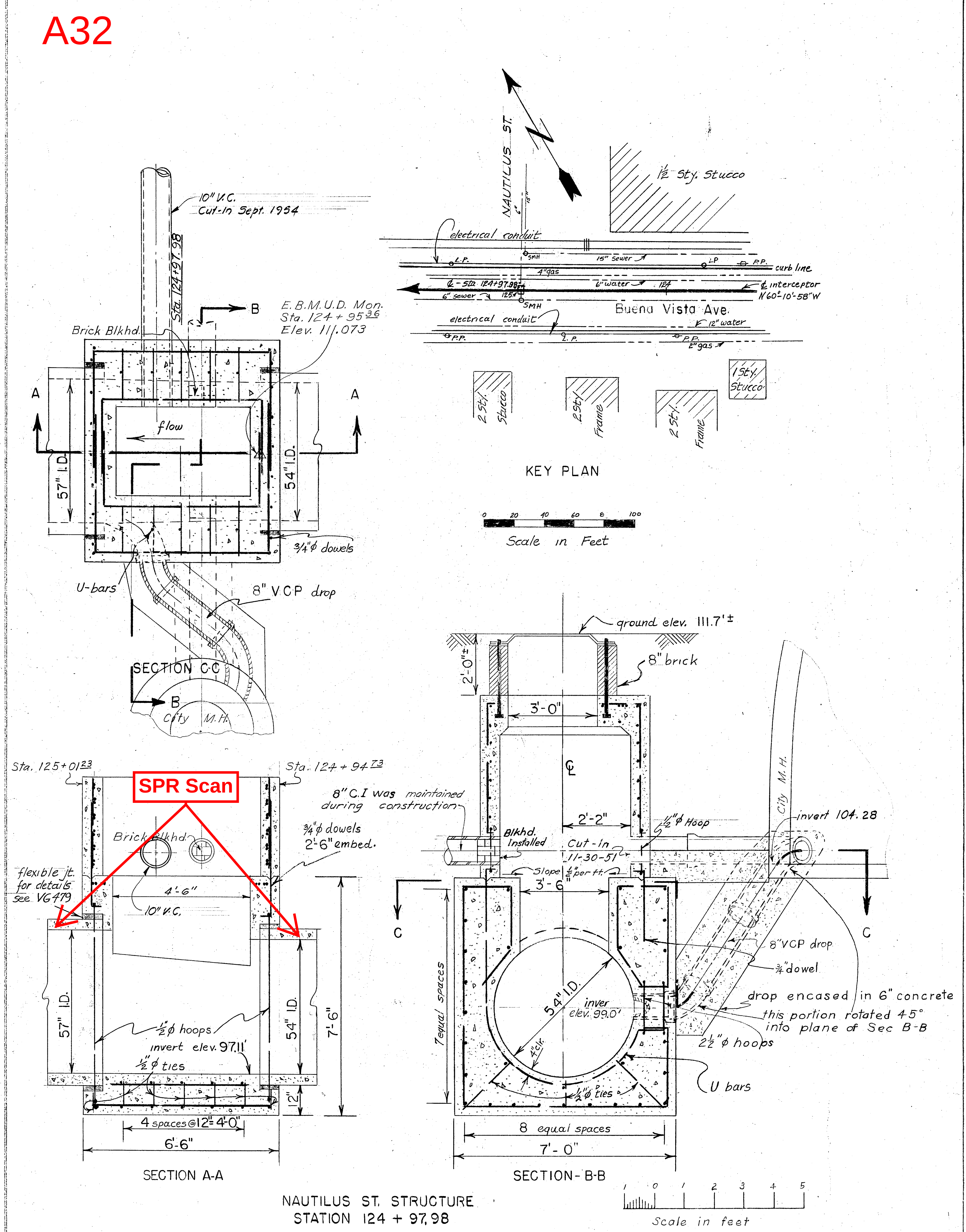
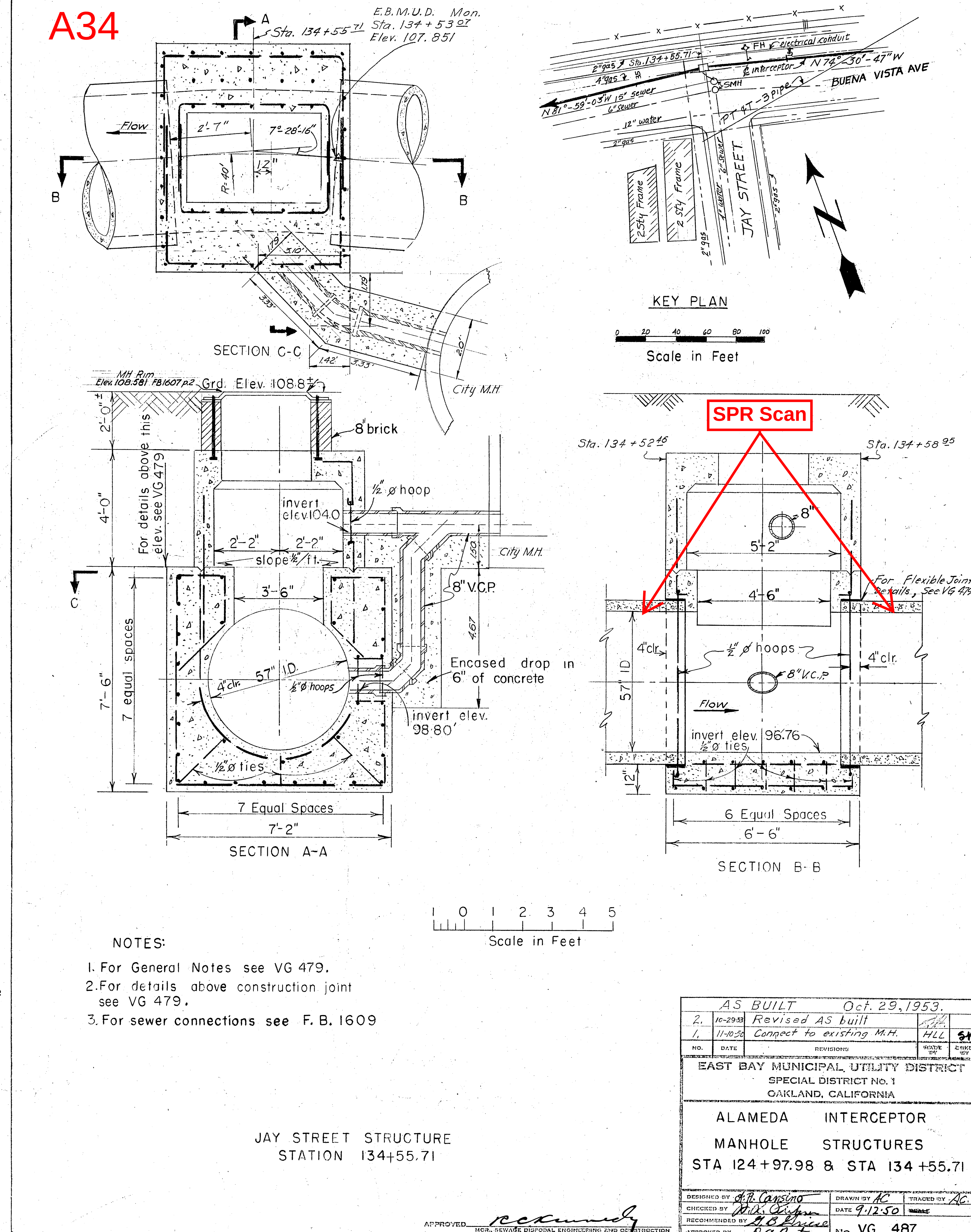

A32
10" V.C. Cut-in Sept. 1954
Sta. 124+97.98
E.B.M.U.D. Mon. Sta. 124+95 36 Elev. 111.073
Brick Blkhd.
flow
57" I.D.
54" I.D.
3/4"ϕ dowels
U-bars
8" VCP drop
SECTION C-C
City M.H.
NAUTILUS ST.
1½ Sty. Stucco
electrical conduit
15" sewer
4" gas
6" water
curb line
interceptor N 60°-10'-58" W
Buena Vista Ave.
electrical conduit
12" water
2" gas
2 Sty. Stucco
2 Sty. Frame
2 St'y Frame
1 Sty. Stucco
KEY PLAN
Scale in Feet
Sta. 125+01 23
Sta. 124+94 73
SPR Scan
8" C.I. was maintained during construction
3/4"ϕ dowels 2'-6" embed.
Brick Blkhd.
flexible jt. for details see VG 479
4'-6"
10" V.C.
½"ϕ hoops
invert elev. 97.11'
½"ϕ ties
4 spaces @ 12" = 4'-0"
6'-6"
7'-6"
12"
SECTION A-A
ground elev. 111.7'±
8" brick
3'-0"
2'-2"
½"ϕ Hoop
invert 104.28
Blkhd. Installed
Cut-in 11-30-51
Slope ¼" per ft.
3'-6"
8" VCP drop
¾" dowel
drop encased in 6" concrete
this portion rotated 45° into plane of Sec B-B
2½"ϕ hoops
U bars
54" I.D.
invert elev. 99.0'
½"ϕ ties
7 equal spaces
8 equal spaces
7'-0"
SECTION-B-B
NAUTILUS ST. STRUCTURE
STATION 124 + 97.98
Scale in feet

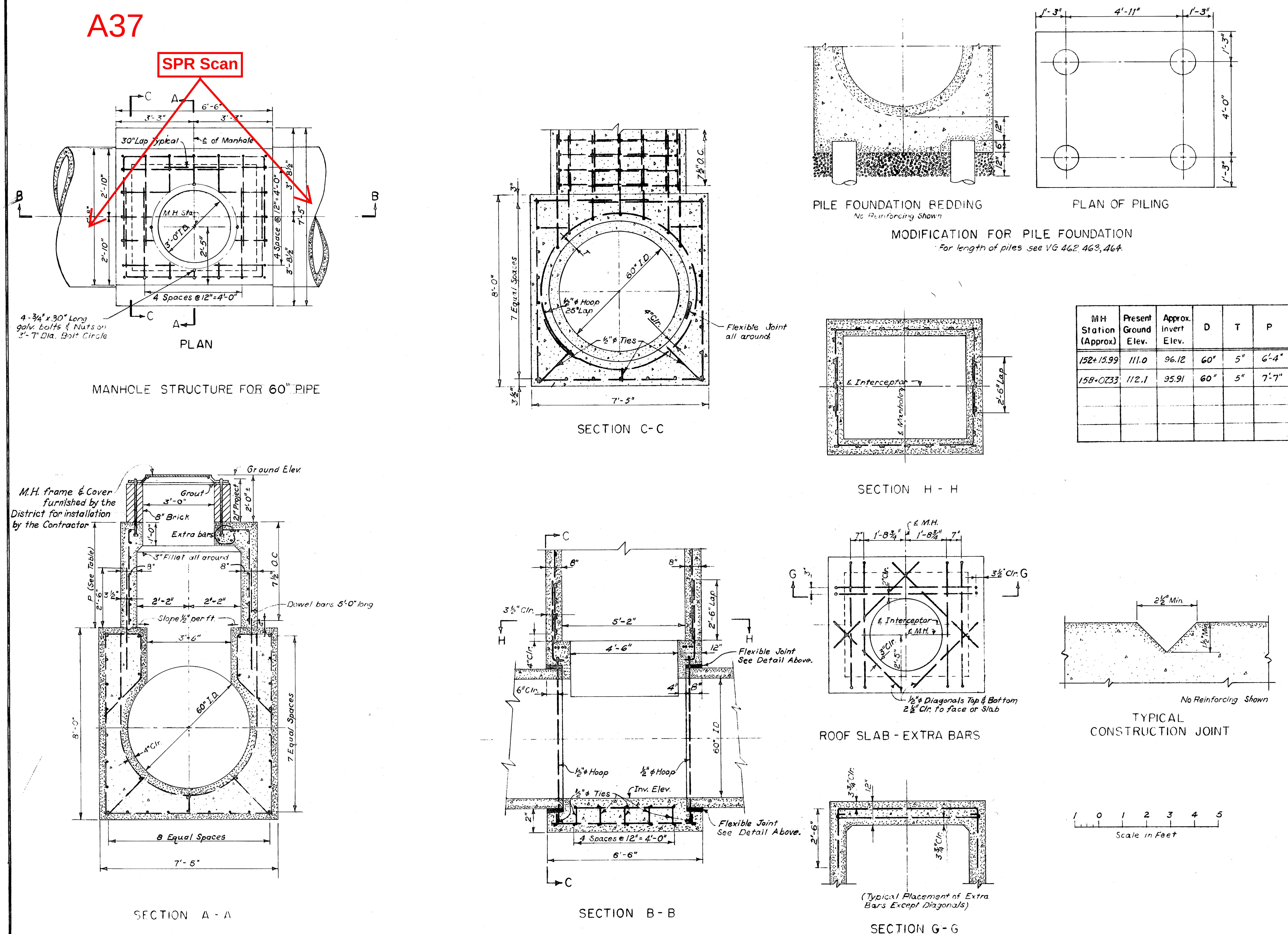

A34
Sta. 134+55 71
E.B.M.U.D. Mon. Sta. 134+53 07 Elev. 107.851
Flow
2'-7"
7'-28'-16"
12"
SECTION C-C
City M.H.
MH Rim Elev. 108.58
Grd. Elev. 108.8±
8" brick
½"ϕ hoop
invert elev. 104.0
2'-2"
slope ¼"/ft.
3'-6"
For details above this elev. see VG 479
8" V.C.P.
Encased drop in 6" of concrete
57" I.D.
½"ϕ hoops
invert elev. 98.80'
½"ϕ ties
7 equal spaces
7'-2"
SECTION A-A
electrical conduit
Sta. 134+55.71
interceptor N 74°-30'-47" W
BUENA VISTA AVE
15" sewer
6" sewer
12" water
JAY STREET
2 Sty Frame
KEY PLAN
Scale in Feet
SPR Scan
Sta. 134+52 46
Sta. 134+58 95
8"
5'-2"
4'-6"
For Flexible Joint Details, see VG 479.
4" clr.
½"ϕ hoops
8" V.C.P.
Flow
57" ID
invert elev. 96.76
½"ϕ ties
6 Equal Spaces
6'-6"
SECTION B-B
Scale in Feet
NOTES:
1. For General Notes see VG 479.
2. For details above construction joint see VG 479.
3. For sewer connections see F.B. 1609
JAY STREET STRUCTURE
STATION 134+55.71
AS BUILT Oct. 29, 1953.
Revised AS built
Connect to existing M.H.
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA
ALAMEDA INTERCEPTOR
MANHOLE STRUCTURES
STA 124+97.98 & STA 134+55.71
No. VG 487

A35


SHERMAN STREET STRUCTURE
STA. 144+69.68
SECTION C-C
KEY PLAN
SECTION A-A
SECTION B-B
BENTON STREET STRUCTURE
STA 137+66.07
SECTION C-C
KEY PLAN
SECTION A-A
SECTION B-B
SPR Scan
NOTES
1. For General Notes see V.G. 479.
2. For details above construction joint see V.G. 479.
3. For Flexible Joint Detail see VG 479.
4. For Sewer Connections See Field Book 1609
AS-BUILT Oct. 26, 1953.
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA
ALAMEDA INTERCEPTOR
MANHOLE STRUCTURES
STA. 137+66.07 & STA. 144+69.68
No. VG 485

A37

SPR Scan



MH Station (Approx.)	Present Ground Elev.	Approx. Invert Elev.	D	T	P		Remarks	End Of Pipe
152+15.99	111.0	96.12	60"	5"	6'-4"		St Charles Street	152+18.57 152+13.40
158+07.33	112.1	95.91	60"	5"	7'-7"		Chapin Street	158+09.92 158+04.75

GENERAL NOTES:

1. All bars 3/8" dia. unless otherwise noted.
2. Reinforcing steel 3" clear of face of concrete unless otherwise noted.
3. All exterior corners chamfered 1".
4. For additional details see Plan & Profile.
5. Pile foundation used only if called for by the Engineer.
6. Final manhole stations determined by the Engineer. Invert elevations changed if manhole stations are changed.

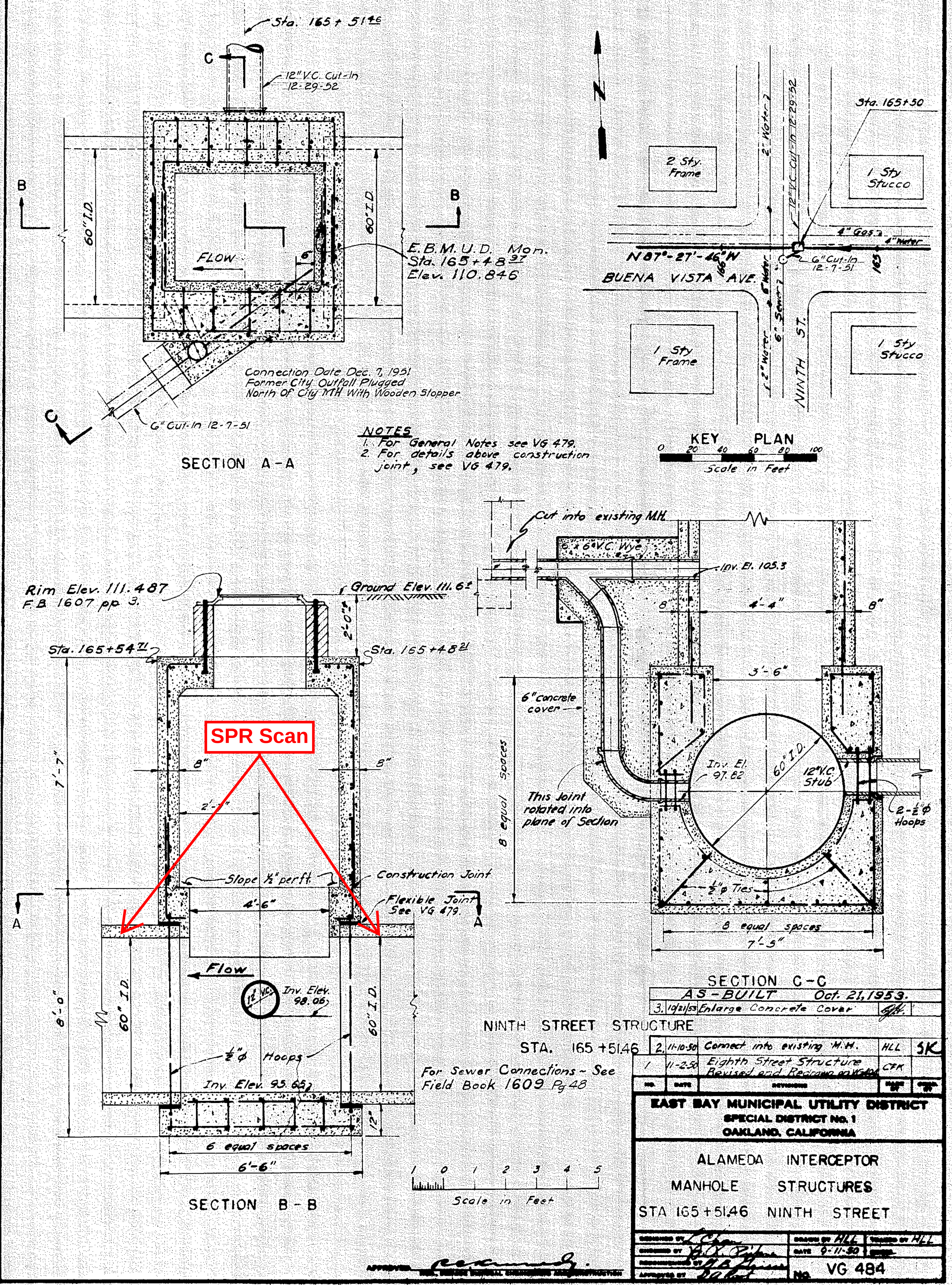
AS-BUILT Oct. 20, 1953.

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA

ALAMEDA INTERCEPTOR
STANDARD MANHOLE
FOR 60" I.D. PIPE

Designed by MOUNT | Drawn by MOUNT | Date 3-21-50
No. VG 479

A39


SPR Scan
Sta. 165+51.46
12" V.C. Cut-In 12-29-52
FLOW
60" I.D.
E.B.M.U.D. Mon.
Sta. 165+48.37
Elev. 110.846
Connection Date Dec. 7, 1951
Former City Outfall Plugged
North Of City MH With Wooden Stopper
6" Cut-In 12-7-51
SECTION A-A
NOTES
1. For General Notes see VG 479.
2. For details above construction joint, see VG 479.
Sta. 165+50
2 Sty. Frame
1 Sty Stucco
1 Sty Frame
1 Sty Stucco
N 87°-27'-46" W
BUENA VISTA AVE
NINTH ST.
KEY PLAN
Scale in Feet
Cut into existing M.H.
6"x6" V.C. Wye
Inv. El. 105.3
Rim Elev. 111.487
F.B. 1607 pp 3.
Ground Elev. 111.6±
Sta. 165+54.71
Sta. 165+48.21
7'-7"
8"
2'-3"
Slope ½" per ft.
Construction Joint
Flexible Joint See VG 479.
4'-6"
Flow
Inv. Elev. 98.06
½" ϕ Hoops
Inv. Elev. 95.65
8'-0"
12"
6 equal spaces
6'-6"
SECTION B-B
6" Concrete cover
This Joint rotated into plane of Section
8 equal spaces
4'-4"
3'-6"
Inv. El. 97.62
60" I.D.
12" V.C. Stub
2-½" ϕ Hoops
½" ϕ Ties
7'-5"
SECTION C-C
AS-BUILT Oct. 21, 1953.
Enlarge Concrete Cover
Connect into existing M.H.
Eighth Street Structure Revised and Redrawn
NINTH STREET STRUCTURE
STA. 165+51.46
For Sewer Connections - See Field Book 1609 Pg 48
Scale in Feet
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA
ALAMEDA INTERCEPTOR
MANHOLE STRUCTURES
STA 165+51.46 NINTH STREET
VG 484


A46A
Sta. 205+68
Cut-in 11-18-53 By Bethlehem Steel
Bulkhead with clay Plug
12" Y Branch with 10" Spur
Y Installed by: Scott Co. 4-10-53
Cut and finished V branch neat to manhole wall
8" VCP stub
1/2" ø diag. top+bot. 2 1/2" clr to face of slab
SECTION C-C
City of Alameda connection made July 24, 1952. No flow. Contractor was Stolte, Inc.
Scale – Ft.
TYNAN AVE
CPRY
10" V.C.P. Cut-in 11-18-53
8" V.C.P. Cut-in 7-24-52
Sta. 205+68
KEY PLAN
Scale – Ft.
Std. E.B.M.U.D. Mon. Sta. 205+65.25 Elev. 103.261
for MH detail see VG 493
Ground Elev. 104.8
Pipe Lined
SPR Scan
8" flexible joint see VG 493
Inv. Elev. 96.26
1/2" ø Hoops
1/2 ø ties
Inv. Elev. 93.95
"2" added on each end of structure as special length of pipe was too short.
4 equal spaces
4'–0"
6'–0"
SECTION A-A
3'-0"
Ground Elev. 104.8 ±
Elev. 103.25
8" VCP stub
Invert elev. 98.41'
Inv. Elev. 101.91
Inv. Elev. 96.26
60" ID
4" clr.
8 equal spaces
7'-6"
SECTION B-B
TYNAN AVENUE STRUCTURE
STATION 205+68
Sta. 196+42.78
15" Cut-In 7-23-52 By Contractor
15" VCP stub
SECTION C-C
1/2" ø diag. top+bot. 2 1/2" clr. to face of slab
℄ interceptor
KEY PLAN
Scale – Ft.
for MH detail see VG 493
ground elev. 104.5' ±
8" brick
15" VCP stub
8" flexible joint see VG 493
4'-6"
Flow
1/2" ø hoops
1/2" ø ties
invert elev. 94.28'
4 – equal spaces
4'-0"
6'-6"
SECTION A-A
1/2" ø hoops
15" VCP stub
watertight bulkhead
invert elev. 100.15'
3" fillet
5'-0"
60" I.D.
4" clr.
10 equal spaces
8 equal spaces
7'-5"
SECTION B-B
STATION 196+42.78
NOTES
1. For General Notes see VG 493
2. For pile foundation details see VG 493
3. Gravel underdrain at option of Engineer, see specifications
8-20-51 Revision of Manhole Structure
AS-BUILT Jan. 14, 1954.
5-7-51 Moved M.H. Sta. 40'-0" South
10-23-50 Corrected Notes No. 1 & 2
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA
ALAMEDA INTERCEPTOR
MANHOLE STRUCTURES
STA. 196+42.78 & STA. 205+68
No. VG 481


A47
A48
SPR Scan
SPR Scan
Assumed to be similar to A47 & A48 for purposes of showing SPR scan location
Cut-in 11-18-53 By Bethlehem Steel
Bulkhead with clay Plug
12" Y Branch with 10" Spur
Y Installed by: Scott Co. 4-10-53
Cut and finished Y branch neat to manhole wall
8" VCP stub
1/2" ø diag. top+bot. 2 1/2" clr to face of slab
SECTION C-C
City of Alameda connection made July 24, 1952. No flow. Contractor was Stolte, Inc.
TYNAN AVE
CPRY
KEY PLAN
Scale-Ft.
for MH detail see VG 493
Ground Elev. 104.8
Std. E.B.M.U.D. Mon. Sta. 205+65.25 Elev. 103.261
8" flexible joint see VG 493
Inv. Elev. 96.26
Inv. Elev. 93.95
1/2" ø Hoops
1/2" ø ties
2" added on each end of structure as special length of pipe was too short.
4 equal spaces
4'-0"
6'-10"
SECTION A-A
8" VCP stub
Invert elev. 98.41'
Inv. Elev. 101.91
Inv. Elev. 96.26
Elev. 103.25
60" ID
4" clr.
8 equal spaces
7'-6"
SECTION B-B
TYNAN AVENUE STRUCTURE
STATION 205+68
15" Cut-In 7-23-52 By Contractor
15" VCP stub
interceptor
diag. top+bot. 2 1/2" clr. to face of slab
SECTION C-C
for MH detail see VG 493
ground elev. 104.5'±
8" brick
15" VCP stub
8" flexible joint see VG 493
4'-6"
Flow
1/2" ø hoops
1/2" ø ties
invert elev. 94.28'
4 - equal spaces
4'-0"
6'-6"
SECTION A-A
1/2" ø hoops
15" VCP stub
watertight bulkhead invert elev. 100.15'
3" fillet
5'-0"
60" I.D.
4" clr.
10 equal spaces
8 equal spaces
7'-5"
SECTION B-B
STATION 196+42.78
NOTES
1. For General Notes see VG 493
2. For pile foundation details see VG 493
3. Gravel underdrain at option of Engineer, see specifications
8-20-51 Revision of Manhole Structure
AS-BUILT Jan. 14, 1954.
5-7-51 Moved M.H. Sta. 40'-0" South
10-23-50 Corrected Notes No. 1 & 2
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA
ALAMEDA INTERCEPTOR
MANHOLE STRUCTURES
STA. 196+42.78 & STA. 205+68
VG 481

N26

D	D-LOAD	T	L
66"	Up to 2000-D	5½"	3'-9"
	2000-D and over	7¼"	
84"	Up to 2000-D	7"	4'-6"
	2000-D and over	8¾"	

- Pile Foundation Bedding was used as directed by the Engineer.
- The Engineer directed the spacing, length & no. of piles required.
- Underdrain & crushed rock called for by Engineer.

NOTES
- Refer to PLAN & PROFILE for M.H. location & elevations.
- All bars ½" φ unless otherwise noted.
- Exterior corners were chamfered 1".
- Flexible joint details are typical for joining R.C. pipe to all structures.

AS-BUILT NOV. 5, 1963

Rev. No.	Date	Description
3	12-15-48	Inserted additional Brick courses. Rev. reinf. steel Sec. G-G & H-H
2	9-30-48	Pile Foundation Bedding Added.
1.	8-10-48	Inserted four courses of brick between M.H. Frame & M.H. Sect. A-A

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA

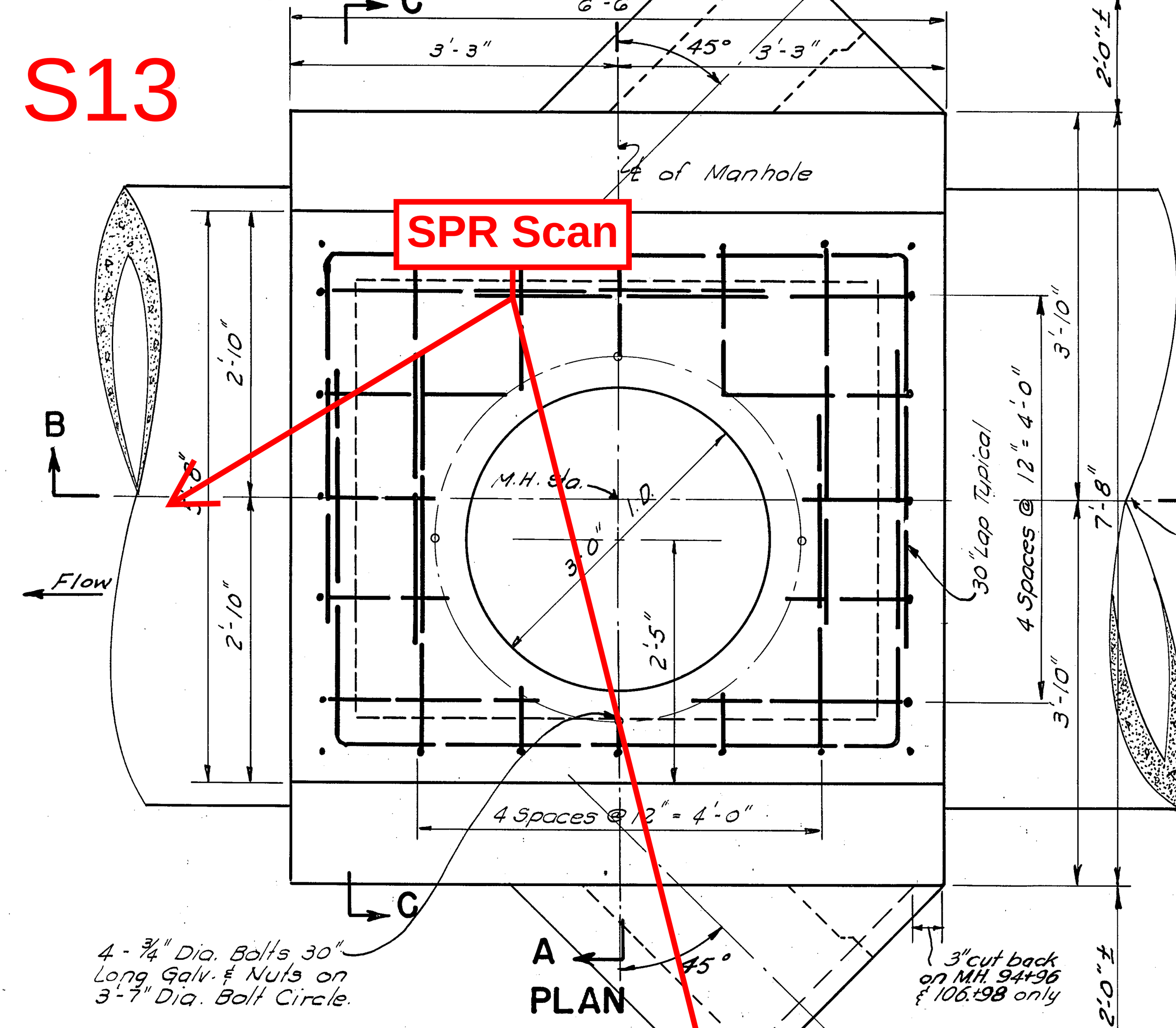
NORTH INTERCEPTOR
STANDARD MANHOLES
FOR 66" & 84" PIPE

DRAWN BY Koretsky — SCALE As Shown
TRACED BY Giuliano — DATE June 11, 1948
CHECKED BY Harrison
APPROVED BY — NO. VG 327
APPROVED: CHIEF ENGINEER & GENERAL MANAGER

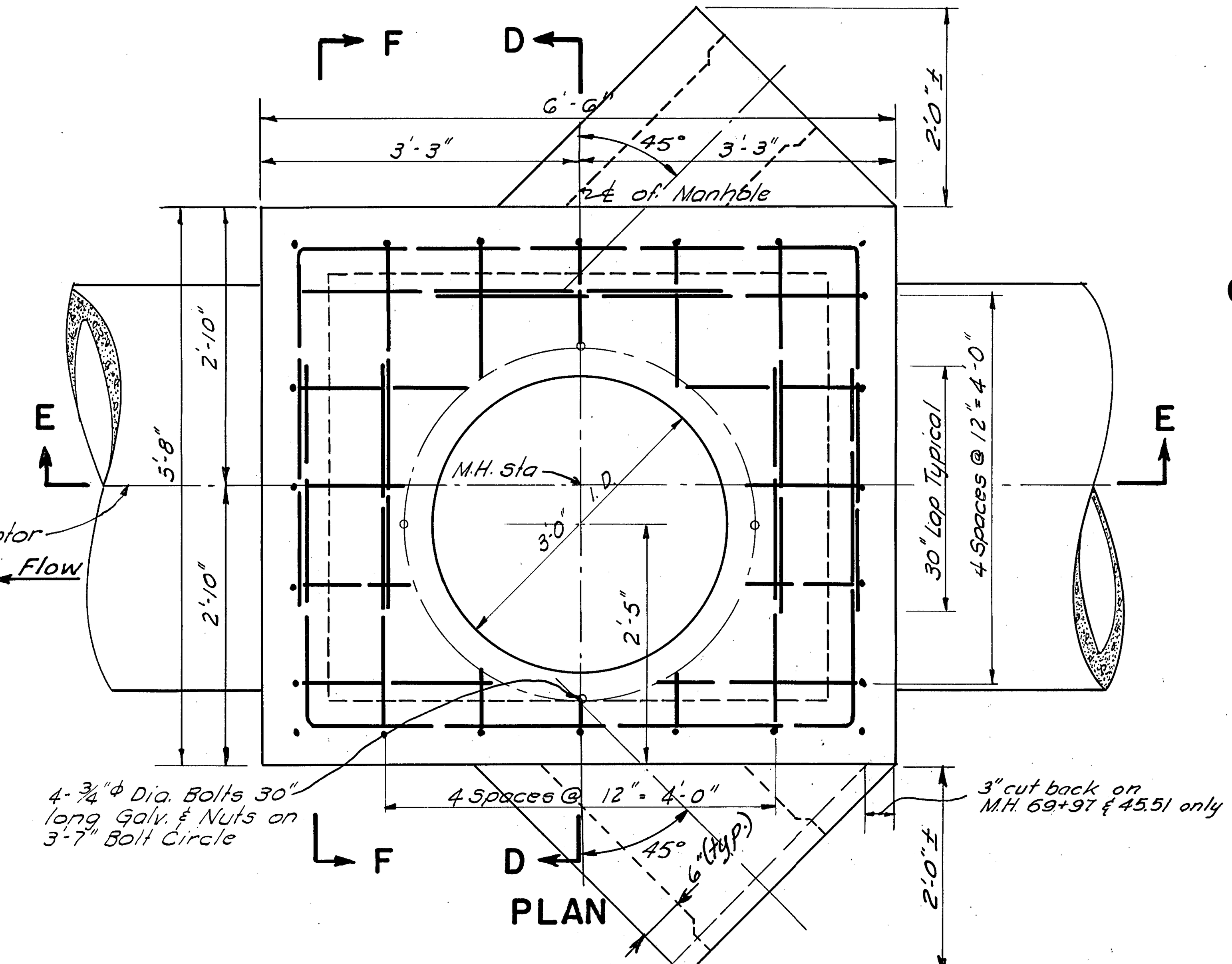
N31


SPR Scan
-Downstream pipe
-Upstream pipe
PLAN
(See EXTRA BARS for additional roof slab reinforcing)
PLAN 66" I.D. PIPE M.H
PLAN 84" PIPE M.H.
EXTRA BARS
SECTION C-C
SECTION D-D Similar
(Typical placement of extra bars except diagonals.)
FLEXIBLE JOINT DETAIL
Reinforcing steel not shown.
No Scale
D | D-LOAD | T | L
66" | Up to 2000-D | 5½" | 3'-9"
66" | 2000-D and over | 7¼" | 3'-9"
84" | Up to 2000-D | 7" | 4'-6"
84" | 2000-D and over | 8¾" | 4'-6"
SECTION E-E
SECTION F-F
FLEXIBLE JOINT & MODIFICATIONS TO M.H. WHERE M.H. IS BUILT PRIOR TO LAYING PIPE
Scale: None
SECTION M-M
SECTION G-G
SECTION H-H
SECTION J-J
SECTION K-K
PILE FOUNDATION BEDDING
· Pile Foundation Bedding was used as directed by the Engineer.
· The Engineer directed the spacing, length & no. of piles required.
· Underdrain & crushed rock called for by Engineer.
NOTES
· Refer to PLAN & PROFILE for M.H. location & elevations.
· All bars ⅜" φ unless otherwise noted.
· Exterior corners were chamfered 1".
· Flexible joint details are typical for joining R.C. pipe to all structures.
For details or dimensions not shown or noted see Case I.
CASE I Shaft up to 10'-0"
CASE II Shaft more than 10'-0"
SECTION A-A
SECTION B-B
SECTION L-L
CASE I Shown
CASE II Similar
AS-BUILT NOV. 5, 1963
3 | 12-15-48 | Inserted additional Brick courses. Rev. reinf. steel Sec. G-G & H-H
2 | 9-30-48 | Pile Foundation Bedding Added.
1. | 8-10-48 | Inserted four courses of brick between M.H. Frame & M.H. Sect. A-A.
Rev. No. | Date | Description
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA
NORTH INTERCEPTOR
STANDARD MANHOLES
FOR 66" & 84" PIPE
DRAWN BY KORETSKY
TRACED BY GIULIANO
CHECKED BY HARRISON
SCALE AS SHOWN
DATE JUNE 11, 1948
NO. VG 327
CHIEF ENGINEER & GENERAL MANAGER

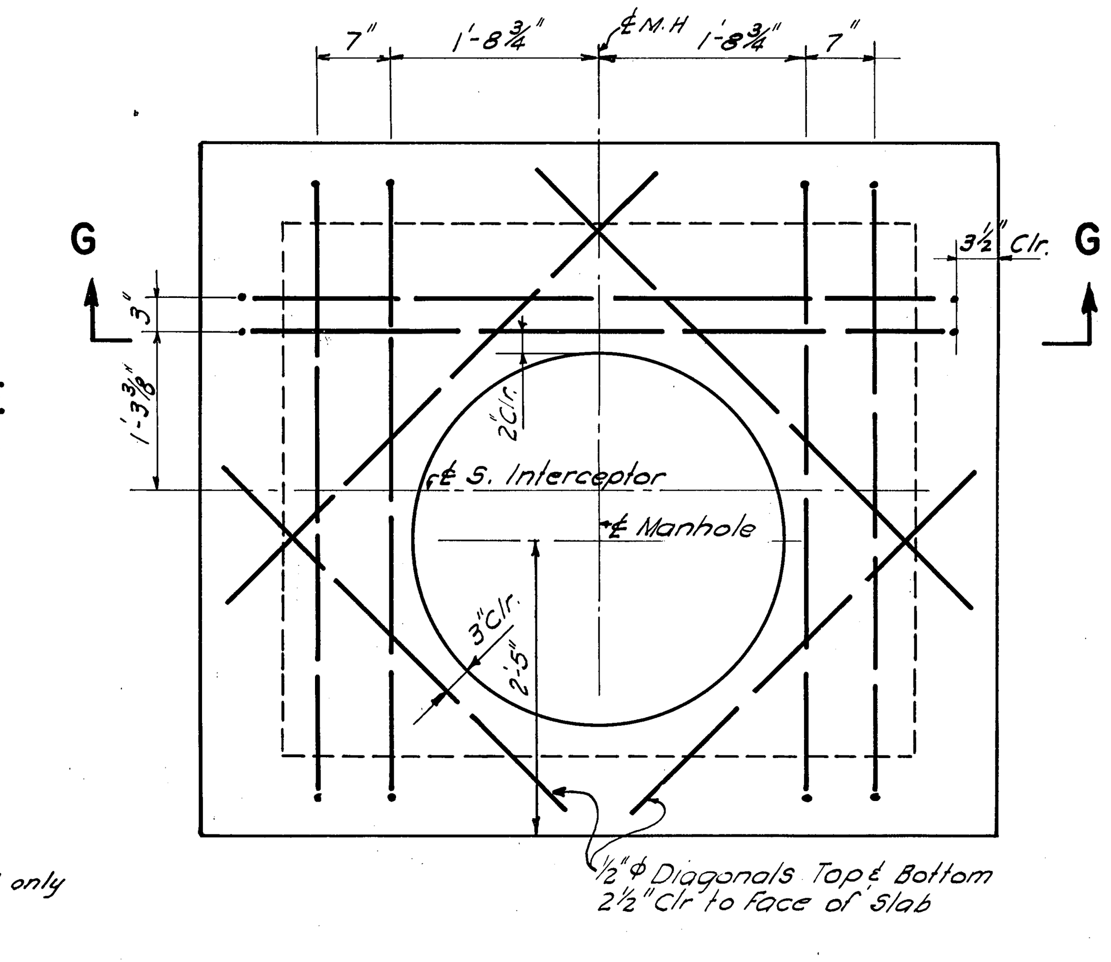
D	D-LOAD	T	L
66"	Up to 2000-D	5½"	3'-9"
	2000-D and over	7¼"	
84"	Up to 2000-D	7"	4'-6"
	2000-D and over	8¾"	



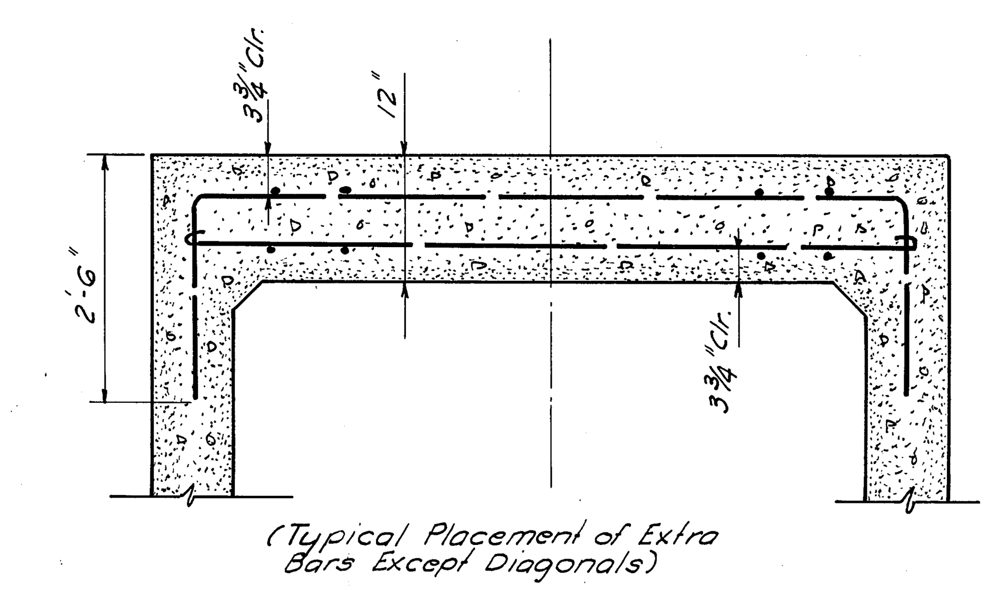
MANHOLE STRUCTURE FOR 63" PIPE



MANHOLE STRUCTURE FOR 42" PIPE

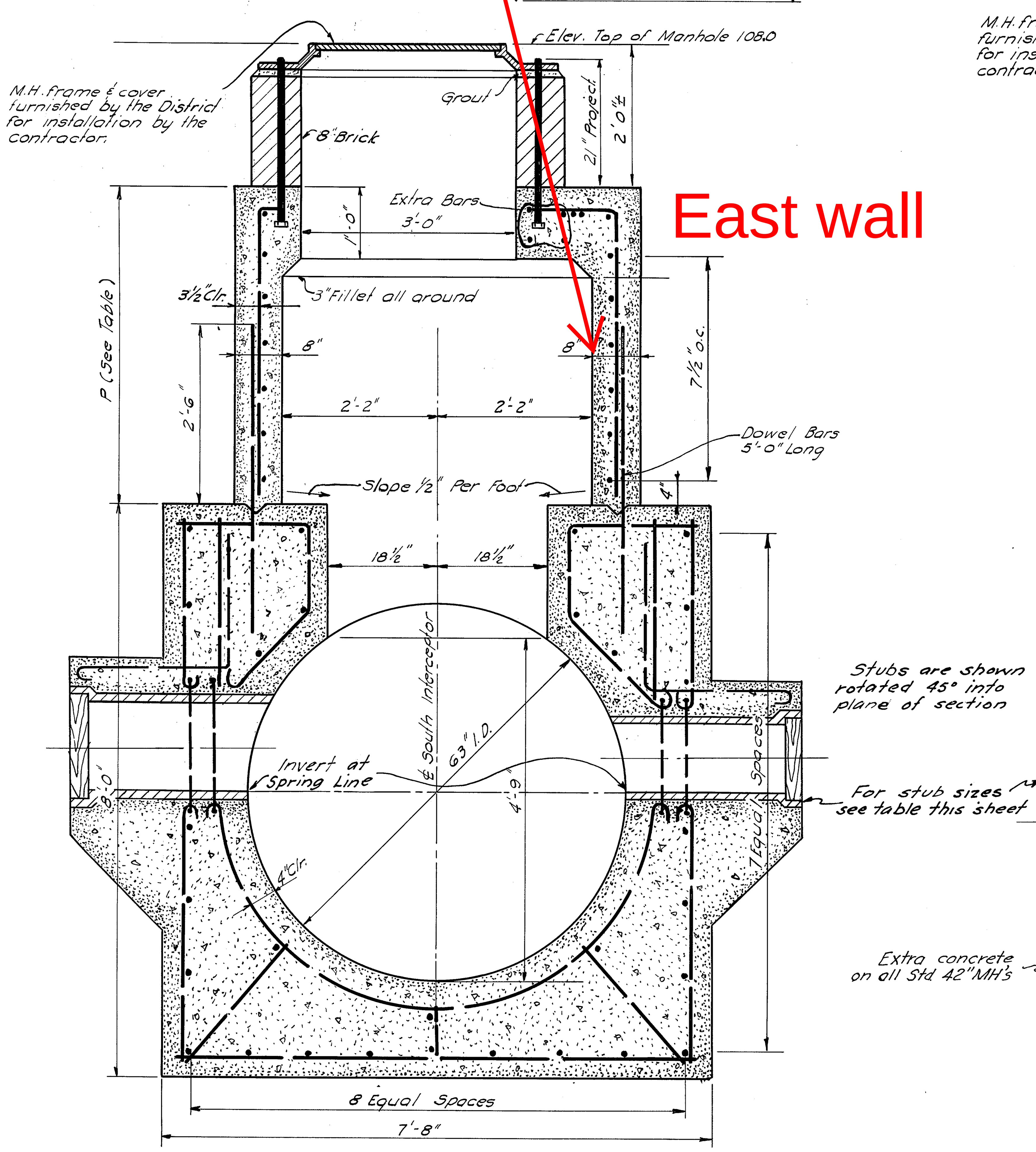


ROOF SLAB — EXTRA BARS

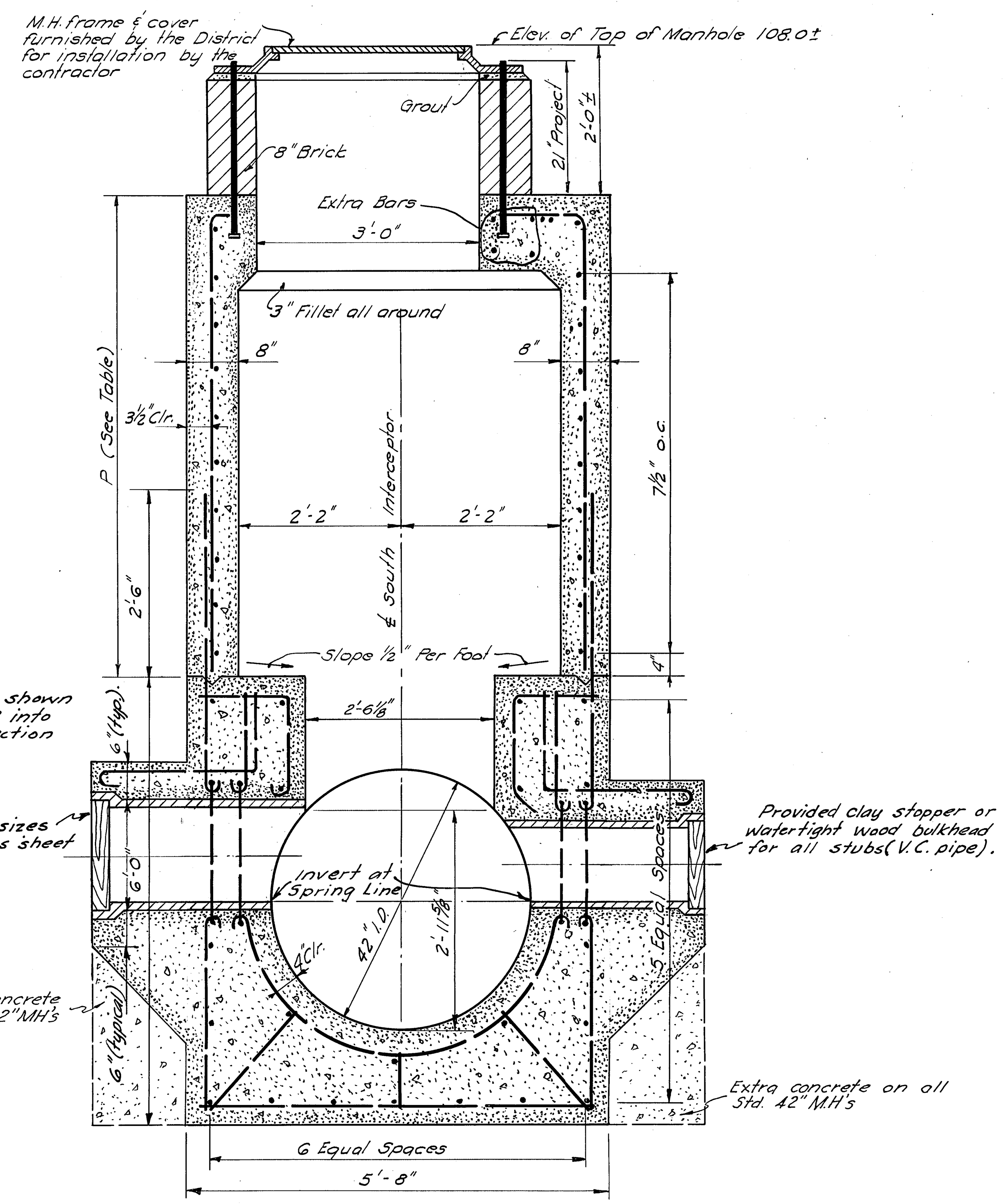


SECTION G-G

M.H. STA.	PRESENT GROUND ELEV.	INVERT ELEV. (APPROX.)	D	T (MIN.)	P (APPROX)	STUB SIZE N. or E. Side	STUB SIZE S. or W. Side	REMARKS	M.H. RIM ELEV.
35+50.50	105.2±	96.51	42"	3 3/4"	4'-9 1/2"	12"	15"	8" conn. made to W. side 11-17-64	107.90
45+51.49	104.5±	95.67	42"	3 3/4"	5'-7 1/2"	12"	15"	14" conn. made to W. side 8-29-61.	107.90
69+96.81	103.6±	93.55	42"	3 3/4"	7'-8 1/2"	12"	12"		107.88
94+96.08	+5.0± 101.0±	91.73	63"	5 1/4"	7'-8"	12"	15"	8" Conn. made to E. side 6-30-63 MH Chimney raised approx. 5'	107.89
106+97.71	100.0±	91.13	63"	5 1/4"	8'-4"	12"	15"		107.98
116+98.71	106.0±	90.63	63"	5 1/4"	8'-10"	21"	15"	Angle of 21" stub on VG-858 - Conn. made 5-23-52. 8" conn. to S.W. side (date?)	107.9±
122+58.08	103.6±	90.35	63"	5 1/4"	9'-1"	12"	12"	8" conn. made to W. side 12-23-53. 8" conn. made to E. side 2-14-55.	107.91
130+43.32	106.0±	89.98	63"	5 1/4"	9'-6"	12"	15"	15" conn. made to W. side 11-2-56	107.89



SECTION A-A



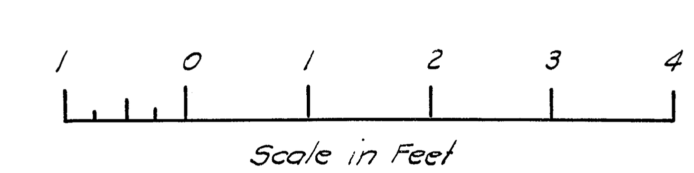
SECTION D-D

GENERAL NOTES

1. For details of Flexible Joint see VG 867
2. All bars 3/4" dia. unless otherwise noted.
3. Reinforcing steel to be 3" clear of face of concrete unless otherwise noted.
4. All exterior corners chamfered 1"
5. For details of Construction Joint see VG 867
6. For additional details see Plan & Profile.

NOTES

1. Work this sheet with VG 867.
2. Pile foundation to be used only if called for by the Engineer.
3. Final manhole stations determined by the Engineer. Invert elevations will change if manhole stations are changed.



APPROVED
MGR. SEWAGE DISPOSAL ENGINEERING AND CONSTRUCTION
R.E. 642

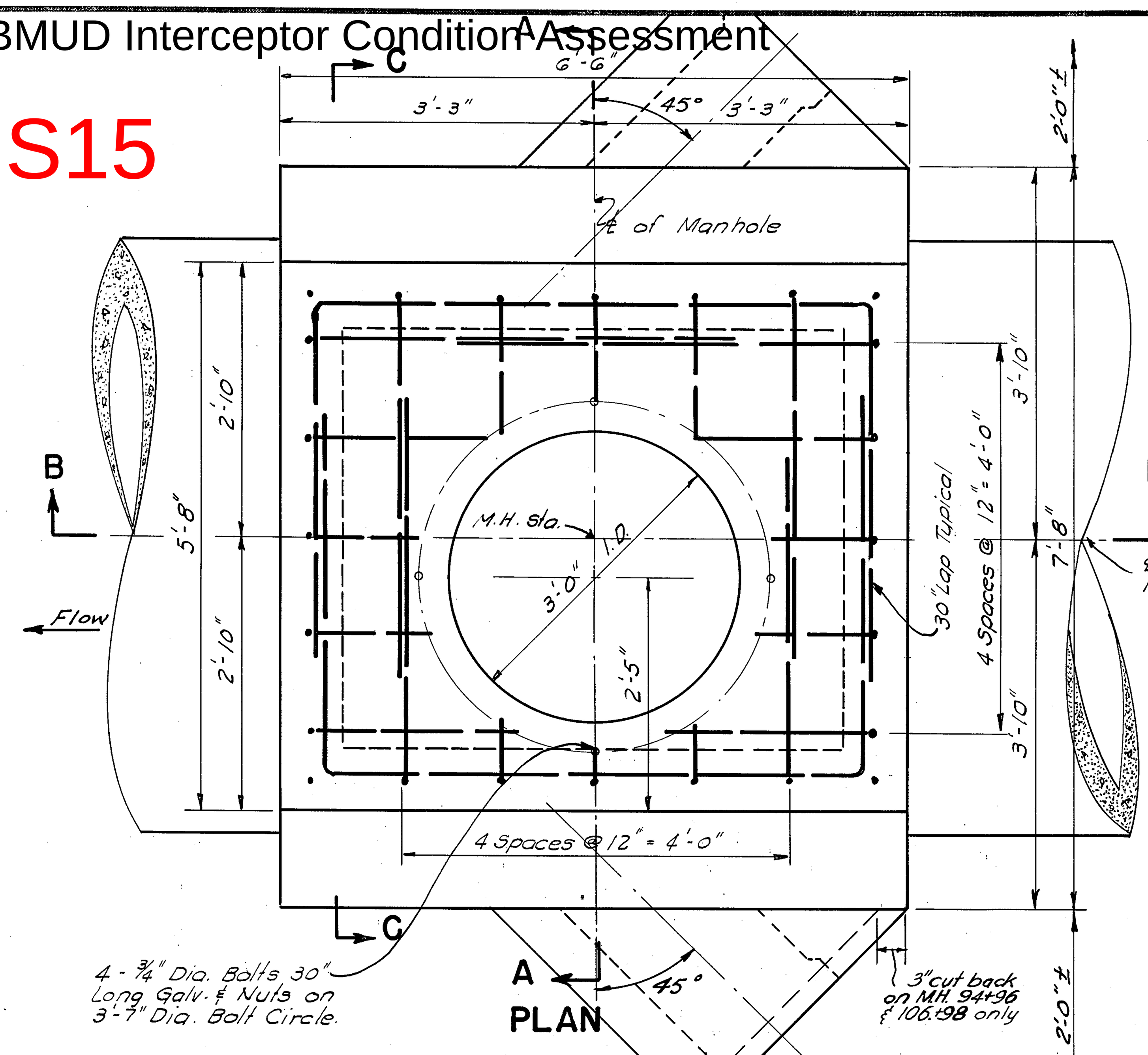
AS-BUILT		5-21-54		
1	5-19-50	Added Stubs. Revise Table	RBB	J.G.P
REV. NO	DATE	DESCRIPTION	BY	CHKD.

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA

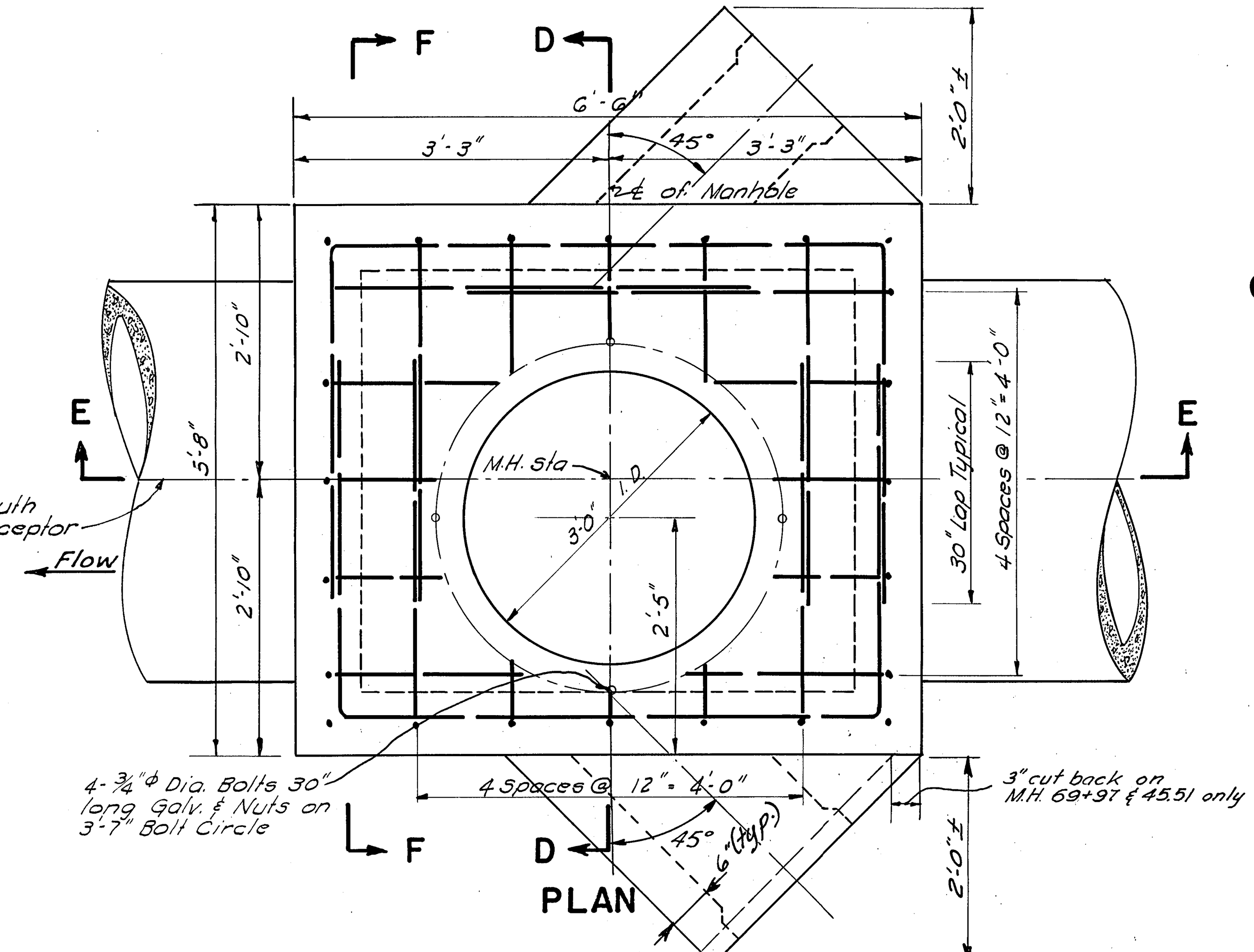
SOUTH INTERCEPTOR
STANDARD MANHOLE
42" I.D. & 63" I.D. PIPE
SHEET 1 OF 2

DRAWN BY R.B.B. & E.W.C.
TRACED BY M.E.C.
CHECKED BY
DATE 12-20-48
RECOMMENDED BY
APPROVED BY
NO. VG 866

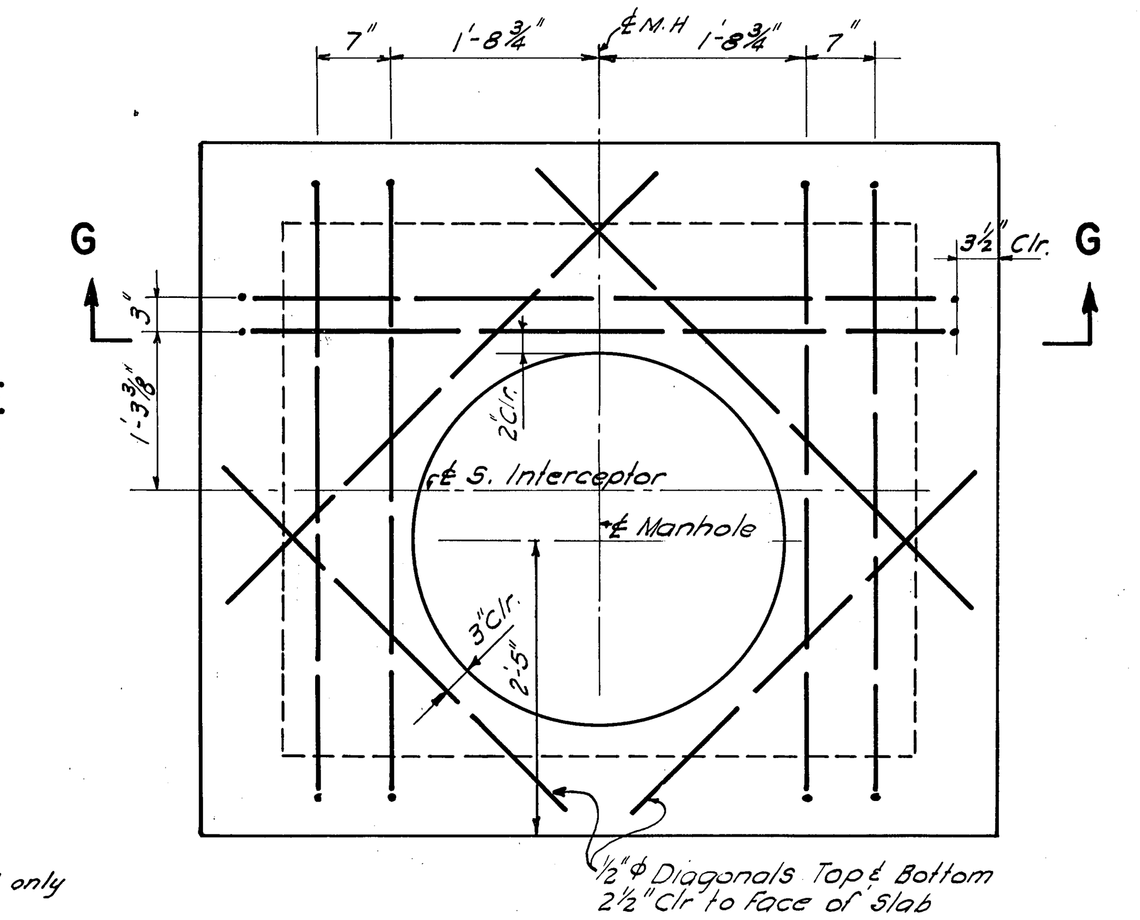
S15



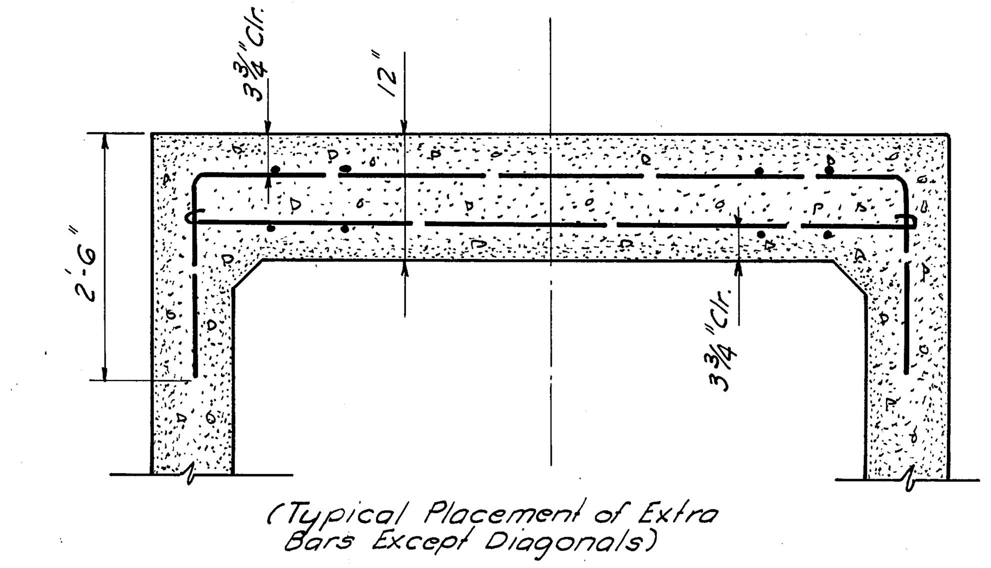
MANHOLE STRUCTURE FOR 63" PIPE



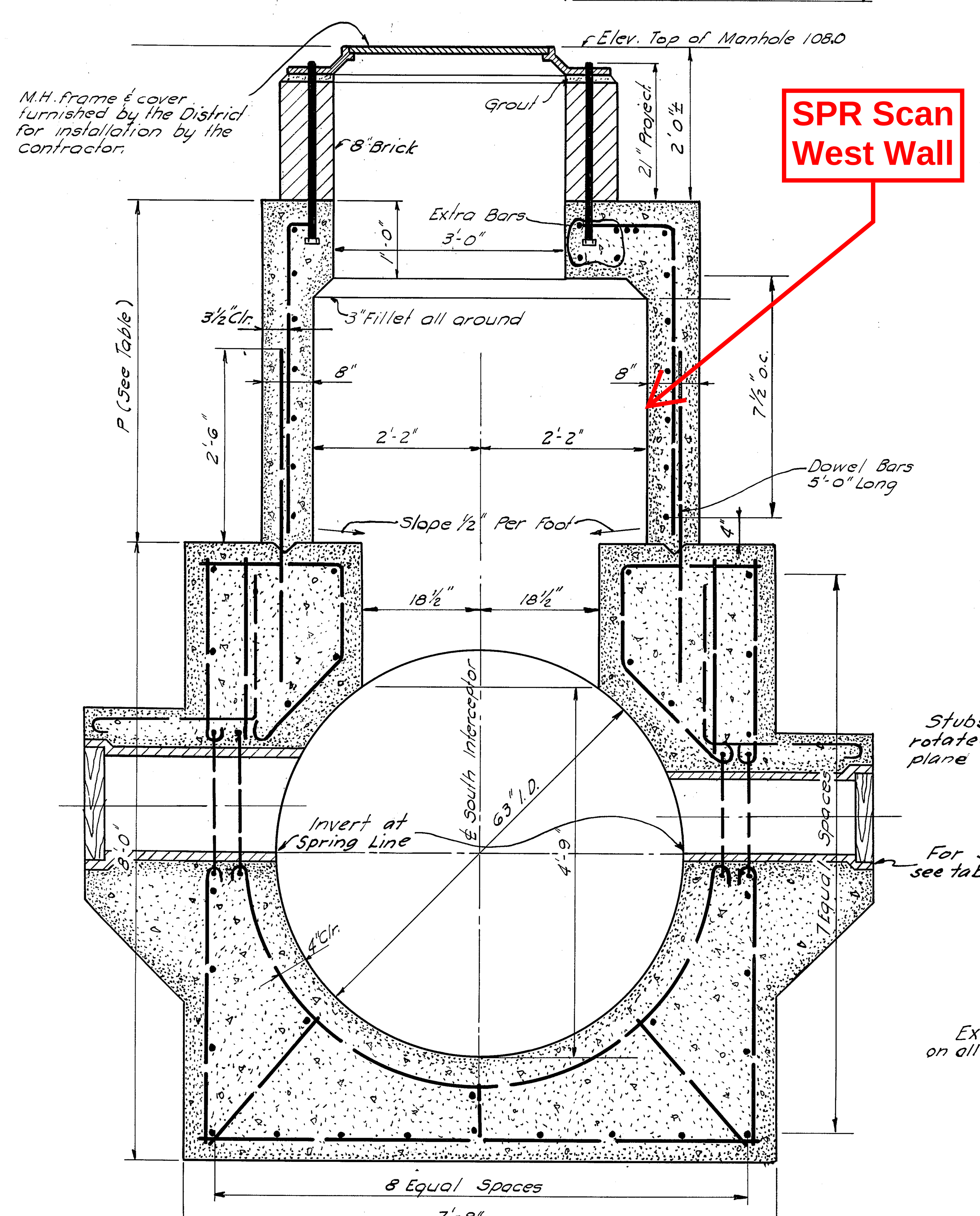
MANHOLE STRUCTURE FOR 42" PIPE



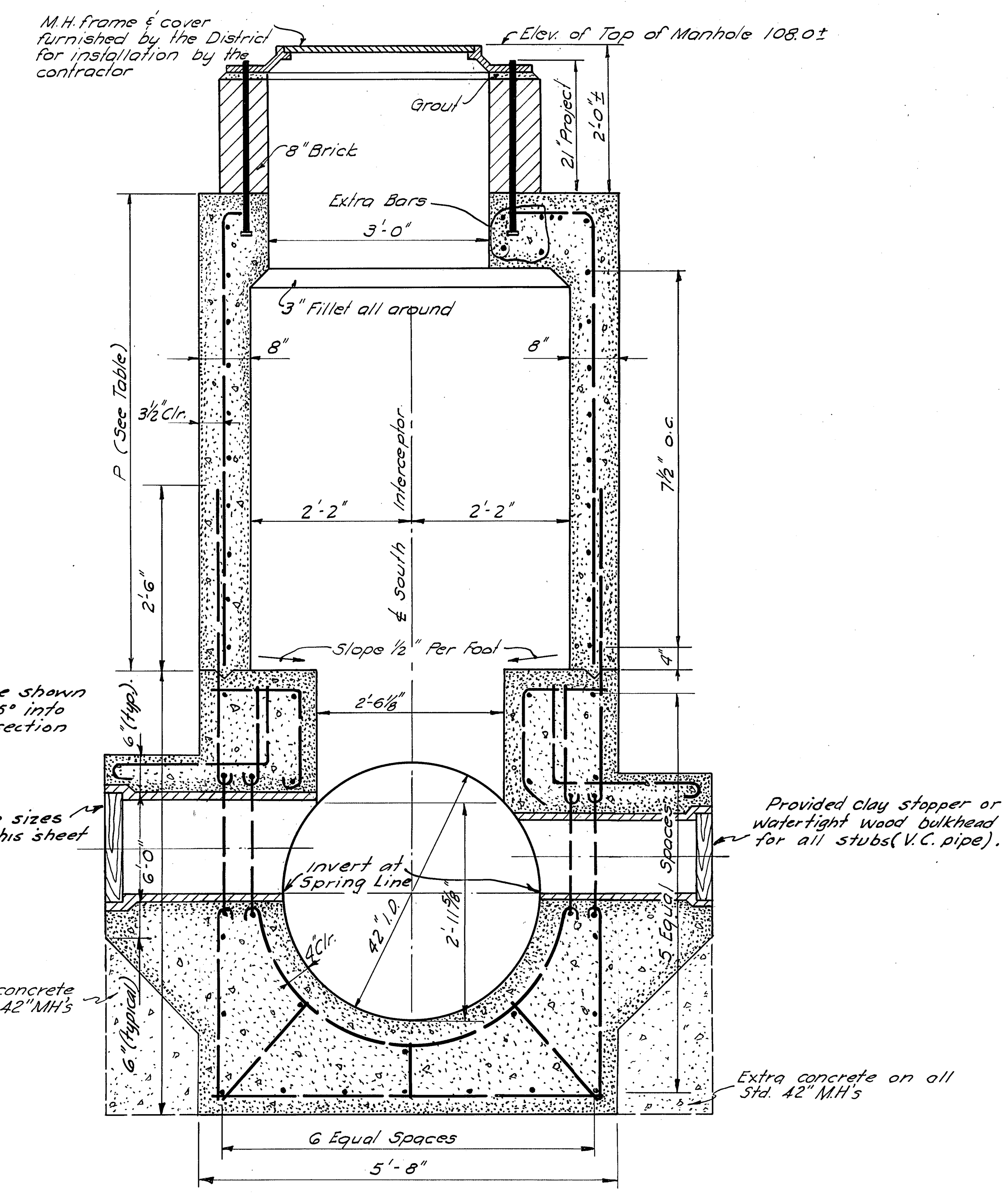
ROOF SLAB — EXTRA BARS



SECTION G-G



SECTION A-A



SECTION D-D

SPR Scan West Wall

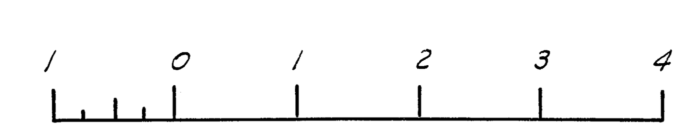
M.H. STA.	PRESENT GROUND ELEV.	INVERT ELEV. (APPROX.)	D	T (MIN.)	P (APPROX)	STUB SIZE N. or E. Side	STUB SIZE S. or W. Side	REMARKS	M.H. RIM ELEV.
35+50.50	105.2±	96.51	42"	3¾"	4'-9½"	12"	15"	8" conn. made to W. side 11-17-64	107.90
45+51.49	104.5±	95.67	42"	3¾"	5'-7½"	12"	15"	14" conn. made to W. side 8-29-61.	107.90
69+96.81	103.6±	93.55	42"	3¾"	7'-8½"	12"	12"		107.88
94+96.08	+5.0± 101.0±	91.73	63"	5¼"	7'-8"	12"	15"	8" Conn. made to E. side 6-30-63 MH Chimney raised approx. 5'	107.89
106+97.71	100.0±	91.13	63"	5¼"	8'-4"	12"	15"		107.98
116+98.71	106.0±	90.63	63"	5¼"	8'-10"	21"	15"	Angle of 21" stub on VG-858 - Conn. made 5-23-52. 8" conn. to S.W. side (date?)	107.9±
122+58.08	103.6±	90.35	63"	5¼"	9'-1"	12"	12"	8" conn. made to W. side 12-23-53. 8" conn. made to E. side 2-14-55.	107.91
130+43.32	106.0±	89.98	63"	5¼"	9'-6"	12"	15"	15" conn. made to W. side 11-2-56	107.89

GENERAL NOTES

1. For details of Flexible Joint see VG 867
2. All bars ¾" dia. unless otherwise noted.
3. Reinforcing steel to be 3" clear of face of concrete unless otherwise noted.
4. All exterior corners chamfered 1"
5. For details of Construction Joint see VG 867
6. For additional details see Plan & Profile.

NOTES

1. Work this sheet with VG 867.
2. Pile foundation to be used only if called for by the Engineer.
3. Final manhole stations determined by the Engineer. Invert elevations will change if manhole stations are changed.



Scale in Feet

APPROVED R.E.642
MGR. SEWAGE DISPOSAL ENGINEERING AND CONSTRUCTION

AS-BUILT 5-21-54

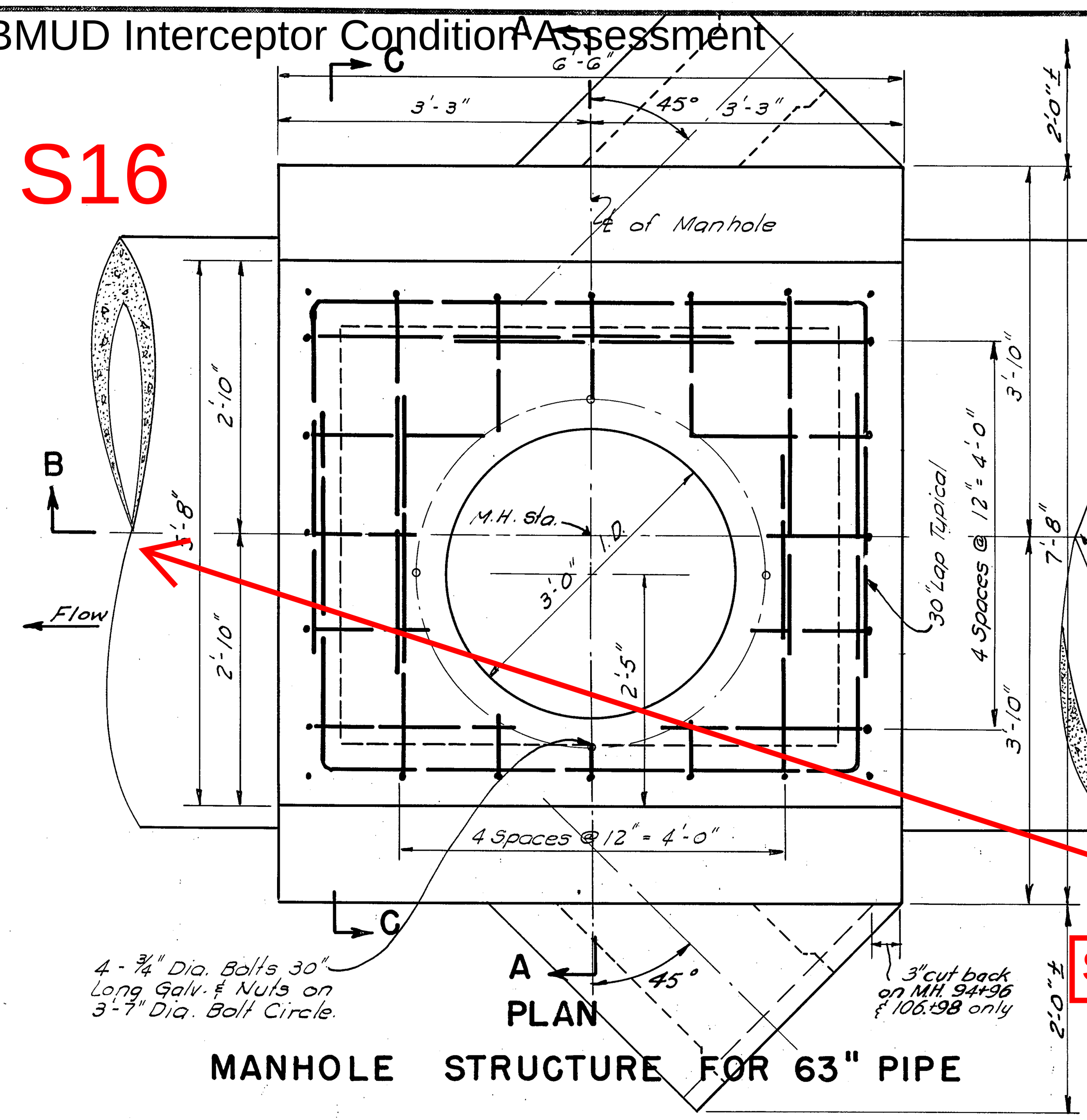
REV. NO.	DATE	DESCRIPTION	BY	CHKD.
1	5-19-50	Added Stubs. Revise Table	RBB	J.G.P.

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA

SOUTH INTERCEPTOR
STANDARD MANHOLE
42" I.D. & 63" I.D. PIPE
SHEET 1 OF 2

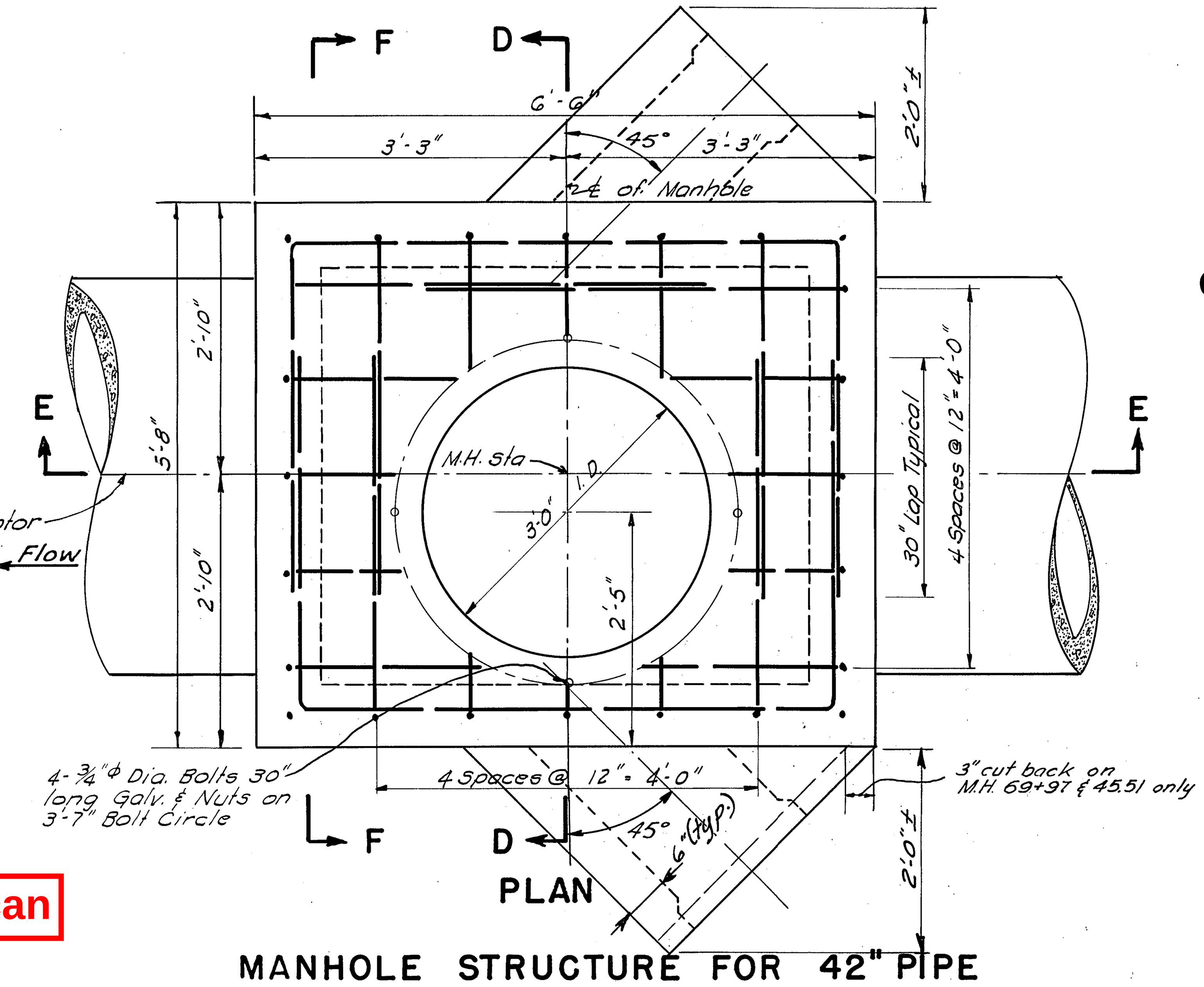
DRAWN BY R.B.R. & R.W.C.
TRACED BY M.E.C.
CHECKED BY H.A. Pirkner
DATE 12-20-49
RECOMMENDED BY D.A. Root
APPROVED BY D.A. Root
No. VG 866

S16



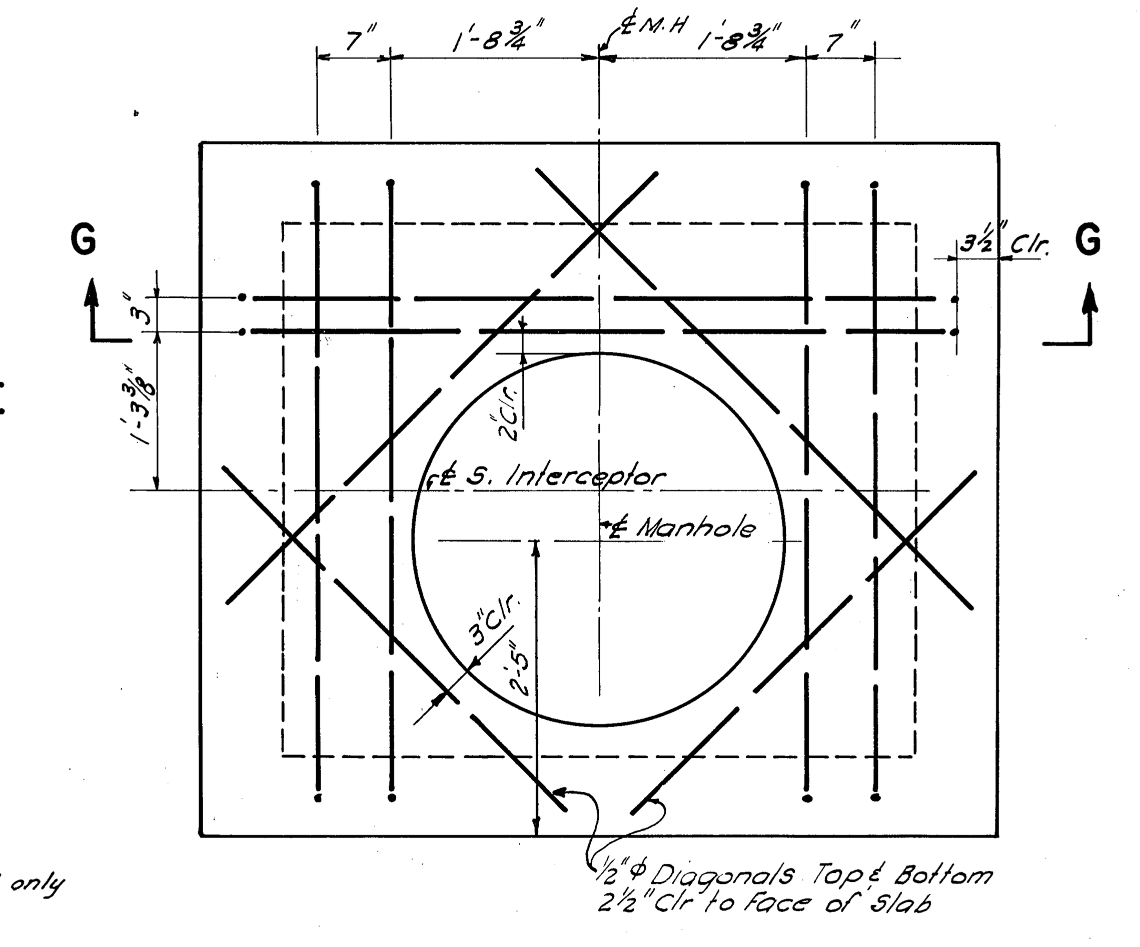
PLAN

MANHOLE STRUCTURE FOR 63" PIPE

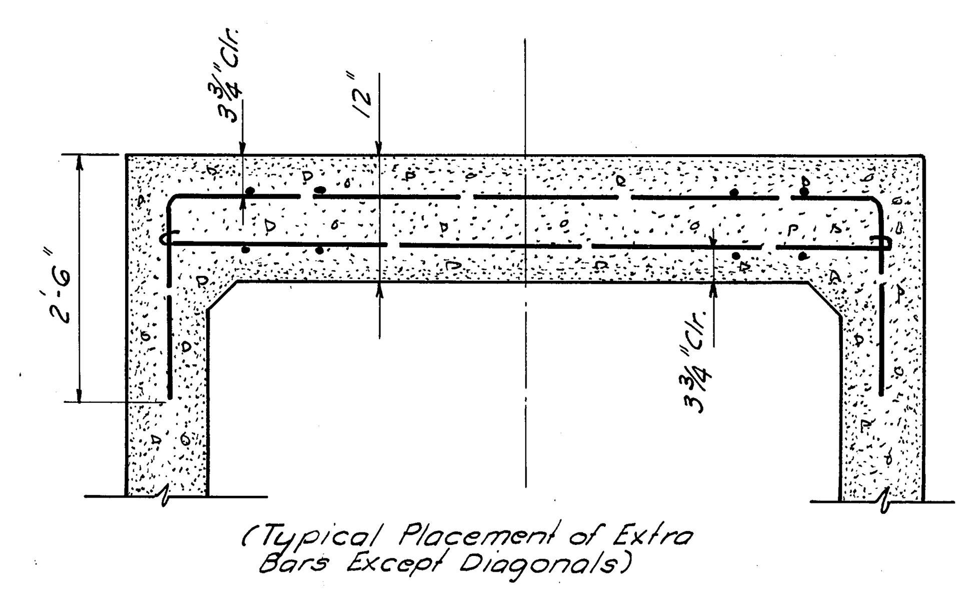


PLAN

MANHOLE STRUCTURE FOR 42" PIPE

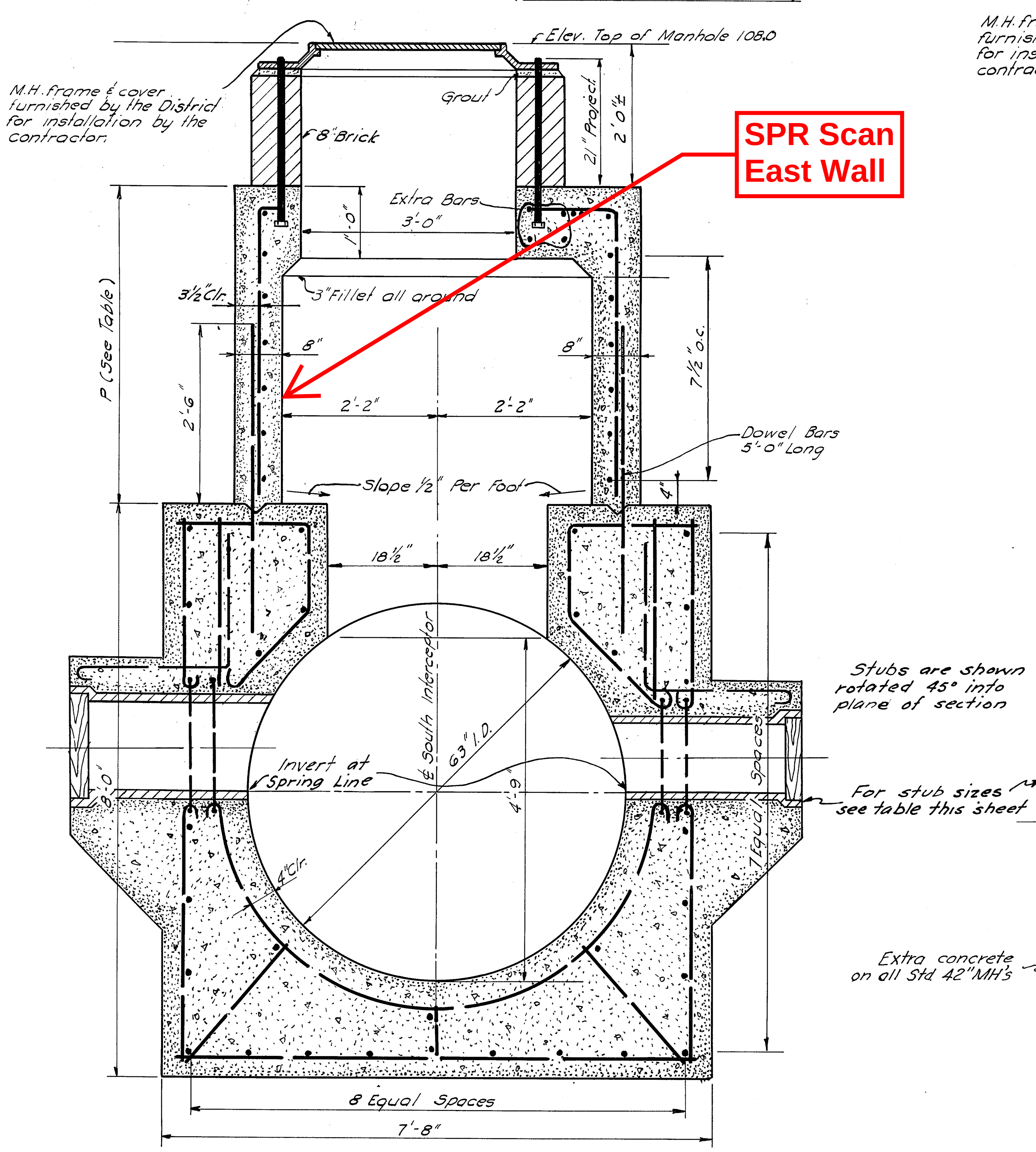


ROOF SLAB — EXTRA BARS

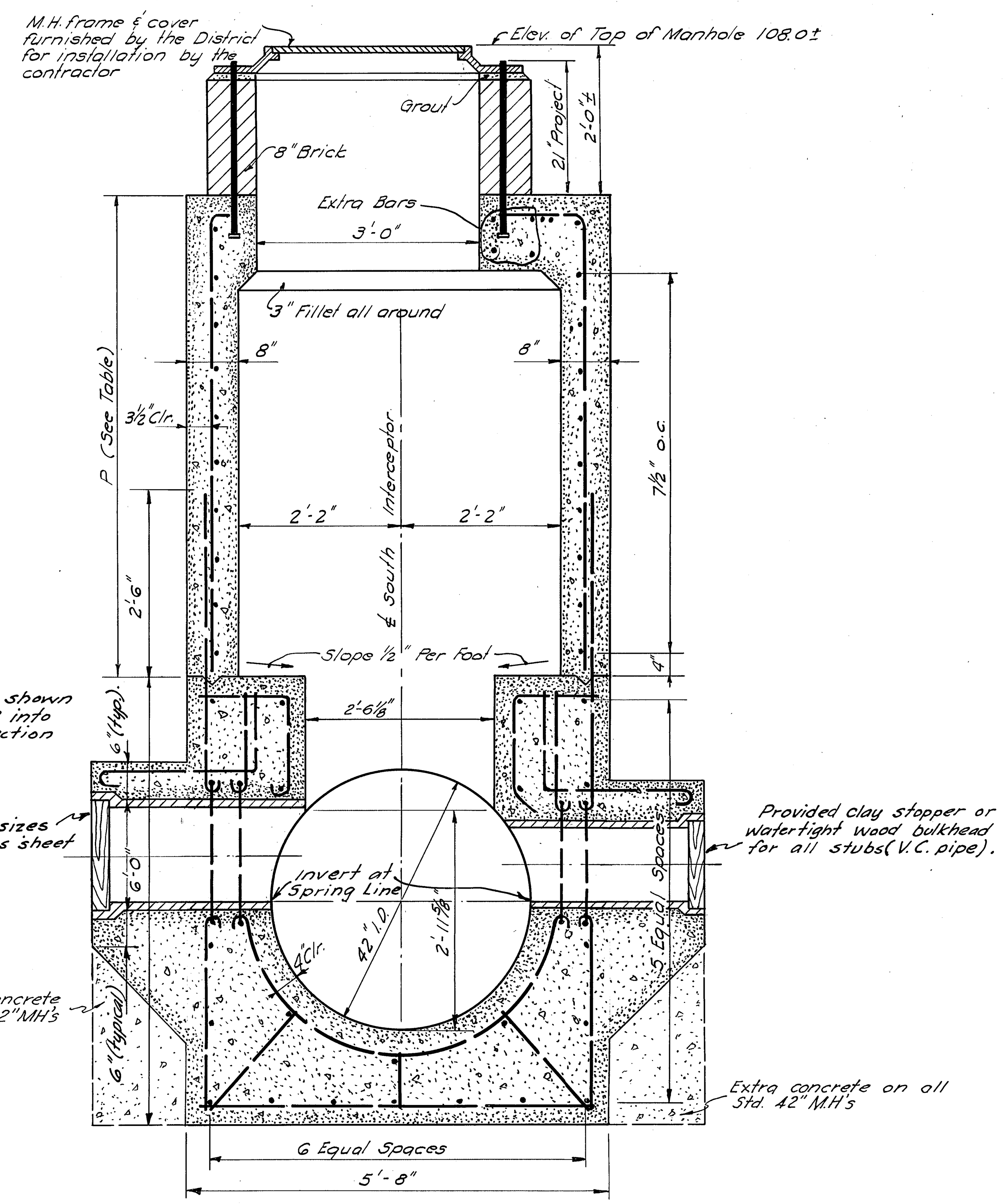


SECTION G-G

M.H. STA.	PRESENT GROUND ELEV.	INVERT ELEV. (APPROX.)	D	T (MIN.)	P (APPROX)	STUB SIZE N. or E. Side	STUB SIZE S. or W. Side	REMARKS	M.H. RIM ELEV.
35+50.50	105.2±	96.51	42"	3¾"	4'-9½"	12"	15"	8" conn. made to W. side 11-17-64	107.90
45+51.49	104.5±	95.67	42"	3¾"	5'-7½"	12"	15"	14" conn. made to W. side 8-29-61.	107.90
69+96.81	103.6±	93.55	42"	3¾"	7'-8½"	12"	12"		107.88
94+96.08	+5.0± 101.0±	91.73	63"	5¼"	7'-8"	12"	15"	8" Conn. made to E. side 6-30-63 MH Chimney raised approx. 5'	107.89
106+97.71	100.0±	91.13	63"	5¼"	8'-4"	12"	15"		107.98
116+98.71	106.0±	90.63	63"	5¼"	8'-10"	21"	15"	Angle of 21" stub on VG-858 - Conn. made 5-23-52. 8" conn. to S.W. side (date?)	107.9±
122+58.08	103.6±	90.35	63"	5¼"	9'-1"	12"	12"	8" conn. made to W. side 12-23-53. 8" conn. made to E. side 2-14-55.	107.91
130+43.32	106.0±	89.98	63"	5¼"	9'-6"	12"	15"	15" conn. made to W. side 11-2-56	107.89



SECTION A-A



SECTION D-D

GENERAL NOTES

1. For details of Flexible Joint see VG 867
2. All bars ¾" dia. unless otherwise noted.
3. Reinforcing steel to be 3" clear of face of concrete unless otherwise noted.
4. All exterior corners chamfered 1"
5. For details of Construction Joint see VG 867
6. For additional details see Plan & Profile.

NOTES

1. Work this sheet with VG 867.
2. Pile foundation to be used only if called for by the Engineer.
3. Final manhole stations determined by the Engineer. Invert elevations will change if manhole stations are changed.

1 0 1 2 3 4

Scale in Feet

APPROVED R.E. Kennedy R.E.642
MGR. SEWAGE DISPOSAL ENGINEERING AND CONSTRUCTION

AS-BUILT 5-21-54

REV. NO.	DATE	DESCRIPTION	BY	CHKD.
1	5-19-50	Added Stubs. Revise Table	RBB	J.G.P.

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA

SOUTH INTERCEPTOR
STANDARD MANHOLE
42" I.D. & 63" I.D. PIPE
SHEET 1 OF 2

DRAWN BY R.B.R. & R.W.C.
CHECKED BY H.R. Pirkner
RECOMMENDED BY D.A. Root
APPROVED BY D.A. Root
TRACED BY M.E.C.
DATE 12-20-49
No. VG 866

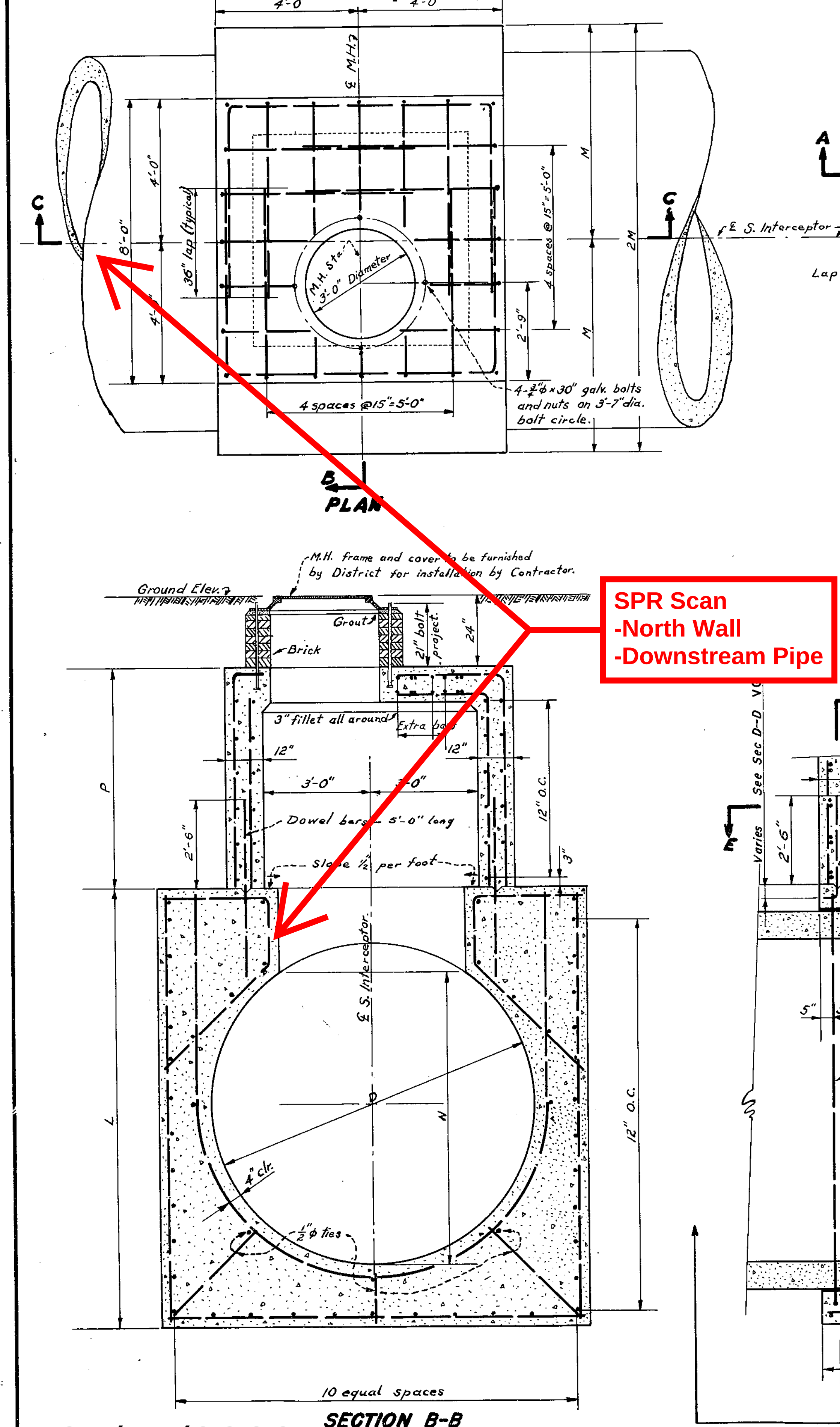
S39

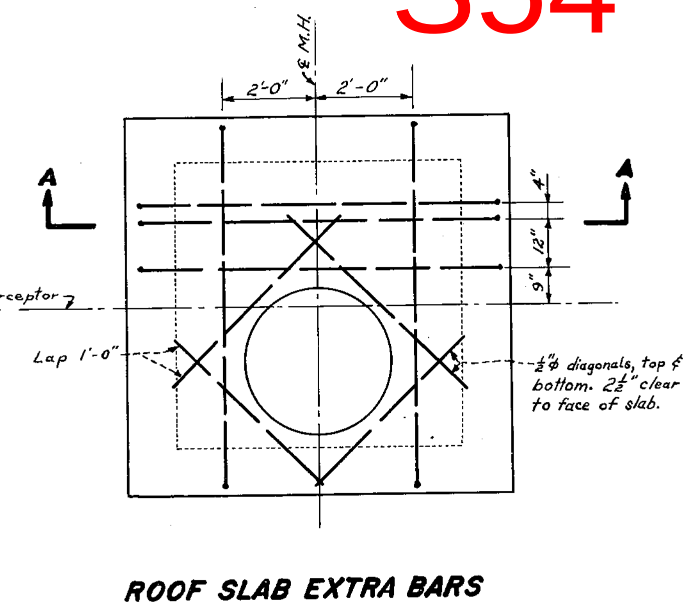

SPR Scan
-East Wall
-Ceiling
-Upstream pipe
PLAN
KEY PLAN
ROOF SLAB BARS
ROOF SLAB EXTRA BARS
SECTION A-A
SECTION B-B
(Typical for Extra bars in roof slab only)
FLEXIBLE JOINT DETAIL
Not to Scale.
Reinforcing Steel not Shown
Existing 36" Dia. R.C. Drain
Existing 36" conc. sanitary sewer Cut-In 12-26-51
EBMUD Mon. Sta. 315+52.25 Elev. 106.270
2 Course Brick Bulkhead
8 Sks 3/4" Max. 4 Sk Conc. Backing
18" V.C. Stub
10" V.C. San. Sew. Presumably Connected By Port of Oakland
Remove existing piles within these limits. 2 piles per bent. Bents spaced 8' o.c. under existing 36" Conc. Sewer.
Top of M.H. Ring Elev. 108.28
M.H. covers & frames set at final road grade of Embarcadero. Elev. furnished by the Engineer.
Top of M.H. Ring Elev. 108.31
M.H. frames & covers furnished by District for installation by Contractor
For steel details of roof slab see Dwg. No. VG 664.
Cohesionless backfill
Construction Joint
Bottom Elev. 91.58
Inv. Elev. 93.16
Inv. Elev. 93.17
Inv. El. 93.66
Pipe No. 3689
Pipe No. 3688
1/2" Caulked Oakum gasket
Additional flexible joint details are shown on Dwg. No. VG 651.
Bitum. joint Compound
Inside of Pipe
Scale in Feet
NOTES
All bars 3/4" unless otherwise noted.
Exterior corners were Chamfered 1".
Refer to Plan & Profile for additional information.
Unless otherwise shown, min. clearance to face of concrete 3" for all bars.
Additional details on Dwg. No. VG 663.
@ dimensions subject to revision to give 3" clearance under existing 36" storm drain.
As-Built Nov. 14, 1952
2 | 1-18-49 | Revised Structure. Specified steel spacing.
1 | 11-15-48 | Misc. drafting corrections
REV. NO. | DATE | DESCRIPTIONS
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT NO. 1
OAKLAND, CALIFORNIA
SOUTH INTERCEPTOR
MANHOLE STRUCTURE
STA. 315+27.00 TO STA. 315+52.08
DRAWN BY F. Giuliano
TRACED BY M.E. Clarke
CHECKED BY F. McCollum
DATE 10-3-48
SCALE As Shown
NO. VG 662
SHEET 1 OF 2
APPROVED CHIEF ENGINEER & GENERAL MANAGER
14


S47
SPR Scan
SPR Scan
-North Wall
-Ceiling
PLAN
SECTION C-C
SECTION B-B
SEC. K-K
KEY PLAN
SCALE IN FEET
NOTES
1. For General Notes refer to VG 797
2. Work this sheet with VG 800 & VG840.
3. Refer to Plan & Profile for additional details.
4. All bars 3/4"φ unless otherwise noted.
5. All exterior corners are chamfered 1".
6. This sheet is drawn for precast pipe alternate. For details of joining of pipe to manholes see Dwg. VG 805. For modifications to this drawing for monolithic pipe alternate see Dwg. VG 840.
7. For dimensions, reinforcement, and details of pipe and cradle refer to VG 807 & VG 808
FLOW
Ground Elevation 109.0±
Ground Elev. 109.0±
M.H. frame and cover was furnished by District for installation by Contractor
EBMUD Mon. 374+94.41 Elev. 106.916
Inv. Elev. 92.29
Inv. Elev. 89.874
Inv. Elev. 89.004
Springline Elev. 93.67
96" Dia. Opening
Two lengths 96" I.D. Pipe For detail see Section B-B
8" V.C.P. Sewer - Cut-In 12-1-67
Note: Existing 15" Stub Broken Back Flush With Outside of Wall.
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA
SOUTH INTERCEPTOR
MANHOLE STRUCTURE - ALICE ST.
STA. 374+94.41
SHEET 1 OF 3
No. VG 799
AS BUILT 4-23-54
DATE 7-5-49
SCALE As Shown

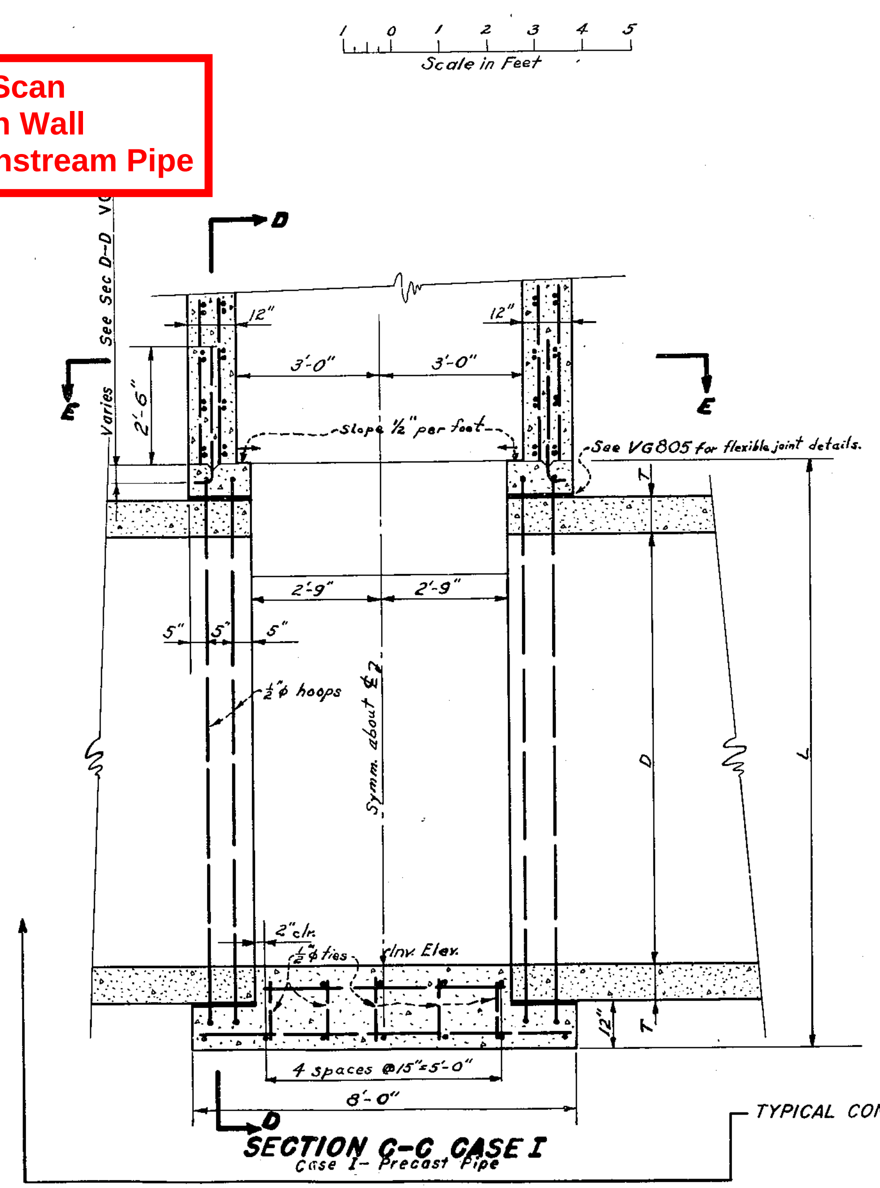

S48
SPR Scan
-West Wall
-Upstream pipe
PLAN
ROOF SLAB-EXTRA BARS
KEY PLAN
SECTION C-C
SECTION D-D
SECTION A-A
SECTION B-B
SECTION E-E
NOTES
1. For General Notes, see Dwg VG 797
2. All steel 3/4"φ unless otherwise noted.
3. Reinforcing steel are 3" clear of all concrete surfaces unless otherwise noted.
4. All exterior corners are chamfered 1".
5. Refer to Plan & Profile for additional details.
6. This sheet is drawn for precast pipe construction. For details of joining pipe to manhole see Dwg. VG 805. For modification to this drawing for monolithic pipe construction, see Dwg VG 839
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA
SOUTH INTERCEPTOR
MANHOLE STRUCTURE
WEBSTER STREET
STA. 382 + 16.00
VG 798

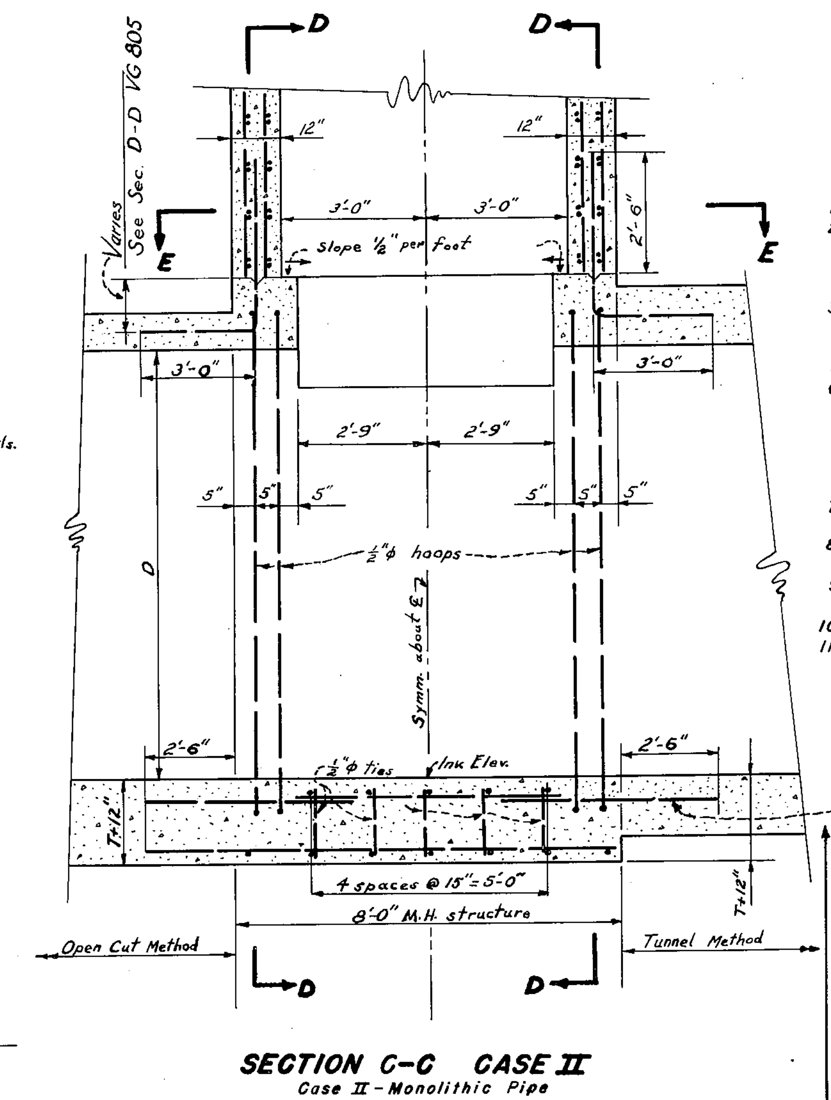

S53
SPR Scan
-East Wall
-Downstream Pipe
PLAN
KEY PLAN
Scale in Feet
NOTES:
1. For General Notes see this sheet.
2. All bars are 3/4"ϕ unless otherwise noted.
3. All exterior corners are chamfered 1".
4. For additional details, see Plan & Profile.
5. For dimensions, reinforcement and details of pipe see Dwg. VG 807 & VG 808
6. For details not shown see intermediate M.H. on VG 804
7. This sheet is drawn for Precast Pipe Alternate. For details of joining of pipe to manhole see Dwg. VG 804 For modification to this dwg. for Monolithic Pipe Alternate, see Dwg. VG 839
GENERAL NOTES
1. Reinforcing steel are deformed rods of intermediate grade as noted in the specifications.
2. Unless otherwise noted on the plans, min. cover for reinforcing are 3".
3. All dowels are embedded 40 diameters. All splices are lap 40 diameters.
4. Typical construction joint details are shown on VG 805
5. For details and dimensions of concrete pipe and bedding, see VG 807
6. For details of joining of pipe to manhole, see Dwg. VG 804. For modification for monolithic pipe alternate see Dwg. VG 839.
SECTION B-B
SECTION C-C
Scale in Feet
AS-BUILT 4-23-54
4-27-50 Added 15" stub & changed 18" stub RBB G.T.K.
11-14-49 Minor Changes J.G.H. HRP
REV. No. DATE DESCRIPTION BY CHKD.
EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA
SOUTH INTERCEPTOR
MANHOLE STRUCTURE — GROVE ST.
STA. 411 + 93.00
DATE 7-5-1949
SCALE As Shown
No. VG 797
APPROVED
CHIEF ENGINEER & GENERAL MANAGER





M.H. STA.	GROUND ELEV. (APPROX)	INVERT ELEV.	D	T (Min.)	N	L	P	2M			REMARKS
356+45	108.0	91.25	84"	7"	6'-4"	9'-10"	6'-6"	9'-6"			For piling plan see VG 805. For lengths of piles see VG 757.
401+50	110.0	88.47	108"	9"	8'-2"	12'-4"	8'-11"	12'-0"			
421+71	107.3	87.96	108"	9"	8'-2"	12'-4"	6'-9"	12'-0"			
452+00	105.2	87.10	108"	9"	8'-2"	12'-4"	5'-6	12'-0"			For piling plan see VG 805. For lengths of piles see VG 766.
462+00	106.5	86.80	108"	9"	8'-2"	12'-4"	7'-1"	12'-0"			
472+14.19	106.8	86.50	108"	9"	8'-2"	12'-4"	7'-9"	12'-0"			
502+80	114.5	85.61	108"	9"	8'-2"	12'-4"	16'-2"	12'-0"			
512+80	112.2	85.29	108"	9"	8'-2"	12'-4"	14'-3"	12'-0"			
522+80	106.6	84.96	108"	9"	8'-2"	12'-4"	9'-0"	12'-0"			
532+80	106.4	84.62	108"	9"	8'-2"	12'-4"	9'-2"	12'-0"			Replace unsuitable foundation material— see VG 807.
553+03	106.0	83.80	108"	9"	8'-2"	12'-4"	9'-7"	12'-0"			
563+03	105.6	83.32	108"	9"	8'-2"	12'-4"	9'-9"	12'-0"			
385+83.61	108.2	88.78	108"	9"	8'-2"	12'-4"	6'-10"	12'-0"			Note 6 not applicable to this M.H.
389+44.09	112.4	88.70	108"	9"	8'-2"	12'-4"	11'-2"	12'-0"			Note 6 not applicable to this M.H.
442+00	107.2	87.42	108"	9"	8'-2"	12'-4"	7'-2"	12'-0"			





NOTES

1. Work this sheet with VG 805.
2. This sheet and VG 805, show M.H. construction for 2 types of pipe.
   Case I – Precast pipe.
   Case II – Monolithic pipe.
3. All bars ¾" ϕ unless otherwise noted.
4. Reinforcing steel to be 3" clear of face of concrete unless otherwise noted.
5. All exterior corners to be chamfered 1".
6. M.H. stations as tabulated on this sheet may be moved to facilitate laying of pipe. Tabulated values of Ground Elev., Invert Elev., and P are to be changed to conform with new stationing. Such changes are to be submitted to the Engineer for approval.
7. Ground Elevations shown on this sheet are approx. and are to be verified in the field.
8. Reinforcing steel for Monolithic pipe not shown on this sheet. Refer to VG 807.
9. Concrete cradle and tunnel lining where used, to terminate 1" from outside face of M.H.
10. For additional details see Plan & Profile.
11. For dimensions, reinforcment, and details of pipe see VG 807 and VG 808.

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA

SOUTH INTERCEPTOR
INTERMEDIATE MANHOLES
SHEET 1 OF 2

DRAWN BY C.F.G.
CHECKED BY A.K. Yee
RECOMMENDED BY D.A. Root
APPROVED BY
TRACED BY S.G.
DATE 7-12-49
SCALE As shown
No. VG 804

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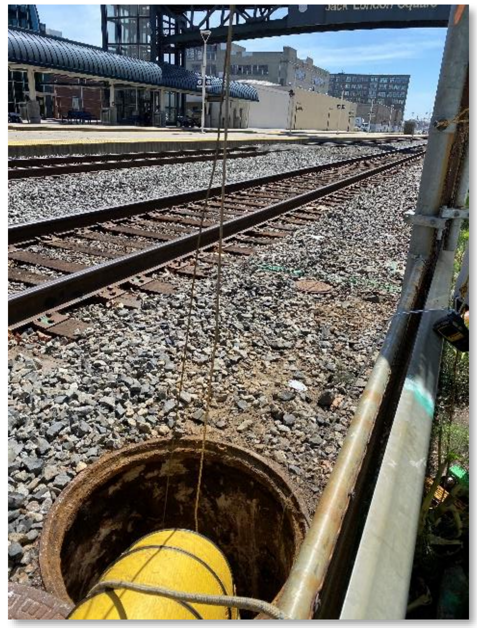
V&A Project No. 22-0108



V&A
consulting engineers
1000 Broadway
Suite 320
Oakland, CA
510.903.6600
510.903.6601, Fax