GEOLOGIC BACKGROUND REPORT
DINGEE RESERVOIR
OAKLAND, CALIFORNIA

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July 15, 2008
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Mr. Yogesh Prashar
East Bay Municipal Utility District
375 Eleventh Street, M.S. 610
Oakland, CA 94607-4240

RE: Geologic Background Report
Dingee Reservoir
Oakland, California

Dear Mr. Prashar:

This letter report summarizes our review of geologic information for Dingee Reservoir in Oakland, California. The subject reservoir is a relatively small, covered reservoir located in a developed residential area. The reservoir was constructed in the late nineteenth century and has been in continuous use since that time.

The purpose of our geologic background report is to provide geologic information for use by the East Bay Municipal Utility District (EBMUD) during their evaluation of the seismic stability of the existing embankment. Our scope of work for this geologic evaluation included:

- Review of published geologic maps covering the site and vicinity
- Review of selected aerial photographs
- Performance of a geologic reconnaissance of the site and vicinity
- Review of EBMUD test boring logs in the reservoir area
- Review of subsurface information from previous studies performed by our firm in the vicinity of the site

1.0 GEOLOGIC SETTING

1.1 Regional Geology

Dingee Reservoir is located in the Oakland Hills, east of San Francisco Bay, in the northern portion of the Coast Ranges geomorphic province of California. The region is characterized by northwest-trending mountain ranges and valleys that generally parallel the major geologic structures, such as the San Andreas and Hayward faults. The oldest widespread rocks in the region are highly deformed sedimentary and volcanic rocks of the Mesozoic-age (the period from 225 million to 65 million years before present) Franciscan Assemblage. These rocks are in fault contact with similar-age sedimentary rocks of the Mesozoic-age Great Valley Sequence. The Mesozoic rocks are, in turn, overlain by a diverse sequence of Tertiary-age (the period from 65 million to 1.8 million years before present) sedimentary and volcanic rocks. Since their deposition, the Mesozoic and Tertiary rocks have been extensively deformed by repeated episodes of folding and faulting.

Within the region, many valleys have been partially filled with unconsolidated sedimentary deposits of Quaternary age (the last 1.8 million years). These deposits, which include alluvium and colluvium, underlie the gently sloping valley bottoms and hillside swales and consist of clay, silt, sand, and gravel.

1.2 Regional Seismicity

Seismic activity within the northern Coast Ranges is generally associated with active faults of the San Andreas system, including major active faults both east and west of the site. The term "active fault" as used herein, refers to a fault that has experienced movement during Holocene time (about the last 11,000 years). The principal active faults in the region are the Hayward fault, the main trace of which is approximately 1,100 feet east of the fill embankment; the San Andreas, 18.6 miles to the southwest; and the Calaveras, 10.5 miles to the east. Other major active faults in the region include the San Gregorio fault, 23 miles to the southwest; the Greenville, 18 miles east; the Rodgers Creek, 20 miles north; and the Concord-Green Valley, 13.6 miles northeast (Jennings, 1994; Wagner, et al., 1990).

The main active trace of the Hayward fault is generally mapped approximately 1,100 feet east of the fill embankment. The Hayward fault is a northwest-trending zone about 51 miles long, which extends from southeastern San Jose, through the east bay communities, into San Pablo Bay. Beneath San Pablo Bay, it probably steps east to the Rodgers Creek fault. To the south, near San Jose, the Hayward fault merges with the Calaveras fault. During historical times, well-documented surface creep has occurred along the Hayward fault at average rates ranging from about 0.2 to 0.4 inches per year (Lienkaemper, et al., 1991).

The Working Group on California Earthquake Probabilities (U.S. Geological Survey [USGS], 2003) has estimated that there is a 27 percent chance of a large earthquake (Magnitude [M] 7.0 or greater) occurring on the Hayward or Rodgers Creek faults by the year 2032. They estimate that there is a 62 percent or higher chance of a large earthquake occurring in the San Francisco Bay Region by the year 2032.

2.0 REVIEW OF PUBLISHED MAPS

Several published geologic and landslide maps cover the site and the vicinity. These maps were prepared by workers at the U.S. Geological Survey, California Geological Survey, and other institutions. A summary of the information shown on these maps is provided below. A complete listing of all maps used in our study is included in the References section at the end of this report.

Radbruch (1969) prepared a geologic map of the Oakland East Quadrangle focusing primarily on bedrock formations. This map shows that the site is underlain by rocks of the Franciscan Formation. The map explanation indicates that these rocks consist principally of sandstone and shale, locally containing some intermixed sheared greenstone, serpentinite, and metamorphic rocks. No landslides are shown within or near the subject site. The Hayward fault is shown to lie approximately 1,100 feet east of the fill embankment. No additional faults are shown within or projecting toward the subject site.

Nilsen (1975) prepared a map of landslides and surficial deposits covering the reservoir area. The site is mapped as undifferentiated bedrock. A small landslide is shown approximately 250 feet northwest of the reservoir. In addition, an area of colluvium (a thick soil deposit) is shown in a swale approximately 300 feet southwest of the site.

Crane (1988) shows that the site is underlain by sedimentary rock of Mesozoic age, generally assigned to the Franciscan Assemblage. No landslides or faults are shown within or projecting toward the site. The Hayward fault is shown to lie approximately 1,100 feet east of the fill embankment.

The seismic hazard map prepared by the California Geologic Survey (CGS, 1999) shows that the site does not lie within an area susceptible to earthquake-induced landsliding or liquefaction. The Alquist-Priolo Earthquake Fault Zone Map (CDMG, 1982) shows that the Hayward fault lies approximately 1,100 feet east of the fill embankment. The site is not within the Alquist-Priolo Earthquake Fault Zone. The western margin of the Alquist-Priolo Earthquake Fault Zone is approximately 400 feet east of the site.

Graymer (2000) shows that the site is underlain by Melange of the Franciscan Assemblage. No active faults or landslides are shown within the site vicinity. The active trace of the Hayward fault is shown to lie approximately 1,100 feet east of the fill embankment.

Dibblee (2005) shows that the site is underlain by greywacke sandstone of the Franciscan Assemblage. A portion of this map is reproduced on Figure 1. These rocks are described as massive to locally bedded, fine grained, hard, fractured, and locally sheared. The active trace of the Hayward fault is shown approximately 1,100 feet east of the fill embankment. No landslides are mapped within the site or vicinity. An unnamed thrust fault is shown trending northwestward through the area approximately 1900 feet southwest of the site. This thrust fault extends into the Berkeley area, where it is shown to be concealed by Quaternary-age alluvium, suggesting that the fault is inactive. To the south, the fault merges with the Hayward fault approximately, one mile southeast of the site.

In summary, the published maps generally agree that the site is underlain by sandstone of the Franciscan Assemblage. No landslides are mapped within or projecting toward the subject site. The maps also agree that the active trace of the Hayward fault is approximately 1,100 feet east of the fill embankment.

3.0 REVIEW OF AERIAL PHOTOGRAPHS

Four single and one stereo-paired set of black and white aerial photographs were reviewed as a part of our study. The photographs were taken between the years 1939 and 1998 and range in scale from 1:12,000 to 1:36,000. A complete listing of the photographs used in our study is included in the References section at the end of this report. A summary of the information observed on the photographs is provided below.

The 1939 photograph shows that the reservoir has been constructed and is covered and that all the major roads in the project vicinity had been constructed by that time. Some houses are present in the area, including one house on the northwest side of the Estates Drive below the reservoir embankment and several houses along the north side of Bullard Drive. The topography suggests that reservoir construction included excavations in much of the reservoir area and construction of a fill embankment including the main embankment and fill beneath and downslope of Estates Drive. The 1946 photograph shows that a row of trees has been planted on the embankment and the north side of the reservoir. No major changes were observed on the 1947 aerial photograph. The 1957 aerial photograph shows that a bowl has been excavated east of the reservoir and the trees previously present in that area have been removed. No major changes were visible on the 1958 aerial photograph.

The 1998 and 2005 aerial photographs show that the site is roughly in its current condition. All the surrounding lots have been developed. No indications of landsliding are visible along the margins of the reservoir or embankment.

4.0 SITE RECONNAISANCE

We performed a geologic reconnaissance of the site on April 15, 2008, and June 11, 2008. The reservoir is covered and most of the surrounding area is covered with varying amounts of vegetation. In addition, the surrounding lots are heavily developed. A number of sandstone outcrops were observed around the perimeter of the reservoir, as shown on Figure 2. The sandstone was typically yellowish brown in color, weak to moderately strong, moderately to closely fractured, and moderately to deeply weathered. The rock outcrops and our aerial photograph review suggest that most of the reservoir area is underlain by sandstone bedrock at a shallow depth. We found no evidence of landslides within or close to the reservoir.

5.0 SUBSURFACE CONDITIONS

Available subsurface information for the area was reviewed as a part of our investigation. The information reviewed included ten test borings performed by EBMUD along the western side of the reservoir. In addition, we reviewed subsurface information from borings previously performed by our firm for projects on the west side of Estates Drive. The EBMUD borings along the reservoir embankment show that the western portion of the reservoir consists primarily of a large fill embankment. Sandstone (bedrock) outcrops were visible at the extreme northern and southern ends of the embankment, as shown on Figure 2. In general, the fill thickens toward the center of the embankment, and appears to be thickest in the vicinity of Borings XV-2 an XV-8. The fill also underlies a portion of Estates Drive and extends down slope to Harbord Drive. The borings shows that the embankment fill consists principally of soft to stiff, silty to sandy clay with some intermixed silt and gravel. The EBMUD logs indicate the depth of fill is approximately 20 feet in thickness at the center of the embankment.

Below the fill, the borings generally encountered silty to sandy native clay soil a few feet in thickness. These native soils were generally soft to stiff, saturated and relatively homogenous. The native soil appears to be relatively continuous beneath the fill.

Sandstone bedrock was encountered in all of the borings, with the exception of boring XV-2, which did not reach bedrock. The sandstone ranged from friable to moderately strong and deeply to moderately weathered. The uppermost two to four feet of the bedrock was typically deeply weathered. Blow counts of sandstone were typically high indicating high relative strength.

6.0 DISCUSSIONS AND CONCLUSIONS

Our evaluation found that the site is underlain principally by sandstone bedrock throughout the reservoir area. The presence of sandstone was confirmed in the majority of the subsurface borings in the area and by our own surface mapping of sandstone outcrops of the site vicinity (Figure 2). The western side of the reservoir consists of a large fill embankment consisting mainly of silty clay. The fill overlies a layer of native soil consisting principally of sandy to silty clay.

We found no evidence of landsliding around the margins or the reservoir or in the fill embankment. We therefore judge that the risk of landsliding along the north, east, and south margins of the reservoir is very low during the expected life of the project.

We found no evidence of creep or movement within the fill embankment along the west side of the reservoir. The static and seismic stability of this embankment is being evaluated by EBMUD and will be detailed in a separate report.

We found no indications that active faults cross or project toward the subject site. The closest known active fault is the Hayward fault, approximately 1,100 feet east of the fill embankment. The risk of fault-related ground rupture in the reservoir area is judged to be very low.

7.0 LIMITATIONS

This report has been prepared for the exclusive use of EBMUD and their consultants in accordance with generally accepted engineering geology and geotechnical engineering practices for the specific application of the stability evaluation of Dingee Reservoir in Oakland, California. No other warranty, either expressed or implied, is made. In the event that any changes in the nature, design, or location of the reservoir occur or are significantly different from what has been noted above, the conclusions contained in this report should not be considered valid unless the changes are reviewed and the conclusions of this report modified or verified in writing.

The findings of this report are valid as of the present date. However, the passing of time will likely change the conditions of the existing reservoir due to natural processes or the works of man. In addition, due to legislation or the broadening of knowledge, changes in applicable or appropriate standards may occur. Accordingly, the findings of this report may be invalidated, wholly or partly, by changes beyond our control. Therefore, this report should not be relied upon after three years without being reviewed by this office.

If you have any questions concerning this report, please call us.

Very truly yours,

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REFERENCES

California Division of Mines and Geology, 1982, Alquist-Priolo Earthquake Fault Zone Map, Oakland East Quadrangle: dated January 1, 1982, 1:24,000.

Crane, Ron C., 1988, Geologic Map of the Oakland East Quadrangle: in Field Trip Guide to the Geology of the San Ramon Valley and Environs, distributed by the Northern California Geological Society, 1:24,000.

Dibblee, Thomas W., Jr., 2005, Geologic Map of the Oakland East Quadrangle, Contra Costa and Alameda and Counties, California: Dibblee Geology Center Map #DF 160. 1:24,000.

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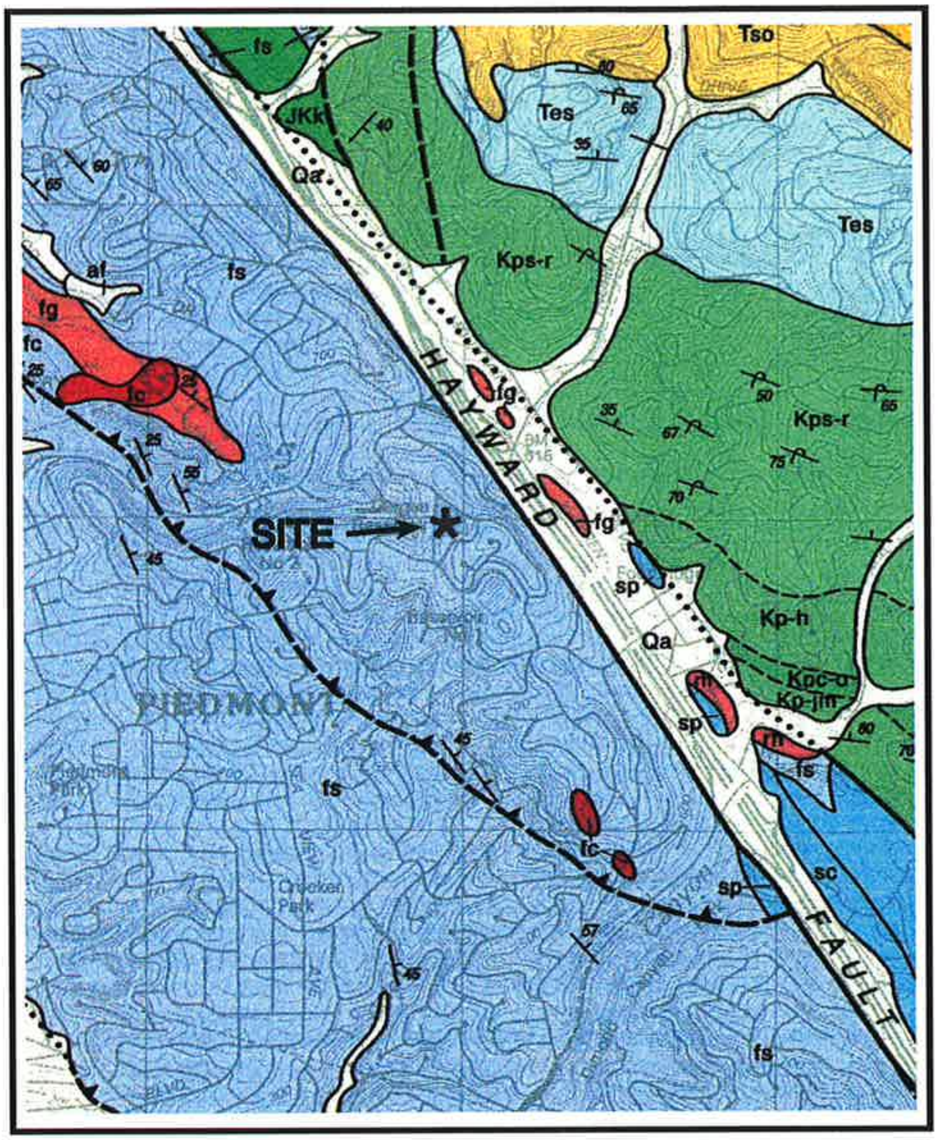
Wagner, D. L., E. J. Bortugno, and R. D. McJunkin, 1990, Geologic Map of the San Francisco-San Jose Quadrangle, California: California Division of Mines and Geology Regional Geologic Map Series Map No. 5A (Geology), 1:250,000.

Working Group on California Earthquake Probabilities (WGCEP), 2003, " Earthquake Probabilities in the San Francisco Bay Region 2002 – 2031:A summary of Findings. U. S. Geological Survey Open File Report 03-214.

AERIAL PHOTOGRAPHS

DATE	SCALE	PHOTO ID	TYPE	SOURCE
08/02/39	1:20,000	BUT-BUU-286-46	B/W	AKAI
01/28/46	1:20,000	GS-CP-6-38	B/W	AKAI
03/24/47	1:20,000	AV11-3-14	B/W	AKAI
05/04/47	1:12,000	AV253-11-24	B/W	AKAI
05/03/57	1:12,000	AV253-11-27, 28	B/W	PAS
03/02/58	1:36,000	SF Area-2-111	B/W	PAS
08/24/98	1:12,000	AV6100-11-30, 31	B/W	PAS
03/09/05	1:10,000	KAV 9010-40-9, 10	B/W	PAS

PAS refers to Pacific Aerial Surveys of Oakland, California



Geologic Units:

af	Fill
Qa	Alluvium (Quaternary)
Tso	Sobrante Sandstone (Miocene)
Tes	Sandstone (Eocene)

Panoche Formation (Cretaceous):

Kps-r	Redwood Cyn. Fm.
Kp-h	Shepard Cr. Fm.
Kpc-o	Oakland Conglomerate
Kp-jm	Joaquin Miller Shale
JKk	Knoxville Formation (Jurassic and/or Cretaceous)
sp	Serpentinite
rh	Leona Rhyolite

Franciscan Assemblage (Jurassic and Cretaceous):

fs	Graywacke Sandstone
fg	Greenstone
sc	Sheared Silicious Rock
fc	Chert

Map Symbols:

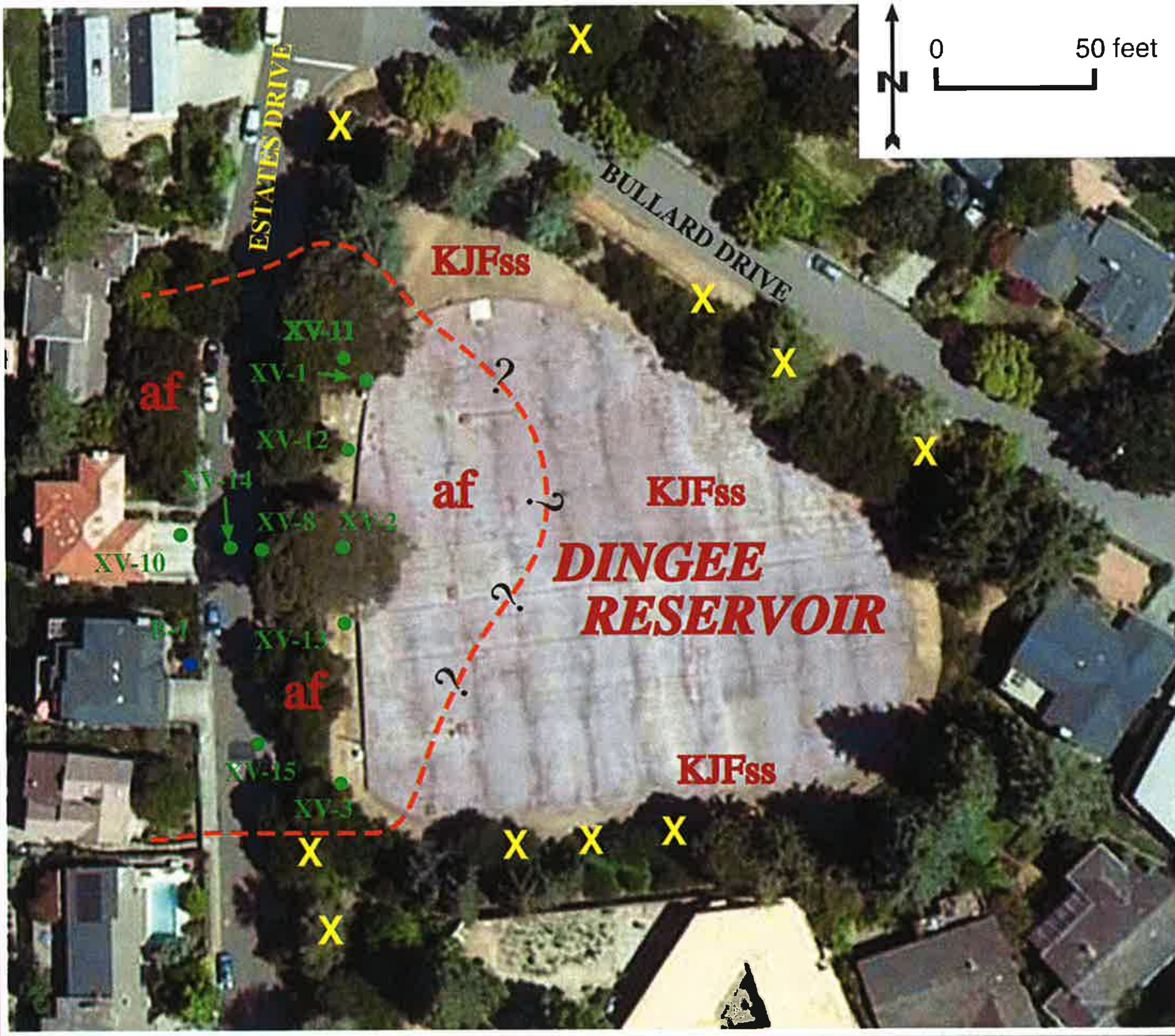
- Fault, dashed where approximate, dotted where concealed
- Thrust Fault, location approximate, hachures on upthrown side
- Geologic Contact, approximate
- 50 Strike and dip of bedding

Source: Dibblee, Thomas W., 2005, "Geologic Map of the Oakland East Quadrangle"

N

0 2000 feet

ALAN KROPP & ASSOCIATES JOYCE ASSOCIATES	**Area Geologic Map** Dingee Reservoir Oakland, California	**FIGURE** **1**



EXPLANATION

af	Fill
KJFss	Graywacke Sandstone (Franciscan Assemblage)
(red dashed line)	Geologic Contact, approximate
X	Sandstone Outcrop
XV-3 ●	EBMUD Boring
B-1 ●	Alan Kropp & Assoc. Boring

ALAN KROPP & ASSOCIATES

JOYCE ASSOCIATES

Site Geologic Map
Dingee Reservoir
Oakland, California

FIGURE
2