Project No.
9472.000.000

June 1, 2012

Ms. Ginger Zhang
East Bay Municipal Utility District (EBMUD)
375 Eleventh Street
Oakland, CA 94607

Subject: 39th Avenue Reservoir
4290 Maybelle Avenue
Oakland, California

GEOLOGIC REVIEW AND RECONNAISSANCE

Dear Ms. Zhang:

At your request, we have conducted a site-specific geologic evaluation of the East Bay Municipal Utility District (EBMUD) 39th Avenue Reservoir in Oakland, California. Based on information provided EBMUD we understand that the 39th Avenue Reservoir was constructed in 1920 and is located on an approximately 8 acre site west of Highway 13 in the Redwood Heights area of Oakland. The site is bounded by 39th Avenue to the northwest and Reinhardt Drive to the east.

The purpose of our geologic evaluation was to provide a preliminary characterization of the geologic conditions and hazards present at the site and provide recommendations for additional field exploration, if necessary. Our scope included the following:

1. Review of available geologic maps, aerial photographs, plans, and literature relevant to the site.

2. A site reconnaissance to observe site conditions and to look for potential fault related features such as offset curbs, en-echelon cracking, fault scarps, etc.

3. Delineate fault locations on a plan with reference to the site based on review of available data and site reconnaissance.

4. Prepare cross sections across the main and auxiliary dams utilizing existing plans, data and information provided by EBMUD.

5. Preparation of this letter summarizing the findings of our review and site reconnaissance, and provide recommendations for field exploration, if necessary.

6. In addition, EBMUD provided us with plans, reports, boring logs and piezometer and survey data for the site (see attached references).

SITE DESCRIPTION

Based on review of information provided by EBMUD we understand that the reservoir has a capacity of 10.2 million gallons. Borings drilled within the reservoir in 1959 as part of a rehabilitation soils investigation indicate that the reservoir is lined with 5 to 6 inch concrete slabs. The reservoir is covered with corrugated aluminum, steel and fiberglass roof panels. A roughly 11 to 12 foot wide, paved, perimeter maintenance road surrounds the reservoir. An approximately 2.5 foot wide concrete drainage ditch is present on the outside edge of the perimeter maintenance road. Seven drop inlet structures are present in-line with the drainage ditch. Based on personal communication from EBMUD engineers we understand that subdrains are present below the base of the reservoir and that these drain into a drainage structure east of the auxiliary dam. We also understand that the reservoir inlet/outlet line runs below the main dam towards the west.

Elevations at the site based on NGVD 29 range from approximately 411 feet at the base of the reservoir to approximately 454 feet at the top of the existing cut slope north of the reservoir. The reservoir crest is at an elevation of approximately 433 feet. The lowest elevation that is not inside of the reservoir is approximately 418 feet at a low spot located approximately 150 feet west of the main dam. Ponded water was observed at this location at the time of our site visit on April 17, 2012.

Review of the 1897 Concord fifteen minute quadrangle covering the site and the June 30, 1919 East Bay Water Company plan for the reservoir indicate that the reservoir was constructed in an area that was a natural closed depression or pond. The reservoir was constructed with cuts and fills that enhanced the existing pond. The main dam was constructed by placing a fill embankment in roughly the central portion of the pond. A fill embankment was also placed at the eastern end of the natural depression to form the auxiliary dam.

The 1919 plans indicate that approximately 3 to 4 feet of native material was excavated from the area that now forms the base and lower side slopes of the existing reservoir. This material was likely used as fill for construction of the two fill embankment dams. The fill embankments have inclinations of roughly 2:1 on their outboard sides and 3:1 on the reservoir sides.

REGIONAL GEOLOGY

The 39th Avenue Reservoir site is located on the western edge of the East Bay Hills. The East Bay Hills lie within the region of coastal California referred to by geologists as the Coast Ranges geomorphic province. The Coast Ranges have experienced a complex geological history characterized by Late Tertiary folding and faulting that has resulted in a series of northwest-trending mountain ranges and intervening valleys. The site is located on the western edge of an uplifted range of hills locally referred to as the East Bay Hills block, bounded on the west by the active Hayward Fault and on the east by the active Calaveras Fault.

Bedrock in the Coast Ranges consists of igneous, metamorphic and sedimentary rocks that range in age from Jurassic to Pleistocene. The present physiography and geology of the Coast Ranges are the result of deformation and deposition along the tectonic boundary between the North American plate and the Pacific plate. Plate boundary fault movements are largely concentrated along the well-known fault zones, which in the area include the San Andreas, Hayward, and Calaveras faults, as well as other lesser-order faults.

SITE GEOLOGY

More specifically, the site is located within an area that has geomorphology that is strongly influenced by the Hayward fault zone in the East Bay Hills. Based on geologic mapping by Dibblee (2005), Graymer (1995), Crane (1988), and Radbruch (1969) the site is underlain by volcanic rock designated by most as the Jurassic Leona Rhyolite - Jsv (Figure 1). The Leona Rhyolite comprises a late Jurassic keratophyre and quartz keratophyre composed of highly altered, intermediate silicic lavas and dike rocks that stratigraphically overly the Coast Range ophiolite complex. Based on outcrops observed in the cut-slopes at the site the Leona Rhyolite can be described as tan to brown, moderately strong to strong, closely fractured to crushed, and highly weathered. The geologic structure in the area is dominated by the historically active, right-lateral, strike-slip Hayward fault, which can be characterized as an anastomosing series of fault splays, fault bound blocks/slivers and smaller order en echelon faults, and pressure ridges.

Residual soil and colluvium are present overlying the bedrock at most locations at the site. The colluvium is likely thickest near the central part of the original pond or closed depression that occupied the site prior to construction of the reservoir. The native soils generally comprise light brown to dark brown silty clays and sandy clays with scattered angular gravel derived from the underlying Leona Rhyolite. Artificial fill is also present at various areas of the site most notably the two reservoir embankments. Based on 1959 boring logs the artificial fill generally comprises brown to dark grey silty clay with varying amounts of rhyolite gravel.

FAULTING AND SURFACE RUPTURE

The site is located within a State of California Earthquake Fault Zone and Holocene active faults are known to pass through the subject site, according to the published State of California Earthquake Fault Zone Map covering the site (Reference 2, CGS, 1982) (Figure 2). According to the State of California, a fault is considered to be “active” if it has had identifiable movement within the last 11,000 years; the time period for a “potentially active fault” is approximately 1.6 million years. According to the State Earthquake Fault Zone Map two active traces of the Hayward fault are mapped as approximately located crossing the site with a northwesterly trend and a third trace is mapped east of the site. One of the approximately located traces passes through the inboard side of the main dam and the other mapped trace is located approximately 170 feet west of the western edge of the reservoir. Based on information compiled by Lienkaemper discussed below, the mapped fault trace located approximately 170 feet west of the reservoir displays the most definitive evidence of fault creep. A third mapped trace of the fault is located approximately 650 feet east of the auxiliary dam.

In 1977, ENGEO conducted an Alquist Priolo Investigation of the Hayward Fault Zone on a site located approximately 1800 feet northwest of the subject site. The investigation found clear evidence for recent fault activity in the vicinity of two mapped traces of the Hayward fault (Middle and Eastern). The investigation concluded that the Middle zone contained the most active trace of the fault. The middle zone is along the same trend as the two traces mapped through the subject site and the eastern zone is along the same trend as the eastern trace mapped 650 feet east of the auxiliary dam.

Creep has been documented on the Hayward fault in this area. This means that some segments of the fault move incrementally in very small sub-millimeter displacements (creep) with no associated seismicity (A-seismic). Studies by Lienkaemper (2006, updated 2008) to show the location of evidence for recent movement on active traces within the Hayward Fault Zone indicates distinct and certain evidence of right lateral offset curbs, fence lines, left stepping en echelon cracks within pavement and surveyed offset frames in the vicinity of the site. These features are recent evidence of right-lateral creep along the westernmost mapped trace of the Hayward fault. The fault trace based on Lienkaemper’s mapping is shown on Figure 3. In the vicinity of the site, Lienkaemper’s mapped fault trace compares closely with the westernmost mapped trace shown on the State Earthquake Fault Zone Map. The differences between the mapped traces are likely related to the different data and information used to determine the location of the fault or faults, the overall uncertainty with respect to the faults exact location in addition to the fact that surface rupture and deformation should be anticipated to occurs in a zone that is wider than the lines that are shown on the maps. It should be noted that the Hayward Fault Zone Boundary as mapped on the State of California Earth Quake Fault Zone Map (1982) in the vicinity of the site is approximately 2,200 feet wide from east to west.

Based on our review of 1939 stereo paired aerial photographs covering the site we noted two distinct fault parallel features that correspond with the mapped fault trace that crosses the main dam. One of the features evident in the historic photos is a very distinct linear swale south of the reservoir that disappears abruptly at the southern edge of the reservoir (Figure 3). The other feature is a fault parallel break in slope north of the reservoir.

The most recent major earthquake to occur on the Hayward fault took place in 1868 and generated an approximately 25 mile long surface rupture from Warm Springs in Fremont to southern Berkeley. Historical survey data indicate an average of approximately 6 feet of horizontal movement occurred along the ruptured fault segment during the 1868 earthquake. The estimated recurrence interval for major earthquakes along the Hayward fault is approximately 150 years and the estimated slip rate is roughly 9mm/yr ±2mm/yr.

Typical moment magnitude estimates for a major earthquake on the Hayward fault range from 6.5 to 7.3. Estimated maximum surface displacements vary significantly with earthquake moment magnitude. Based on empirical relationships among moment magnitude, rupture length and surface displacement developed by Wells and Coppersmith (1994) the estimated maximum surface displacement along the Hayward fault for a moment magnitude 7.3 earthquake is approximately 17 feet. Based on the same relationships the estimated maximum surface displacement along the Hayward fault for a moment magnitude 6.5 is approximately 1.5 feet.

SEISMICITY

Numerous small earthquakes occur every year in the region, and as discussed above large (>M7) earthquakes have been recorded and can be expected to occur in the future. Based on the 2010 USGS Quaternary Fault and Fold Database (QFFD), the nearest active fault, as discussed above, is the Hayward fault. As discussed above the Hayward fault at this location is mapped as three approximately located active traces on the State of California Earthquake Fault Zone Map (Reference 2, Figure 2). Therefore, we recommend that the fault trace mapped closest to the site be used in the seismic analysis. In this case, we recommend that the fault mapped through the main dam be used to determine the distance because it is closest to the critical features to be analyzed.

As part of the Uniform California Earthquake Rupture Forecast Version 2 (UCERF 2) moment magnitudes for various fault segment rupture scenarios have been modeled for the segments of the Hayward-Rogers Creek faults. Fault rupture models used in UCERF 2 divide the Hayward-Rogers Creek faults into three segments that include the Hayward South (HS), the Hayward North (HN) and the Rogers Creek (RC). Moment magnitudes for the various modeled rupture combinations range from 6.5 to 7.3. The estimated moment magnitude for an earthquake where the entire Hayward-Rogers-Creek fault ruptures is 7.3.

Other active faults located near the site include the Northern Calaveras fault, located approximately 9 miles to the east, the Concord-Green Valley fault, located approximately 13 miles to the east, and the San Andreas fault located approximately 18 miles to the west. Many earthquakes of low magnitude occur every year throughout the region, most are concentrated along the San Andreas, Hayward, and Calaveras Faults.

The Uniform California Earthquake Rupture Forecast (UCERF, 2008) evaluated the 30-year probability of a M6.7 or greater earthquake occurring on the known active fault systems in the Bay Area, including the Hayward fault. The UCERF generated an overall probability of 63 percent for the Bay Area as a whole, and a probability of 31 percent for the Hayward fault, 7 percent for the Calaveras fault, and 3 percent for the Concord-Green Valley fault.

COMPILATION OF MAPS, PLANS AND REPORTS

On April 19, 2012, an ENGEO Certified Engineering Geologist made a visit to the EBMUD office in Oakland to review available plans and reports regarding the reservoir. For our review, we were provided various documents and among them was a June 30, 1919 plan that showed original ground contours and proposed grading contours for construction of the reservoir. We were also provided with a 1960 soils and foundation investigation report for the rehabilitation of the reservoir. The 1960 report included subsurface boring data and a site plan depicting boring locations. We compiled this information in AutoCAD with geo-referenced 1/9th arc second topography from LIDAR mapping along the Hayward fault, historic aerial photo imagery, historic topographic maps and various geologic and fault maps covering the area. Using the compiled information we constructed a preliminary geologic map (Figure 4) and cross sections through the most critical areas of the main dam (Section 1) and auxiliary dam (Section 2) (see attached Figure 5). Elevations in the cross sections are based on NGVD 29. Based on the existing subsurface boring data it appears that both of the dams were constructed directly on existing native clayey soils. Cross Section 1 indicates up to approximately 20 feet of native soil underlying the main dam fill embankment and Cross Section 2 indicates roughly 10 feet of native soil underlying the auxiliary dam fill embankment. Cross Section 1 crosses the two western mapped traces of the Hayward fault according to the State of California AP Map. One of the mapped traces projects through the reservoir side of the main dam fill embankment (Figure 5).

Piezometer data from 4 piezometers (UD-20, 21, 22 and 23) was provided for our review. The piezometer data from the two piezometers in the main dam (UD-20 and 21) appears to reflect very closely changes in the reservoir water level. There is less correlation between the water level in the reservoir and the piezometers in the auxiliary dam (UD-22 and 23). The approximate average groundwater elevations from the piezometers were used in both of the cross sections (Figure 5).

SITE RECONNAISSANCE

On April 17, 2012, an ENGEO Certified Engineering Geologist met with two EBMUD engineers at the 39th Avenue Reservoir for a tour of the site. Following the site tour, the ENGEO geologist spent roughly half a day mapping, making observations and taking photographs at the site and in the surrounding neighborhood. The observations were focused primarily on evidence of recent fault related activity.

As discussed above, the Hayward fault is a creeping fault in this area. Common evidence of recent creep related fault movements include offset man-made features such as curbs, sidewalks, fences, walls etc. Other common features include systematic cracking within roadway pavements (left stepping en-echelon cracks), severely cracked and patched pavements and areas of chronic subsurface utility repair resulting from cracked and disrupted utilities. Observations from the reconnaissance are compiled on Figure 3 of this report.

Of note, observation of a spring north of the main dam in the approximate mapped location of the Hayward fault was observed. This is noted because faults often form groundwater barriers and as a result, springs are often found along faults. In addition right lateral off-set curbs were observed on Dunsmuir Avenue located two streets north of the reservoir on the same approximate trend as the mapped trace of Hayward fault that crosses the main dam. Right lateral offset curbs and deflected curb-lines were also observed along the western AP mapped trace of the fault near the entrance gate to the reservoir at the end of Maybelle Avenue and on both 39th Ave and Dunsmuir Ave located north of the reservoir (see Figure 3). It should also be noted that no obvious signs of fault creep related movement was noted within the perimeter roadway around the reservoir or within the concrete exposed adjacent to the reservoir.

DISCUSSION AND RECOMMENDATIONS

Based on our site reconnaissance and document review, the 39th Avenue Reservoir is located in a geologically active and structurally complex area within the Hayward Fault Zone. This zone is characterized by anastomosing and en echelon faults, synthetic shears, fault bound blocks and slivers, and various geomorphic features associated with strike slip faulting (i.e. sag ponds, shutter ridges, linear ridges, troughs and benches). The current AP Map delineates an active trace of the Hayward fault across the main dam of the reservoir and another trace approximately 170 feet west. The trace located west of the reservoir shows distinct and certain evidence of recent fault creep. The fault trace mapped through the dam shows less definitive evidence of fault creep however strong geomorphic evidence, spring activity and an offset curb towards the north provide strong evidence for the presence of a fault at this location.

According to the empirical relationships among moment magnitude, rupture length and surface displacement developed by Wells and Coppersmith (1994) the estimated maximum surface displacement along the Hayward fault for a moment magnitude 7.3 earthquake is approximately 17 feet. How this offset could be distributed across the faults within the zone during a major earthquake is difficult to estimate. Due to this uncertainty we think it would be prudent to assume that offsets for individual faults within the zone have the potential to experience the maximum estimated offset.

Based on the existing subsurface boring data it appears that both of the dams were constructed directly on 10 to 20 feet of existing native clayey soils. The depth to bedrock and thickness of native soil downslope away from the toe of the dams is not known based on the available information.

In our opinion, subsurface exploration should be undertaken to determine the presence and/or location of faults that cross the reservoir and to provide information downslope from the toe of the dam to eliminate data gaps, supplement the existing data and to support preparation of complete cross sections that can be used for slope stability analysis. Based on the above we recommend the following exploration:

- We recommend that (a) fault trench(es) be excavated across the mapped trace of the fault that crosses the main dam. Through fault trenching it should be possible to determine the existence and/or location of the fault and features associated with surface rupture. Due to the potential for elevated groundwater conditions, the location of the reservoir and property boundary constraints the logistics of fault trenching may be difficult and require significant planning.

- We also recommend that additional borings be drilled at the site to constrain subsurface conditions and geometries downslope of the reservoir dams. The previous boring at the toe of the main dam did not encounter bedrock and no borings were drilled downslope of the reservoir dams. Because of this we recommend that one boring be drilled roughly 30 feet downslope of the toe of each of the reservoir dams and that at least one boring be drilled at the lowest point at the toe of the main dam to determine depth to bedrock. We suggest that continuously sampled borings be considered due to the potential presence of thin weak soil layers, and high quality samples should be recovered for strength testing.

Based on existing available data and that collected from the above recommended exploration we recommend that the following analysis be performed:

- We recommend that seismic slope stability analysis be performed to evaluate the stability of the main dam and auxiliary dam embankments under seismic loading.

- We also recommend that if through exploration it is determined that a fault crosses the reservoir or embankments that analysis be performed to evaluate the effects of anticipated fault rupture displacement on the integrity of the reservoir and the stability of the embankment dam.

The conclusions and recommendations contained in this report are solely professional opinions. The professional staff of ENGEO Incorporated strives to perform its services in a proper and professional manner with reasonable care and competence but is not infallible. This report is based upon the review of published geologic information, documents made available by EBMUD, field and other conditions discovered at the time of preparation of ENGEO's report.

We are pleased to provide our services to you on this project and look forward to consulting further with you in the future.

Sincerely,

ENGEO Incorporated

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Raymond P. Skinner, CEG
Principal

Attachments: Selected References
Figure 1 – Regional Geologic Map
Figure 2 – Alquist Priolo Earthquake Fault Zone Map
Figure 3 – Fault Compilation and Reconnaissance Observation Map
Figure 4 – Preliminary Geologic Map
Figure 5 – Cross Sections

SELECTED REFERENCES

1. California Geological Survey Special Publication 117A (2008). Guidelines for Evaluation and Mitigating Seismic Hazards in California.

2. California Geological Survey - California Division of Mines and Geology, 1982, State of California Special Studies Zones, Oakland East Quadrangle, California.

3. Crane, R., 1988, Geologic Map of the Oakland East Quadrangle, Geology of the Mount Diablo Region, in Guidebook for 1988 Pacific Section NCGS Convention.

4. Dibblee, T. W., Jr., 2005, Geologic Map of the Oakland East Quadrangle, Alameda and Contra Costa Counties, DF-160.

5. East Bay Municipal Utility District (EBMUD), Piezometer Data, 39th Ave Reservoir, 2001 - 2012.

6. East Bay Municipal Utility District (EBMUD), Log of Borings and Piezometer Data, 39th Ave Reservoir, July 7, 1970, sheet 5966.

7. East Bay Municipal Utility District (EBMUD), Surveillance Monuments, 39th Ave Reservoir, July 7, 1970, sheet 5966- G-3.

8. East Bay Municipal Utility District (EBMUD), Piezometer Locations, 39th Ave Reservoir, July 7, 1970, sheet 5966 G-1.

9. East Bay Municipal Utility District (EBMUD), Soils and Foundation Investigation (Report Excerpts), 39th Ave Reservoir, September 20, 1960.

10. East Bay Municipal Utility District (EBMUD), Soils and Foundation Investigation Location of Borings, 39th Ave Reservoir, September 20, 1960, sheets 4384 G-3.

11. East Bay Municipal Utility District (EBMUD), General Layout, 39th Ave Reservoir, September 20, 1960, sheet 4384 G-2.

12. East Bay Municipal Utility District (EBMUD), Soils and Foundation Investigation Log of Borings, 39th Ave Reservoir, September 20, 1960, sheets 4384 G-4 and G-5.

13. East Bay Water Company, June 30, 1919, 39th Ave. Reservoir Showing Contours and Checkerboard, Oakland, California, Scale 1 inch = 3 feet. 24"x36" plan sheet.

14. ENGEO, 1977, Alquist-Priolo Investigation Along the Hayward Fault Zone, Property Along 35th and Redwood Road, Oakland, California, N7-0959-B1

15. Google Earth, historic aerial photo imagery available for site spanning from the year 1993 to 2011.

SELECTED REFERENCES (continued)

16. Graymer, R.W., et al.; 1995, Geologic Map of the Hayward Fault Zone, California, USGS, Open File Report 95-597 Sheet 1 of 3.

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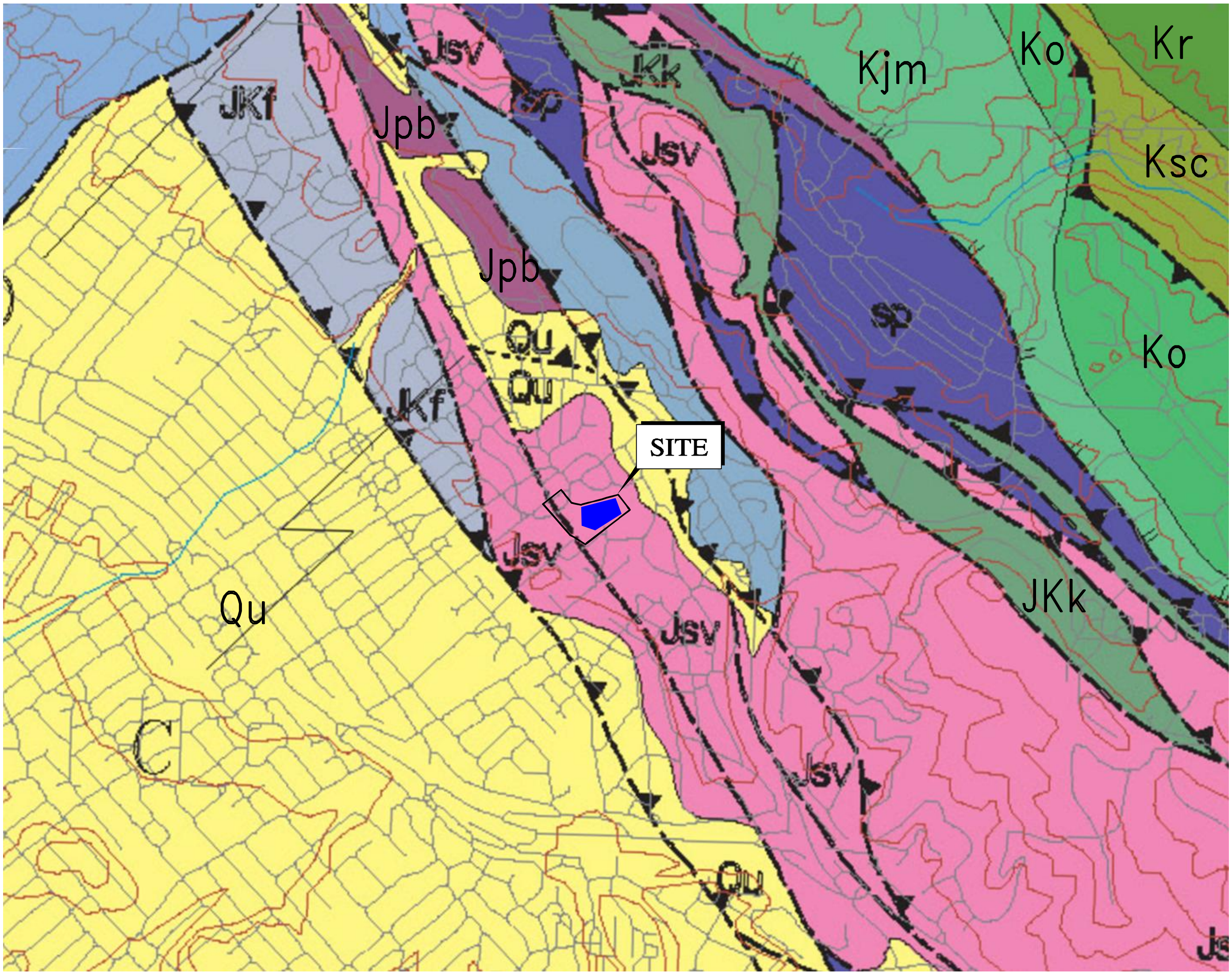
18. Lienkaemper, J.J., 2008, Digital Database of Recently Active Traces of the Hayward Fault, California, USGS, To Accompany DS-177.

19. Pacific Aerial Surveys; August 8, 1939, flight BUT-BUU, Line 289, frames 46-48,

20. Radbruch, D.H., 1969, Areal and Engineering Geology of the Oakland East Quadrangle, USGS, GQ-69

21. Wells, D.L., and Coppersmith, K.J., New Empirical Relationships among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement, Bulletin of the Seismological Society of America, Vol 84, No. 4, pp974-1002, August 1994.

22. 2007 Working Group on California Earthquake Probabilities, 2008, The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2): U.S. Geological Survey Open-File Report 2007-1437 and California Geological Survey Special Report 203 [http://pubs.usgs.gov/of/2007/1437/].



EXPLANATION

BEDROCK CONTACT-DASHED WHERE GRADATIONAL OR APPROXIMATELY LOCATED

FAULT-DASHED WHERE INFERRED, DOTTED WHERE CONCEALED

Qu	UNDIVIDED QUATERNARY DEPOSITS
Kr	REDWOOD CREEK FORMATION
Ksc	SHEPARD CANYON FORMATION
Ko	OAKLAND SANDSTONE
Kjm	JOAQUIN MILLER FORMATION
JKk	KNOXVILLE FORMATION
Jsv	KERATOPHYRE
Jpb	PILLOW BASALT AND BASALT
JKf	FRANCISCAN COMPLEX

N

0 FEET 2000
0 METERS 1000

BASE MAP SOURCE: GRAYMER, 1995

ENGEO
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REGIONAL GEOLOGIC MAP - GRAYMER

EBMUD 39TH AVENUE RESERVOIR

OAKLAND, CALIFORNIA

PROJECT NO.: 9472.000.000	FIGURE NO. 1
SCALE: AS SHOWN	
DRAWN BY: PC	CHECKED BY: RS

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ORIGINAL FIGURE PRINTED IN COLOR

EXPLANATION

1906 C — FAULTS CONSIDERED TO HAVE BEEN ACTIVE DURING HOLOCENE TIME AND TO HAVE A RELATIVELY HIGH POTENTIAL FOR SURFACE RUPTURE; SOLID LINE WHERE ACCURATELY LOCATED, LONG DASH WHERE APPROXIMATELY LOCATED, SHORT DASH WHERE INFERRED, DOTTED WHERE CONCEALED; QUERY (?) INDICATES ADDITIONAL UNCERTAINTY. EVIDENCE OF HISTORIC OFFSET INDICATED BY YEAR OF EARTHQUAKE-ASSOCIATED EVENT OR C FOR DISPLACEMENT CAUSED BY CREEP OR POSSIBLE CREEP

EARTHQUAKE FAULT ZONE BOUNDARIES; DELINEATED AS STRAIGHT-LINE SEGMENTS THAT CONNECT ENCIRCLED TURNING POINTS SO AS TO DEFINE EARTHQUAKE FAULT ZONE SEGMENTS

N

0 FEET 2000
0 METERS 1000

BASE MAP SOURCE: CDMG, 1993

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EARTHQUAKE FAULT ZONE MAP

EBMUD 39TH AVENUE RESERVOIR

OAKLAND, CALIFORNIA

PROJECT NO.: 9472.000.000	FIGURE NO. 2
SCALE: AS SHOWN	
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G:\Drafting\DRAFTING2_Dwg\9472\000\EBMUD 39TH Ave Res\9472000000-2-AP Fault Map-0412.dwg Plot Date: 5-02-12 pcrockett

ORIGINAL FIGURE PRINTED IN COLOR

N

0 FEET 100
0 METERS 30

OBSERVATION POINTS

1. APPROXIMATE LOCATION OF WATER SEEPAGE
2. APPROXIMATE LOCATION OF RIGHT LATERAL OFFSET CURB
3. APPROXIMATE LOCATION OF ROTAED CURB PANEL AND SEVERELY CRACKED SIDEWALK
4. APPROXIMATE LOCATION OF RIGHT LATERAL OFFSET CURB
5. APPROXIMATE LOCATION OF MINOR CURB DEFLECTION
6. APPROXIMATE LOCATION OF RIGHT LATERAL OFFSET CURB
7. APPROXIMATE LOCATION OF POSSIBLE OFFSET CURB AND SEVERE PAVEMENT DISTRESS
8. APPROXIMATE LOCATION OF RIGHT LATERAL OFFSET CURB
9. APPROXIMATE LOCATION OF MINOR SLUMP IN CUT SLOPE. WATER SEEPING FROM SLOPE AT TIME OF SITE VISIT

EXPLANATION

- (red line) APPROXIMATE LOCATION OF HAYWARD FAULT CONSIDERED TO HAVE BEEN ACTIVE DURING HOLOCENE TIME AND TO HAVE A RELATIVELY HIGH POTENTIAL FOR SURFACE RUPTURE (STATE OF CALIFORNIA EARTHQUAKE FAULT ZONE MAP, 1982-REFERENCE 2)
- (blue line) APPROXIMATE LOCATION OF FAULT ZONE BOUNDARIES (STATE OF CALIFORNIA EARTHQUAKE FAULT ZONE MAP, 1982-REFERENCE 2)
- (black line) APPROXIMATE LOCATION OF HAYWARD FAULT (LIENKAMPER, 2008)

BASE MAP SOURCE: USGS EROS DATA CENTER

ENGEO Expect Excellence	FAULT COMPILATION AND RECONNAISSANCE MAP EBMUD 39TH AVENUE RESERVOIR OAKLAND, CALIFORNIA	PROJECT NO.: 9472.000.000 SCALE: AS SHOWN DRAWN BY: PC CHECKED BY: RS	FIGURE NO. 3

ORIGINAL FIGURE PRINTED IN COLOR

N

0 FEET 20
0 METERS 10

EXPLANATION

APPROXIMATE LOCATION OF HAYWARD FAULT (EARTHQUAKE FAULT ZONE MAP)

APPROXIMATE LOCATION OF SPRING

UD-23 APPROXIMATE LOCATION OF BORING (EBMUD, 1959)

Qaf ARTIFICIAL FILL

Qc COLLUVIUM

Jsv KERATOPHYRE (LEONA RHYOLITE)

BASE MAP SOURCE: USGS EROS DATA CENTER (AERIAL AND CONTOURS), ALAMEDA COUNTY GIS (PARCEL LINES)

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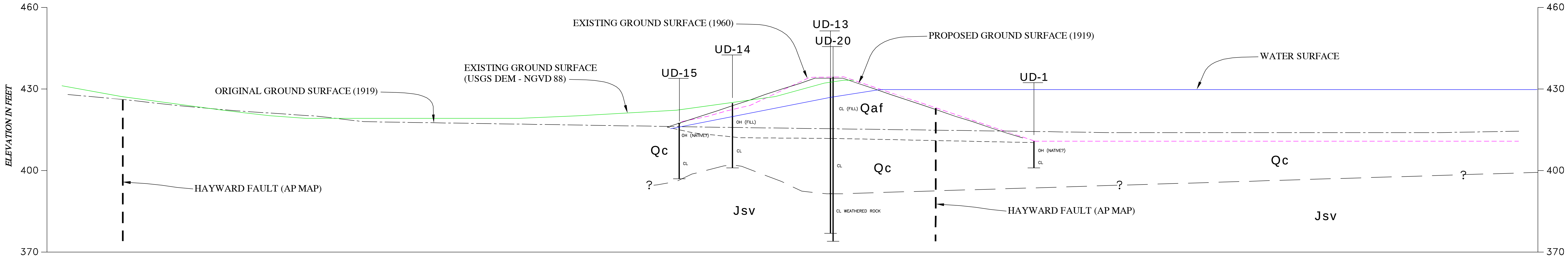
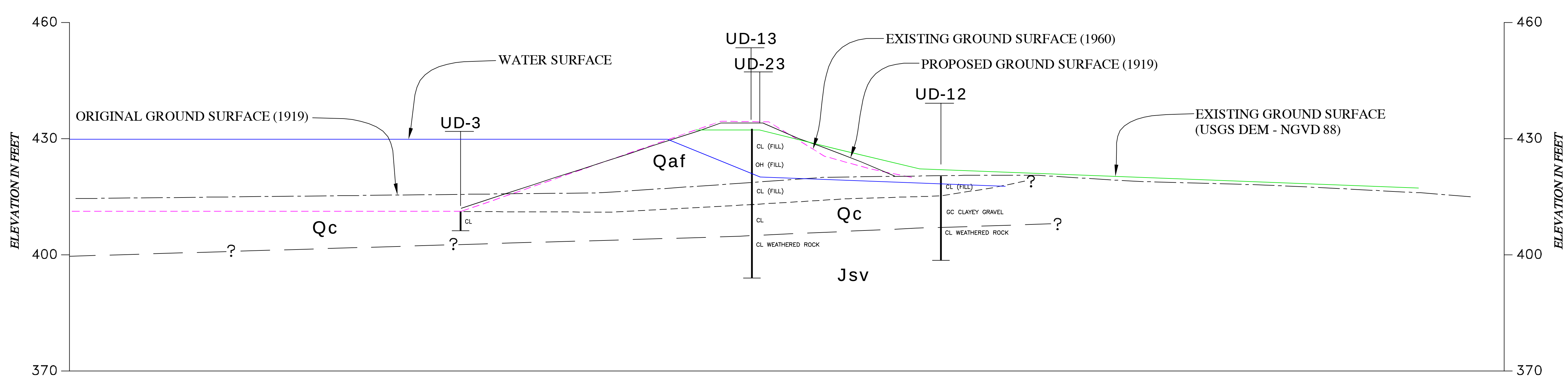
PRELIMINARY GEOLOGIC MAP
EBMUD 39TH AVENUE RESERVOIR
OAKLAND, CALIFORNIA

PROJECT NO.: 9472.000.000
SCALE: AS SHOWN
DRAWN BY: PC
CHECKED BY: RS
FIGURE NO 4

ORIGINAL FIGURE PRINTED IN COLOR





EXPLANATION

Qaf	ARTIFICIAL FILL (1920)
Qls	COLLUVIUM (NATIVE SOIL)
Jsv	KERATOPHYRE (LEONA RHYOLITE)
UD-23	APPROXIMATE LOCATION OF BORING (EBMUD, 1959)

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CROSS SECTIONS
EBMUD 39TH AVENUE RESERVOIR
OAKLAND, CALIFORNIA

PROJECT NO.: 9472.000.000	FIGURE NO. 5
SCALE: 1"=30'	
DRAWN BY: PC	CHECKED BY: RS

EAST BAY MUNICIPAL UTILITY DISTRICT

39th Avenue Reservoir Replacement Project
Supporting Documentation

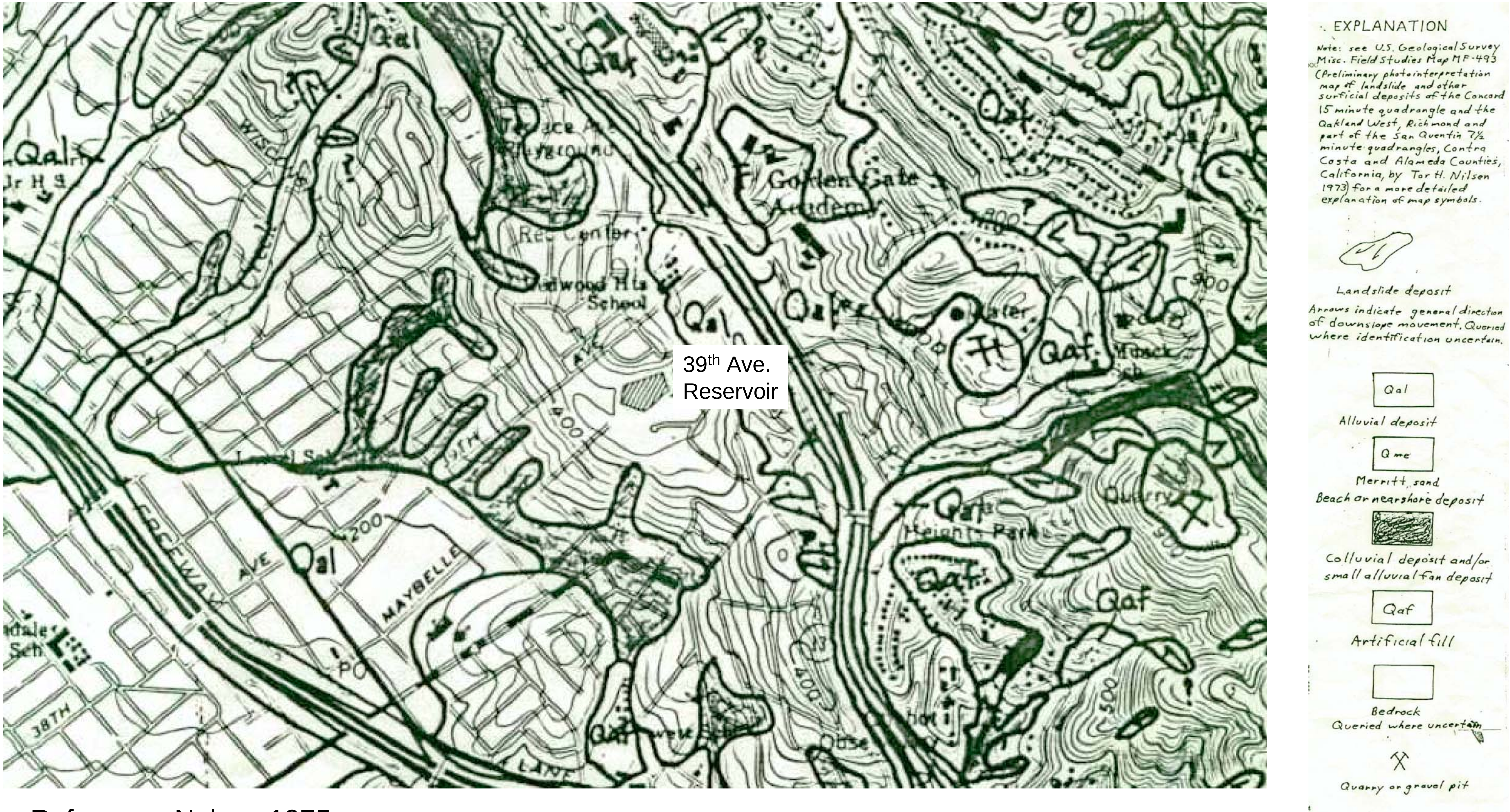
Prepared by Materials Engineering

- **Alquist-Priolo Special Studies Zone, July 2012**
- **USGS Oakland East Landslides Map, July 2012**
- **Hayward Fault Map, Feb 2012**

August 2012

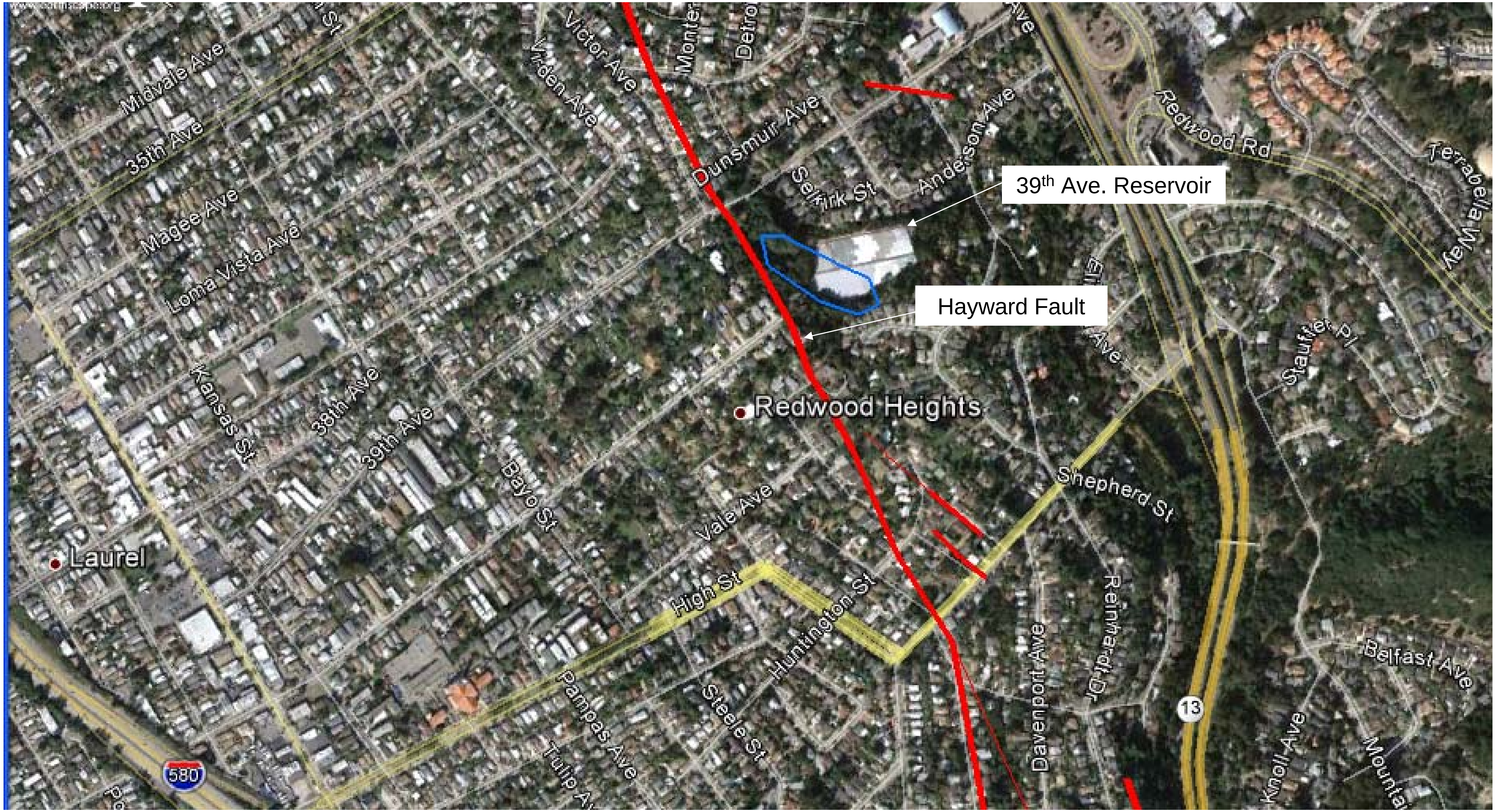
Reference: CDMG 1982

EBMUD	39th AVENUE RESERVOIR REPLACEMENT PROJECT **Alquist-Priolo Special Studies Zones**	Date: July 2012 **PLATE**



Reference: Nelsen 1975

EBMUD	39th AVENUE RESERVOIR REPLACEMENT PROJECT **Map of Landslide and Other Surficial Deposits of Oakland East**	Date: July 2012 **PLATE**



Reference: Google Earth

EBMUD	39th AVENUE RESERVOIR DAM SEISMIC STABILITY EVALUATION	Date: February 2012
	HAYWARD FAULT MAP	**PLATE 5**