Pipeline Rebuild Program Update

Planning Committee

July 8, 2025

Dustin La Vallee, Senior Civil Engineer

Dennis Knisely, Construction and Maintenance Superintendent

Agenda

- Pipeline Rebuild Overview
- Fiscal Year (FY) 2025 Review
  - Project Selections and Design
  - Pipeline Construction
  - Research and Innovations
- Next Steps

Ductile Iron Pipe Installation

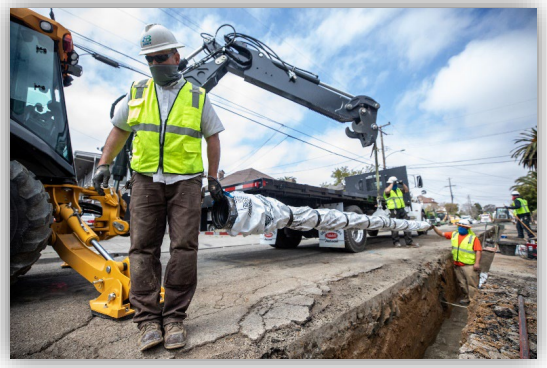
Pipeline Rebuild Overview

- Established in FY 2015 to reach a sustainable long-term pipeline replacement rate
- Reduce main breaks and water loss
- Perform pilot studies on pipeline renewal technologies and process improvements
- Promote teamwork, research, and innovation across District
- Leverage improvements

Trench Excavation

Steel Pipe Installation

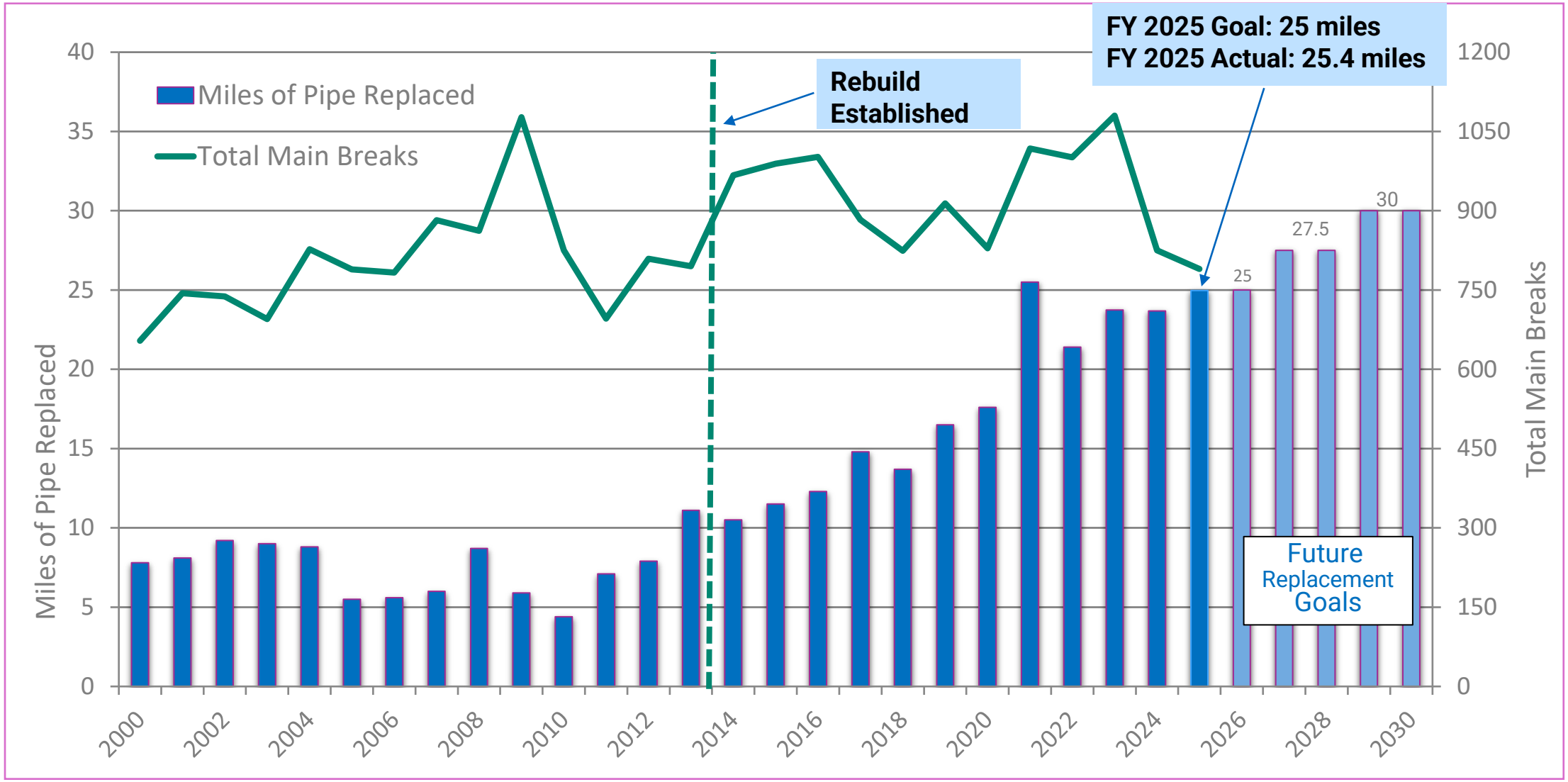
Pipeline REBUILD



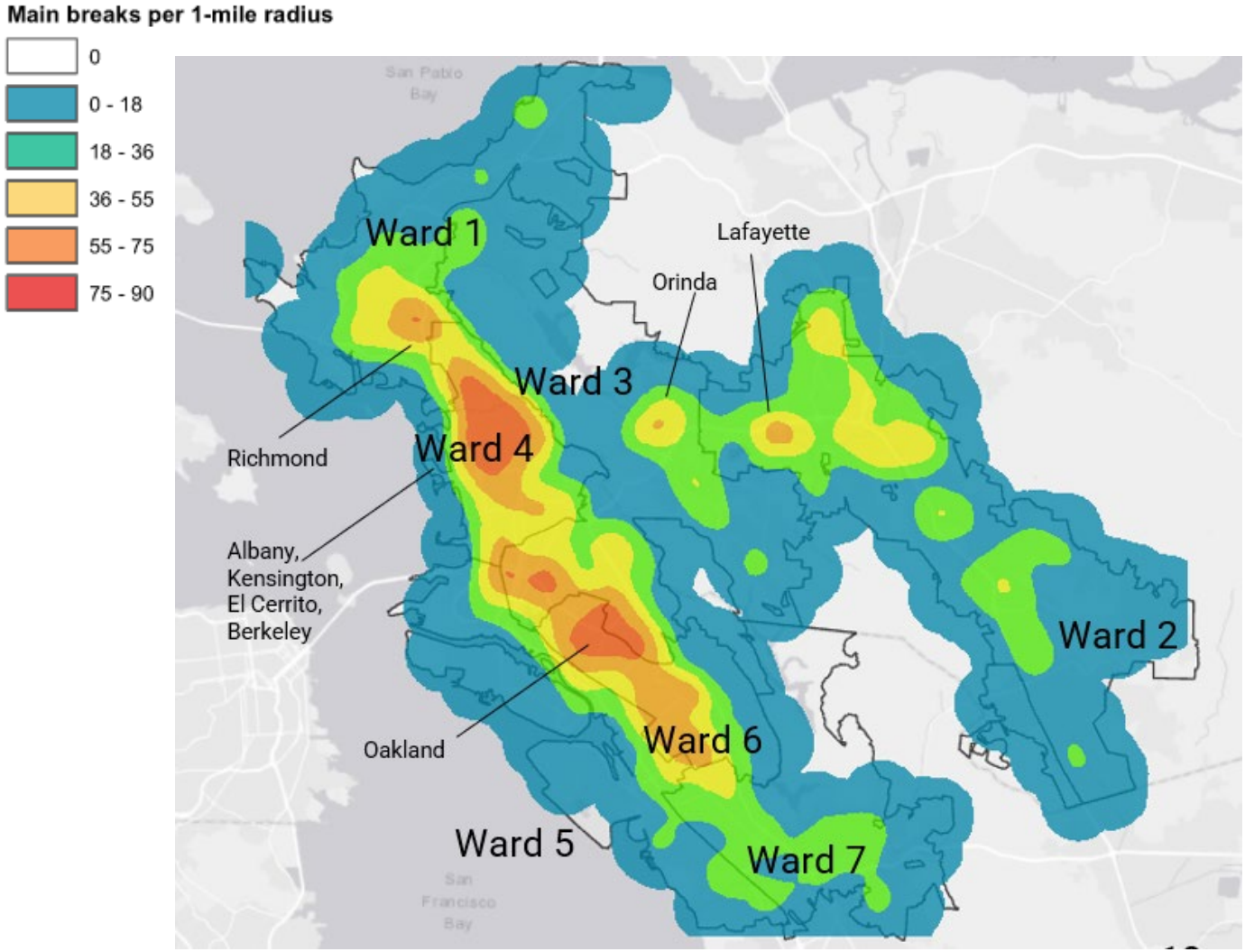
Ductile Iron Pipe Installation

EBMUD

Pipe Replacement vs Leaks



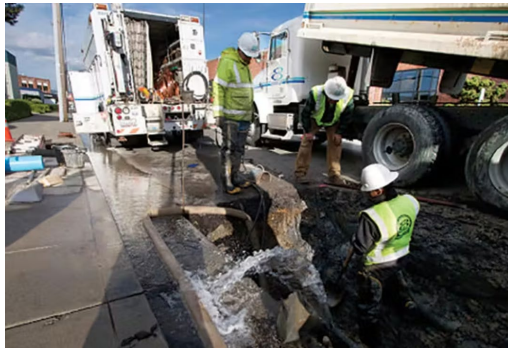
Main Break Density (2018 to 2024)



Ward	Breaks / 100 miles (2018-2024)	Miles Installed (FY 2018-2025)	Miles Installed (FY25)
1	19	23.4	4.2
2	22	25.8	7.2
3	27	25.5	2.4
4	36	35.3	3.3
5	14	9.7	1.4
6	32	34.7	6.2
7	14	7.2	0.7

Note: the table does not include pipeline abandonment and pipelines replaced under the Relocations and System Improvements Programs. The American Water Works Association (AWWA) benchmark for a well-maintained water system is in the range of less than 15 to 30 breaks per 100 miles of pipe.

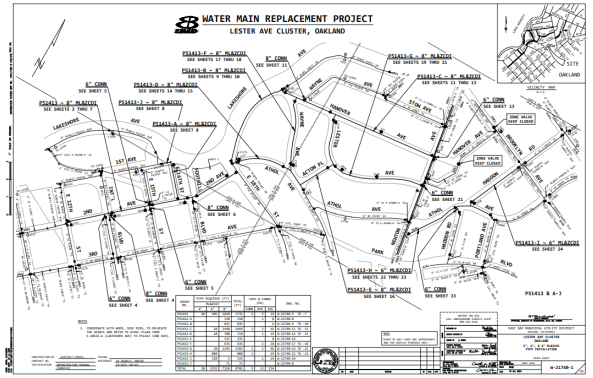
FY 2025 Project Selection and Design



Collect Leak Data

Attach leak data to ArcGIS pipeline map

Run pipeline risk model and select project clusters



Prepare Design Drawings

- Utilized a Likelihood of Failure (LOF) model incorporating pipe leak data, pipe age, and material type, alongside Consequence of Failure (COF) criteria such as proximity to critical customers, major roadways, and environmental factors, to prioritize projects.
- Completed 25 miles of detailed design drawing packages for pipe replacement
- Performed close coordination with District pipeline crews including design and pre-construction job walks to confirm alignments
- Continued coordination with cities, counties, and other utility agencies to schedule and plan projects ahead of planned paving

Research and Innovation

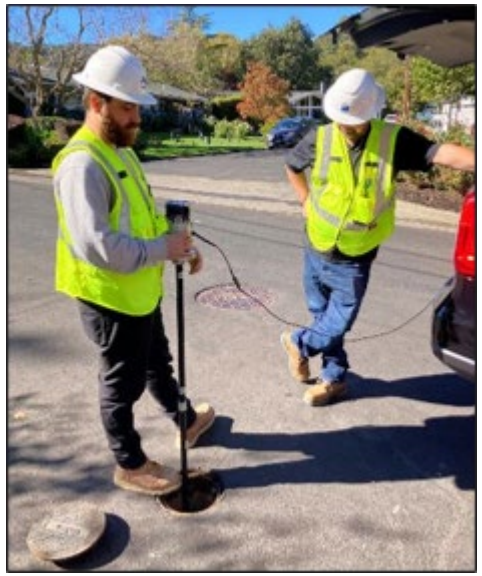
Condition Assessment Pilots

- Completed pilots of non-invasive condition assessment in Lafayette and Berkeley on approximately 8,000 feet of pipelines
  - Pipelines evaluated included steel, AC, CI, and PVC
- Beginning non-invasive condition assessment pilot in Pleasant Hill in June 2025. Pilot will evaluate approximately 7,000 feet of pipelines

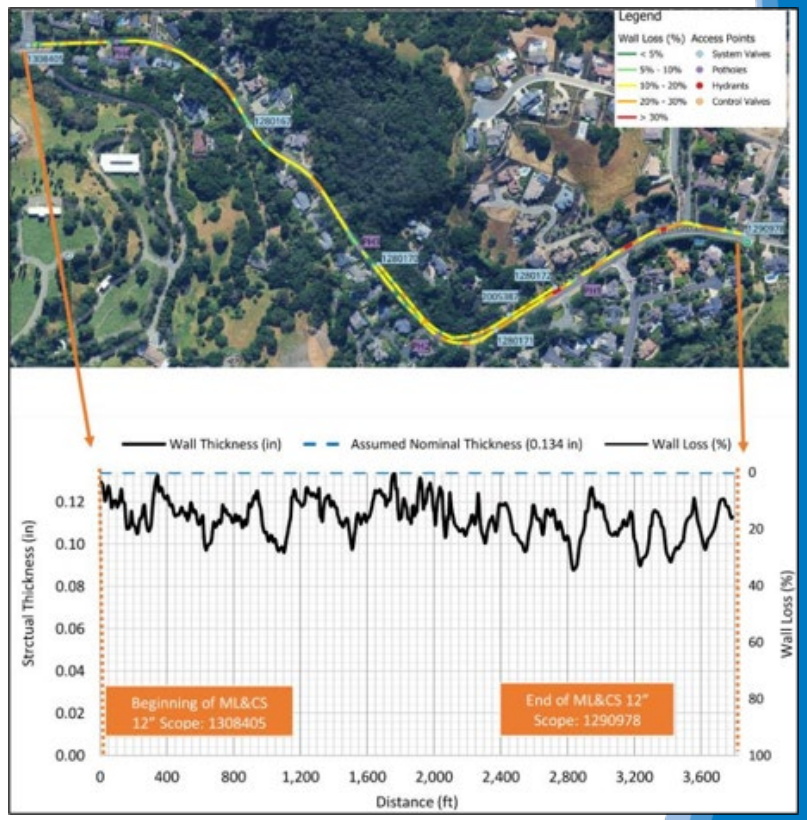
Data Loggers

Sensor Connection

Thickness Measurements



Condition Assessment

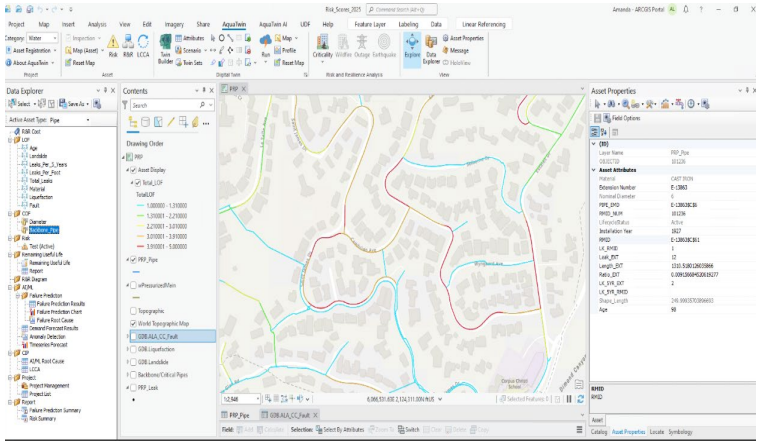


Pipe Stiffness Measurements

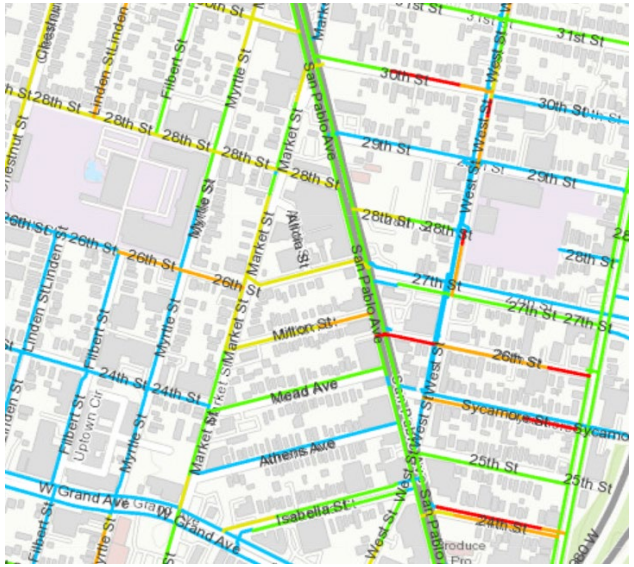
Research and Innovation

Risk Model Improvements

- Incorporated consequence of failure factors into risk model for FY 2026
- Piloted asset management software allowing for more flexibility on LOF and COF adjustments
- Issued RFP for artificial intelligence (AI) / machine learning (ML) risk model
- Finalizing agreement with UC Berkeley to work on LOF and COF with CSI
  - SFPUC and LADWP also looking to coordinate on this study



AquaTwin Asset



District Risk Model

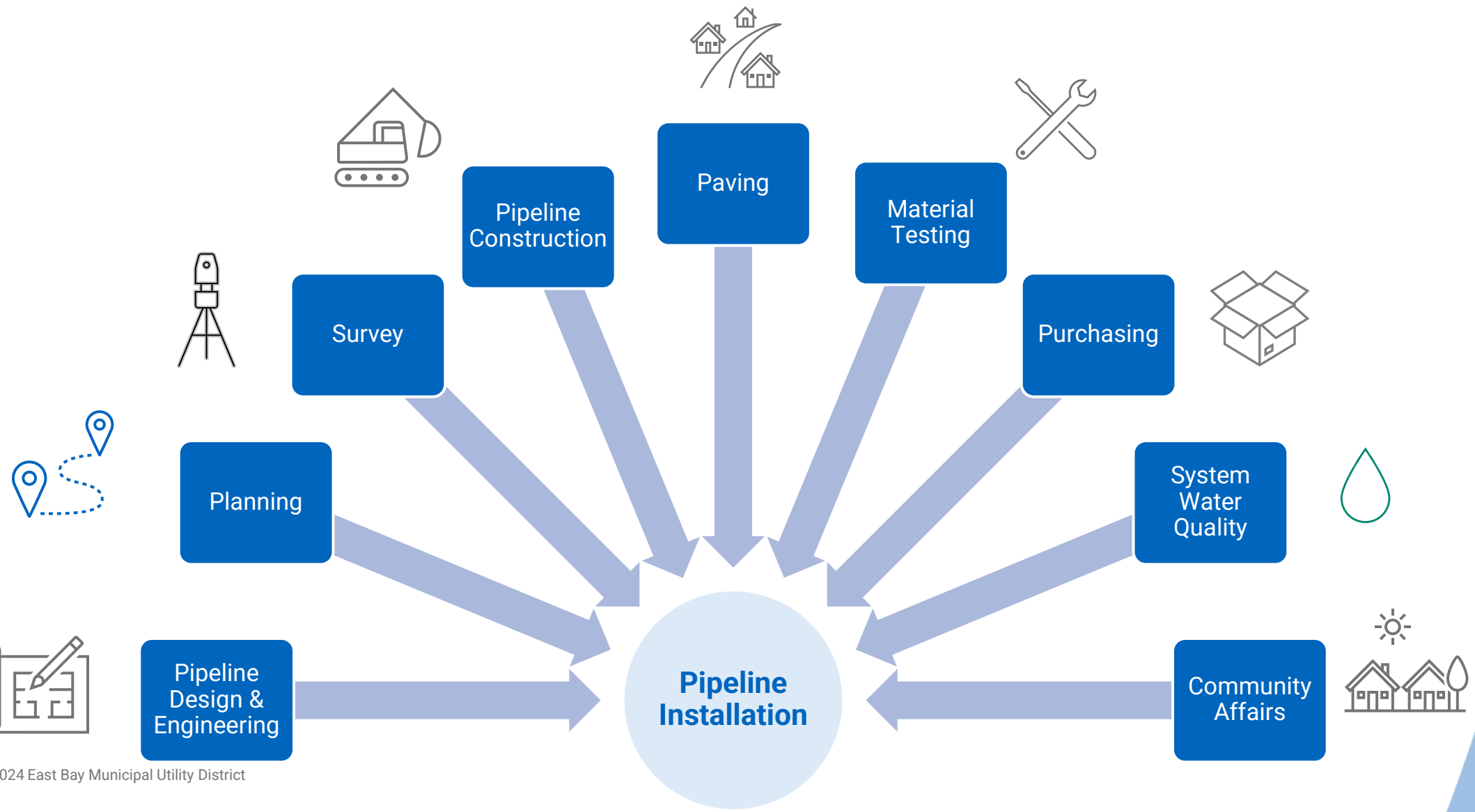
Pipeline Construction Overview

Pipeline Construction Division Staffing

- 12 Pipeline Crews, 1 Service Crew
  - Pipeline Crew = 8 Staff Members
  - Service Crew = 5 Staff Members
- 6 Utility Laborers
- 8 Paving Crews
  - Paving Crew = 8 Staff Members

Pipeline Construction Crew

Pipeline Rebuild Stakeholders

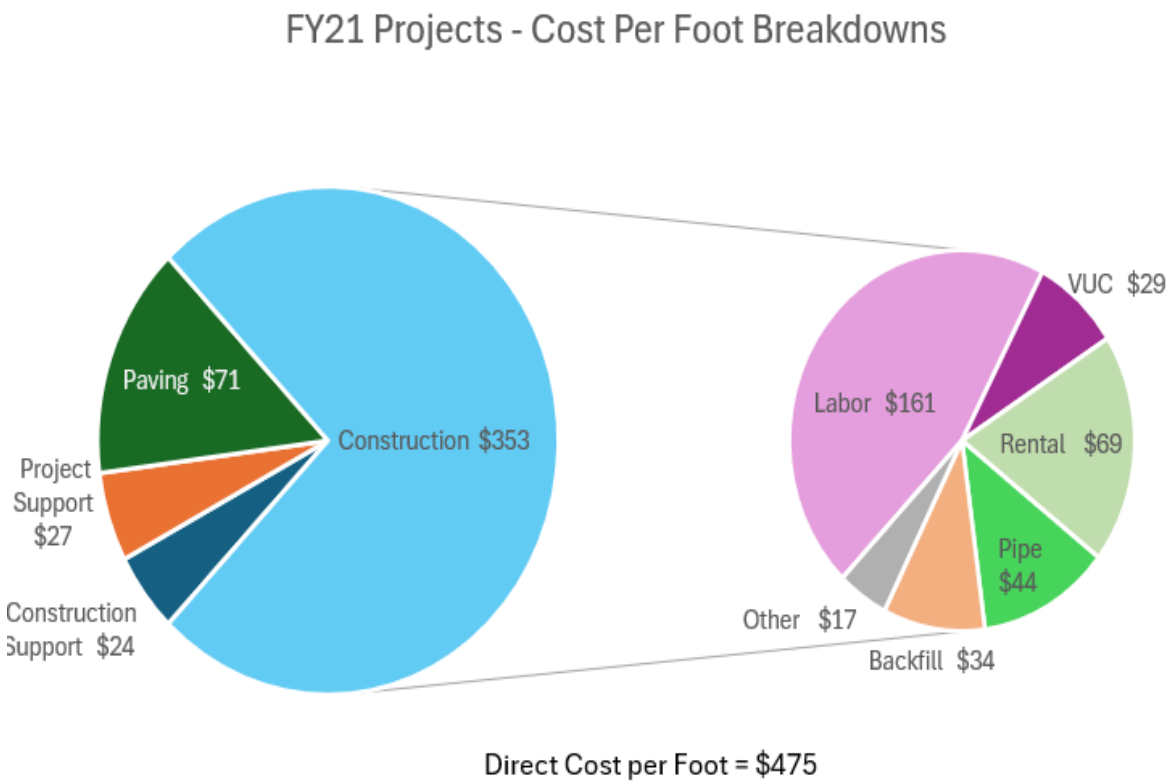


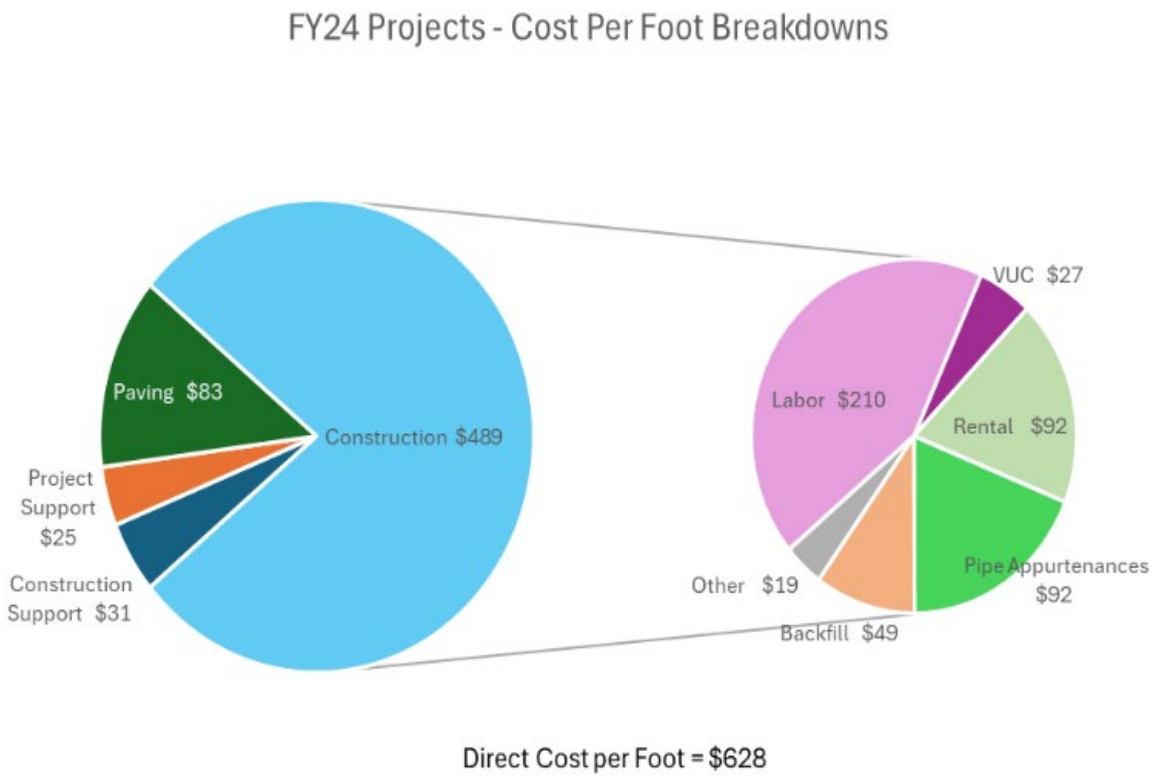
Pipeline Rebuild Cost Summary

	FY 2021		FY 2024		FY 2025	
Project Category	Spent	Miles Installed	Spent	Miles Installed	Spent	Miles Installed
Infrastructure Renewals (IR)	$57.2M	23.20	$80.6M	23.60	$88.6M	23.35
Relocations	$2.0M	0.63	$5.4M	0.69	$6.5M	1.04
System Improvements	$13.0M	1.60	$3.0M	1.03	$2.4M	1.05
Trench Soils	$4.8M	-	$5.0M	-	$4.3M	-
KPI Mileage Goal	-	20 miles	-	22.5 miles	-	25 miles
Totals	**$77.0M**	**25.40**	**$94.0M**	**25.30**	**$101.8M**	**25.40**
IR Average Cost ($/mi)	*$2.5M /mi*		*$3.4M /mi*		*$3.8M /mi*	
IR Trench Soils ($/mi)	*$0.19M /mi*		*$0.18M /mi*		*$0.16M /mi*	
IR Average Cost w/ Trench Soils ($/Mile)	**$2.7M/mi**		**$3.6M/mi**		**$4.0M/mi**	

Increase in IR cost of $8 million between FY 2024 and FY 2025 due to higher material costs (more 12-inch diameter mains and higher percentage of DI pipe) and higher labor & rental costs

FY 2021 to FY 2024 Average IR Unit Costs





Increase in average IR unit cost from $2.5 to 3.4 million/mile driven by a range of factors including:

- Higher material and labor costs
- Increase in equipment rental costs
- Increasingly stringent permit conditions
- Factors impacting crew efficiency including changes in pipe materials, more challenging IR projects, etc.

Next Steps

- FY 2026 Mileage Goal of 25 miles
- Expand Direct Hauling of Trench Soils
- Advance risk model through AI / ML and continue to incorporate COF factors related to customers impacts
- Continue to pilot condition assessment technologies to better understand the condition of distribution pipelines
- Identify design and construction efficiencies that can be implemented starting in FY 2027 to increase productivity

Questions?

Pipeline Installation

Center for Smart Infrastructure Update

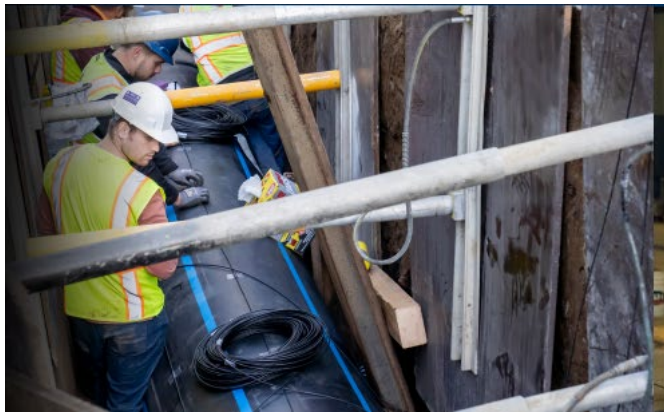
Planning Committee

July 8, 2025

Pongsiri Prachya, Senior Civil Engineer

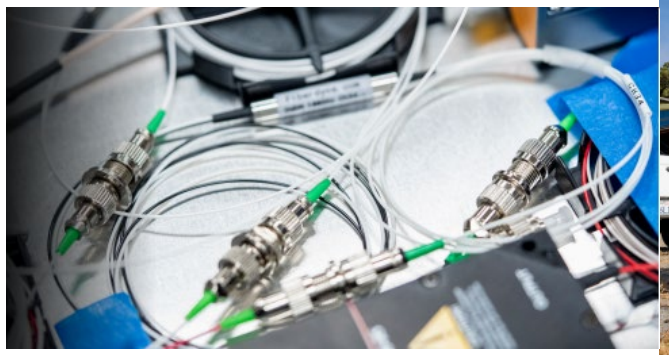
What is Center for Smart Infrastructure (CSI)?

- Partnership between
  - Infrastructure Owners
  - Academia
  - Industry
  - Consultants
- Goal: address challenges facing water and wastewater utilities
- Interdisciplinary hub for infrastructure research and innovation



Fiber Optics Installation on EBMUD Pipeline

Pipe Testing Apparatus



Fiber Optic Cables

“Spot” the Robot Dog

Overview

- Phase 1 Update
- Phase 2
- Next Steps

Berkeley
CENTER FOR
Smart Infrastructure

EBMUD

Phase 1 Accomplishments

- Constructed pipeline testing facility at Richmond Field Station
- Conducted pipe and appurtenance tests
- Installed and monitoring advanced sensing on Summit pipeline project
- Launched CE 112 class on water and wastewater design and operations
- Held multiple workshops

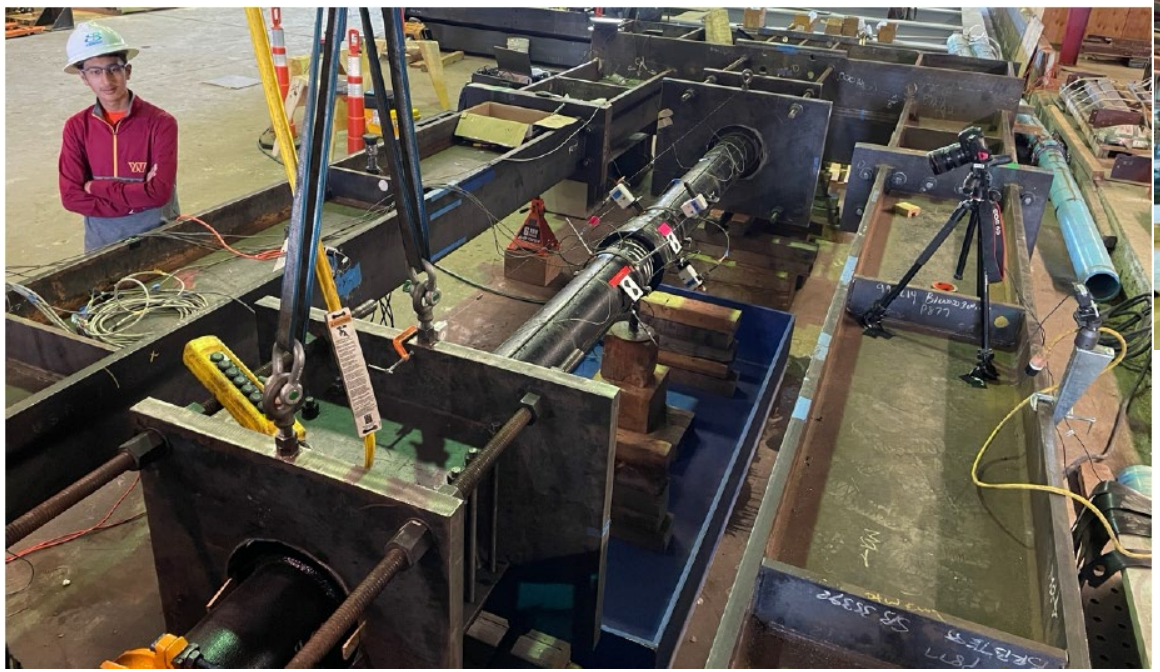
CSI Richmond Field Station Facility “Then”

CSI Richmond Field Station Pipe Testing Facility

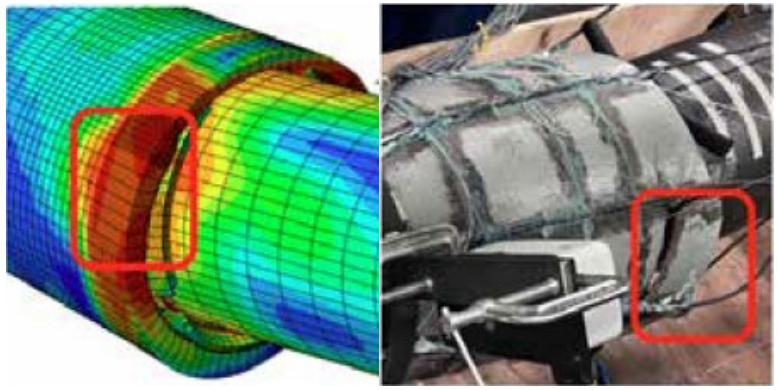
Video of Pipe Testing Facility

Pipe Testing Center

Four-Point Bending Testing Apparatus



Tension/Compression Testing Apparatus

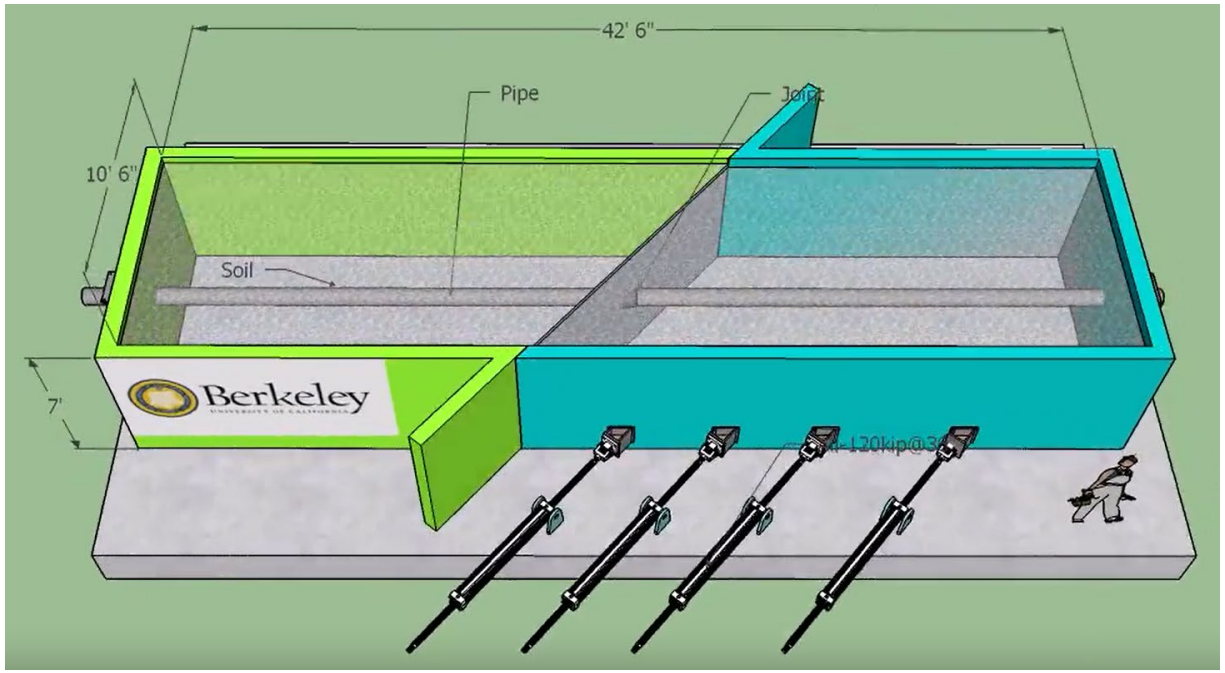


Finite Element Model – Detailed Analysis of Failure

Pipe Testing Center

Split Basin

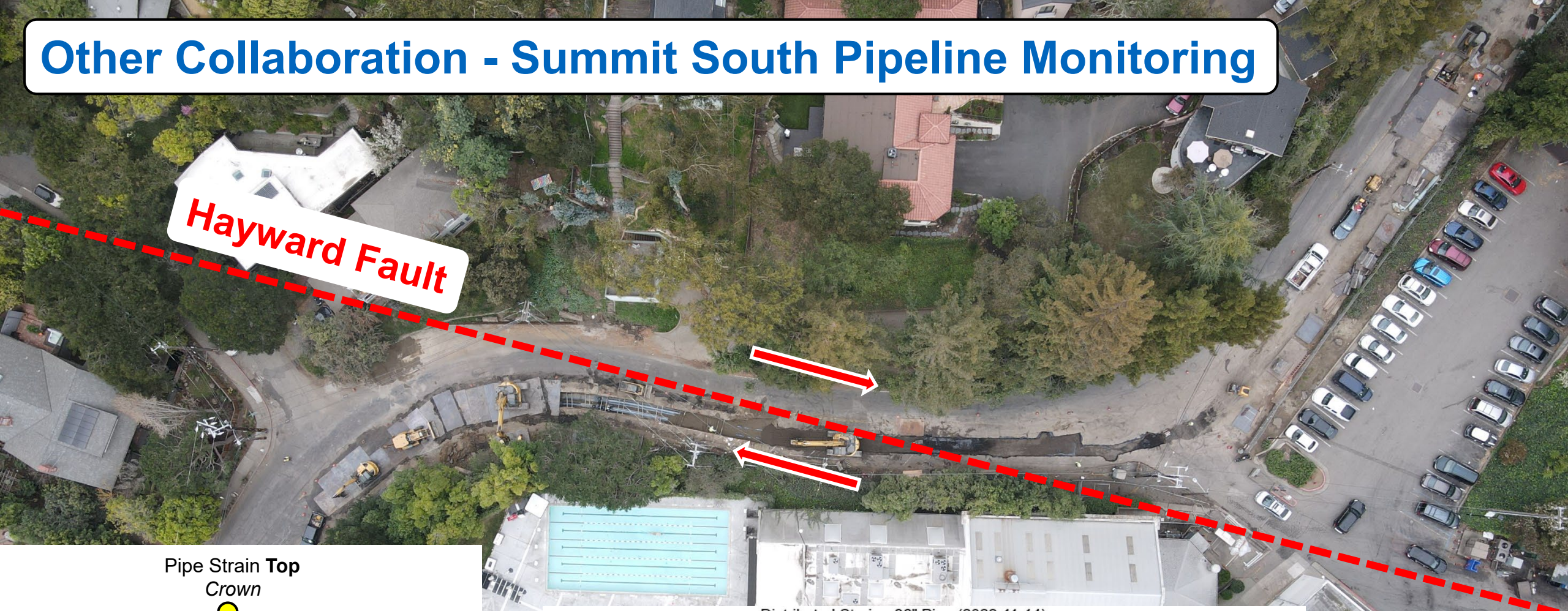
- Capable of simulating fault rupture effects (similar to Hayward Fault)
- Soil-pipe interface

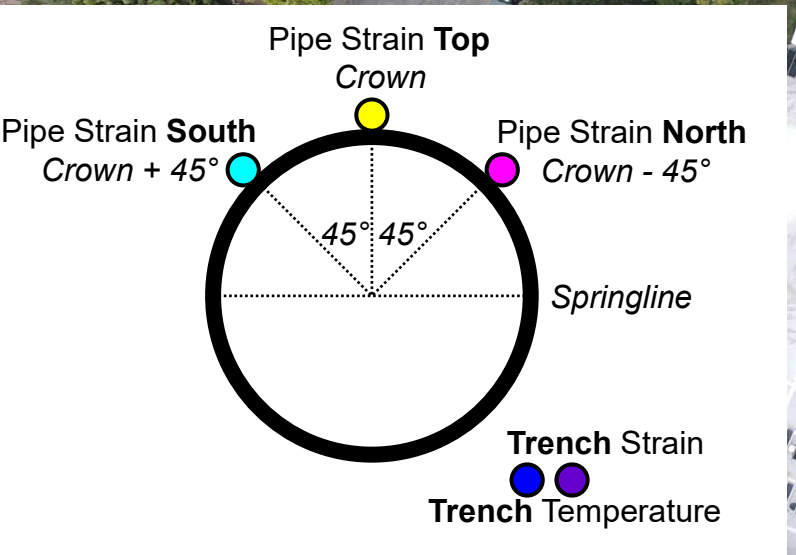


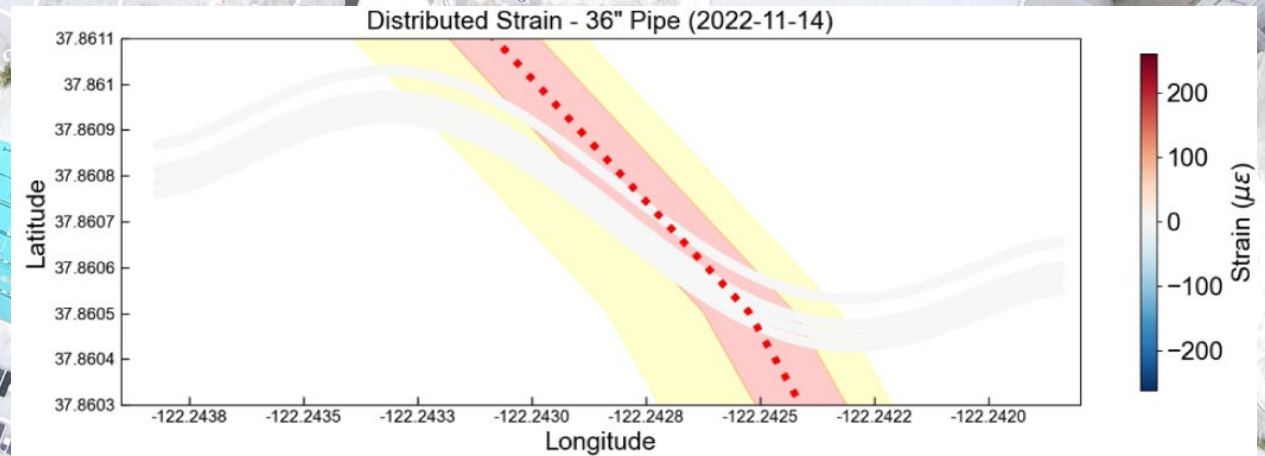
Testing Apparatus

Split Basin before Backfill

Other Collaboration - Summit South Pipeline Monitoring







CE 112 - EBMUD Class & Internship

Water and Wastewater Systems Design and Operation

- Water Supply and Natural Resources
- Water and Wastewater Systems Design and Operations

CE 112 in classroom

CE 112 class at Sobrante Water Treatment Plant

- Infrastructure Maintenance, Renewal, and Replacement
- Sustainability and Resilience
- Emergency and Community

Phase 2 – Project Specific Research

Pipeline

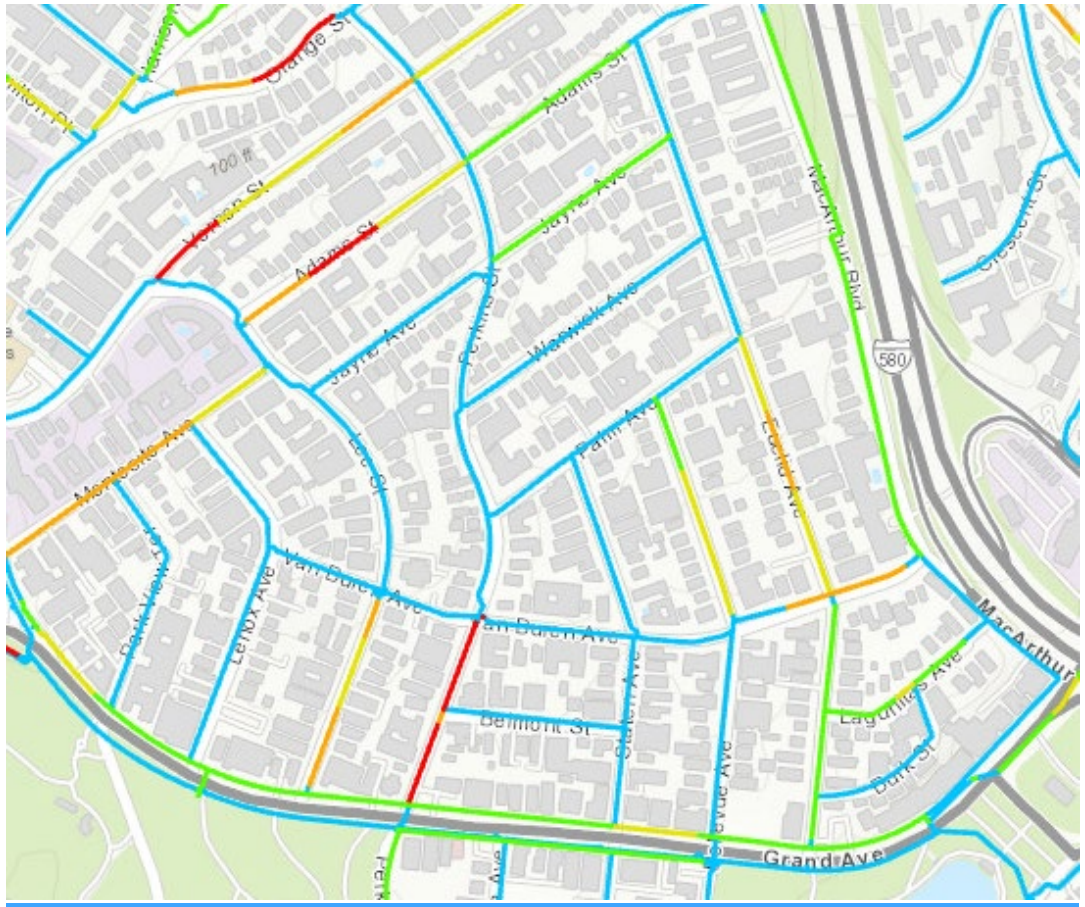
- Cement Mortar Lining of Mokelumne Aqueduct
- Monitoring Settlement of Mokelumne Aqueduct using satellite
- Pipeline Likelihood and Consequence of Failure
- Pipeline Fragility Curves for Seismic Resilience
- Pipeline Performance in Landslide
- Cured In-Place Pipeline (CIPP)
- Field Lok Gasket Testing

Geotech and Wastewater

- Unlined Spillway Channel Performance and Upgrades
- Embankment Dam Fragility Curves and Post-Earthquake Response
- Untethered Video Inspection of Sanitary Sewer System

Distribution Pipeline LOF and COF

- Definitions:
  - LOF is Likelihood of Failure
  - COF is Consequence of Failure
- Current risk models calculate LOF, but do not forecast pipeline degradation rates
- Develop an LOF model that can forecast pipeline degradation
- Develop COF model to predict risk and impact



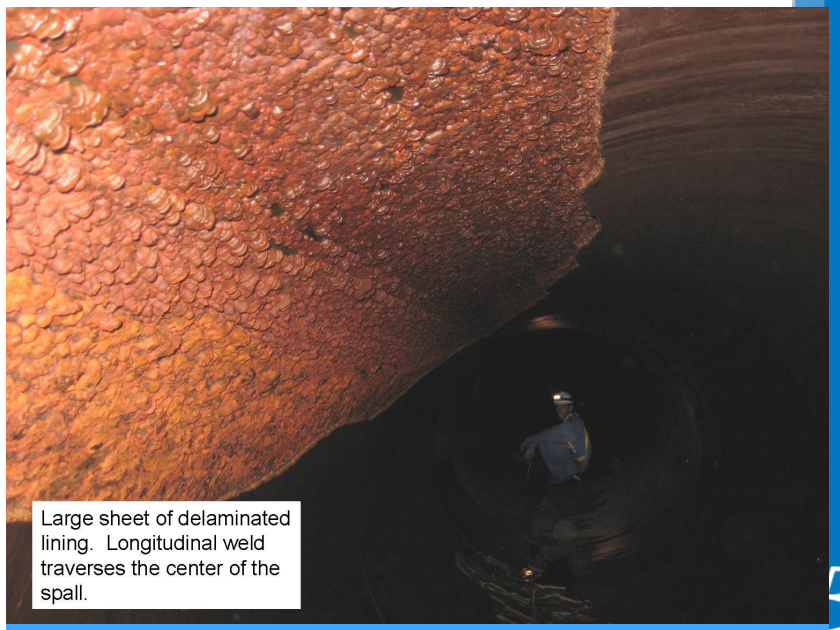
Current District LOF Model

CML Mokelumne Aqueducts

- 3 Mokelumne Aqueducts convey raw water from Pardee
- Cement Mortar Lining (CML) is failing, resulting in corrosion of steel pipe
- Failure is greater in the aboveground sections
- Need for improved CML mix design capable of withstanding daily thermal expansion and contraction of steel pipe
- CSI will perform thermal and cyclic testing

Aboveground Section of Mokelumne Aqueduct

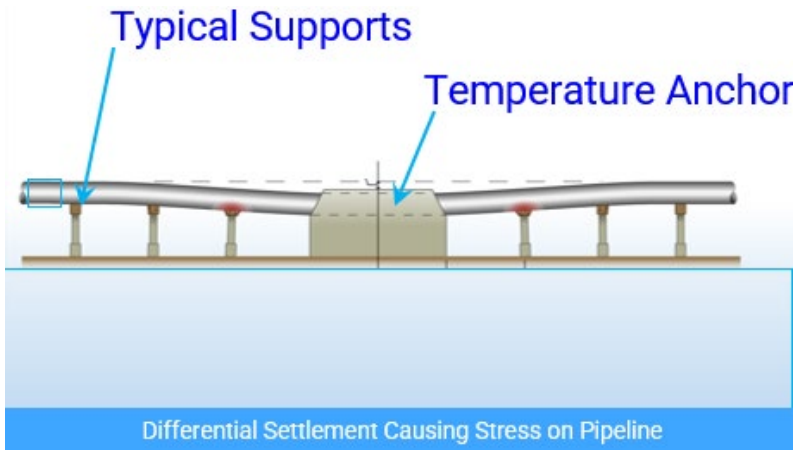
Cement Mortar pieces form debris dams reducing hydraulic capacity

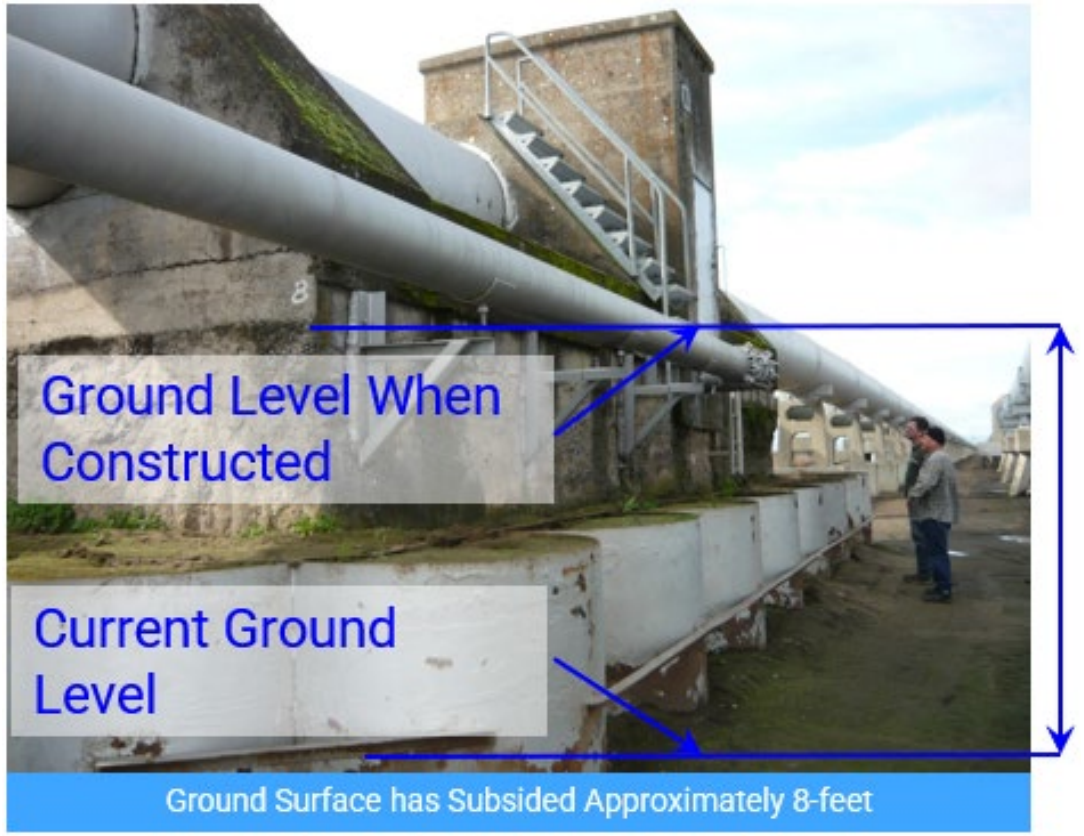


Internal Corrosion of Steel Pipe at CML Failure

Satellite Monitoring of Mokelumne Aqueduct Settlement

- Exposed piles
- Subsidence creating structural concerns
- Failure: costly to repair and may impact operation
- Remote monitoring via satellite





Unlined Spillway Channel Performance and Upgrades

- Pardee and Camanche Spillways
- Experienced erosion with relatively minor floods
- Potential for larger flood to damage spillway, which is costly to repair
- Floods predicted to worsen due to climate change
- Develop predictive models for erosion and scour potential
- Develop effective mitigation measures

Pardee Spillway

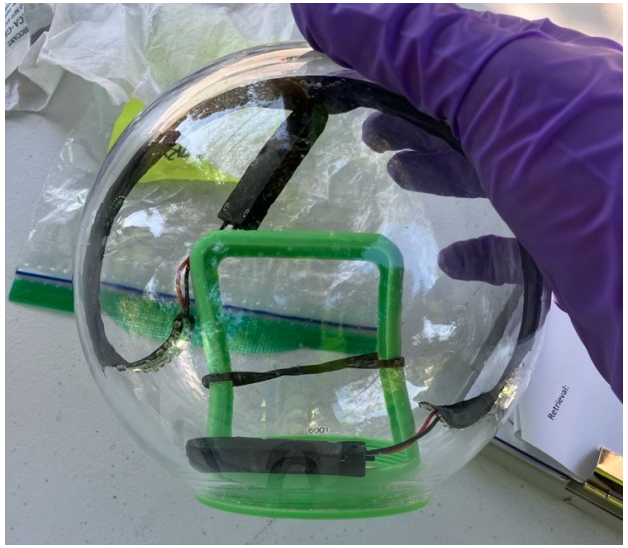
Embankment Dam Fragility Curves and Post-Earthquake Response

- 22 Earth Embankment Dams
- Limited ability to perform rapid earthquake risk assessment
- Develop a post-earthquake inspection criterion
- Develop a real-time monitoring program

39th Avenue Reservoir, Oakland

Untethered Camera Sewer Inspection

- New method of sewer inspection
- Inspection with action camera during low flows
- Longer inspection length than corded camera crawler
- CSI to evaluate and develop a SLAM algorithm to pinpoint sources of rapid inflow and infiltration
  - Simultaneous Localization and Mapping (SLAM) via multi-sensor fusion with visual, gyroscopic, and accelerometer data



Action camera mount in a 6” acrylic sphere

Camera in sewer during inspection

Next Steps

- Continue to engage with agencies, manufacturers, and researchers
- Further the development of remote sensing and pipeline monitoring technologies
- Expand the large-scale pipeline testing capabilities
- Expand the collaboration to other areas of water and wastewater
- Expand the collaboration to other emerging issues
- Board consideration of Phase 2 collaboration agreement for $2.8 million

Photo: October 11, 2024 CSI Workshop on Pipeline Testing for Hazard Resilience

Questions?

EBMUD

Flowing into the Future

Photo Credit: City of Sacramento

Water Forum 2050

Planning Committee

July 8, 2025

Max A. Fefer, Associate Civil Engineer

EBMUD

Agenda

- Background of District's Interest
- What is the Sacramento Region Water Forum?
- Water Forum 2050
- District Participation in Water Forum 2050 and Benefits
- Next Steps

District Interest in Sacramento Region

- Freeport + Folsom South Canal
- Central Valley Project contract
- Long-term partnership with Placer County Water Agency (PCWA)
- Other potential supplemental supplies

What is the Water Forum?

- Diverse group of 40+ business and agricultural leaders, citizen groups, environmentalists, water managers, and local governments in the Sacramento region.
- Two co-equal goals
  - Provide a reliable and safe water supply for the Sacramento region's economic health and planned development.
  - Preserve the fishery, wildlife, recreational, and aesthetic values of the Lower American River.
- Original Water Forum Agreement was signed in 2000 and expires soon.
- Water Forum 2050 is a successor agreement to account for new challenges like climate change.

Photo Credit: City of Sacramento

Benefits of Original Water Forum Agreement

- Created a strong regional culture of trust, collaboration, and transparency.
- Advanced critical infrastructure projects without litigation.
- Built significant habitat enhancements on the Lower American River.
- Provided environmental flows and drought water supply for the District from PCWA 2014, 2015, and 2022.

Salmond habitat restoration
Photo Credit: City of Sacramento

Why Water Forum 2050?

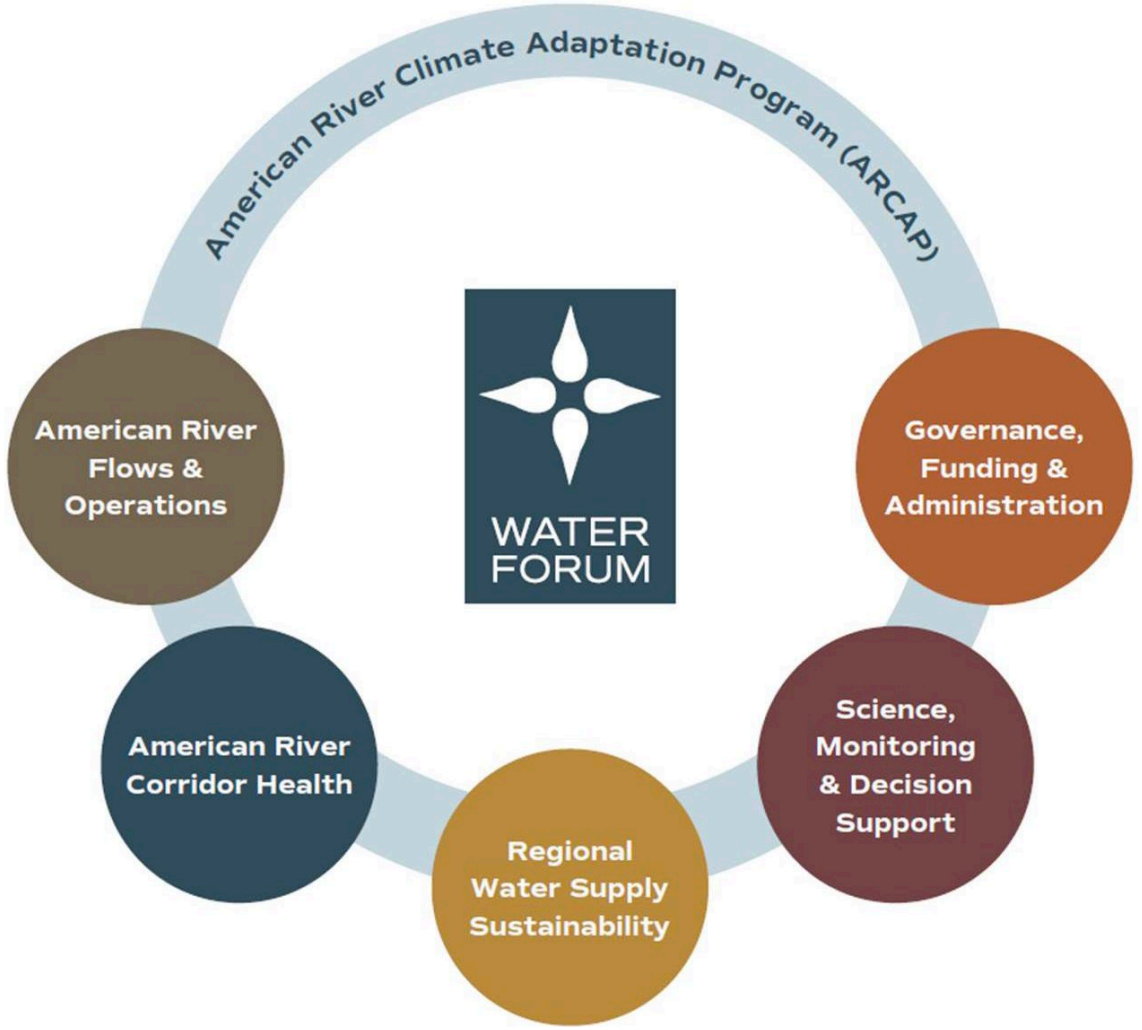
Climate change, droughts, and extreme weather are key drivers for a new agreement.

Folsom Dam
Photo Credit: City of Sacramento

Lower American River
Photo Credit: City of Sacramento

Water Forum 2050 Program Areas

- Continues and modernizes the work of the Water Forum through 2050.
- An updated framework for:
  - Collaboration
  - Action
  - Adaptive Management
  - Regional Planning
  - Developing drought resilient water supplies (ARCAP)
- Goal - Contribute tangible volumes of water toward the co-equal objectives.



American River Climate Adaptation Program (ARCAP)

- Create and deploy measurable quantities of water through regional actions to support the co-equal objectives.
  - Opportunities for the District to participate in potential supplemental supply projects such as the Sacramento Regional Groundwater Bank.
- Strategic safeguard against worsening climate conditions and decreased storage in Folsom Reservoir.
- An "insurance policy" to protect regional water supplies and the lower American River during extreme dry periods.

District Participation and Benefits

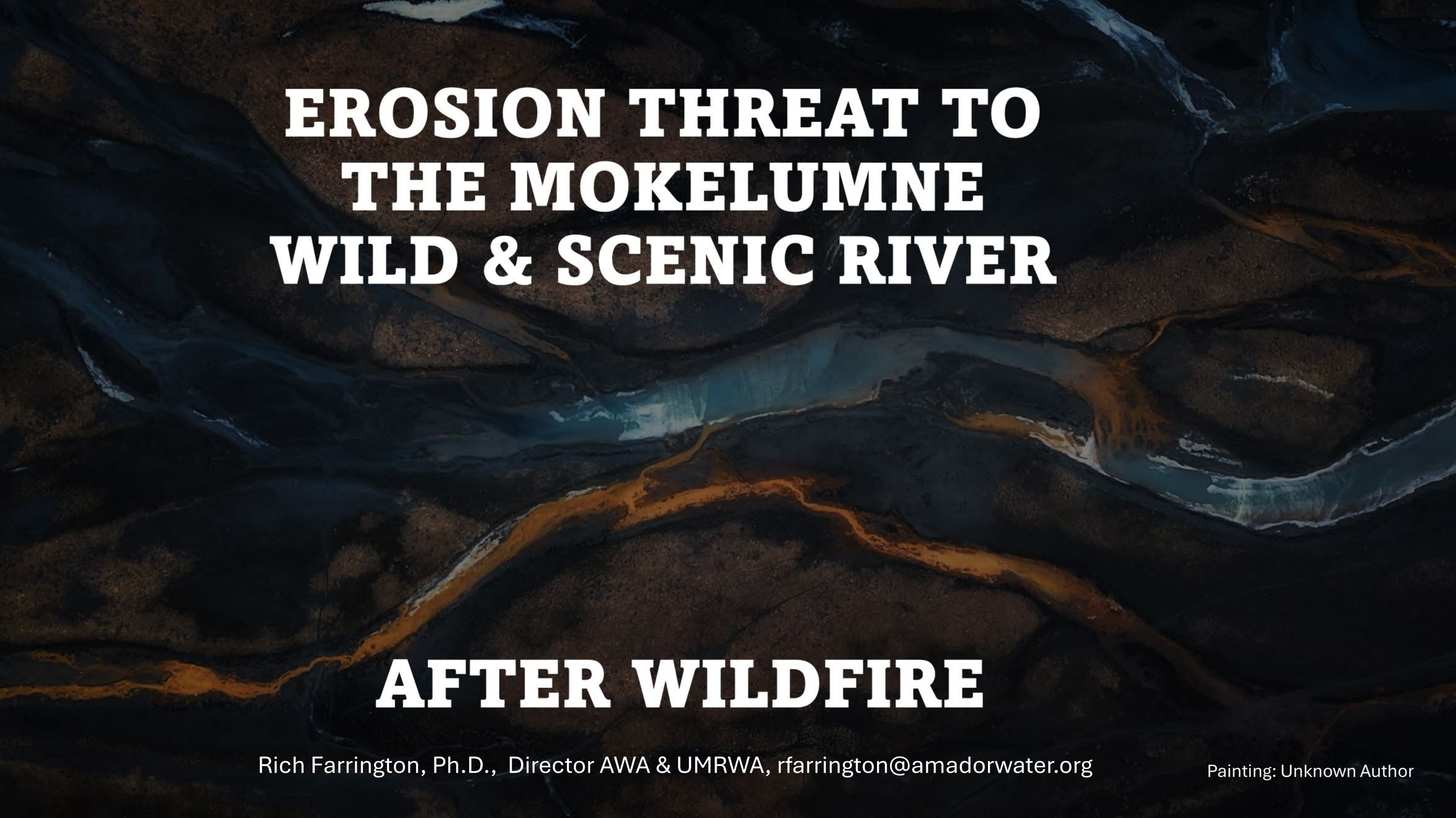
- Support the co-equal objectives of the Water Forum.
- Continue water conservation plans consistent with state law.
- Regional support for diversion of water from the Sacramento River at Freeport during droughts:
  - Seat at the table to support long-term water transfer project with Placer County Water Agency (up to 47,000 acre-feet in dry years).
  - Reinforces District's presence in regional water supply planning to represent our interests.
- Build and strengthen District's partnerships with Sacramento region water agencies that are developing drought water supply projects.
- Provide annual funding ($29,602 in Fiscal Year 2026) for Water Forum staffing, river data gathering, hydro-dynamic modeling, habitat restoration planning, and more.

Next Steps

- Staff recommends District participation in Water Forum 2050
- Board feedback and discussion

Questions?

Lower American River
Photo Credit: City of Sacramento



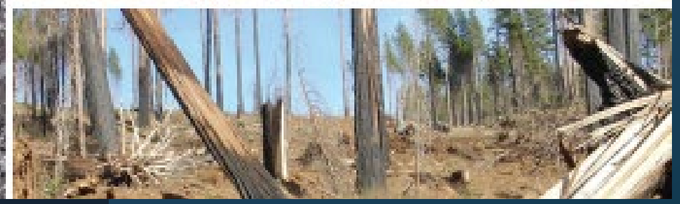
EROSION THREAT TO THE MOKELUMNE WILD & SCENIC RIVER

AFTER WILDFIRE

Rich Farrington, Ph.D., Director AWA & UMRWA, rfarrington@amadorwater.org

Painting: Unknown Author

Upper Mokelumne River



2014 MACA Study, Sierra Nevada Conservancy
https://sierranevada.ca.gov/what-we-do/mokelumne-watershed-avoided-cost-analysis/
https://www.researchgate.net/publication/301676614

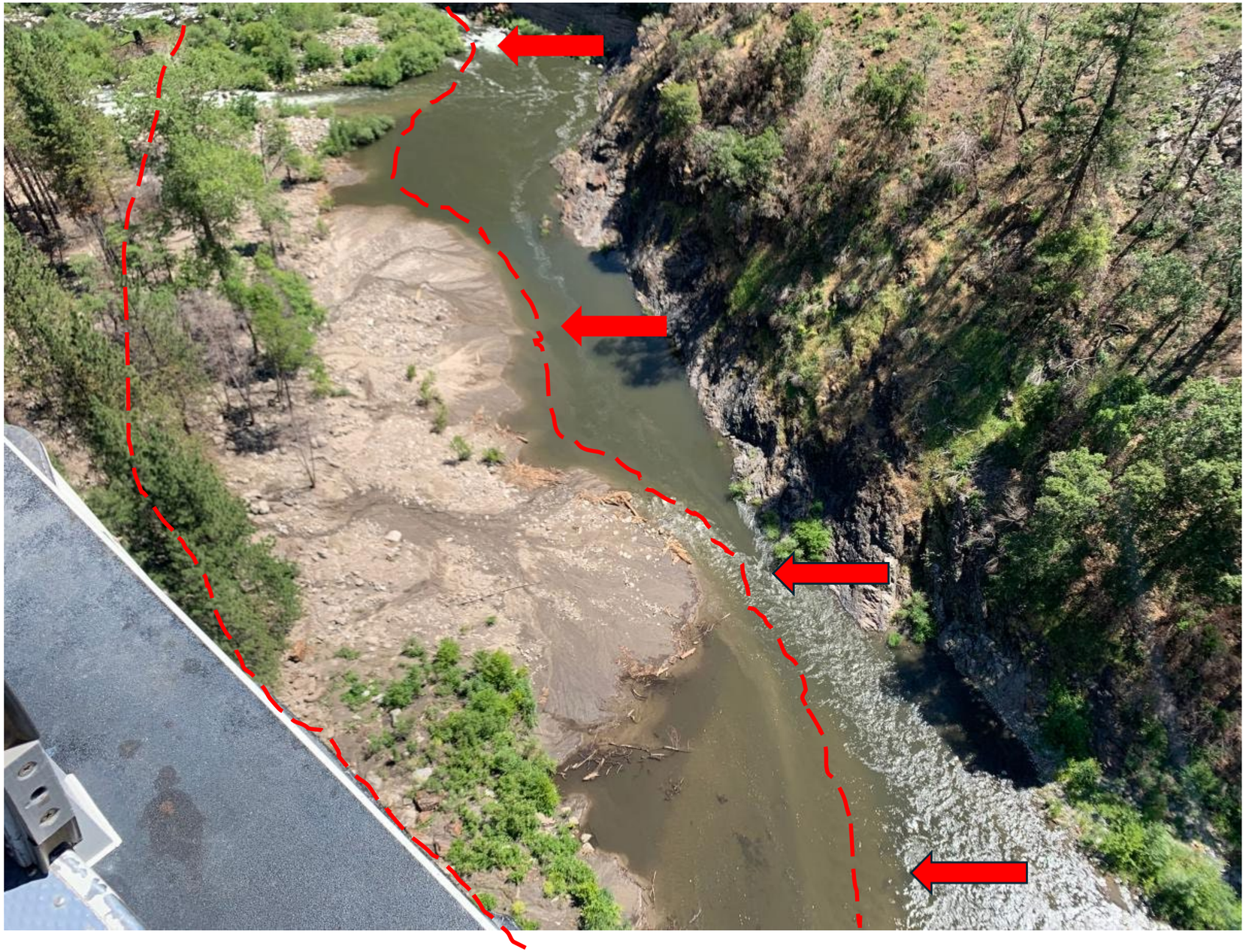
This could be the

Mokelumne River

from debris flows after the Dixie mega wildfire

(North Fork Feather River 1 year after 2021 Dixie Fire)

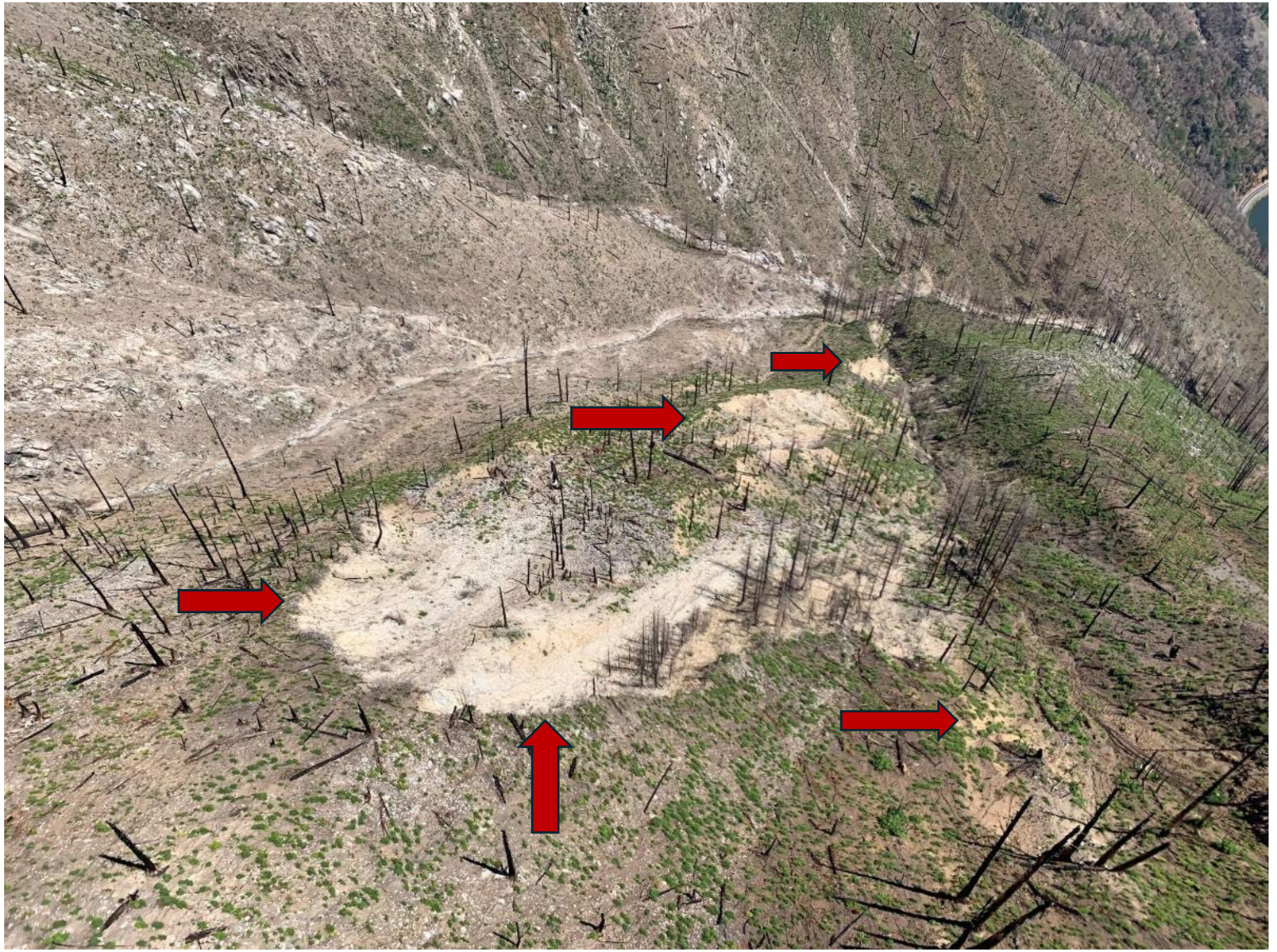
Photo: Cal Geological Survey, Don Lindsay; https://www.usgs.gov/programs/landslide-hazards/science/dixie-fire-post-fire-debris-flows-a-tale-two-storms



Debris-flow deposits in the North Fork Feather River

1 yr After
2021 Dixie Fire of
963,711 ac.

Cal Geological Survey



Origination of Debris Flow deposits

in North Fork Feather River

1 yr after the 2021 Dixie Fire

US Geological Survey: “Debris-flow risk can be elevated for several years after a wildfire”

Photo: Cal Geological Survey

Debris Flow Deposit Dixie Fire Burn Area in 2022

Debris Flow is a fast moving mixture of mud, water, boulders, and logs

Cal Geological Survey

Fish kill

In the Klamath River after the 2022 60,000 Acre McKinney Fire and a massive debris flow.

Photo: Karuk Tribe per LA Times 8/10/2022

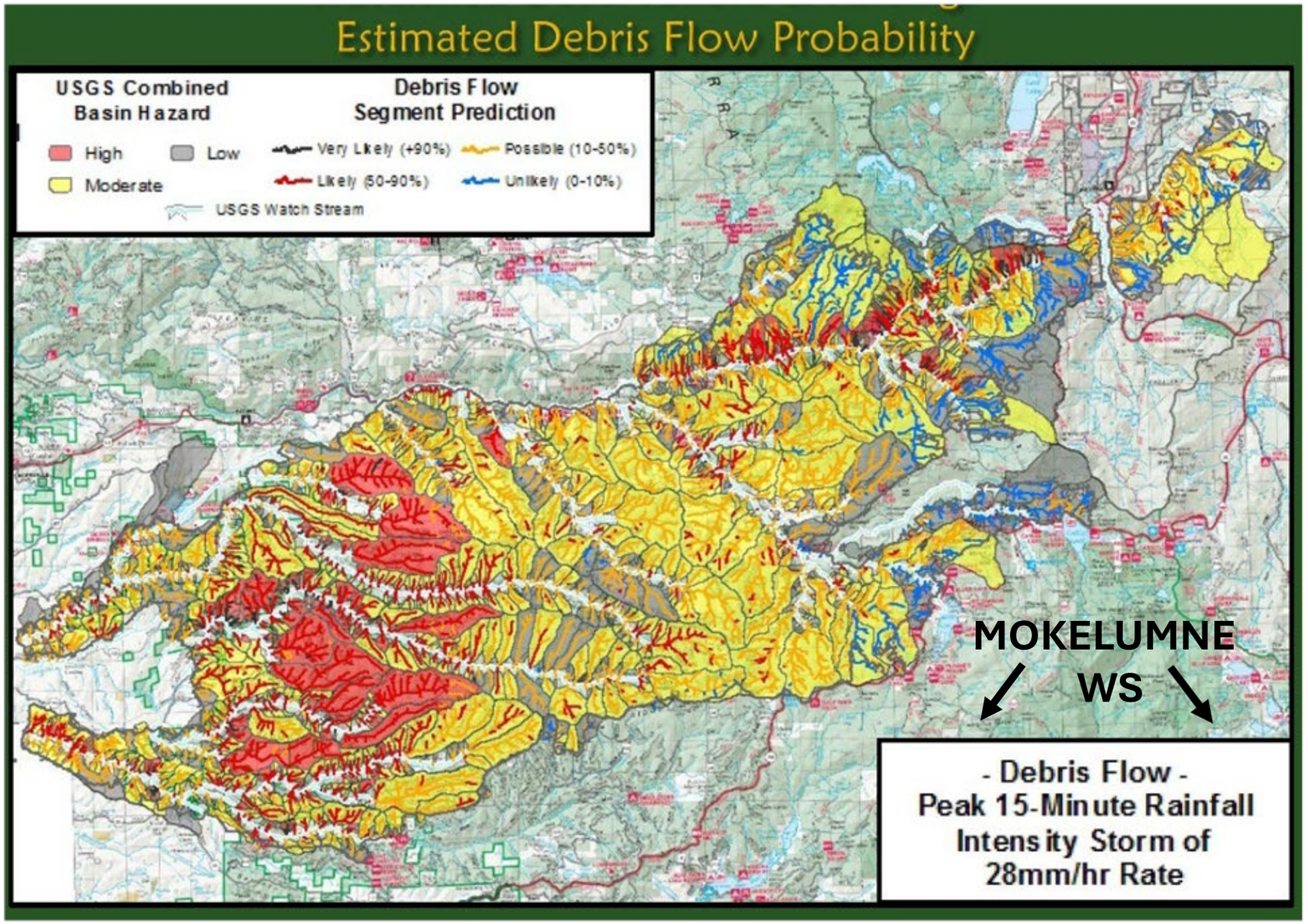
2022 Debris Flow scars
1 year after Dixie Fire,

North Fork Feather River

Note: Severely Burned Veg

Photo credit: Cal Geological Survey

2021 CALDOR FIRE (221,835 ac) USGS Debris Flow Probability in 15 min. of a 1 inch/hr storm: USGS



EXPLANATION

- Sediment Retention Basins
- Basin Outlet
- Fire Perimeter

Basin Volume (m^3)

- < 1,000 m^3
- 1,000-10,000 m^3
- 10,000-100,000 m^3
- > 100,000 m^3

Projection is WGS84 Web Mercator

Predicted volume, in cubic meters (m^3), of a debris flow in response to the design rainstorm with a peak 15-minute rainfall intensity of 24 mm/h

Burned Area Emergency Response (BAER) Assessment Report Summary, Eldorado National Forest and Lake Tahoe Basin Mgt Unit, USDA Forest Service, October 2021 (Source: USGS Hazard Map)

This could be the Mokelumne Watershed

Dixie Fire - 963,711 ac.

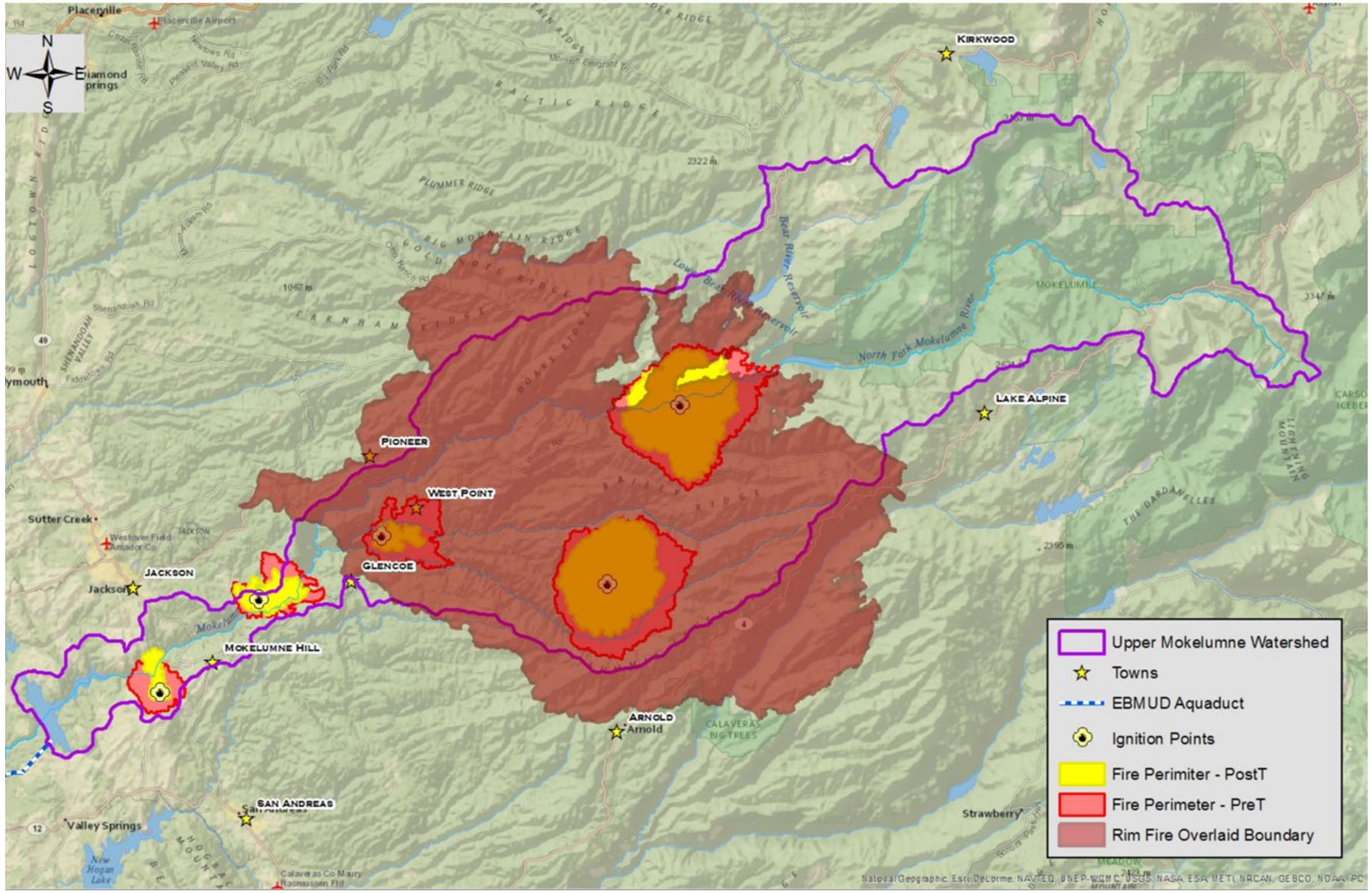
July 26, 2021

2022 USFS "Wildfire Crisis Strategy":
"Wildfires have been growing in size, duration, and destructivity over the past 30 years"

(https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/WCS-Second-Landscapes.pdf)

Photo: INCIWEB

2013 Rim Fire (257,314 ac.) Outline on Mokelumne Watershed & MACA Modeled Fires



Costs would be much higher from a fire the size of the Rim Fire

2014 MACA (Mokelumne Avoided Cost Analysis) Modeled Fires (Yellow & Dark Red, Lighter Red is Rim Fire). MACA concluded cost of Prevention is much less than the cost of the fire.

Cal Sierra Nevada Conservancy

https://sierranevada.ca.gov/what-we-do/mokelumne-watershed-avoided-cost-analysis/https://www.researchgate.net/publication/301676614

Wildfire is a Threat to Drinking Water Quality

After a 2015 fire near Solimar Beach in Ventura, Ca.

Photo: Joel Angel Juárez / Associated Press

“Central Valley Water Quality Control Board and Wildfire” website

Research shows increased concentrations of contaminants including nutrients (e.g. nitrates and phosphorus), polycyclic aromatic hydrocarbons, copper, zinc, mercury, lead, and other metals. Several of these pollutants can be harmful to human health and toxic to aquatic life. Many pollutants absorb, or attach, to suspended particles such as sediment.”
https://www.waterboards.ca.gov/centralvalley/water_issues/wildfire_and_water_quality/

2004 Power Fire

Dead forest covered in chemical laden ash

North Fork Mokelumne

Photo by Kent Lambert, EBMUD, 2004 Power Fire

Fuel/fire “tinderbox” threat in the North Fork Mokelumne Watershed

In the 2004 Power Fire (17,000 ac) area from brush & dead trees

Photo: R.Farrington, 2022

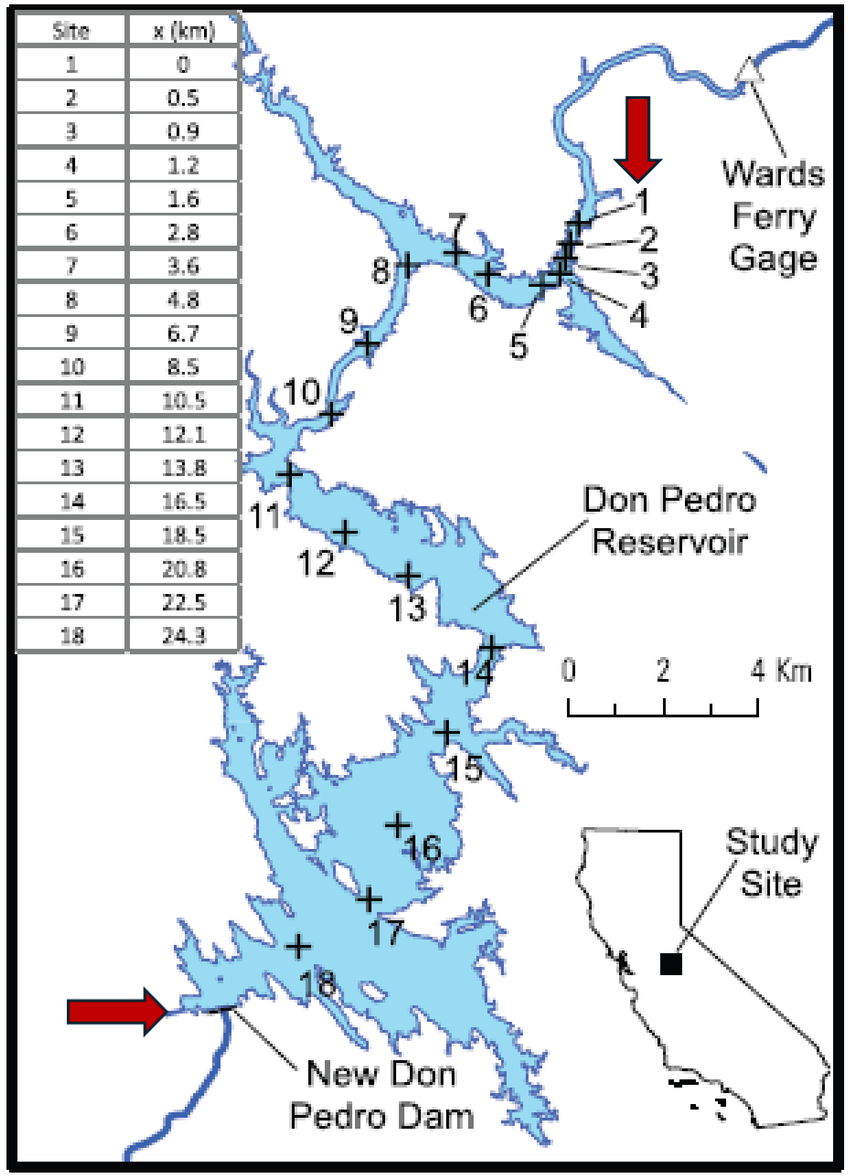
Fuel breaks

Saved Pollock Pines and Sly Park from 2021 Caldor Fire (221,835 ac)

per

Greg Hawkins, Parks and Rec Manager, El Dorado Irrigation District

https://sierranevada.ca.gov/fire-adapted-50-project-protects-communities-from-caldor-fire/

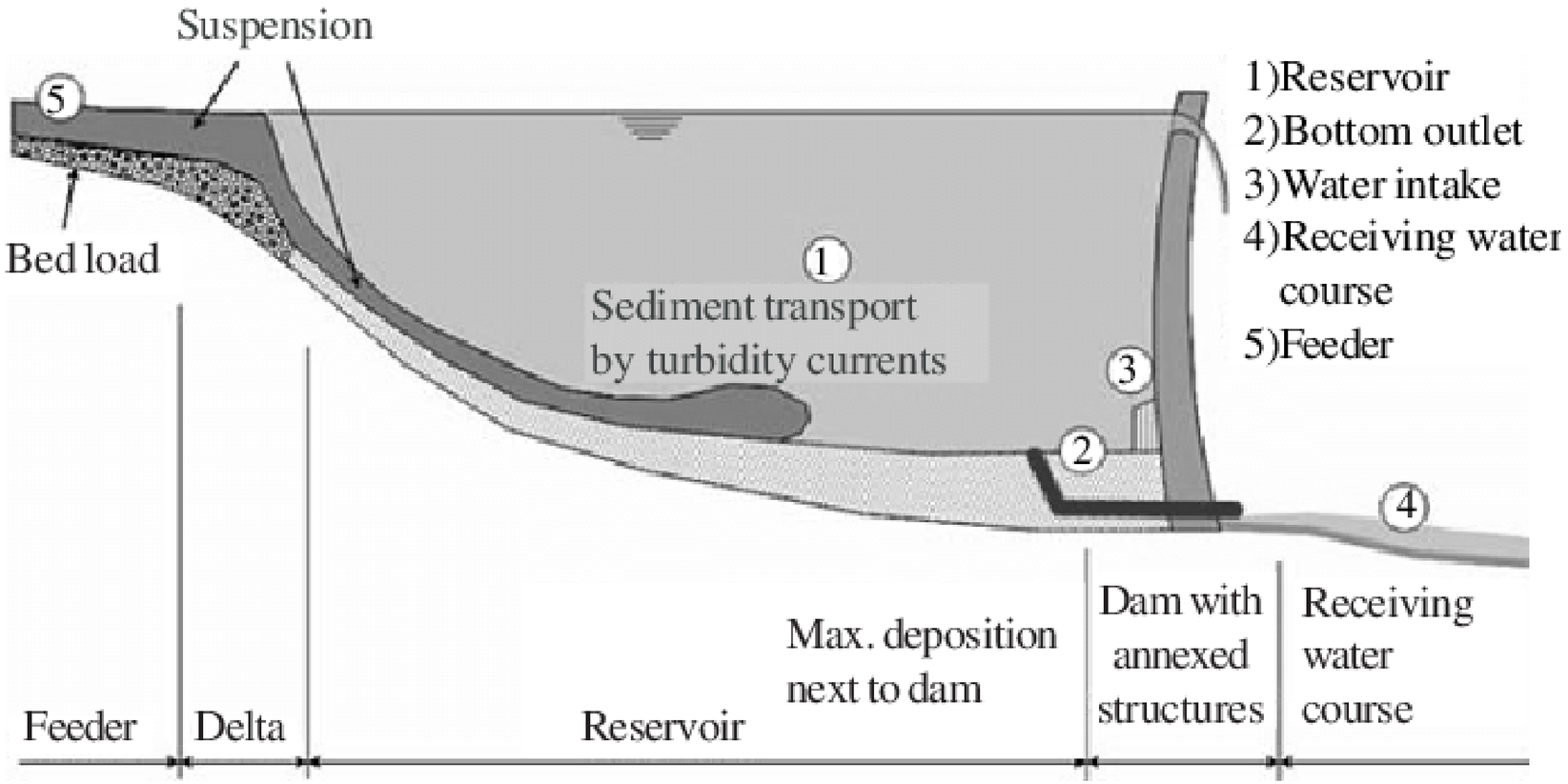


Don Pedro Reservoir study showing underwater turbidity currents flowed 15 miles 2-3 years following the 2013 Rim Fire (257,314 ac).

February 2015
December 2015
and March 2016

From: "Turbidity Current Observations in a Large Reservoir Following a Major Wildfire," **Wright and Marineau, Journal of Hydraul. Eng., 2019**, 145(8): 06019011

Post 2013 Rim Fire (257,314 ac.) – Turbidity currents flowed 15 miles Underwater in Don Pedro Reservoir during 3 Storms after the fire:



2 & 3 years after the fire:

February 2015, December 2015, and March 2016.

This could happen to Pardee

"Turbidity Current Observations in a Large Reservoir Following a Major Wildfire," Wright and Marineau, J. Hydraul. Eng., 2019, 145(8): 06019011

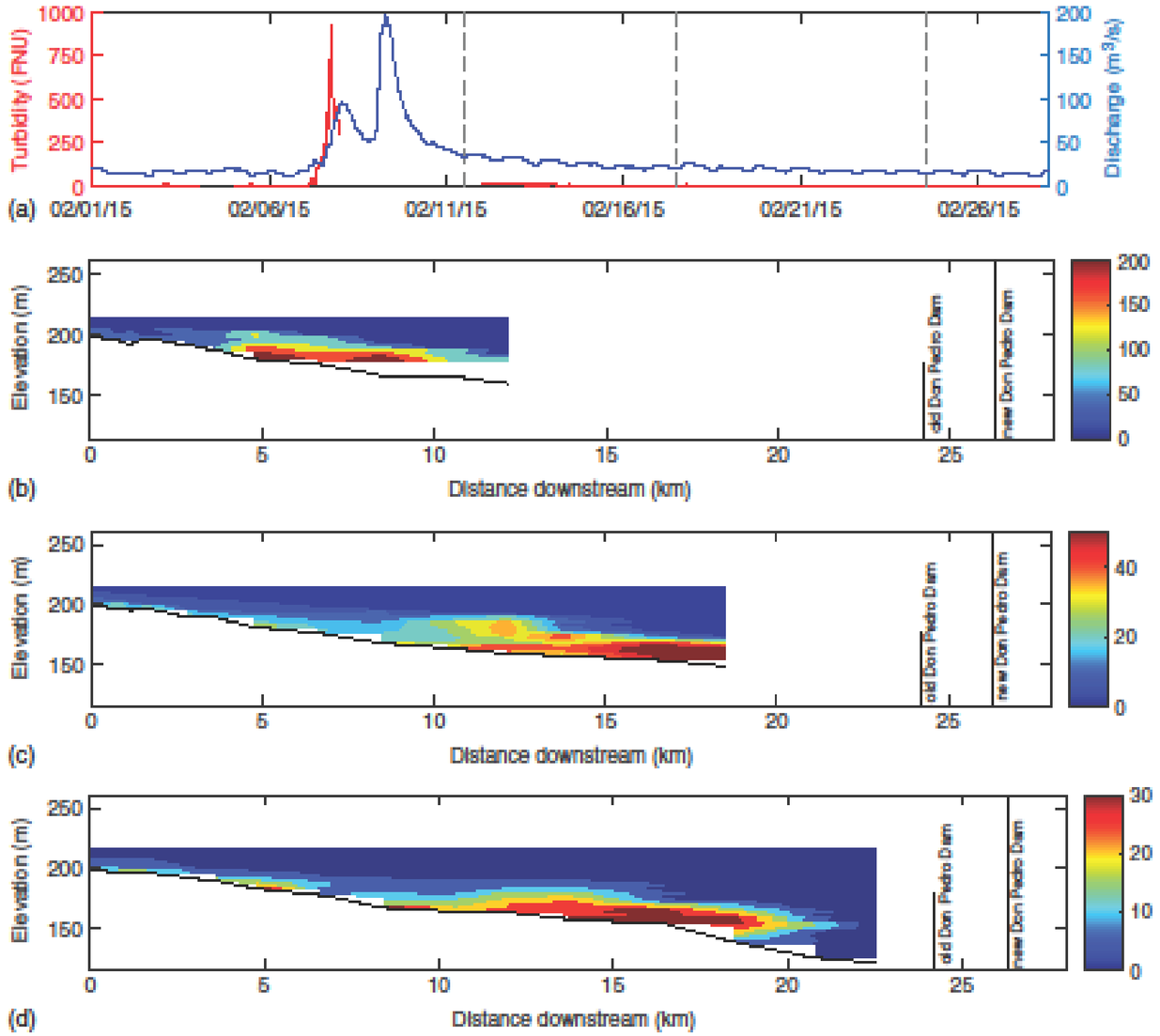


Fig. 2. (Color) Reservoir inflows and turbidity profiling results for the February 2015 event: (a) reservoir inflow and turbidity at Wards Ferry gauge; (b) turbidity profiling on February 11; (c) turbidity profiling on February 17; and (d) turbidity profiling on February 24. Vertical dashed lines in panel (a) indicate dates of turbidity profiling. The turbidity color bar scale is different in each panel.

One turbidity current in Don Pedro Res., Ca. after 2013 Rim Fire

February 2015 storm:

(Station 1 to Dam is over 15 miles)

From Wright and Marineau, Journ., Hydraul. Eng., 2019, 145(8): 06019011

Some Thoughts

- **Mega wildfires have been increasing in size and intensity over the last 30 years (USFS). Fire is likely to burn the Upper Mokelumne Watershed like the recent megafires in the Sierra (Dixie, Caldor, Rim, King, Butte, KNP, etc).**

- **<u>The Mokelumne designated Wild & Scenic River & other resources could be heavily damaged by debris flows after a fire.</u>**

- **The Costs of restoration, including water treatment and recovery of reservoirs and other infrastructure after a fire will be expensive over the short & long-term.**

- **The 2014 MACA (Mokelumne Avoided Cost Analysis) showed it's less expensive to invest in prevention to avoid all the costs incurred by wildfires.**

- **Prevent severe mega wildfire impacts to the Mokelumne W&S River.**

This could be the

Wild & Scenic MOKELUMNE RIVER

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Photo: Cal Geological Survey, Don Lindsay
https://www.usgs.gov/programs/landslide-hazards/science/dixie-fire-post-fire-debris-flows-a-tale-two-storms