Attachment E
to Technical Memorandum No.2

Geotechnical Evaluation of Ross Valley Detention Basins (Except Phoenix Lake)

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GEOTECHNICAL AND GEOLOGIC FEASIBILITY STUDY LOMA ALTA, LEFTY GOMEZ FIELD, MEMORIAL PARK AND RED HILL PARK DETENTION BASINS WATERSHED FLOOD DAMAGE REDUCTION & CREEK MANAGEMENT STUDY MARIN COUNTY, CALIFORNIA

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Project 960.05

Prepared For:
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CERTIFICATION

This document is an instrument of service, prepared by or under the direction of the undersigned professionals, in accordance with the current ordinary standard of care. The service specifically excludes the investigation of radon, asbestos or other hazardous materials. The document is for the sole use of the client and consultants on this project. No other use is authorized. If the project changes, or more than two years have passed since issuance of this report, the findings and recommendations must be reviewed by the undersigned.

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LOMA ALTA, LEFTY GOMEZ FIELD, MEMORIAL PARK
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I. INTRODUCTION

This report presents the results of our geotechnical and geologic feasibility evaluation for Loma Alta Detention Basin (DB), Lefty Gomez Field DB, Memorial Park DB and Red Hill Park DB as part of the Watershed Flood Damage Reduction and Creek Management Study, Marin County, California. The locations of the project sites are shown on Figure 1, Site Location Map. Our work was performed in accordance with our Agreement for Professional Services dated January 5, 2010 and Modification No. 1 dated February 26, 2010. The purpose of our current services is to review available data, evaluate geologic and geotechnical conditions, and provide our opinion regarding the feasibility of using the proposed sites as detention basins. The scope of our services includes the following:

- Review of geologic and geotechnical data available from the design team, local government sources (Town of Fairfax, Town of San Anselmo and Division of the State Architect (DSA)), published USGS and CGS data, and relevant Miller-Pacific reference data;
- Site reconnaissance at each of four sites to observe and evaluate existing site conditions and local geology;
- Aerial photography study for evaluation of geologic features suggestive of development hazards;
- Review of site plan and topographic mapping provided by the design team;
- Development of opinions regarding site-specific geologic hazards, potential mitigation measures, preliminary geotechnical recommendations and general development guideline;
- Preparation of this Geotechnical Feasibility Report.

This report is intended for the exclusive use of Marin County Flood Control and Water Conservation District, Stetson Engineers and their consultants on this project. No other use is authorized without the express written consent of Miller Pacific Engineering Group.
Supplemental services are expected to include a design level geotechnical investigation report based on subsurface exploration and laboratory testing at chosen sites, geotechnical consultation and plan review, and construction inspection and testing.

II. PROJECT DESCRIPTION

Four sites in central Marin County are being considered for development or redevelopment as Flood Control Detention Basins. A site location map is presented on Figure 1. Loma Alta DB is located in an undeveloped ravine upslope of White Hill School in Fairfax which is currently part of the Loma Alta Open Space Preserve under the management of the Marin County Open Space District. Lefty Gomez Field DB in Fairfax and Memorial Park DB and Red Hill Park DB in San Anselmo are currently developed as municipal parks.

Preliminary site plans indicate that the Loma Alta DB, along a tributary from the Loma Alta open space preserve, will require construction of an approximately 25 feet high and 200 feet wide earthen dam within an existing drainage ravine. The upstream and downstream slopes are planned at 4:1 (horizontal:vertical) inclinations. The project site is currently undeveloped. It should be noted that dams less than 25 feet in height and store less than 50 acre-feet of water would not be within Division of Safety of Dams (DSOD) jurisdiction.

Proposed construction of Lefty Gomez Field DB would be accomplished primarily by excavation to a maximum depth of roughly 22 feet below existing ground surface. A dike would also be constructed along the eastern side of the detention basin with a maximum height of about 8 feet. The detention basin side of the dike is currently planned with 2:1 (horizontal:vertical) slopes and the outboard side with 1:1 slopes. Concrete detention walls, 2 and 5 feet tall, are planned along the northern portion of the detention basin. A concrete dam (20 feet above channel bed) would be located in the creek channel in the northeast corner of the DB area.

Planned grading of Memorial Park DB is also primarily excavation to a maximum depth of rough 20 feet below existing ground surface. A low dike would be constructed along the southern side of the detention basin with a maximum height of 9 feet. The detention basin side of the dike is currently planned with 2:1 (horizontal:vertical) slopes and the outboard side with 1:1 slopes.

The proposed Red Hill DB would be created by construction of a compacted fill dike along the southern side to a maximum height of 12 feet. The detention basin side of the dike is currently planned with 2:1 (horizontal:vertical) slopes and the outboard side with 1:1 slopes.

Development of Lefty Gomez Field, Memorial Park, and Red Hill Park as detention basins will mainly require demolition of existing park improvements. All proposed detention basins include ancillary improvements such as spillways, gated inlet and/or outlet culverts, and slope protection.

The project team currently includes Marin County Flood Control and Water Conservation District, Stetson Engineers, Noble Consultants, Geomorph, and WRA Consultants.

III. SITE CONDITIONS

A. Regional Geology

The site is located within the Coast Range Geomorphic Province of California. The regional bedrock geology consists of complexly folded, faulted, sheared, and altered sedimentary, igneous, and metamorphic rock of the Jurassic-Cretaceous age (65-190 million years ago) Franciscan Complex.

The regional topography is characterized by northwest-southeast trending mountain ridges and intervening valleys formed from tectonic activity between the North American Plate and the Pacific Plate. Extensive faulting during the Pliocene Age (1.8-7 million years ago) formed the uneven depression that is now the San Francisco Bay. More recent tectonic activity is concentrated along the San Andreas Fault zone, a complex group of generally parallel faults.

Regional geologic mapping (USGS 2000) indicates that Loma Alta DB and Lefty Gomez Field DB are underlain by a significant amount of alluvial valley sediments, while the surrounding hills are underlain by sandstone, shale, and mélange of the Franciscan Complex. Memorial Park DB and Red Hill Park DB are also mapped as being underlain by alluvial deposits. The ridge separating Memorial Park DB and Red Hill Park DB is mapped as Franciscan sandstone, while the prominent knoll to the east of Red Hill Park DB is mapped as greenstone. A regional geologic map is presented on Figure 2.

B. Site Reconnaissance

We performed a site reconnaissance on February 19, 2010 at each of the four sites to observe and document existing conditions, as well as to evaluate the potential effects of site conditions on the proposed development.

Loma Alta DB is an unnamed tributary at the north end of Glen Drive in Fairfax, bounded by White Hill School to the south and by natural, undeveloped slopes to the east, west and north. Currently, the land is managed by the Marin County Open Space District. Slopes to the north and east were observed to be underlain by slightly to moderately weathered sandstone of the Franciscan Complex, with a thin veneer of residual soil at the surface. Slopes in these areas, particularly to the east, show terracing commonly associated with soil creep, but do not exhibit any signs of global instability. To the east of the creek, bedrock was observed to be highly weathered and somewhat less competent than on the west, and slopes east of the ravine are characterized by deeply incised eroded channels which are choked with debris. We observed numerous small slumps and debris flows, as well as common raveling and sloughing of creek banks and trail cut slopes. The bottom of the ravine consists of unsorted silts, sands, and

gravels typical of alluvial deposits as well as tree limbs and other debris.

We did observe a drainage channel on the slope east of the proposed dam which is relatively steep and, were the dam constructed in the proposed location, would discharge runoff across the downstream face of the dam, likely resulting in adverse erosion patterns which could affect the stability and lifespan of the dam. Significant geologic features observed during our site reconnaissance are shown on Figure 3.

Lefty Gomez Field DB is bounded by Sir Francis Drake Avenue to the south, Shadow Creek Court to the west, and Fairfax Creek to the north. The west side of the field abuts a residential development built along Sherman Court in the late 1960s and early 1970s. We observed a large outcrop of relatively fresh Franciscan graywacke at the south end of the field, but did not observe in-situ bedrock elsewhere on the site, including at the location of the proposed spillway at the northeast corner of the site. The field currently sits approximately 10 feet above the flowline of the creek, and our observations suggest most of the excavation required to lower the field elevation would be in alluvial deposits with bedrock in the southern portion. Geologic features observed are shown on Figure 4.

Memorial Park DB consists of a natural grass athletic field, a relatively new playground, tennis courts, and ancillary improvements. It is bounded on the south, west and north by commercial and residential development, and on the east by a steep, heavily vegetated slope. The slope is at an approximate inclination of 1.5:1 (horizontal:vertical), except at the base, where approximately 8 to 10 feet of soil is retained by large eucalyptus trees, forming a vertical face roughly 8 feet tall. About 100 feet above the vertical face, we observed a large headscarp, measuring roughly 20 feet tall and 150 feet across, marking the uppermost extend of an older landslide. We did not observe evidence of recent movement such as ground cracks, leaning trees, or excessive seepage, and the slide debris is covered with vertical eucalyptus trees on the order of 60 to 80 feet tall, suggesting the slide predates the trees. The composition of the slide debris suggests bedrock composed of Franciscan sandstone, which is consistent with the mapped geology. Aside from the steep slope east of the site, we did not observe any evidence of large-scale slope instability. Significant geologic features observed are shown on Figure 5.

Red Hill Park DB is located just east of Memorial Park and is currently occupied by an artificial-turf athletic field and associated improvements, which were completed in early 2009. The Park is bounded by Sunnyhills Drive on the west and Shaw Drive on the east. Red Hill shopping center lies to the south of the site at an elevation approximately 15 feet below the current field elevation. The shopping center and field are separated by a retaining wall approximately 13 feet high. Undeveloped slopes surrounding the park show evidence of minor soil creep, but we did not observe any evidence for large-scale slope instability. Site reconnaissance observations are

shown on Figure 6.

C. Review of Reference Documents

We reviewed documents held by various local agencies and authorities in an effort to find geologic or geotechnical information pertinent to the potential detention basin locations. On March 4, 2010 we visited both the Town of Fairfax and the Town of San Anselmo to view files on nearby structures and improvements. At the Town of San Anselmo we looked at information related to the Red Hill Park improvements, Sunny Hills Services, Ross Valley School District Office Building, Red Hill Shopping Center and various nearby residences. Unfortunately there was very little geologic or geotechnical information available to aid our evaluation. At the Town of Fairfax, we requested or reviewed files for the nearby White Hill Middle School and various adjacent residences. No relevant geologic or geotechnical information was contained in the files.

We contacted the Division of the State Architect on March 8, 2010 and viewed files for the Ross Valley School District Office Building, Red Hill School, Red Hill Park Improvements, and White Hill Middle School. We were unable to locate geotechnical or soils reports for these jobs. DSA reports that some jobs may not have required geotechnical reports, and that those jobs for which geotechnical reports were required have incomplete or missing files.

Historic Aerial Photographs – We reviewed historic aerial photographs of each site available from HJW Geospatial/Pacific Aerial Surveys of Oakland, California. We reviewed the photographs on March 3, 2010 to obtain information about site history and development. Historic photographs are summarized below with dates, identifications, and our review notes. Selected aerial photographs are presented on Figures 7 through 9.

Loma Alta Tributary DB:

Date	Photo ID	Comments
03-01-58	SFAREA-1-7	Site is undeveloped, and Smith Saddle water tanks have not yet been built. Grading appears to have begun for White Hill School to the south of the site.
07-02-70	AV957-02-20	Water tanks at Smith Saddle have been constructed, but no other development of the site has taken place. The main building at White Hill School is in place to the south of the site.
04-17-75	AV1187-02-20	No development at site since 1970. Residential development south of site along Glen Drive is occurring.
04-01-80	AV1840-02-21	No development at site since 1975. Residential development south of site along Glen Drive is occurring.
05-03-82	AV2140-02-21	No development at site since 1980.
03-15-90	AV3766-7-27	No development at site since 1982.
08-09-95	AV4890-15-51	No development at site since 1990. Residential development along Glen Drive to south of site is mostly complete.
03-06-05	KAV9010-14-2	No development at site since 1995. Development along Glen Drive has been completed.

Lefty Gomez Field DB:

Date	Photo ID	Comments
03-01-58	SFAREA-1-7	Sir Francis Drake Blvd. is in place, and grading for White Hill School appears to be underway. Glen Drive is unpaved and no residential development has taken place.
07-02-70	AV957-02-20	Residential development along Glen Drive and Sherman Court has begun and the main building at White Hill School is in place. The site has not yet been developed.
04-17-75	AV1187-02-20	Residential development along Glen Drive and Sherman Court is ongoing and a baseball field has been constructed at the site.
04-01-80	AV1840-02-21	Development of Sherman Court is complete, and development along Glen Drive continues to advance to the north and west. White Hill School has a new building.
05-03-82	AV2140-02-21	No major changes at the site since 1980.
03-15-90	AV3766-7-27	White Hill School has been expanded and development of Glen Drive has advanced slightly to the west.
08-09-95	AV4890-15-51	White Hill School has continued to expand. Shadow Creek Court and Maiden Lane have been constructed to the west of the site but no homes have yet been built.
03-06-05	KAV9010-14-2	Residential development to the north and west of the site is complete.

Memorial Park DB and Red Hill Park DB:

Date	Photo ID	Comments
12-14-53	AV124-01-01	Memorial Park's baseball field and tennis courts are in place and are bounded by existing residential development to the west and south. The north side of the park appears undeveloped open space, although the Log Cabin is already in place. Scattered single-family homes occupy the land where Red Hill Shopping Center will be built, and Red Hill Park is a natural drainage channel which has yet to be filled and developed.
07-09-63	AV550-03-15	No major changes since 1953.
07-02-70	AV957-03-22	Sonoma Avenue and Sunnyhills Drive have been built, as has Red Hill Shopping Center. North of the shopping center, the old natural drainage has been filled and leveled, and Sunnyhills Drive appears to follow its current alignment. Residential development which previously occupied the southern tip of the prominent knoll separating Memorial and Red Hill Parks has been demolished and redevelopment has not yet begun.
04-17-75	AV1187-03-21	Memorial Park has been improved to include 3 baseball diamonds. A new apartment complex occupies the space between the parks where previous development had been demolished. Red Hill Park now contains an oval track and a tennis court at the southeastern corner. The Sunnyhills Autistic Services center to the northwest of Red Hill Park appears to be nearing completion.
04-01-80	AV1840-03-26	The Sunnyhills Services center and Robin's Nest School are complete. The apartment complex south of Memorial Park has added a second set of tennis courts.
05-03-82	AV2140-04-23	The parking lot north of Memorial Park near the Log Cabin has been paved, and additional grading near the Robin's Nest School northeast of Red Hill Park appears to have taken place.
03-15-90	AV3766-09-26	No major changes since 1982.
03-06-05	KAV9010-16-4	The playground at the northwest corner of Memorial Park has been constructed.

D. Anticipated Subsurface Conditions

Based on our review of regional and local geologic maps as well as geotechnical reports for nearby sites, we anticipate Loma Alta DB is underlain by 10 to 20 feet of alluvial deposits over Franciscan Bedrock. We anticipate a thicker alluvial deposit on the order of 20-30 feet at Lefty Gomez Field DB. Memorial Park DB should be underlain by relatively shallow bedrock on the west side of the site, with bedrock increasing in depth to the west. At Red Hill Park DB, Red Hill Park, we have previously encountered up to 10 feet of fill atop alluvial deposits. Bedrock at Red Hill Park DB is anticipated to be between 20 and 30 feet deep. The depth to groundwater is not known at this time.

E. Seismicity

Active Faults in the Region- The project site is located within a seismically active area and will therefore experience the effects of future earthquakes. Earthquakes are the product of the build-up and sudden release of strain along a "fault" or zone of weakness in the earth's crust. Stored energy may be released as soon as it is generated or it may be accumulated and stored for long periods of time. Individual releases may be so small that only sensitive instruments detect them, or they may be violent enough to cause destruction over vast areas.

Faults are seldom single cracks in the earth's crust but typically are braids of breaks that comprise shatter zones which link to form networks of major and minor faults. Within the Bay Area, faults are concentrated along the San Andreas Fault zone. The movement between rock formations along either side of a fault may be horizontal, vertical, or a combination and is radiated outward in the form of energy waves. The amplitude and frequency of earthquake ground motions partially depends on the material through which it is moving. The earthquake force is transmitted through hard rock in short, rapid vibrations, while this energy movement becomes a long, high-amplitude motion when moving through soft ground materials, such as Bay Mud.

An "active" fault is one that shows displacement within the last 11,000 years and, therefore, is considered more likely to generate a future earthquake than a fault that shows no sign of recent rupture. The locations of the currently known active faults relative to the project sites are shown on Figure 10.

Historic Fault Activity- Numerous earthquakes have occurred in the region in historic times. The results of our computer database search indicate that 55 earthquakes (Richter Magnitude 5.0 or larger) have occurred within 150 kilometers (93 miles) of the site area between 1735 and 2010. The five most significant historic earthquakes to affect the project site are summarized in Table A.

TABLE A
SIGNIFICANT EARTHQUAKE ACTIVITY
Proposed Detention Basin Sites
Marin County, California

Epicenter (Latitude, Longitude)	Richter Magnitude	Fault	Year	Distance
37.80, -122.20	6.8	Hayward	1836	40 km
37.60, -122.40	7.0	San Andreas	1838	46 km
37.70, -122.10	6.8	Hayward	1868	53 km
38.20, -122.40	6.2	Rodgers Creek	1898	28 km
37.70, -122.50	8.2	San Andreas	1906	33 km

Reference: USGS (2009)

Probability of Future Earthquakes – The historical records do not directly indicate either the maximum credible earthquake or the probability of such a future event. To evaluate earthquake probability in this region, the USGS has assembled a group of researchers into the "Working Group on California Earthquake Probabilities" (2008) to estimate the probabilities of earthquakes on active faults. Potential sources were analyzed considering fault geometry, geologic slip rates, geodetic strain rates, historic activity, and micro-seismicity, to arrive at estimates of probabilities of earthquakes with a Moment Magnitude greater than 6.7 by 2038.

The probability studies focus on seven "fault systems" within the Bay Area. Fault systems are composed of different, interacting fault segments capable of producing earthquakes within the individual segment or in combination with other segments of the same fault system. The probabilities for the individual fault segments in the San Francisco Bay Area are presented on Figure 10.

In addition to the seven fault systems, the studies included probabilities of "background earthquakes." These earthquakes are not associated with the identified fault systems and may occur on lesser faults (i.e., West Napa) or previously unknown faults (i.e., the 1989 Loma Prieta and 2000 Mt. Veeder – Napa earthquakes). When the probabilities on all seven fault systems and the background earthquakes are combined mathematically, there is a 62 percent chance for a magnitude 6.7 or larger earthquake to occur in the Bay Area by the year 2032. Smaller earthquakes (between magnitudes 6.0 and 6.7), capable of considerable damage depending on proximity to urban areas, have about an 80 percent chance of occurring in the Bay Area by 2032 (USGS, 2008).

Additional studies by the USGS regarding the probability of large earthquakes in the Bay Area are ongoing. These current evaluations include data from additional active faults and updated geological data.

IV. GEOLOGIC HAZARDS

A. General

This section identifies potential geologic hazards at the property site, their significant adverse impacts, and recommended mitigation measures. The significant geologic hazards at the project site are seismic ground shaking and liquefaction.

B. Fault Surface Rupture

Under the Alquist-Priolo Special Studies Zone Act, the California Division of Mines and Geology (CDMG) produced 1:2000 scale maps showing all active faults. None of the proposed detention basin sites are located within an Alquist-Priolo Special Studies Zone and none are near any of the known active faults. The potential for fault surface rupture at the sites is remote.

Location	Mitigation measures required
Loma Alta DB Lefty Gomez Field DB Memorial Park DB Red Hill Park DB	*No mitigation measures required.*

C. Seismic Shaking

The sites will experience seismic ground shaking similar to other areas in the seismically active Bay Area. The intensity of ground shaking will depend on the characteristics of the causative fault, distance from the fault, the earthquake magnitude and duration, and site-specific geologic conditions. The locations of the project sites relative to known active faults are shown on Figure 10. Table B presents the expected ground accelerations at the sites shown for earthquakes on various nearby active faults. These acceleration values are for an earthquake originating on the closest portion of the fault to each site.

TABLE B
ESTIMATED PEAK GROUND ACCELERATIONS
Proposed Detention Basin Sites
Marin County, California

Location	Deterministic PGA	Probabilistic 10% in 50 yrs.	Probabilistic 2% in 50 yrs.
Loma Alta DB	0.31 g	0.47 g	0.74 g
Lefty Gomez Field DB	0.31 g	0.47 g	0.75 g
Memorial Park DB	0.30 g	0.48 g	0.74 g
Red Hill Park DB	0.30 g	0.48 g	0.73 g

Reference: Abrahamson and Silva (2008), Boore and Atkinson (2008), Campbell and Bozorgnia (2008), Chiou and Youngs (2008), Idriss (2008), USGS (2010)

Location	Mitigation measures required
Loma Alta DB Lefty Gomez Field DB Memorial Park DB Red Hill Park DB	*Structures should be designed in accordance with the most recent version of the California Building Code. Seismic design guidelines and preliminary recommendations are presented in Section V of this report. Site-specific seismic design criteria will be presented in a design-level Geotechnical Investigation Report.*

D. Liquefaction Potential

Liquefaction refers to the sudden, temporary loss of soil strength during strong ground shaking. This phenomenon can occur where there are saturated, loose, granular (sandy) deposits subjected to seismic shaking. Liquefaction-related phenomena include settlement, flow failure, slope instability and lateral spreading. Because all four sites are located at least partially on alluvial deposits, the potential for liquefaction exists. Mapping by the USGS (2000) indicates all four sites lie in a zone of high liquefaction susceptibility, as shown on Figure 11. This will be confirmed based on subsurface exploration associated with our design level geotechnical investigation.

Location	Mitigation measures required
Loma Alta DB Lefty Gomez Field DB Memorial Park DB Red Hill Park DB	*Subsurface exploration is required to evaluate liquefaction potential. Site-specific liquefaction mitigation recommendations will be presented in a design-level Geotechnical Investigation Report. Potential mitigation may include ground improvement or retaining structures that limit lateral displacements.*

E. Seismic Induced Ground Settlement

Ground shaking can induce settlement of loose granular soils above the water table. Based on regional geologic mapping, all four sites are underlain by alluvium comprised of discontinuous strata of sand, silt, and clay. At Lefty Gomez Field DB, Memorial Park DB and Red Hill Park DB, which have been developed as municipal parks, the alluvial soils underlying park improvements has likely been compacted to prolong the lifespan of the improvements, and therefore densification of soils during a seismic event is low. At Loma Alta DB, which is undeveloped and unimproved, alluvium is expected to be less consolidated, and therefore more susceptible to seismic densification. However, we will confirm subsurface conditions during our design level geotechnical investigation.

Location	Mitigation measures required
Loma Alta DB	*Subsurface exploration required for evaluation of seismic densification hazard. Site-specific mitigation recommendations will be presented in a design-level Geotechnical Investigation Report. Mitigation measure may include removal of loose soils and replacement with compacted fill.*
Lefty Gomez Field DB Memorial Park DB Red Hill Park DB	*No mitigation measures required.*

F. Lurching and Ground Cracking

Lurching and associated ground cracking can occur during strong ground shaking. The ground cracking generally occurs along the tops of slopes where stiff soils are underlain by soft deposits or along steep channel banks. Loma Alta DB (Loma Alta Tributary) is bounded on three sides by steep terrain which is likely underlain with weathered bedrock. Lefty Gomez Field DB (Lefty Gomez Field) is currently bordered on the north by a creek channel approximately 10 feet deep and having near-vertical banks susceptible to lurching or cracking. Memorial Park DB and Red Hill Park DB are relatively flat sites and are not expected to be susceptible to lurching or cracking.

Location	Mitigation measures required
Loma Alta DB Memorial Park DB Red Hill Park DB	*No mitigation measures are required.*
Lefty Gomez Field DB	*Construction of the detention basin will eliminate the southern creek bank. Also, construction of a concrete retaining wall along the northern bank as indicated on preliminary plans will mitigate the potential for cracking and lurching in a seismic event. More detailed site-specific mitigation recommendations will be presented in a design-level Geotechnical Investigation Report.*

G. Erosion

Sandy soils on moderate slopes or clayey soils on steep slopes are susceptible to erosion when exposed to concentrated surface water flow. The potential for erosion is increased when

established vegetation is disturbed or removed. Loma Alta DB is vulnerable to erosion due to the expected colluvial and residual soil layers on the steep terrain at the site. Active erosion features were observed during our site reconnaissance. Sedimentation of the detention basin should be anticipated during major rainfall events. Careful attention should be given to the design and location of the proposed embankment in order to best mitigate the potential for adverse erosion and sedimentation patterns.

Preliminary plans indicate Lefty Gomez Field DB, Memorial Park DB, and Red Hill Park DB are to be constructed with perimeter dikes having slopes of 1:1 (horizontal:vertical). Slopes steeper than 2:1 will need to be designed and constructed with geogrid reinforcement. Erosion-control measures should be implemented to prevent adverse erosion patterns from affecting the planned cut slopes or embankments.

Location	Mitigation measures required
Loma Alta DB	*Existing erosion features should be repaired and stabilized as part of the detention basin construction. Careful attention should be given to the collection and control of surface drainage from the adjacent slopes to minimize erosion of embankment, slopes and reduce sedimentation within the basin. Erosion-control measures are discussed in further detail in Section V of this report. More detailed site-specific mitigation recommendations will be presented in a design-level Geotechnical Investigation Report.*
Lefty Gomez Field DB Memorial Park DB Red Hill Park DB	*Erosion-control measures including erosion control mats and planting should be implemented on all slopes to prevent loss of material. More detailed site-specific mitigation recommendations will be presented in a design-level Geotechnical Investigation Report.*

H. Seiche and Tsunami

Seiche and tsunamis are short duration earthquake-generated water waves in enclosed bodies of water and the open ocean, respectively. None of the sites are in close proximity to San Francisco Bay or the Pacific Ocean, and all are at elevations of at least 70 feet above sea level. Therefore, the likelihood of damage due to seiche or tsunami is remote.

Location	Mitigation measures required
Loma Alta DB Lefty Gomez Field DB Memorial Park DB Red Hill Park DB	*No mitigation measures required*.

I. Flooding

Typical adverse impacts from flooding are water damage to structures and furnishings. Based on Flood Insurance Rate Mps (FIRMs) published by the Federal Emergency Management Agency (FEMA), Memorial Park DB is located within the 500-year flood zone. None of the other

sites are located within a FEMA 100- or 500-year flood zone. Therefore, the potential for damage to improvements due to large-scale flooding is low. Construction of the detention basin(s) will further reduce the risk of flooding.

Location	Mitigation measures required
Loma Alta DB Lefty Gomez Field DB Memorial Park DB Red Hill Park DB	*Intent of detention basins is to temporarily hold flood waters. Design of detention basins should allow for short term hydrostatic pressures and drawdown conditions.*

J. Settlement

Consolidation settlement occurs from structures and other surface loads that cause deformation of soft, compressible clays. The project sites are expected to be underlain with thick deposits of dense or stiff alluvial sandy gravel, silt, and clay overlying bedrock. Soft compressible clay layers are not expected at the project sites. We will confirm subsurface conditions during our design level geotechnical investigation. At this time, we judge the potential for significant settlement to be low.

Location	Mitigation measures required
Loma Alta DB Lefty Gomez Field DB Memorial Park DB Red Hill Park DB	*No mitigation measures required.*

K. Expansive Soil

Expansive soil occurs when clay particles interact with water causing volume changes in the clay soil. The clay soil may swell when saturated and shrink when dried. This phenomenon generally decreases in magnitude with increasing confinement pressure at depth. These volume changes may damage lightly loaded foundations, flatwork, and pavements. During our site reconnaissance the ground was saturated due to recent rains and we did not observe shrinkage cracks induced by expansive soil shrink/swell. Based on our site inspections, soils onsite at all four locations are primarily varying quantities of gravels, sands, and low-plasticity silts and clays.

Location	Mitigation measures required
Loma Alta DB Lefty Gomez Field DB Memorial Park DB Red Hill Park DB	*No mitigation measures required.*

L. Slope Instability/Landsliding

Weak soils and bedrock on moderate to steep slopes can move downslope due to gravity. Slope instability is often initiated or accelerated from soil saturation and groundwater pressure. The primary adverse effect of slope instability is damage to structures and improvements.

Loma Alta DB is surrounded by steep topography and potentially unstable soils. Previous landslides and debris flows have occurred in the hills upslope of the proposed detention basin. Significant slope instability was not observed at the proposed embankment site or detention basin. Slope instability upslope of the proposed site could result in impoundment of soil and rock debris within the detention basin. The potential of slope instability at the proposed embankment location is low. However, the potential for instability in the surrounding hillsides is moderate to high.

Lefty Gomez Field DB is surrounded by relatively level terrain. Provided the planned cuts are 2:1 or flatter, we judge the risk of significant slope instability at Lefty Gomez Field DB is low. Subsurface exploration should be performed to confirm the existing soil types would be stable at the planned cut slopes.

Memorial Park DB is bounded on the east by a relatively steep slope which shows evidence of previous instability and landsliding. Although the observed landslide area appears inactive, the soil and slope conditions are susceptible to reactivation and instability during drawdown of impounded flood waters. Therefore the potential for localized slope instability at the site is moderate to high.

Red Hill Park DB is bounded by moderate slopes showing evidence of soil creep, but no sign of global instability. The planned grading involves construction of a fill embankment on general level terrain. Therefore, we judge the risk of significant slope instability at Red Hill Park DB to be low.

Location	Mitigation measures required
Loma Alta DB	*Existing erosion features near the proposed embankment should be stabilized and surface water collected and discharged into an appropriate drainage course. Periodic maintenance should be planned to remove soil and rock debris. Additional site-specific recommendations based on subsurface exploration should be included in a design-level Geotechnical Investigation Report. The planned embankment should be designed to achieve a minimum factor of safety of 1.5 for static conditions and minimal displacements (less than 1 foot) during strong seismic shaking.*
Lefty Gomez Field DB	*Subsurface exploration should be performed to evaluate the soil and groundwater conditions that may be exposed in the planned cut slopes.*
Memorial Park DB	*The stability of the existing landslide area will need to be evaluated in consideration of the planned grading and use of the detention basin. Based on the results of the analyses, landslide stabilization may be required. Subsurface exploration should be performed to evaluate the soil and groundwater conditions that may be exposed in the planned cut slopes.*
Red Hill Park DB	*The planned dike should be designed to achieve a minimum factor of safety of 1.5 for static conditions and have minimal displacements (less than 1 foot) during strong seismic shaking.*

M. Seepage

Groundwater seepage can saturate soils causing instability for inclined slopes. During periods of significant water storage in the detention basins, water seepage through or beneath the containment embankments or dikes could cause saturated soil conditions and ponded water at the surrounding properties. The potential for seepage conditions within the detention basins cut slopes is high. The potential for seepage through or under the planned embankments and dikes is moderate.

Location	Mitigation measures required
Loma Alta DB Red Hill Park DB	*The planned embankment should be constructed with low permeability fill or with an impermeable core A cut-off trench may be required in the foundation to control seepage under the embankment. Additional site-specific seepage control recommendations based on subsurface exploration should be included in a design-level Geotechnical Investigation Report.*
Lefty Gomez Field DB Memorial Park DB	*Subsurface exploration and monitoring should be performed to evaluate the soil and groundwater conditions that may be exposed in the planned cut slopes. Subsurface drainage improvements, such as horizontal drains or subdrains, may be required to lower groundwater levels near slopes. Weak soil areas, if present, need to be over-excavated and reconstructed with subsurface drainage and compacted fill buttresses. Low permeability fill and cut-off trenches should be utilized for the low perimeter dikes.*

V. CONCLUSIONS AND RECOMMENDATIONS

General

Based on our site inspections, research and evaluation, it is our professional opinion that development of all four proposed detention basin sites is feasible from a geotechnical and geologic standpoint. The significant issues that need to be considered in development are the potential for strong ground shaking, potential liquefaction at Lefty Gomez Field, Memorial Park and Red Hill Park Detention Basins, and potential slope instability at Loma Alta and Memorial Park Detention Basins.

General guidelines for project planning and preliminary recommendations are provided in the following sections. A geotechnical investigation with subsurface exploration and laboratory testing will be required to provide site specific evaluations, geotechnical recommendations and criteria for use in the design and construction of the project.

Development Guidelines and Preliminary Recommendations

Seismic Design – The seismic design of structures and dams should be in accordance with the most recent version of the California Building Code (CBC, 2007). Based on our reconnaissance, a CBC soil type of S_D (stiff soil profile) will likely apply in the channel area of Loma Alta DB and a soil type of S_B (rock profile) will likely apply to surrounding slopes. A CBC soil type of S_D (stiff soil profile) will likely apply to Lefty Gomez Field DB, DB-3 and Memorial Park DB. We recommend the CBC coefficients and site values shown in Table C for use in equations 30-4 through 30-8 to calculate the design base shear of new construction. Subsurface exploration of the project sites must be conducted to confirm the CBC coefficients.

TABLE C
2007 CBC FACTORS
Marin County Detention Basin LOMA ALTA DB Slopes
Marin County, California

Factor Name	Coefficient	CBC Table	Site Specific Value
Site Class[1]	$S_{A,B,C,D,E, or F}$	1613.5.2	S_B
Spectral Acc. (short)	S_s	1613.5.1	1.50 g
Spectral Acc. (1-sec)	S_1	1613.5.1	0.66 g
Site Coefficient	F_a	1613.5.3 (1)	1.0
Site Coefficient	F_v	1613.5.3 (2)	1.0

(1) Site Class B Description: Rock profile with shear wave velocities between 2,500 ft./sec. and 5,000 ft./sec.

TABLE D
2007 IBC FACTORS
Marin County Detention Basins LOMA ALTA DB Channel and LEFTY GOMEZ FIELD DB, MEMORIAL PARK DB and RED HILL PARK DB
Marin County, California

Factor Name	Coefficient	CBC Table	Site Specific Value
Site Class[1]	$S_{A,B,C,D,E, or F}$	1613.5.2	S_D
Spectral Acc. (short)	S_s	1613.5.1	1.50 g
Spectral Acc. (1-sec)	S_1	1613.5.1	1.00 g
Site Coefficient	F_a	1613.5.3 (1)	1.0
Site Coefficient	F_v	1613.5.3 (2)	1.5

(1) Site Class D Description: Stiff soil profile with shear wave velocities between 600 and 1,200 fps, Standard Penetration Test N values between 15 and 50, and undrained shear strength between 1,000 and 2,000 psf.

Site Grading – Site grading at the proposed detention basin is expected to consist of a combination of excavation and fill placement.

1. Preparation – Clear all grass, brush, roots, over-sized debris and organic material from within the new project work area. Loose soil or highly permeable soil needs to be stripped within the foundation area of planned embankments or dikes. Near residential areas, cut-off trenches will likely be required below perimeter dikes to reduce the potential for groundwater seepage beneath the dikes. Any live utilities within the planned excavation areas will need to be located, capped and re-routed prior to grading.

2. Excavations – Excavations up to a depth of roughly 20 feet may be performed to create the detention basins. Excavations will generally be into stiff alluvial soils and should be possible with conventional grading equipment (i.e. scrapers and dozers). Localized area of hard bedrock may be encountered within portions of the Lefty Gomez DB.

3. Fill Criteria – Most on-site material will likely be suitable for re-use as compacted fill. For fill material, we recommend using non-expansive soil and rock free of organic matter, with a Liquid Limit of less than 40, a Plasticity Index of less than 20, a minimum R-value of 20, and conforms to the gradation limits in Table D. Select clayey impermeable fill material will be needed for the embankment core and perimeter dikes. The permeability criteria for the select fill should be determined based on design level analyses. Typical values would be less than 10^{-6} cm/sec.

TABLE E
FILL GRADATION LIMITS
Marin County Detention Basins
Marin County, California

Particle Size	Percent Finer by Dry Weight
4 inch	100
No. 4 sieve	20 - 100
No. 200 sieve	0 - 50

4. Compacted Fill – Structural fill and scarified subgrades should be conditioned to near their optimum moisture content. Properly moisture conditioned and cured on-site materials should subsequently be placed in loose horizontal lifts of 8 inches thick or less and uniformly compacted to at least 90 percent relative compaction for general fill area. The proposed embankments should be compacted to at least 95% relative compaction to provide a firm unyielding, impermeable surface. Relative compaction, maximum dry density, and optimum moisture content of fill materials should be determined in accordance with ASTM Test Method D 1557, “Moisture-Density Relations of soils and Soil-Aggregate Mixtures Using a 10-lb. Rammer and 18-in. Drop”.

5. Slopes – Preliminary site plans indicate that perimeter dikes at Lefty Gomez Field DB, Memorial Park DB and Red Hill Park DB are planned with 1:1 (horizontal:vertical) slopes. If possible all cut and fill slopes should not be steeper than 2:1. If steeper slopes are required, they will need to be specifically designed and will likely require geotextile reinforcement and erosion control mats. Site-specific recommendations regarding perimeter dikes and slope stability will be presented in a design-level Geotechnical Investigation Report.

For temporary slopes, the Federal Occupational Safety and Health Administration (OSHA) has promulgated rules for Excavations, 29 CFR Part 1926, October 31, 1989. OSHA dictates allowable slope configurations and minimum shoring requirements based on categorized soil types. In conformance with OSHA's categorization, on site soils are expected to be “Type C.” The Contractor may elect to use a variety of shoring and temporary slope configurations, but his operations must conform to Federal and State OSHA regulations. Additionally, it should be made clear that the safety of excavations, slopes, construction operations, and personnel are the sole responsibility of the Contractor.

Performance of cut slopes will be influenced by the length of time the cut is unsupported, groundwater seepage, surface runoff over the cut face, bedding planes of rock, soil materials

and other factors. Permanent and temporary cut slopes should be inspected by a Geotechnical Engineer during construction.

6. Retaining Structures – Retaining structures could be utilized in the site grading to improve stability of landslide areas, enlarge the storage capacity of the detention basin, or reduce the inclination of steep slopes. Based on the anticipated site conditions, soil nailed, reinforced shotcrete retaining structures would be best suited for the cut areas and mechanically stabilized earth (MSE) walls, such as Keystone or Versa-lok, would be best suited in the fill areas.

VI. SUPPLEMENTAL SERVICES

Following preliminary approval of the project, a geotechnical investigation including subsurface exploration and laboratory testing will be needed to provide geotechnical evaluation, analyses, recommendations and criteria for the design and construction of the project.

During design we should provide geotechnical consultation to the design team regarding geologic and geotechnical condition that could impact the project. We should review plans and specifications as they are developed to confirm that the intent of our geotechnical recommendations has been incorporated and provide supplemental recommendations, if needed.

During construction, we must observe and test the geotechnical portions (foundations, subsurface drainage and site grading) of the project to confirm that subsurface conditions are as expected and the contractor's work is performed in accordance with the contract documents.

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United States Geological Survey (USGS), "National Seismic Hazards Map Program," Version 5.0.9, October 06, 2008.

SITE LOCATION

SCALE

0 2000 4000 8000 FEET

0 1000 2000 METERS

NORTH

REFERENCE: DeLorme 3D TopoQuads, 1999

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SITE LOCATION MAP

Marin County Flood Control
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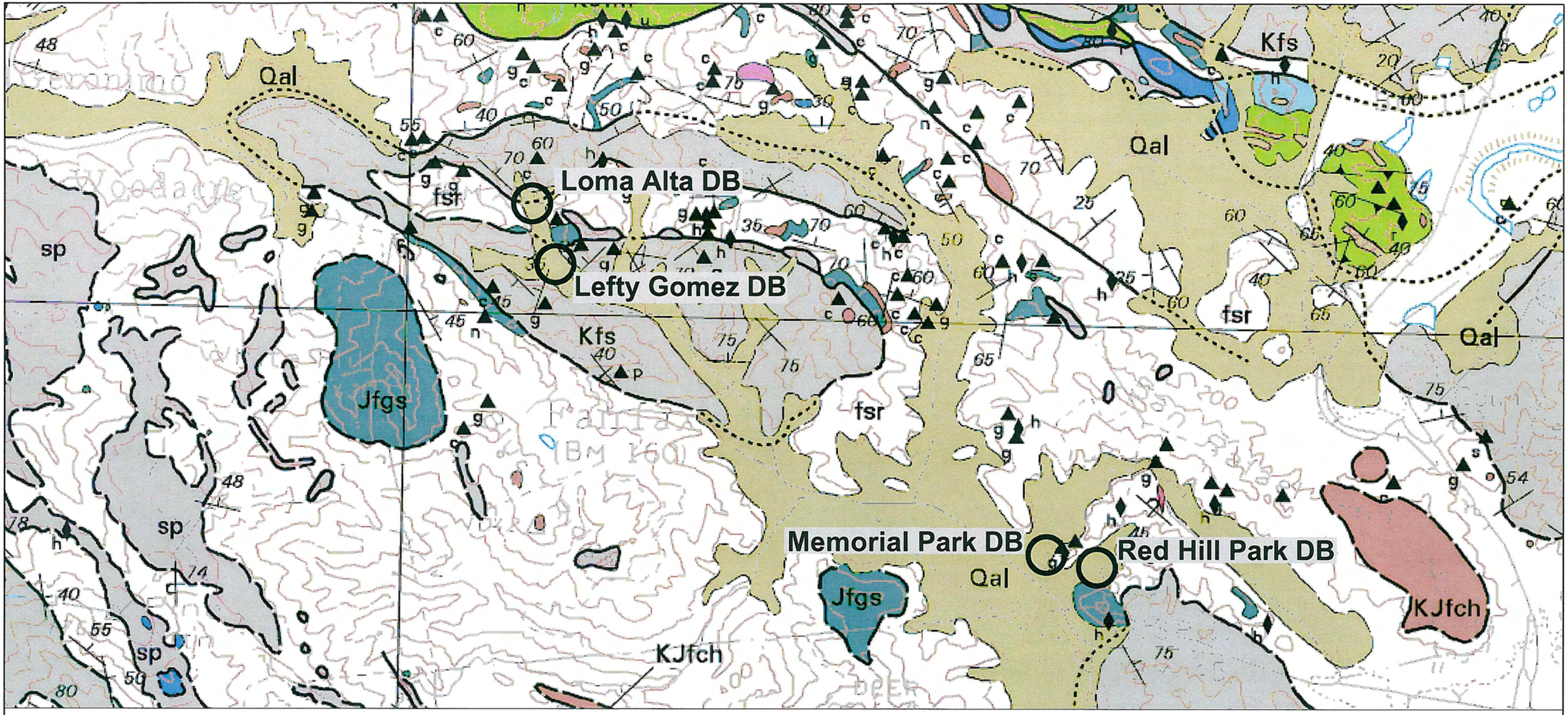
Project No. 960.05 Date: 3/2/10

Designed
Drawn JSC
Checked

1
FIGURE



LEGEND

- **Qal - Alluvium (Quaternary)**
  Stream and channel deposits, typically poorly-sorted discontinuous beds of silts, sands and gravels

Franciscan Complex

- **Kfs - Sandstone and Shale (Cretaceous)**
  Sandstone commonly medium to thick-bedded, fine- to coarse-grained arkosic wacke (graywacke) with dark gray to black shale interbeds
- **Jfgs - Greenstone (Jurassic)**
  Commonly well-bedded pillow lavas with minor intrusive diabase. Smaller masses often widely fractured; larger masses typically highly weathered and intensely fractured
- **Fsr - Melange**
  Composed chiefly of sandstone and shale with lesser amounts of volcanic and metmorphic rock. Typically highly sheared, highly weathered, and intensely fractured.
- **sp - Serpentinite**
  Slightly to highly altered ultramafic rock, typically highly sheared, outcrops often lenticular or irregular

APPROXIMATE SCALE
0 1250 2500 5000 FEET

NORTH

REFERENCE: Blake Jr., M.C., Graymer, R.W., and Jones, D.L., "Geologic Map and Map Database of Parts of Marin, San Francisco, Alameda, Contra Costa, and Sonoma COunties, California: A Digital Database", United States Geological Survey Miscellaneous Field Study MF-2337 Version 1.0, 2000

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GEOLOGIC MAP

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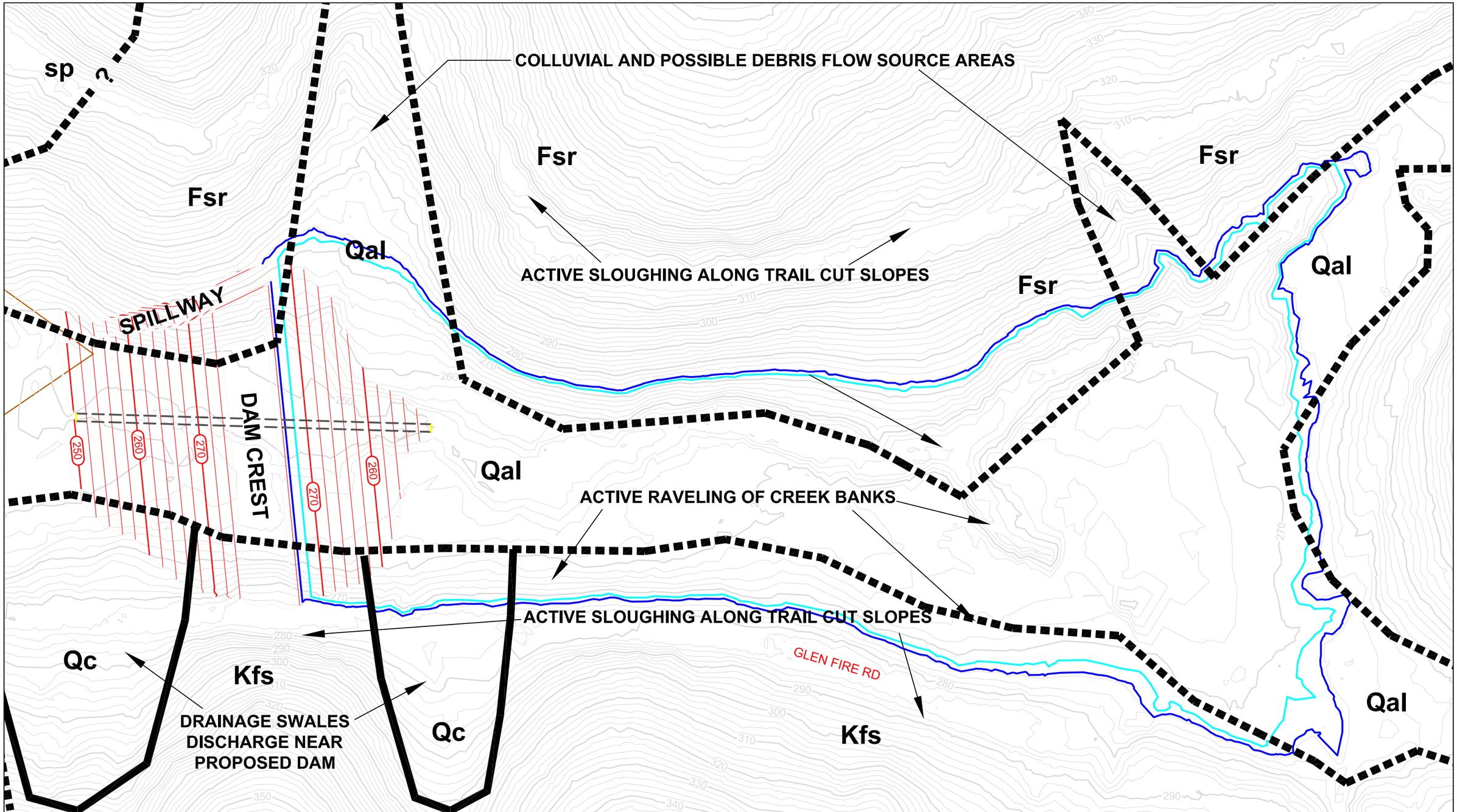
Drawn MFJ
Checked

2
FIGURE



LEGEND:

- EXISTING 2 FT CONTOURS
- PROPOSED 2 FT CONTOURS
- NORMAL WSE (ELEV=217')
- MAXIMUM WSE (ELEV=218.5')

GEOLOGIC UNITS

- Fsr = FRANCISCAN MELANGE
- sp = SERPENTINITE
- Qal = ALLUVIAL DEPOSITS

SCALE (FEET)

0 50 100 200 FEET

NORTH

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LOMA ALTA DB SITE PLAN

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Drawn MFJ
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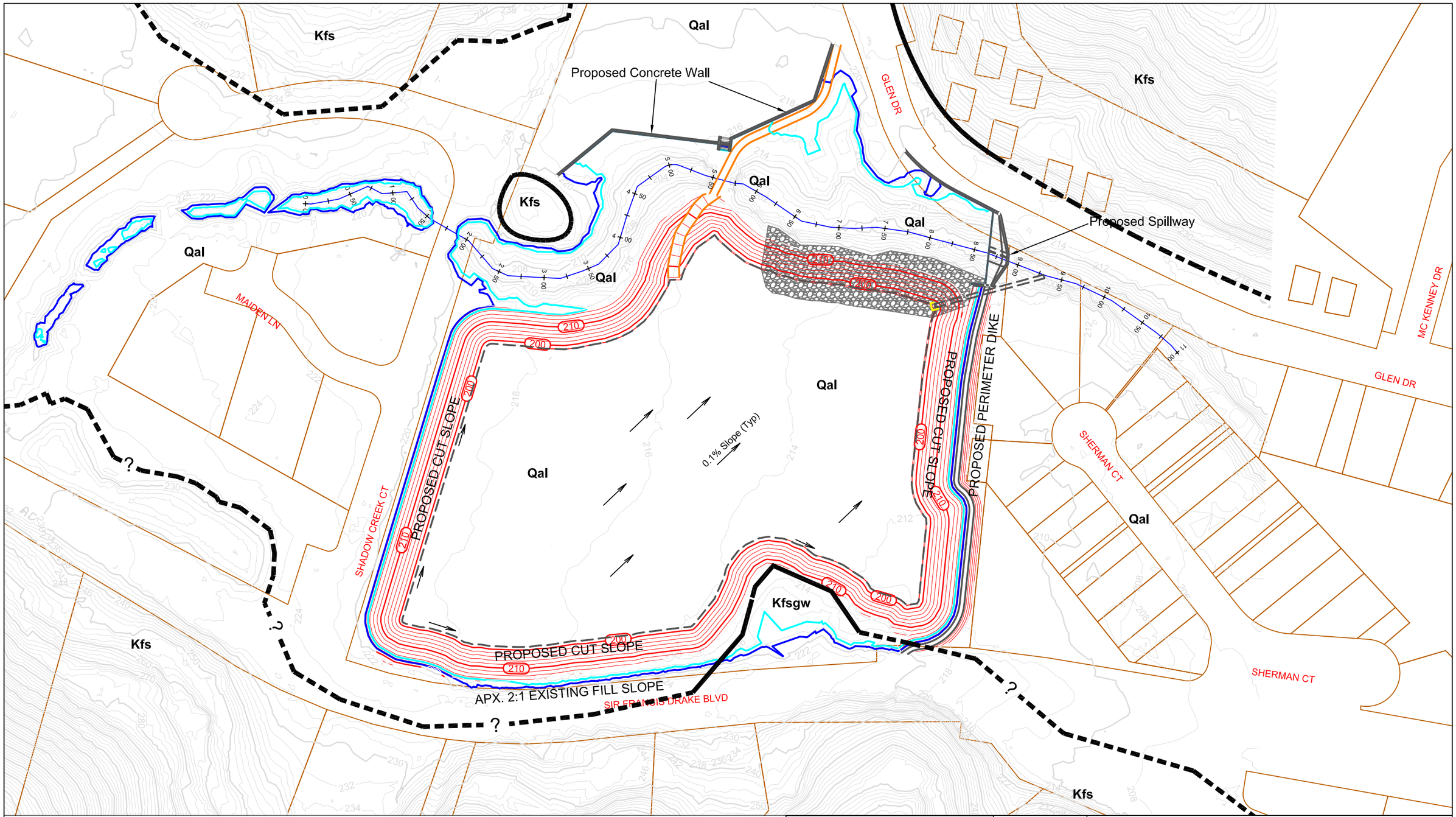
3
FIGURE



LEGEND:

- EXISTING 2 FT CONTOURS
- PROPOSED 2 FT CONTOURS
- NORMAL WSE (ELEV=217')
- MAXIMUM WSE (ELEV=218.5')

GEOLOGIC UNITS

- Kfs = FRANCISCAN SANDSTONE AND SHALE
- Kfsgw = FRANCISCAN GRAYWACKE SANDSTONE
- Qal = ALLUVIAL DEPOSITS

SCALE

0 50 100 200 FEET

NORTH

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FILE: 960,05SPb.dwg

LEFTY GOMEZ DB SITE PLAN

Marin County Flood Control
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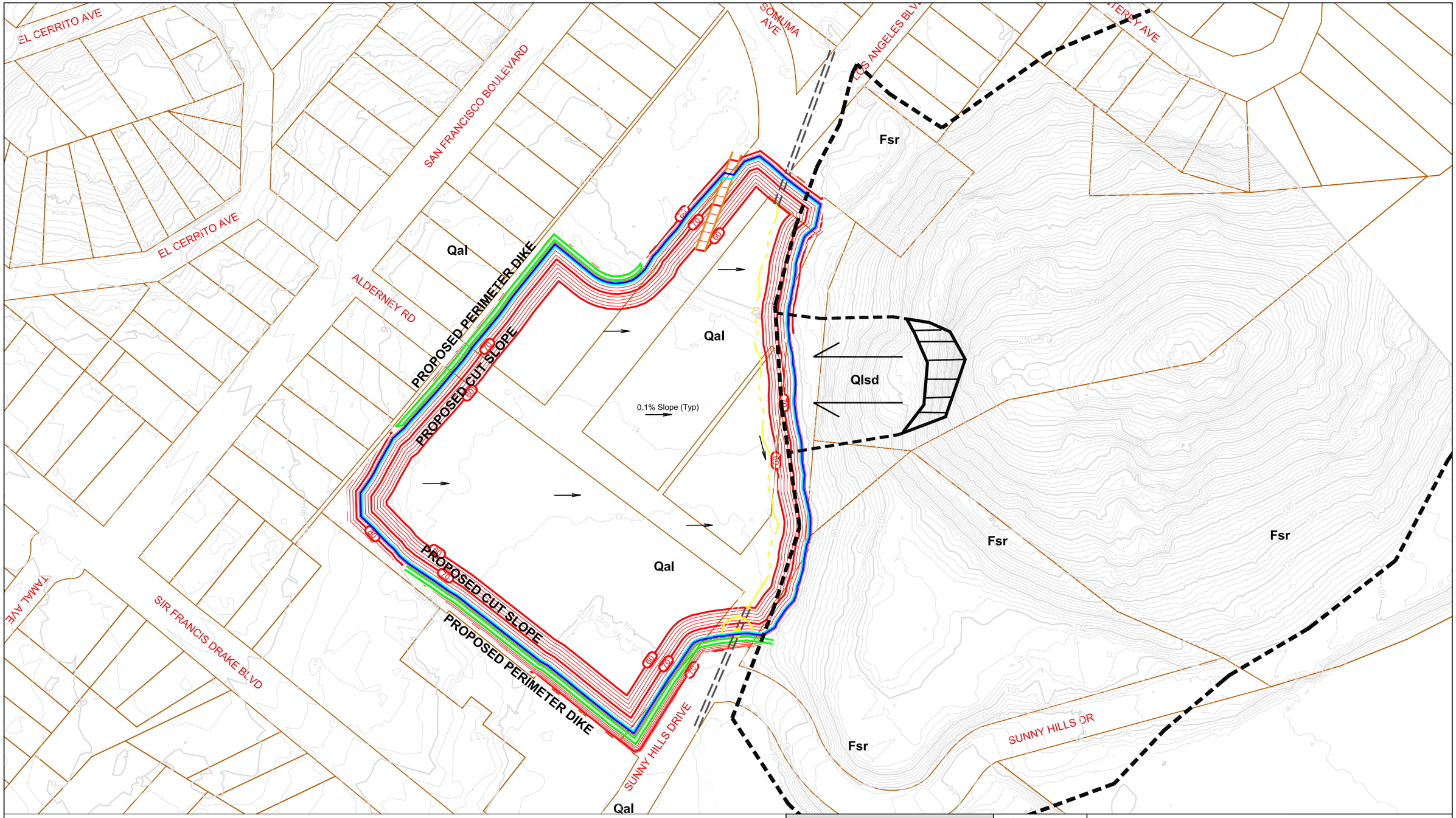
Drawn MFJ
Checked

4
FIGURE



LEGEND:

- EXISTING 2 FT CONTOURS
- PROPOSED 2 FT CONTOURS
- NORMAL WSE (ELEV=217')
- MAXIMUM WSE (ELEV=218.5')

GEOLOGIC UNITS

- Qlsd = LANDSLIDE DEBRIS (DORMANT)
- Qal = ALLUVIAL DEPOSITS
- Fsr = FRANCISCAN MELANGE

SCALE

0 60 120 240 FEET

NORTH

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MEMORIAL PARK DB SITE PLAN

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Checked

5
FIGURE

Qal

Fsr

Qaf

HILLS DRIVE

SUNNY HILLS DR

PROPOSED DIKE

Existing Culvert

RED HILL SHOPPING CENTER

LEGEND:

EXISTING 2 FT CONTOURS

PROPOSED 2 FT CONTOURS

NORMAL WSE (ELEV=217')

MAXIMUM WSE (ELEV=218.5')

GEOLOGIC UNITS

Qal = ALLUVIAL DEPOSITS

Fsr = FRANCISCAN MELANGE

SCALE (FEET)

0 40 80 160 FEET

NORTH

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FILE: 960,05SPDB6.dwg

RED HILL PARK DB SITE PLAN

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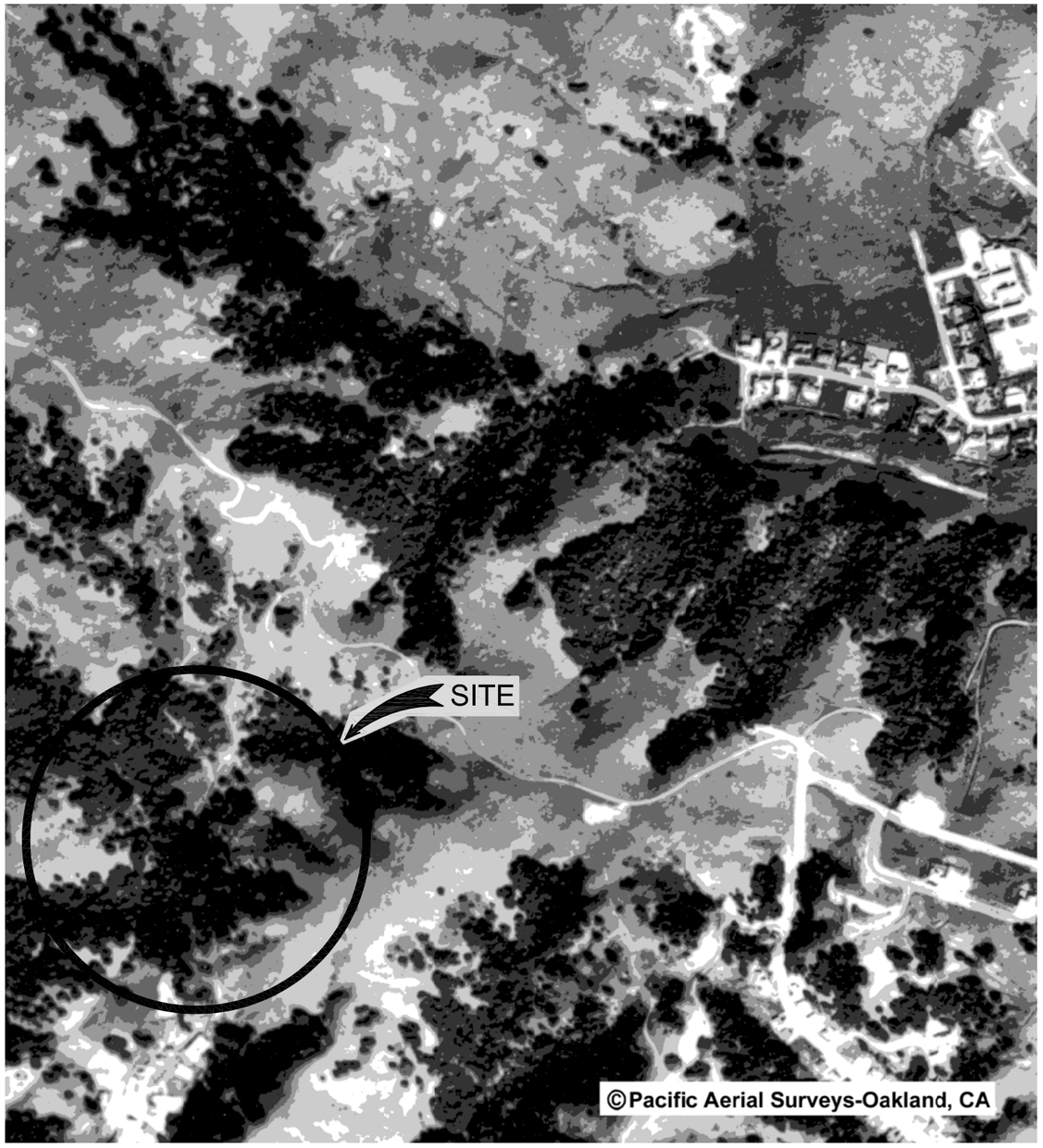
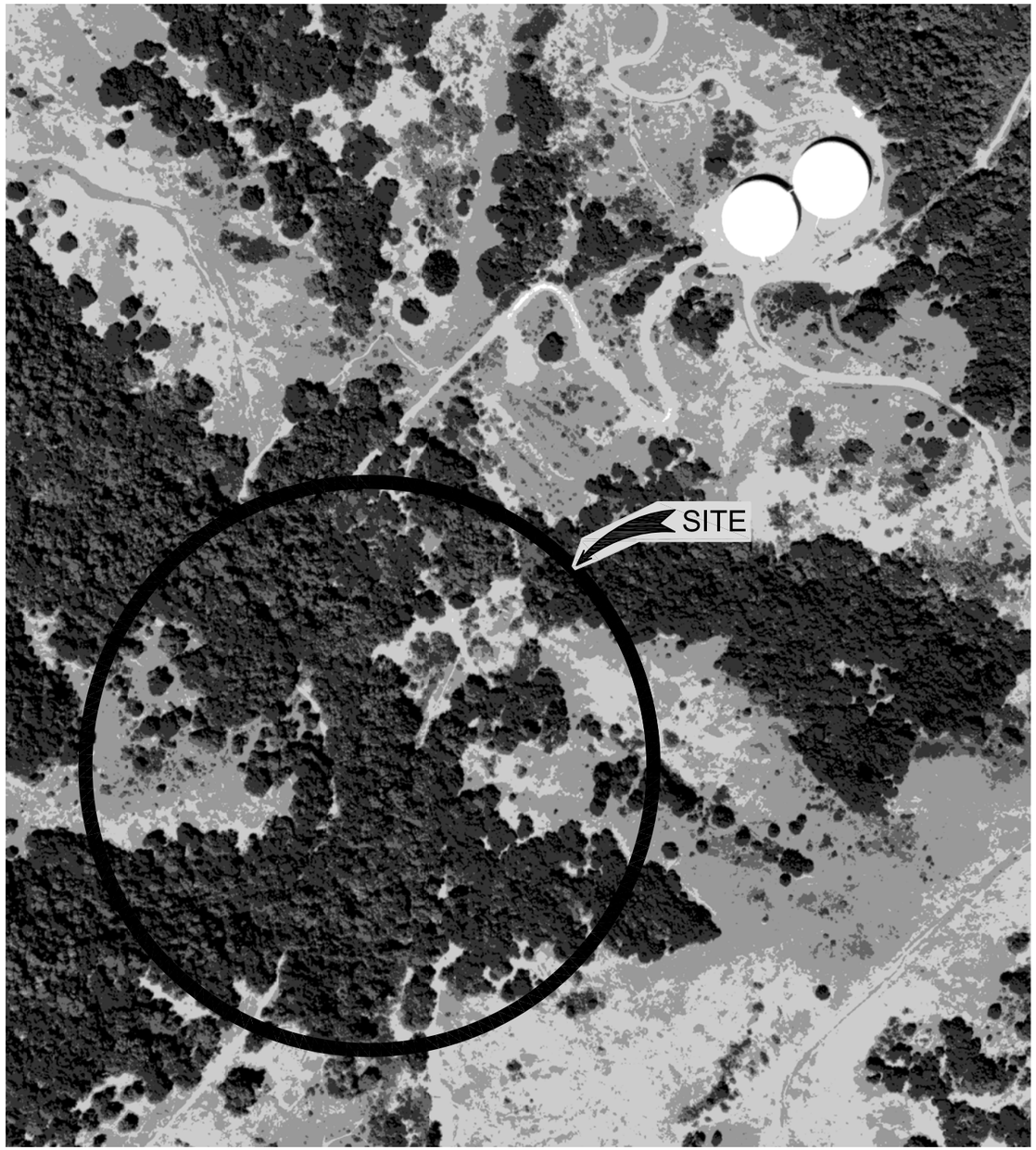
Drawn MFJ
Checked

6
FIGURE



AERIAL PHOTOGRAPH TAKEN MARCH 8, 1958
NOTE FIRE ROADS AND ABSENCE OF WATER TANKS AT SMITH SADDLE (CENTER LEFT)



AERIAL PHOTOGRAPH TAKEN AUGUST 9, 1995
NOTE WATER TANKS AT SMITH SADDLE (UPPER RIGHT)

NORTH

PHOTOS COURTESY OF PACIFIC AERIAL SURVEYS, OAKLAND, CALIFORNIA

PHOTOGRAPHS NOT SHOWN TO SCALE

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LOMA ALTA HISTORIC AERIAL PHOTOGRAPHS

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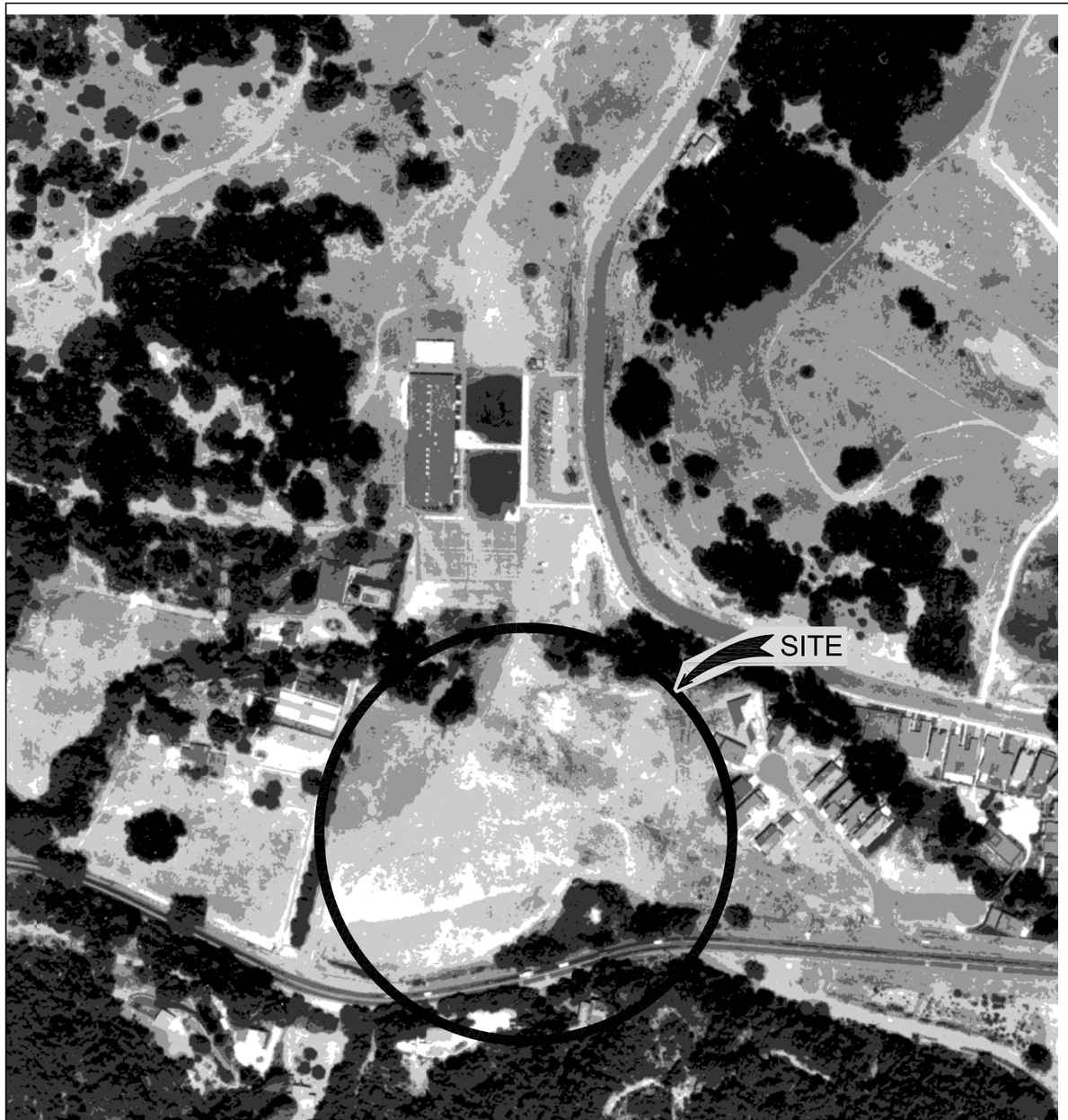
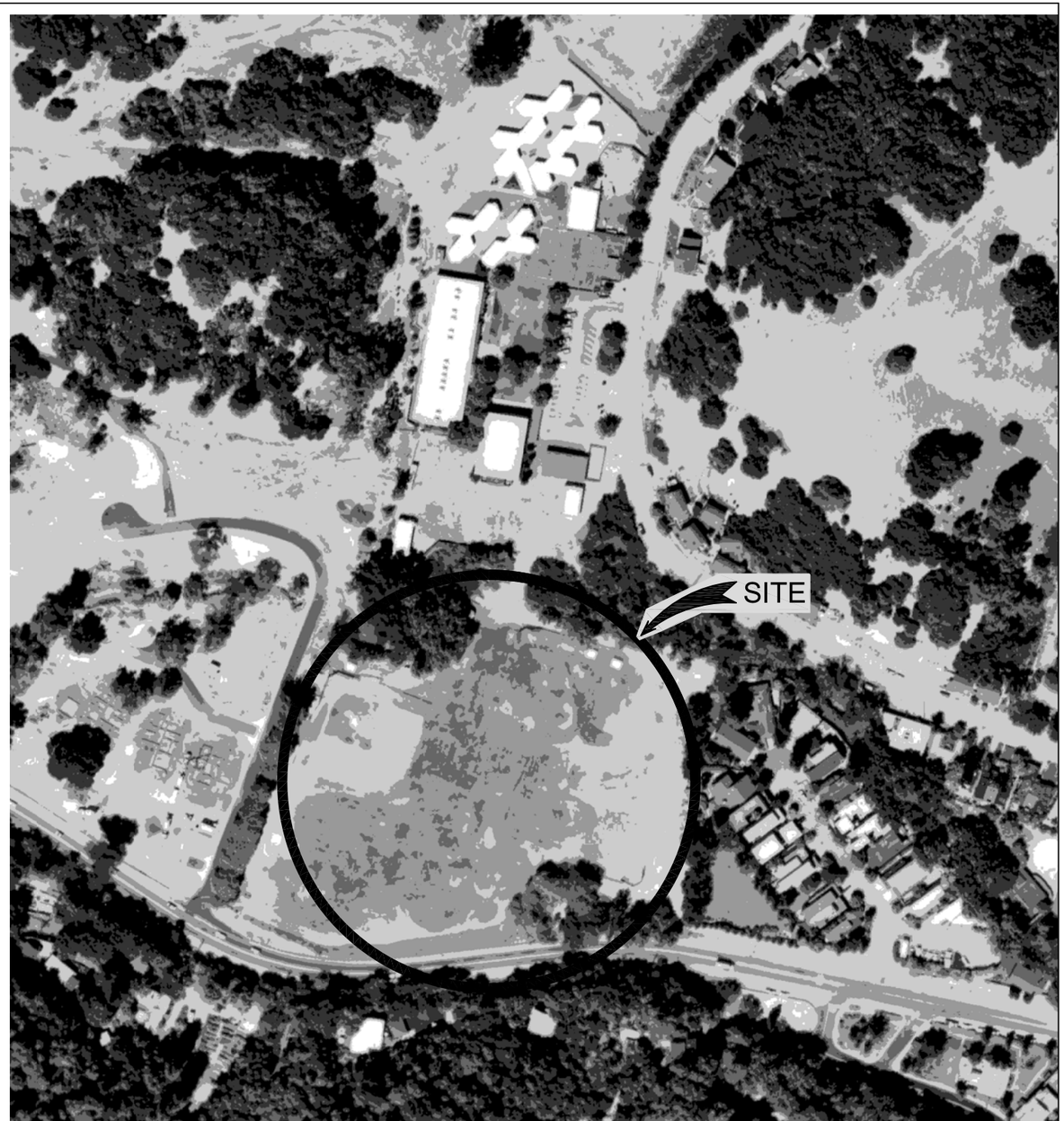
Checked

7
FIGURE



AERIAL PHOTOGRAPH TAKEN JULY 2, 1970



AERIAL PHOTOGRAPH TAKEN AUGUST 9, 1995

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FILE: 960,05DB2AERIALS,dwg

LEFTY GOMEZ HISTORIC AERIAL PHOTOGRAPHS

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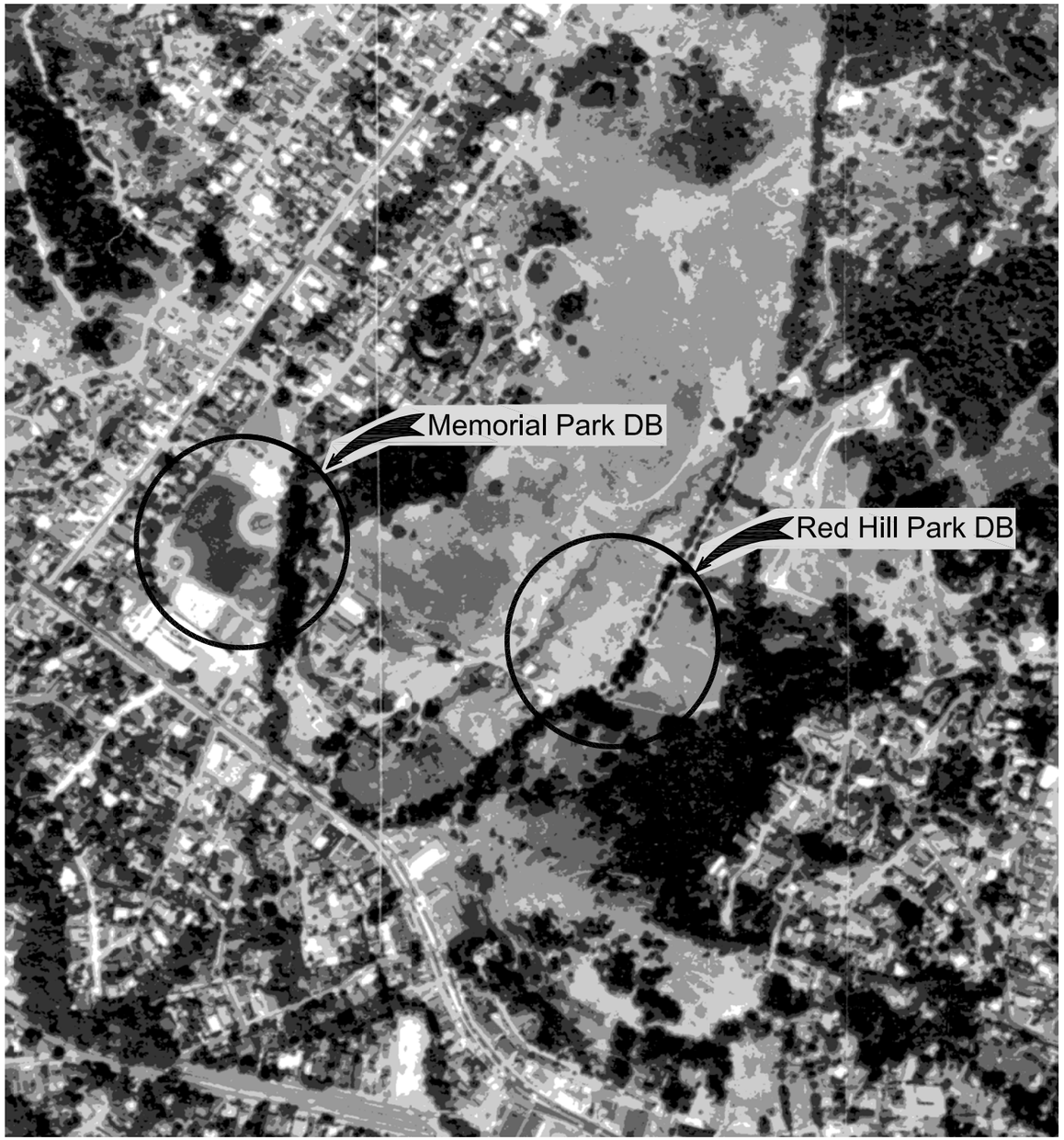
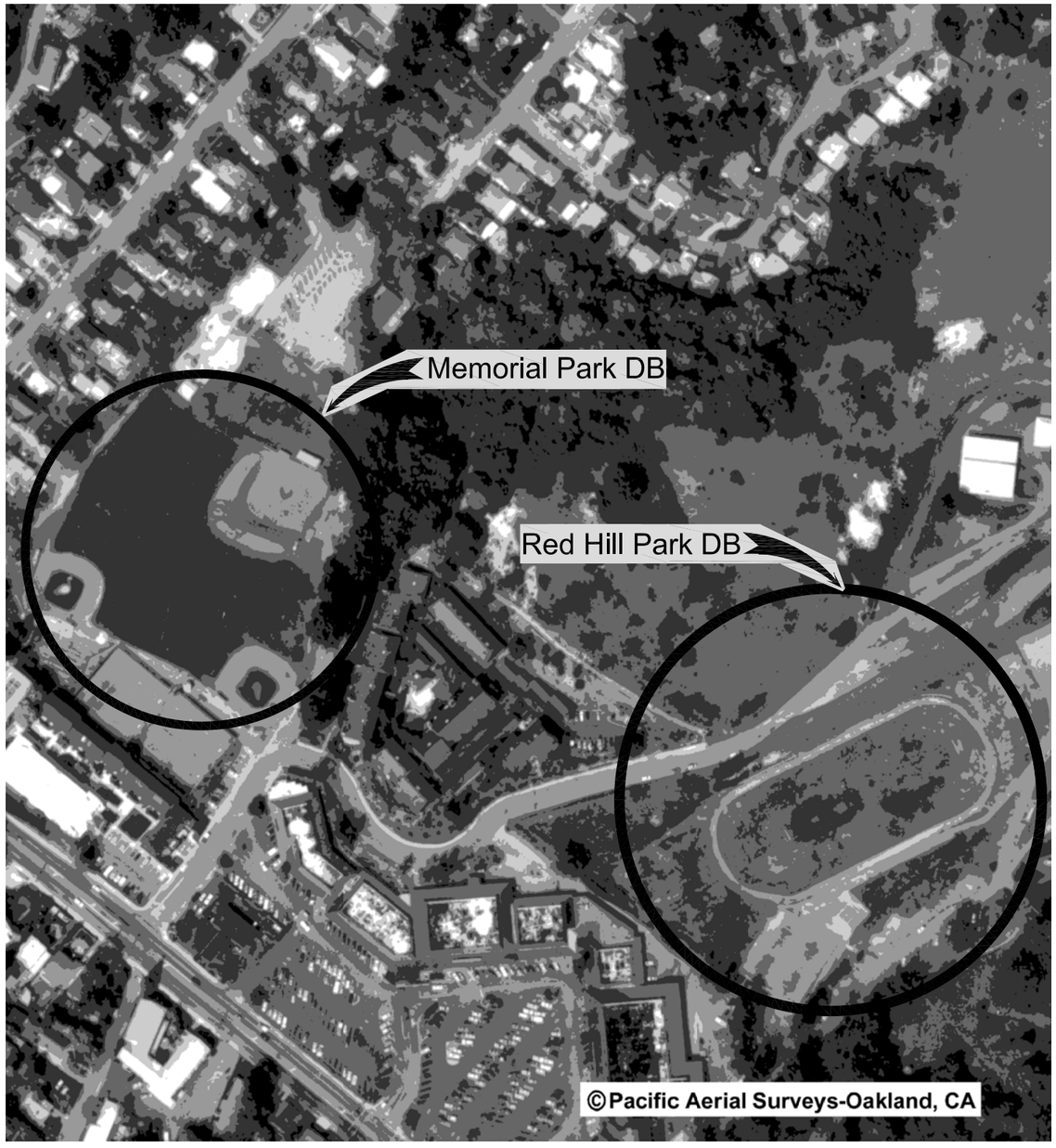
Drawn MFJ
Checked

8
FIGURE



AERIAL PHOTOGRAPHY TAKEN JULY 9, 1963
NOTE NATURAL DRAINAGE CHANNEL AT DB-6 SITE.



AERIAL PHOTOGRAPHY TAKEN MARCH 15, 1990
NOTE EXTENT OF DEVELOPMENT AND OF FILL PLACED AT DB-6 RELATIVE TO 1963 PHOTO.

NORTH

PHOTOS COURTESY OF PACIFIC AERIAL SURVEYS, OAKLAND, CALIFORNIA

PHOTOGRAPHS NOT SHOWN TO SCALE

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MEMORIAL PARK AND RED HILL PARK
HISTORIC AERIAL PHOTOGRAPHS

Marin County Flood Control
Flood Damage Reduction
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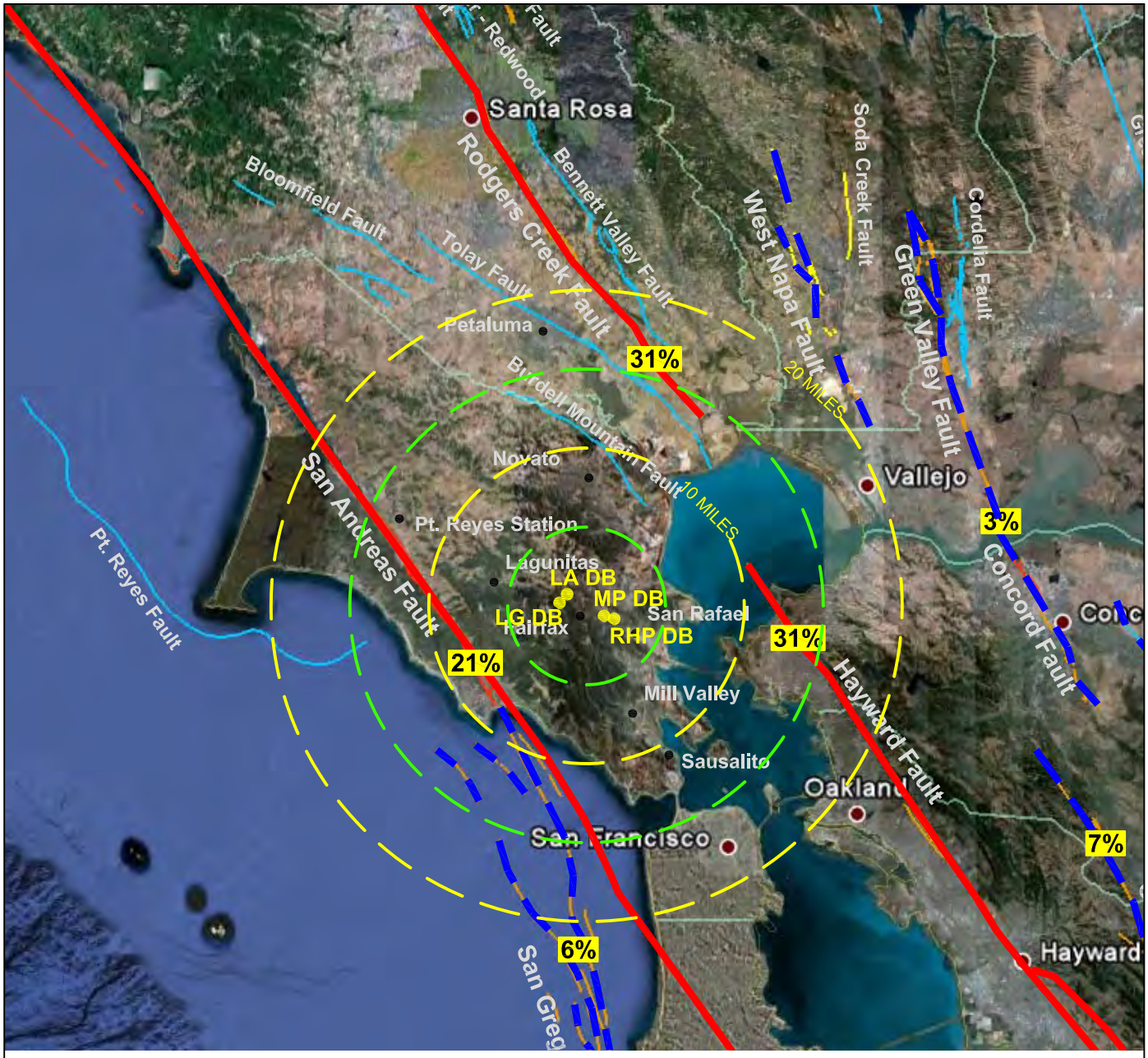
Project No. 960.05 Date: 03/03/10

Drawn MFJ
Checked

9
FIGURE



LEGEND

SITE: LATITUDE, 38.0000°
LONGITUDE, -122.0000°

FAULT	TYPE	CBC DESCRIPTION
	"A"	CAPABLE OF LARGE MAGNITUDE EARTHQUAKES AND HIGH RATE OF SEISMIC ACTIVITY
	"B"	CAPABLE OF LARGE MAGNITUDE EARTHQUAKES OR HIGH RATE OF SEISMIC ACTIVITY

21% PROBABILITY OF M≥6.7 BETWEEN 2008-2038 FOR FAULTS SHOWN. OVERALL PROBABILITY OF 63% IN BAY AREA OF ONE OR MORE M≥6.7 EARTHQUAKES FROM 2008-2038.

LA DB = Loma Alta Detention Basin
MP DB = Memorial Park Detention Basin
LG DB = Lefty Gomez Detention Basin
RHP = Red Hill Park Detention Basin

REFERENCES:

1) ACTIVE FAULT MAP MODIFIED FROM SUMMARY OF EARTHQUAKE PROBABILITIES IN THE S.F. BAY REGION, 2008-2038, THE 2007 WORKING GROUP ON CALIFORNIA EARTHQUAKE PROBABILITIES, 2008.

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FILE: 960.05FM.dwg

ACTIVE FAULT MAP

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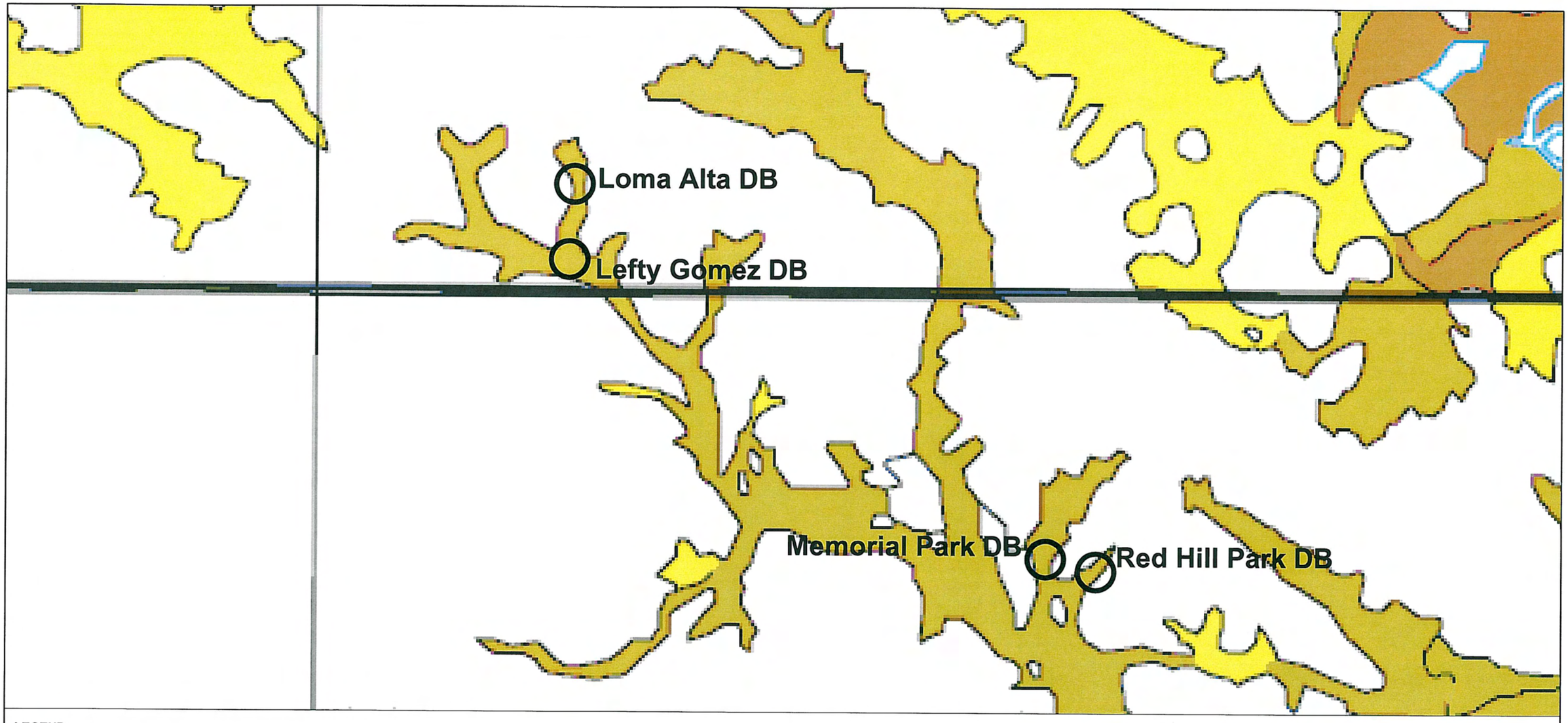
Project No. 960.05 Date: 03-23-10

Drawn MFJ
Checked

10
FIGURE



LEGEND

- Very High Susceptibility
- High Susceptibility
- Moderate Susceptibility
- Low Susceptibility
- Very Low Susceptibility

APPROXIMATE SCALE

0 1250 2500 5000 FEET

NORTH

REFERENCE: Knudsen, et. al., "Perliminary Maps of Quaternary Deposits and Liquefaction Susceptibility, Nine-County San Francisco Bay Region", United States Geological Survey Open-File Report 00-444, 2000

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FILE: 960.05GM.dwg		Marin County Flood Control Flood Damage Reduction & Creek Management Study Project No. 960.05 Date: 03/02/10	Drawn MFJ Checked	11 FIGURE

Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
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