Appendix E2: Fault Rupture Hazard Investigation

Appendices

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FAULT RUPTURE HAZARD INVESTIGATION

PROPOSED MULTI-FAMILY RESIDENTIAL DEVELOPMENT HAWTHORNE BOULEVARD AND VIA VALMONTE TORRANCE, CALIFORNIA

GEOCON
WEST, INC.
GEOTECHNICAL
ENVIRONMENTAL
MATERIALS

PREPARED FOR

MKS RESIDENTIAL
SOLANA BEACH, CALIFORNIA

PROJECT NO. A9201-06-01C

JANUARY 21, 2016

Project No. A9201-06-01
January 21, 2016

MKS Residential
444 South Cedros Avenue
Solana Beach, California 92705

Attention: Mr. Derek Empey, Senior Vice President Development

Subject: FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED MULTI-FAMILY RESIDENTIAL DEVELOPMENT
HAWTHORNE BOULEVARD AND VIA VALMONTE
TORRANCE, CALIFORNIA

Dear Mr. Empey:

Geocon West, Inc. is pleased to submit this revised report summarizing our fault rupture hazard investigation for the proposed multi-family residential development located near Hawthorne Boulevard and Via Valmonte in the city of Torrance, California. The site is located within the boundaries of a city-designated Fault Hazard Management Zone for the Palos Verdes Fault. The purpose of our evaluation was to identify faults that may traverse the site and evaluate the potential for surface fault rupture.

We appreciate the opportunity to be of service to you. Please contact us if you have any questions regarding this report, or if we may be of further service.

Very truly yours,

GEOCON WEST, INC.

Susan F. Kirkgard
CEG 1754

PROFESSIONAL GEOLOGIST SUSAN FRANZEN KIRKGARD No. 1754 CERTIFIED ENGINEERING GEOLOGIST STATE OF CALIFORNIA

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1. EXECUTIVE SUMMARY

This report presents the results of our site-specific fault rupture investigation for the proposed multi-family residential development located near Hawthorne Boulevard and Via Valmonte in the city of Torrance, California (see Figure 1, Vicinity Map). The purpose of our investigation was to collect site-specific subsurface geologic information in order to assess the age and continuity of on-site stratigraphy and to evaluate the location and activity of faults that may impact the proposed development.

The site is an approximately 21-acre irregular-shaped parcel and is currently vacant. As shown on Figure 2, Site Plan, the project area is bounded by Via Valmonte on the north and west, Hawthorne Boulevard on the east, and a 200- to 250-foot-high, north-facing slope with gradients steeper than 1:1 (horizontal to vertical) on the south.

We previously performed a preliminary geotechnical evaluation for the site that consisted of a literature review, including review of published geologic maps and reports, historic topographic maps, available local groundwater level data, and recent nearby fault investigations (Geocon, 2014). With respect to surface fault rupture hazards, our previous report (Geocon, 2014) indicates that inferred splays of the Palos Verdes Fault are located offsite and do not traverse the proposed development. However, the site is located within a city-designated Fault Hazard Management Zone for the Palos Verdes Fault and a site-specific fault investigation is required to assess the potential for surface fault rupture hazards that may impact the proposed development.

This report documents our exploration techniques and findings of a site-specific fault investigation, conforming to current geologic standards-of-practice for evaluation of potential surface fault rupture. The fundamental conclusions of our investigation are:

1. The site is located within a zone of randomly-oriented minor shears, and the main trace of the Palos Verdes fault is located approximately 350 feet to the northeast,
2. The observed minor shears are the consequence of either folding of the northeastern flank of the Palos Verdes Hills or a result of minor local movement during periods of strong ground shaking or liquefaction prior to uplift of this portion of the peninsula,
3. All of the observed minor features are Middle Pleistocene in age,
4. Because active faults are not located within the project boundaries, there are no recommended restrictions on siting buildings intended for human occupancy at the site.

2. PURPOSE AND SCOPE

The purpose of our investigation was to collect site-specific subsurface geologic information in order to assess the age and continuity of on-site stratigraphy and to evaluate the location of faults that may impact proposed development, and determine whether such faults were "active" according to the current State of California definition (Bryant and Hart, 2007).

We previously performed a preliminary geotechnical evaluation for the site that consisted of a literature review, including review of published geologic maps and reports, historic topographic maps, available local groundwater level data, and recent nearby fault investigations. The results of the preliminary geotechnical investigation were presented in a separate report dated November 11, 2014 (Geocon, 2014). We are currently performing a preliminary geotechnical investigation for the proposed development that includes drilling 17 large-diameter borings and excavation of 6 hand-auger borings. The results of the geotechnical investigation will be issued in a separate report.

Based on our prior literature review, the technical background report for the Safety Element of the City of Torrance General Plan (Earth Consultants International [ECI], 2005) indicates that the Palos Verdes Fault is considered active but has not yet been zoned by the State of California under the provisions of the Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code, Division 2, Chapter 7.5, Section 2621 *et seq*.). The ECI (2005) report discusses more recent splays of the Palos Verdes fault mapped by Dibblee (1999), Stephenson et al. (1995) and Jennings (1994) in addition to lineaments identified by Rockwell (2005), all of which are located offsite. As shown on Figure 3, the site is included in the city-designated Fault Hazard Management Zone and a site-specific fault investigation is required to assess the potential for surface fault rupture hazards that may impact the proposed development.

This report summarizes our site-specific fault rupture hazard investigation performed in compliance with current geologic standards-of-practice for evaluation of potential surface fault rupture. Recommendations presented in this report should be included in the final project design to mitigate potential impacts related to a seismic event occurring on the nearby Palos Verdes Fault.

Our scope of services for our site-specific fault investigation included the following main tasks:

- Review of vintage aerial photographs,
- Excavation and logging of three exploratory trenches (total 506 lineal feet).
- Clearing the northwest quarry slope to observe clean exposures of the geologic materials and map any observed faults or fault-related features,
- Pot-holing to expose the contact between the Monterey Formation and the San Pedro Sand,
- Preparation of this report that includes the results of our investigation as well as our recommendations based on our findings.

3. SITE LOCATION AND PROJECT DESCRIPTION

The property is an approximately 23.35-acre irregular-shaped parcel and is currently vacant. As shown on Figure 2, Site Plan, the project area is bounded by Via Valmonte on the north and west, Hawthorne Boulevard on the east, and a 200- to 250-foot-high, north-facing slope with gradients steeper than 1:1 (horizontal to vertical) on the south.

The site topography, north of the steep north-facing slope, has been significantly altered by previous diatomite and diatomaceous soil mining activities. As a result, the existing site topography generally slopes toward the center of the site, which is a topographic low. The area of the topographic low was previously mined to approximately Elevation 150 MSL and later backfilled to create two gently sloping pads, the lower pad at approximately Elevation 190 to Elevation 220 and the upper pad at approximately Elevation 235 MSL to Elevation 245 MSL. Up to 50½ feet of artificial fill is present at the site. Existing slopes bounding the proposed development on the northwest and east-northeast are considered graded slopes (a result of the previous mining operations). The northwest quarry slope ranges from approximately 40 to 80 feet in height and is inclined at gradients ranging from 1¼:1 to 1½:1 (horizontal to vertical). The east-northeast quarry slope (adjacent to Hawthorne Boulevard) is approximately 50 feet in height and is inclined at gradients ranging from 2:1 to 1½:1 (horizontal to vertical).

Based on our discussions, we understand that the planned multi-family residential development will include grading the topographically higher portion of the site on the southeast and filling the topographic lows in the central and northern portions of the site to create one level graded pad. Also, an access road will be graded in the southeastern portion of the site that will connect the proposed development with Hawthorne Boulevard. The proposed access road will be graded through the existing slope along the eastern portion of the property and will not include grading of the north-facing slope along the southern boundary of the development.

4. GEOLOGIC SETTING

4.1 Regional Geology and the Palos Verdes Fault

The site is located on the northern flank of the Palos Verdes Hills, the westernmost onshore uplift of the Peninsular Ranges geomorphic province. The sedimentary rock in the Palos Verdes Hills are folded and faulted into a dome-like structure with the north and south limbs dipping downward away from the central portion of the hills. The sedimentary rocks along the north side of the hills (southern site boundary) dip to the north and northeast at 30 to 75 degrees. The major geologic structure in the area is the generally northwest trending Palos Verdes Fault Zone, generally located along the northern edge of the Palos Verdes Hills between San Pedro Bay on the southeast and Santa Monica Bay on the northwest. The northeastern strand of the fault zone is the boundary between the uplifted Palos Verdes Hills to the south and the Los Angeles Basin to the north, and several strands with strike-slip displacement have been identified within the uplift to the southeast in the vicinity of Gaffey Street.

The Palos Verdes Fault is a zone of right-lateral strike-slip and oblique-slip faults that accommodated 3-4 mm/yr of oblique dextral shear within the greater Inner Continental Borderland. The fault is one of the primary structures that accommodate relative right-lateral motion between the Pacific and North America tectonic plates, and exhibits the fastest slip rate of any fault within the greater Los Angeles region (Stevenson et al., 1995; McNeilan et al., 1996; Brankman and Shaw, 2009). The Palos Verdes Fault lies mostly offshore and is the northernmost structure within an approximately 300-kilometer-long fault system comprising (from northwest to southeast) the Palos Verdes fault zone, the Coronado Bank fault zone and the Agua Blanca fault. This fault system terminates in the north against the Santa Monica-Hollywood-Raymond fault system, which bounds the Western Transverse Ranges tectonic block.

The onshore Palos Verdes Fault Zone is characterized as a transpressional fault system, meaning the overall motion of opposing crustal blocks is defined by fault-parallel translation as well as fault-normal contraction. The kinematics of the onshore fault zone are driven in large part by a 20° bend in the orientation of the Palos Verdes Fault, resulting in the Palos Verdes peninsula as a topographic and structural high. Based on offshore studies of the Palos Verdes Fault Zone, the thickness of the Neogene strata are greater in the hanging-wall than in the footwall, indicating that the Palos Verdes Fault initiated as a Miocene extensional/transtensional structure, and was subsequently inverted in a transpressional tectonic regime (Brankman and Shaw, 2009; Sorlein et al., 2013).

Transpressional strain has, since late Pliocene time, produced uplift of the northwest-trending Palos Verdes anticlinorium. The anticlinorium can be traced more or less continuously for 70 kilometers. Within the Palos Verdes peninsula, the Palos Verdes anticlinorium doubly-plunges to the northwest and southeast, is northeast-vergent, and is cored by Mesozoic basement rocks. The limbs of the anticlinorium involve approximately 4,000 feet of Neogene strata. A flight of emergent marine terraces is cut into the flanks of the anticlinorium. Dating of the terraces established that the average Quaternary uplift rate for the peninsula is in the range of 0.2 to 0.29 m/ka (Bishop et al., 2001; Lajoie et al., 2001).

Activity of individual strands of the fault zone offshore and in the LA Harbor (based on borings, seismic reflection profiling and the presence of sea-floor scarps) indicates late Pleistocene and Holocene age deposits have been offset (Wright, 1991; McNeilan et al., 1996). However, there has been no documented evidence of offset Holocene age sediments onshore, although Stephenson et al., (1995) infer as much as 1000 feet (300 m) of lateral offset of the ancestral Los Angeles River to have occurred in the past ~100,000 years, implying a fast late Quaternary slip rate of 2.6-3.8 mm/yr and a high likelihood that the fault is Holocene-active onshore as well as offshore. Brankman and Shaw (2009) suggest an even faster oblique slip rate of about 4 mm/yr based on offset of a depocenter in San Pedro Bay. Displacement of Plio-Pleistocene age deposits interpreted in well logs along the central onshore section of the fault, and uplift of 13 marine terraces surrounding the Palos Verdes Hills provides support for the interpretation of a reverse component of faulting during the late Quaternary. Base on published estimates of slip rate, a long-term and Holocene slip rate of 3-4 mm/yr seems appropriate, implying fairly frequent (400-900 year recurrence interval; McNeilan et al., 1996) moderate to large (M6.7-M7.3) earthquakes.

As shown on the geologic map in Figure 4, the site is located near several inferred splays of the Palos Verdes Fault. The location of the fault in this area is poorly constrained, but was inferred to be near the base of the slope based on the idea that the strong lineament defining the base of the slope is a direct reflection of the fault's location (ECI, 2005). The ECI (2005) report discusses splays of the fault mapped by Dibblee (1999), Stephenson et al. (1995) and Jennings (1994) and lineaments identified by Rockwell (2005), all which are located offsite. The closest splay of the fault, as shown in the City of Torrance Safety Element of the General Plan, is inferred by Stephenson et al. (1995) and Dibblee (1999) and trends northwest along Via Valmonte from the intersection of Hawthorne Boulevard. Because of the uncertainty in the precise fault location, the city has established a Fault Hazard Management Zone for the Palos Verdes Fault Zone that is several hundred feet wide, surrounding the inferred fault location. As noted on Figure 3, the northern and eastern portions of the site are located within the city-designated Fault Hazard Management Zone.

4.2 Site-Specific Soil Geologic Conditions

Based on published geologic maps and data collected as part of our geotechnical investigation for the planned development, the geologic materials at the site consist of artificial fill, slope debris, Pleistocene age Older Alluvium, San Pedro Sand, Lomita Marl, and sedimentary bedrock of the Miocene age Monterey Formation. Much of these materials are exposed on the slopes at the site and were not encountered as part of our fault investigation, which was conducted along the eastern boundary of the former quarry and along the northwest quarry slope where in-place San Pedro Sand is exposed.

Our trenches exposed primarily San Pedro Sand (600ka – 1M) and artificial fill. Pleistocene age older colluvial soils and marine sand (~200ka – 320ka based on elevation) were locally encountered in the eastern portion of Trench 3, and the marine sand (~200ka – 320ka) was locally encountered in the northern portion of Trench 2. The colluvial soils and marine sand (~200ka – 320ka) were not encountered in Trench 1 or along the northwest quarry slope.

The San Pedro Sand, exposed in our trenches and along the northwest quarry slope, ranges from white (7.5YR 8/1) and light gray (7.5YR 7/1) to yellow (10YR 7/6) and brownish yellow (10YR 6/6), to strong brown (7.5YR 5/6) where oxidized. Grain size ranges from fine- to coarse-grained sand with local gravel-rich beds and some rounded cobbles. The formation is generally massive to thickly bedded and locally cross-bedded. This formation is typically uncemented and friable. As observed in our on-site excavations, the San Pedro Sand dips to the northeast and northwest at approximately 17 to 65 degrees. The sand is characterized as slightly moist and medium dense to dense.

Pleistocene age older colluvial soils that consist of brown (7.5YR 5/4), fine-grained and massive silty sand and sand was encountered in the eastern portion of Trench 3 (between approximately Station 0+30 and 0+35). These soils were deposited on top of the San Pedro Sand, presumably as colluvium on a (now buried) canyon wall.

Pleistocene age marine sand was observed to on-lap onto the colluvial soils and San Pedro Sand, east of Station 0+30 in Trench 3. This unit was also observed to on-lap onto the San Pedro Sand in Trench 2, south of Station 0+30. The marine sand consists of light brown (7.5YR 6/4) fine-grained, well-sorted sand that is generally horizontally bedded. Brown (7.5YR 5/4) clay lamellae, representing a dispersed argillic B horizon, are present in this formation, with the clay lams generally ¼-inch in thickness, discontinuous and slightly undulating. Based on its elevation, the marine sand is interpreted to have been deposited during marine isotope Stage 7 or Stage 9 (~ 200ka to 320ka), or older.

4.3 Groundwater Conditions

Monitoring well data indicate the groundwater level in the area is greater than 80 feet beneath the existing ground surface (LACDPW, 2015). Groundwater was not encountered in the exploratory trenches excavated to a maximum depth of approximately 12.4 feet. Also, groundwater was not encountered in our borings drilled during our geotechnical investigation at the site to a maximum depth of 61.5 feet beneath the existing ground surface within the boundaries of the proposed development.

5. FAULT ACTIVITY CRITERIA

The criteria used in our investigation to evaluate fault activity at the site are the same criteria used by the California Geological Survey that defines an active fault as one that has had surface displacement within Holocene time (about the last 11,700 years). These criteria for defining an active fault are based on criteria developed by the CGS (Bryant and Hart, 2007) for the Alquist-Priolo Earthquake Fault Zoning Program. Faults that have not moved in the last 11,700 years are not considered active.

In general, the activity rating of a fault is determined by establishing the age of the oldest materials overlying the fault that are not displaced by the fault. If datable material is present, an absolute age can sometimes be established; if no datable material exists, then only a relative age can be assigned to the fault.

6. PHOTO – LINEAMENT ANALYSIS

Vintage aerial photographs were assessed for geomorphic indicators of the presence of active faulting in the site vicinity. We acquired stereo-paired aerial photographs flown in 1928, 1947 and 1979, as well as analyzed Google Earth imagery on-line, to search for the presence of scarps or other indicators of active faulting. Because the vintage photography was generally at large scale, we scanned the photos in high-resolution (1200 dpi) and enlarged the area of the site for analysis. We present the results of this analysis in Figure 5, Vintage Aerial Photograph, using the 1928 photograph as the base, as all subsequent imagery shows evidence of cultural development and landscape modification. Even in 1928, the quarry excavations had already begun at the site, as well as elsewhere along the Palos Verdes Hills, but housing and other developments were generally sparse.

As indicated in Figure 5, there is a possible scarp located to the southeast of the site cutting across an alluvial fan, and tonal lineaments in alluvial fans are evident closer to the site to the southeast. To the northwest, there is a weak lineament near the base of slope trending through an early housing development. The lineament is transverse to the street lay-out in the development, suggesting that the lineament may be tectonic in origin. In the immediate vicinity of the site, the base of slope appears smooth in 1928 and there are no apparent scarps or other features that would indicate the presence of a surface fault. The incised drainage southeast of the site, located about where Hawthorne now runs, suggests that the bajada of alluvial fans has some age to it and would likely have experienced ground rupture unless the bajada surface is less than a couple thousand years (the likely oldest age for the most recent event based on McNeilan et al., 1996). The absence of scarps in the site vicinity may indicate that the fault is blind in this area, but located northeast of the site.

Later aerial photographs support the interpretation presented in Figure 5, although by 1947, agriculture had obliterated the tonal lineaments, and further development of quarries to the southeast had modified the area of the apparent scarp in the alluvial fan. By 1979, substantial housing development had occurred, Hawthorne Blvd had been established, and fault-related features are no longer visible.

Our new observations, which are based on the enlarged aerial photography, are consistent with earlier interpretations that the surface trace of the Palos Verdes fault, if present at all (i.e., not blind this far to the northwest), is located to the northeast of the project site. A fault location northeast of the site is also consistent with the quarry lying within the uplifted portion of the Palos Verdes Hills and the fault being the primary cause of this uplift.

7. SITE-SPECIFIC INVESTIGATION

7.1 General

Our site-specific investigation included excavating three exploratory trenches, clearing the northwest quarry wall to observe clean exposures of the San Pedro Sand, and "pot-holing" to expose the contact between the Monterey Formation and the San Pedro Sand.

7.2 Exploratory Trenches

Our initial field investigation was performed on February 2 and 3, 2015 and included excavation of Trench 1 and Trench 2. Trench 1, approximately 323 feet long, was excavated on the lower pad area in the central portion of the site whereas Trench 2, approximately 100 feet long, was excavated on the upper pad east of Trench 1 at the locations shown on Figure 2. Later, on July 6, we excavated Trench 3, approximately 85 feet long, to extend Trench 1 the north and east to provide complete coverage of the proposed structures (See Figure 2).

The trenches were excavated generally perpendicular to the local trend of the Palos Verdes Fault Zone in the area. The trenches were excavated with a standard excavator to depths of approximately 3 to 12.4 feet below the existing ground surface. Trench 1 and Trench 2 were excavated with a 3-foot wide bucket and Trench 3 was excavated with a 5-foot wide bucket. The trench walls were vertical and shored where deeper than 5 feet to allow our geologists to enter the trench.

The surface of the natural sediments exposed on both trench walls was cleaned of smeared earth material and closely examined for indications of faulting. These indications could include offset geologic units, contacts, or laminations (bedding), tectonically disturbed or deformed clay layers, clay gouge, soil- or clay-filled fractures, fissures, or striae on fracture surfaces. Distinct geologic units, based on criteria that included lateral continuity, degree of soil development, color, lithology, fabric (i.e. fining upward sequences), texture, and degree of weathering were delineated by nails and flagging on the trench wall.

The contacts (lithologic and pedogenic) between the designated units, notable geologic features, and locations of minor shears exposed in the trenches were logged in the field. Detailed logging of the trench walls was performed at a scale of 1 inch equals 5 feet. Lateral stationing was established by a standard measuring tape and horizontal string lines (vertical reference datum) along the length of the trenches.

Dr. Thomas Rockwell observed photographic documentation and trench logs of Trench 1 and Trench 2, and was on-site and observed the excavation and logging of Trench 3.

7.3 Clearing of Northwest Quarry Slope

On May 18 and 19, 2015, we cleared a continuous exposure of the San Pedro Sand at the base of the northwestern quarry wall. The limits of the continuous exposure are shown on Figure 2. The purpose of clearing the slope was to provide a clean exposure of the San Pedro Sand to locate and document faults or minor shears that may be present and trace these features upward through the formation to further investigate if they are syn-depositional in nature and confined to this formation. Considering the northwest quarry wall is approximately 40 to 95 feet in height, this potentially provided a large vertical exposure for our evaluation.

Dr. Thomas Rockwell observed the slope exposures on May 26, 2015. Also, Tania Gonzalez of ECI (reviewer for the City of Torrance) visited the site with Rockwell on June 4, 2015 to observe the slope exposure and to discuss the preliminary interpretations regarding the age and origin of the exposed geologic features.

7.4 Pot-Holing

"Pot-holing" was performed along the base of the north-facing slope along the southern project boundary to determine if the contact between the San Pedro Sand and the underlying sedimentary bedrock of the Monterey Formation is faulted or depositional. The locations of the pot-holes are shown on Figure 2.

8. DATA INTERPRETATION

8.1 General

The primary stratigraphic unit observed in the trenches and along the northwest quarry slope consist of the Pleistocene age San Pedro Sand (approximately 600ka to 1Ma in age). The San Pedro Sand consists of fine- to coarse-grained, well-sorted sand that was deposited in a near-shore marine environment. This formation is massive to well-bedded and locally cross-bedded. Bedding in the formation dips to the north at inclinations ranging from approximately 17 to 65 degrees. Pleistocene age marine sand (~200ka to 320ka) that consists of fine-grained sand was observed in the northern and eastern portions of Trench 2 and Trench 3, respectively. Pleistocene age older colluvial soils that consist of fine-grained, massive silty sand and sand were encountered in the eastern portion of Trench 3.

8.2 Exploratory Trenches

Many minor shears were observed cutting the San Pedro Sand in Trench 1. As indicated in Figure 6 (Log of Trench 1), generally two sets of shears were observed; one as a very low angle set with nearly horizontal shear surfaces that are consistently cross-cut by a higher angle set. Based on this observation, the high-angle set is interpreted to be younger than the low angle set. Observed offsets along these minor shears were on the order of 2 inches or less.

Trench 2 was excavated topographically higher than Trench 1 and therefore exposed a younger section of the San Pedro Sand. As shown on Figure 7 (Log of Trench 2 and Trench 3), only two minor shears were observed in this trench, both confined to the San Pedro Sand. The northern shear bifurcates into two branches as it extends upward and each branch terminates within the San Pedro Sand. The second shear extends to the base of the fill materials and the upward termination of the shear could not be determined. Each of these shears exhibited minor offsets on the order of a few inches or less. The number of minor shears observed in Trench 2 was far fewer than the number of minor shears observed in Trench 1, which suggests that the minor shears may die out upward in the San Pedro Sand, and are therefore middle Quaternary in age.

Trench 3, excavated from the northern terminus of Trench 1 to the north and east (See Figure 2), exposed older marine sand that lapped onto the older colluvial soils (between approximately Station 0+3- and 0+35) and the San Pedro Sand. As shown in Figure 7, only four minor shears were observed in the San Pedro Sand, all exhibiting minor offsets of about 2 inches. More importantly, all of these shears were observed to terminate within the San Pedro formation so we can confidently demonstrate that these shears are not related to active faulting (by the State definition). Minor shears were not observed in the older colluvial soils.

8.3 Northwest Quarry Wall

The entire length of the northwest quarry wall was cleared to expose a clean exposure of the San Pedro Sand. Only a small area did not expose native sediments, but rather, exposed fill soils. The location and orientation of the minor faults we observed on the northwest quarry slope are shown on Figure 2. The majority of the observed minor shears that were exposed are confined to the San Pedro Sand. We can confidently eliminate these features as active faults. However, because of thick fill soils (up to 5 feet thick) covering the northwest quarry slope in some areas, and because of the surficial instability of the slopes in their current condition, several of the observed shears could not be traced up the slope to determine where they terminate. With respect to those shears, we could not determine if they cut the modern soil, which would indicate young activity, or whether the soil is formed across the shears, which would indicate inactivity. As for the shears for which absolute determination could not be made, all had minor displacements of a few inches or less and were similar to the shears that could be shown to be inactive. This observation argues that, as a set, the entire group of very minor shears are inactive, as we discuss later.

8.4 Pot-Holing

"Pot-holing" was performed along the base of the north-facing slope along the southern project boundary to determine if the contact between the San Pedro Sand and the underlying sedimentary bedrock of the Monterey Formation is faulted or depositional. If a fault is present, its location would need to be determined across the property to establish set-backs, as required by State law. If the contact is depositional in nature, then the primary fault issues to be addressed have to do with the minor shears exposed in the three exploratory trenches, and whether a fault lies along the northern project boundary.

We excavated several pot-holes (pits) along the base of the north-facing slope at the locations shown on Figure 2. We observed a gravelly sand unit in the pits that could be interpreted as either non-marine terrace deposits or Sand Pedro Sand overlying the Monterey Formation bedrock. However, the sand was friable and uncemented and, due to caving conditions, it was difficult to conclude with a high degree of confidence whether the sand was non-marine terrace or San Pedro Sand and whether the contact between the two formations is depositional. The results of the "pot-holing" were inconclusive, although we found no evidence for the presence of a fault nor evidence of secondary shears in either formation that would be expected had a fault been present at the contact. Together, the likelihood of the presence of a fault between the San Pedro Sand and Monterey Shale was considered very low.

Later, as part of our concurrent geotechnical investigation, we observed in detail the contact between the San Pedro Sand and the Monterey Formation in large-diameter boring B2. Based on our observations in this boring, it was determined with a high degree of confidence that the contact between the San Pedro Sand and the underlying Monterey Formation bedrock is depositional in nature. Photo 13 and Photo 14 in Appendix A show the depositional contact between the San Pedro Sand and the underlying Monterey Formation siltstone.

8.5 Characterization of Minor Shears

As previously discussed, most of the minor shears exposed within the site boundaries can be confidently dated to the Middle Pleistocene. This statement is based on the observation that most of the observed shears die out in the San Pedro Sand, and that this formation is dated at various locations throughout the Los Angeles Basin region as being on the order of 600,000 to 1,000,000 years in age (Ponti, 1989; Yeats and Rockwell, 1991). This implies that most of the observed minor shears formed in the same timeframe and are greater than a half million years in age.

The orientations of the minor shears observed in the trenches and the northwest quarry wall are shown on Figure 2 and in Figure 8, Stereonet of Minor Shears. The variable orientations of the observed shears not only argue that they are minor in nature but also that they are not structurally related to the main fault. We interpret these minor shears as the consequence of folding of the northeastern flank of the Palos Verdes Hills rather than as rooted tectonic features. Alternatively, they could represent minor movement during periods of strong ground shaking (ground shatter) or minor movement during liquefaction prior to uplift of this portion of the peninsula.

9. CONCLUSIONS

The results of our fault rupture hazard investigation indicate the site is located within a zone of minor shearing and the main trace of the Palos Verdes fault is located 350 feet to the northeast. As previously discussed, we interpret these minor shears as the consequence of folding of the northeastern flank of the Palos Verdes Hills rather than as rooted tectonic features. Alternatively, they could represent minor movement during periods of strong ground shaking (ground shatter) or minor movement during liquefaction prior to uplift of this portion of the peninsula.

It is our interpretation that all of the observed minor shears are of similar age, and therefore Middle Pleistocene in age. This is based on the reasoning that: 1) most of the minor shears can be demonstrated to die out in the San Pedro Sand, with the remaining indeterminate because of previous grading at the site; 2) the minor shears exhibit a random orientation and are likely formed from processes other than tectonic faulting.

The absence of active faults in the trenches or along the northwest quarry wall provide a strong line of evidence that the main trace of the Palos Verdes Fault Zone is not located on the site. Also, geomorphic indicators (topographic and tonal lineaments) observed on enlarged vintage aerial photography are consistent with earlier interpretations that the surface trace of the Palos Verdes fault, if present at all (i.e., not blind this far to the northwest), is located approximately 350 feet northeast of the project site. This observation is consistent with the quarry lying within the uplifted portion of the Palos Verdes Hills and the fault being the primary cause of this uplift.

10. RECOMMENDATIONS

The minor shears observed at the site are not considered capable of generating earthquakes but are interpreted as either consequence of folding of the northeastern flank of the Palos Verdes Hills or are secondary features related to ground shaking (ground shatter) or minor movement during liquefaction prior to uplift of this portion of the peninsula.

The former mining operation has significantly altered the original ground surface at the site and the majority of the upper portion of the San Pedro Sand has been removed and replaced with up to 50 feet of fill soils. The significantly changed condition at the site results in some uncertainty as to the potential for differential movement along these minor shears during a future earthquake, or simply because of differential settlement. Therefore, we conclude there is a very minor risk that a future earthquake may generate minor secondary slip along these features.

It is our opinion that a structural setback from these features is not warranted. However, mitigation measures are necessary to eliminate the potential for differential settlement that may adversely affect the proposed structures.

To mitigate the effects of potential differential movement beneath proposed structures that may occur as a result of movement along the observed minor shears or fill settlement, we recommend the following combination of geotechnical engineering methods be implemented:

1. Construct reinforced earthfills beneath the structures,
2. Install a slip layer to decouple ground movements from foundation elements,
3. Construct a structurally reinforced mat foundation at a uniform elevation for each building,
4. Install flexible utility lines.

Recommendations for design of these mitigation methods are discussed in detail in our geotechnical investigation report for the site. Adherence to these recommendations will reduce the potential for secondary ground movement, if it occurs, to a level of nonsignificance.

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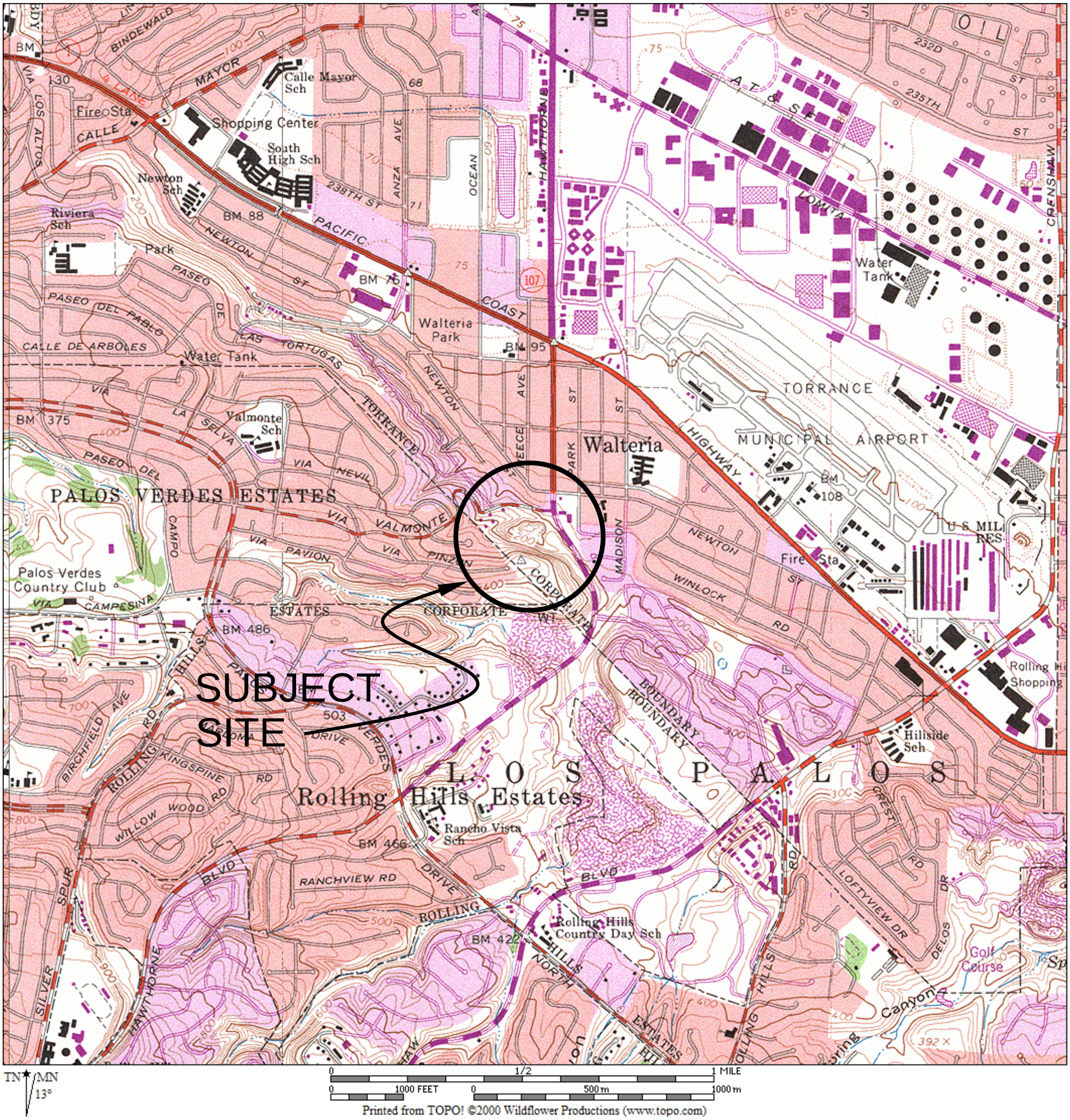

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VICINITY MAP

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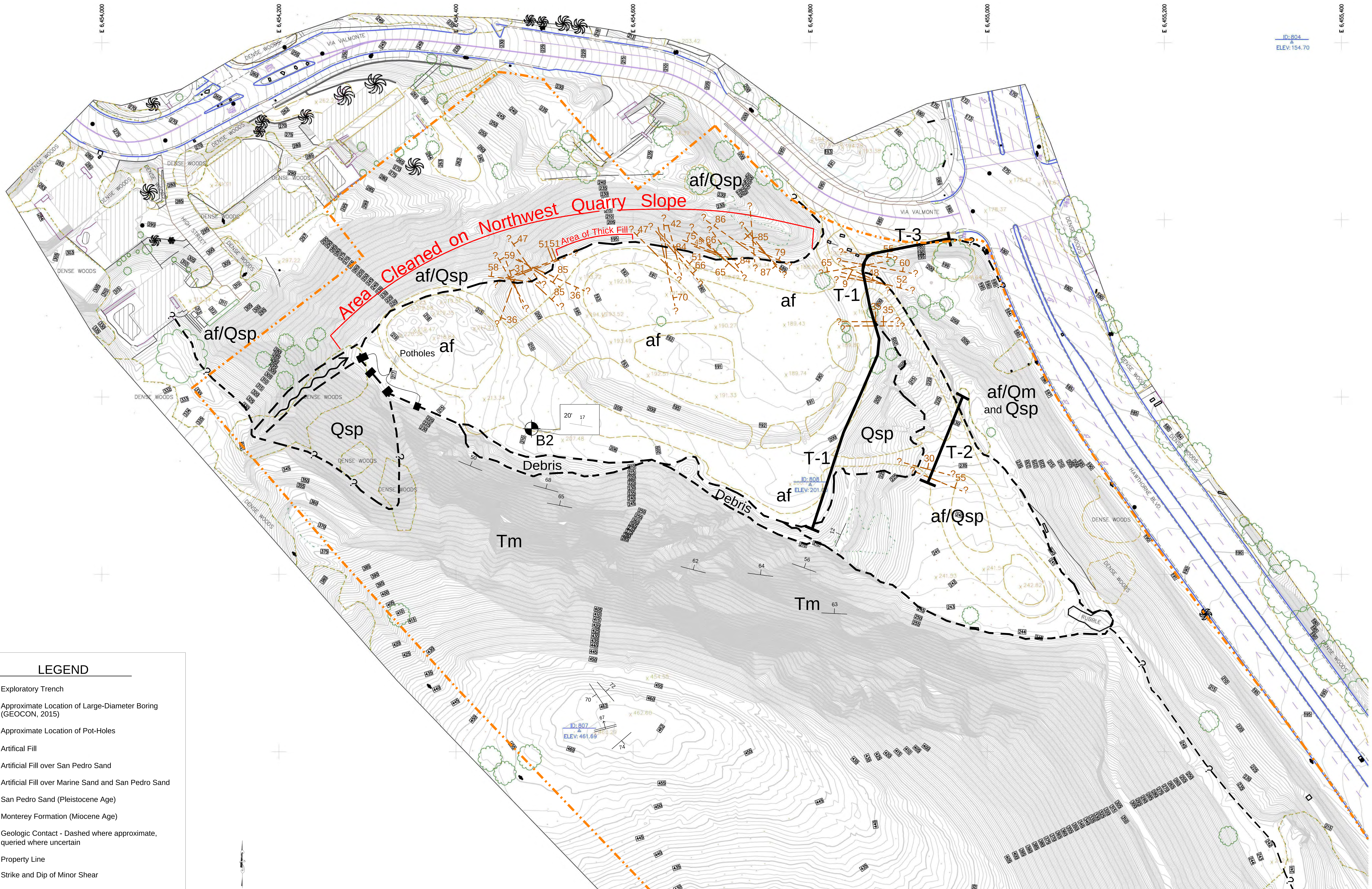
SEPT. 2015	PROJECT NO. A9201-06-01C	FIG. 1



LEGEND

T-3	Exploratory Trench
B2	Approximate Location of Large-Diameter Boring (GEOCON, 2015)
	Approximate Location of Pot-Holes
af	Artifical Fill
af/Qsp	Artificial Fill over San Pedro Sand
af/Qm and Qsp	Artificial Fill over Marine Sand and San Pedro Sand
Qsp	San Pedro Sand (Pleistocene Age)
Tm	Monterey Formation (Miocene Age)
---?---?	Geologic Contact - Dashed where approximate, queried where uncertain
	Property Line
18	Strike and Dip of Minor Shear
18	Strike and Dip of Bedding
	Erosion Gully

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SITE PLAN

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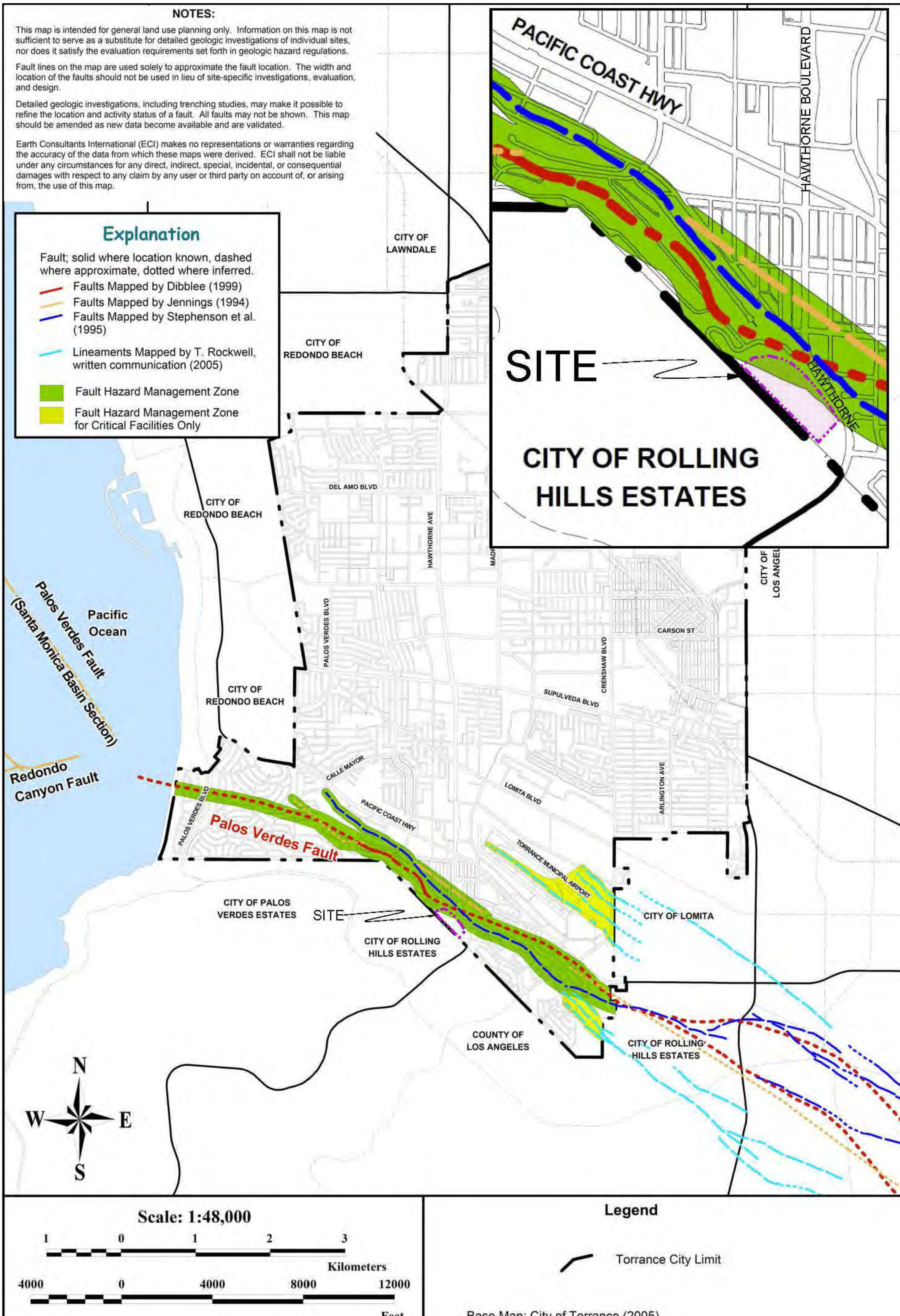
SEPT. 2015 | PROJECT NO. A9201-06-01C | FIG. 2



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FAULT HAZARD MANAGEMENT ZONE

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SEPT. 2015	PROJECT NO. A9201-06-01C	FIG. 3

Reference: DIBBLEE, T. W., Jr., 1999, Geologic Map of the Palos Verdes Peninsula and Vicinity, Redondo Beach, Torrance, and San Pedro Quadrangle, Los Angeles County, California, Dibblee Foundation Map # DF-70.

GEOLOGIC UNITS

af	
Qs	Qa
Qds	Qae

SURFICIAL SEDIMENTS

af *Artificial fill or cut and fill; many areas may not be shown*
Qs *Beach sediments, ranging from sand to cobble-boulder gravel*
Qds *Loose dune and drift sand*
Qa *Alluvium, mostly loamy clay of valley and flood plains; includes fine sand near Palos Verdes Hills*
Qae *Alluvium, similar to* **Qa** *but slightly elevated and locally dissected*

Qls

Qls *Landslide debris; mostly of Monterey Shale*

Qos | Qoa t

OLDER SURFICIAL SEDIMENTS

Qos *Older, stabilized dune and drift sand – mostly unconsolidated fine-grained sand*
Qoa *Older alluvium – nonmarine terrace cover of Woodring et al., 1946; Poland et al., 1959; Cleveland, 1972; sandy loam and loamy clay, includes sand and pebble gravel in Palos Verdes Hills, with pebbles derived mostly from Miocene hard siliceous shale and limestone; includes Palos Verdes Sand of Woodring et al., 1946, not differentiated on this map*
t *Elevated old marine terrace remnants in Palos Verdes Hills, with little or no alluvial sedimentary cover; compiled in large part from Woodring et al., 1946; Cleveland, 1972*

Qsp	
Qtp	Ql

SHALLOW MARINE SEDIMENTS

Nonmarine(?) to shallow marine clastic sediments, weakly indurated; contain abundant marine molluscan fossils and microfossils; Pleistocene (Hallian Stage)

Qsp San Pedro Sand: *Light gray to reddish-tan sand and pebble gravel; pebbles derived mostly from Miocene hard siliceous shale and limestone detritus; massive to locally cross-bedded*
Qtp Timms Point Silt: *Yellowish-gray to gray sandy siltstone, formerly widely exposed in San Pedro*
Ql Lomita Marl: *Gray-white marl and calcareous fine-grained sandstone, gray siltstone, in places with basal gravel of Miocene shale and limestone debris*

— UNCONFORMITY —

Tfp
Tfr

FERNANDO FORMATION
(Formerly Pico Formation, and Repetto Formation of Reed, 1933)
Deep marine clastic sediments; Pliocene age

Tfp *Pico Member, in subsurface only, north of Palos Verdes fault; mostly blue and brown sandy shale and sandy siltstone; late Pliocene age, mostly Venturian Stage*
Tfr *Soft gray siltstone-claystone, locally glauconitic; early Pliocene age, Repettian Stage*

— DISCONFORMITY —

Tmg

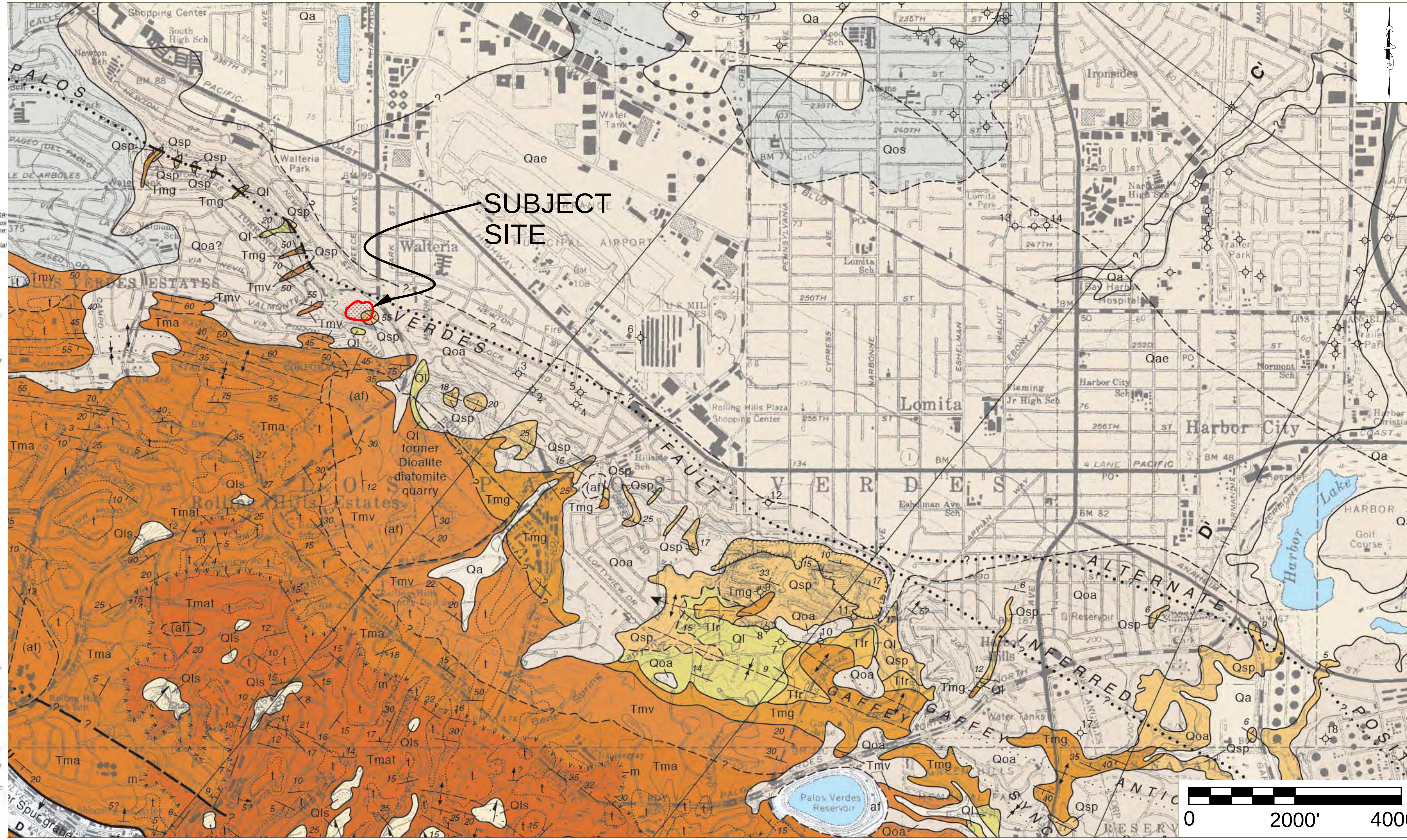
MALAGA MUDSTONE
(Formerly Malaga Mudstone member of Monterey Shale (Woodring et al., 1946)
Deep marine clastic sediments; late Miocene age; similar to "Unamed Shale" of east Los Angeles region (Dibblee, 1989)

Tmg *Light gray sandstone and dark-gray-brown mudstone with diatomaceous strata and limestone concretions; Mohnian – Delmontian Stages (Rowell, 1982)*

Tmv
Tma Tmad
Tmf
Tmat m
Tb Tb

MONTEREY FORMATION
(Equivalent to lower Puente Formation, north of Palos Verdes Fault)
Deep marine biogenic, clastic, and volcanic sediments; early middle to late Miocene age; described below in descending stratigraphic order:

Tmv Valmonte Diatomite – *Soft, white, punky, laminated diatomaceous shale and mudstone, in places up to 125 m thick; Mohnian Stage (Rowell, 1982)*
Tmad *Diatomite in San Pedro area – lithologically very similar to Valmonte Diatomite, but probably equivalent in age to upper part of unit* **Tma**;
Tma Altamira Shale – upper part: *White-weathering, thin-bedded siliceous and phosphatic shale with interbeds of limestone and siltstone, locally organic and diatomaceous; 40 m thick; with cherty and porcelaneous shale at base, up to 15 m thick (Conrad and Ehlig, 1983); Relizian(?) – Mohnian Stages (Rowell, 1982)*
Tmf Point Fermin Sandstone member – *Light gray, bedded, indurated sandstone, contains abundant grains, pebbles and cobbles of blueschist, few of quartzite and basaltic rocks; +/- 40 m thick; early Mohnian Stage (Sloan, 1987)*
Tmat Altamira Shale – lower part: *Mostly light gray shale and mudstone, with tuffaceous and dolomitic strata throughout, with total thickness up to 275 m; at or near top contains white, fine-grained, semi-indurated tuff bed*
M *(Miraleste Tuff of Woodring et al., 1936) about 2 m thick; near middle contains bentonitic Portuguese Tuff* **p** *(of Woodring et al., 1946) up to 25 m thick near Portuguese Bend; contains flows and intrusions of basaltic rocks*
(Tb) *Described separately below; Relizian – Luisian Stages (Rowell, 1982)*
In lower Puente Formation, north of Palos Verdes fault, in subsurface only:
Del Amo zone – *Of Torrance oil field; oil-producing fine-grained sandstone and shale*
Nodular Shale – *Dark brown organic shale with phosphatic laminae and blebs*
Basal Conglomerate – *Poorly sorted, with blueschist debris (San Onofre breccia?)*



LEGEND

FORMATION CONTACT *dashed where inferred or indefinite, dotted where concealed*

MEMBER CONTACT *between units of a formation* **Prominent bed**

CONTACT BETWEEN SURFICIAL SEDIMENTS *located only approximately in places*

FAULT: *Dashed where indefinite or inferred, dotted where concealed, queried where existence is doubtful. Parallel arrows indicate inferred relative lateral movement. Relative vertical movement is shown by U/D (U=upthrown side, D=downthrown side). Short arrow indicates dip of fault plane. Sawteeth are on upper plate of low angle thrust fault.*

FOLDS: overturned, ANTICLINE, SYNCLINE
arrow on axial trace of fold indicates direction of plunge; dotted where concealed by surficial sediments

Strike and dip of sedimentary rocks: inclined, inclined (approximate), overturned, horizontal, vertical

Strike and dip of metamorphic or igneous rock foliation or flow banding or compositional layers: inclined, inclined (approximate), vertical, overturned

OTHER SYMBOLS: Direction of landslide movement, outline of water bodies shown on map, water well, oil well, springs

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GEOLOGIC MAP
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SEPT. 2015 | PROJECT NO. A9201-06-01C | FIG. 4

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Vintage Aerial Photograph		
MKS Residential Hawthorne & Via Valmonte, Torrance, California		
SEPT. 2015	A9201-06-01C	FIG. 5

TRENCH 1

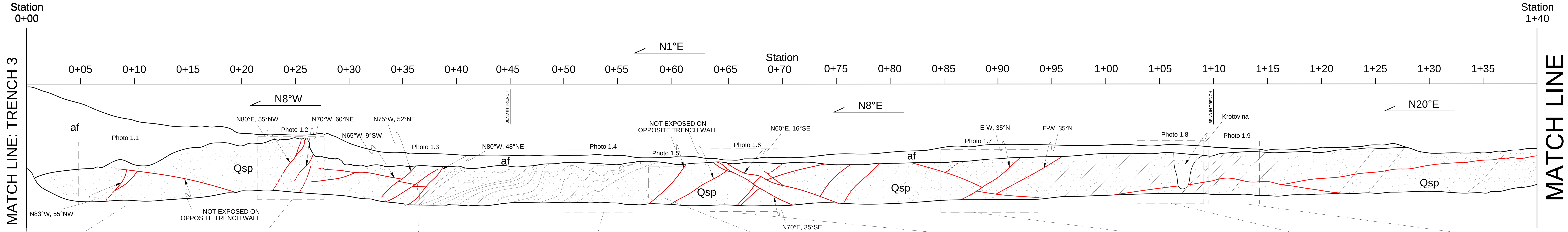


Photo 1.1

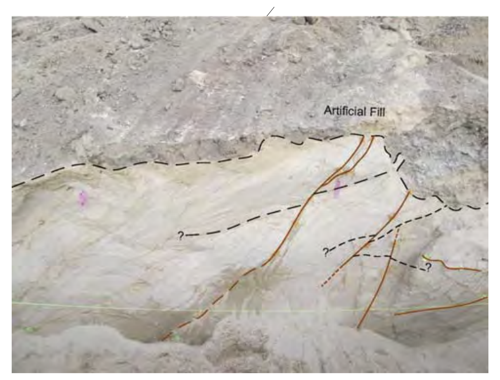

Photo 1.2


Photo 1.3


Photo 1.4


Photo 1.5

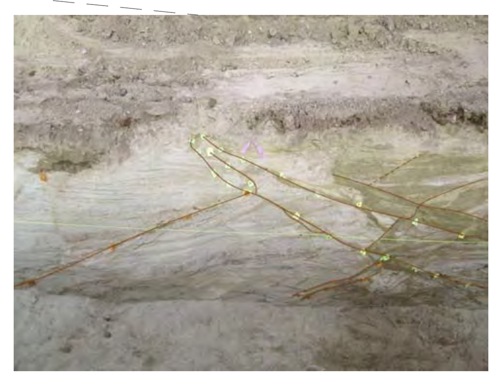
Photo 1.6

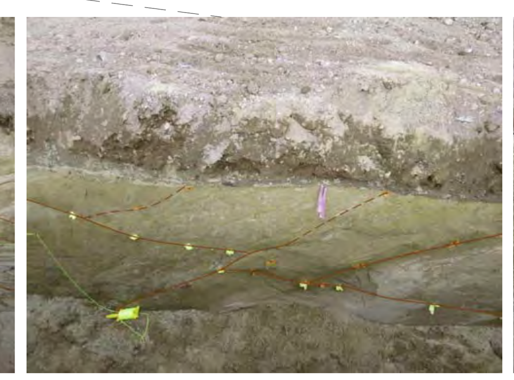
Photo 1.7

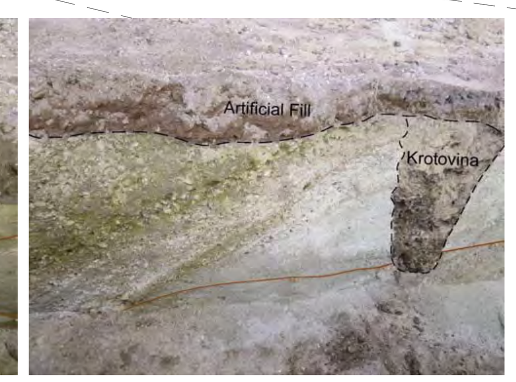

Photo 1.8


Photo 1.9


Photo 1.10

LEGEND

af -	Artificial Fill (Holocene Age)		Bedding
Qsp -	San Pedro Sand (Pleistocene Age)		Minor Shear
			Pebbly Bed with Oxidation

SCALE (H&V): 1" = 5'

0 5' 10'

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LOG OF TRENCH 1

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SEPT. 2015 | PROJECT NO. A9201-06-01C | FIG. 6

TRENCH 2

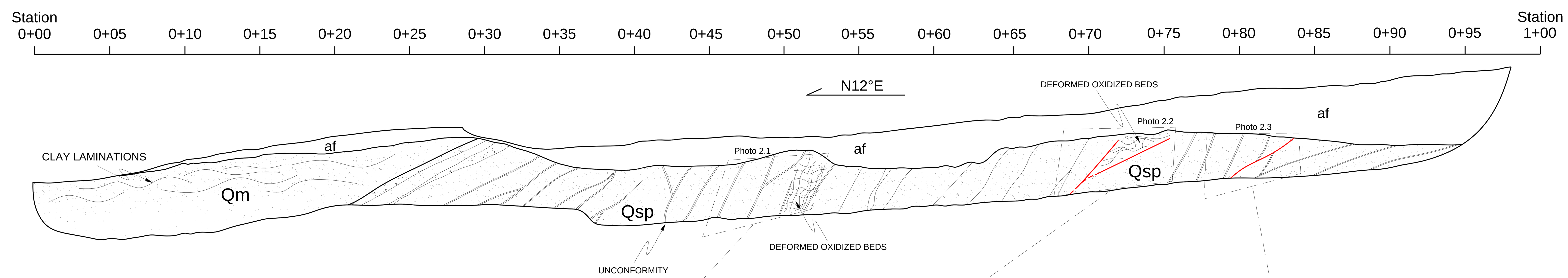

Photo 2.1

Photo 2.2

Photo 2.3

TRENCH 3

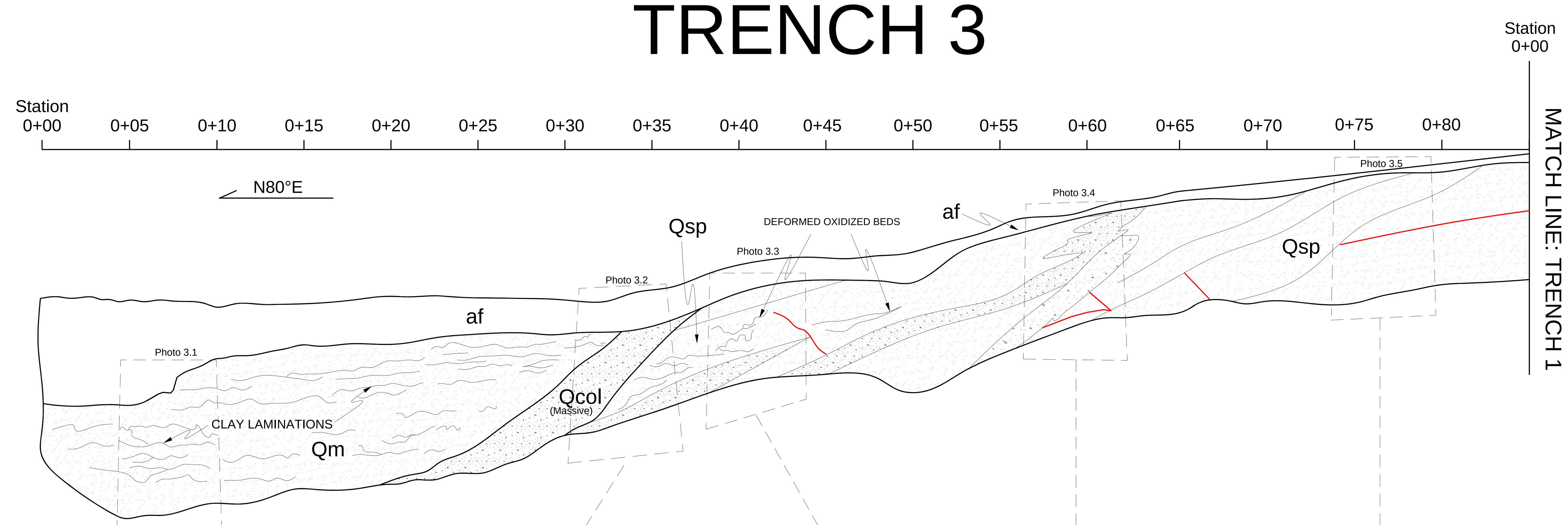

Photo 3.1

Photo 3.2

Photo 3.3

Photo 3.4

Photo 3.5

LEGEND

af -	Artificial Fill		Bedding
Qm -	Marine Sand (Pleistocene Age)		Minor Shear
Qcol -	Colluvium (Pleistocene Age)		
Qsp -	San Pedro Sand (Pleistocene Age)		

SCALE (H&V): 1" = 5'

0 5' 10'

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LOG OF TRENCH 2 AND TRENCH 3

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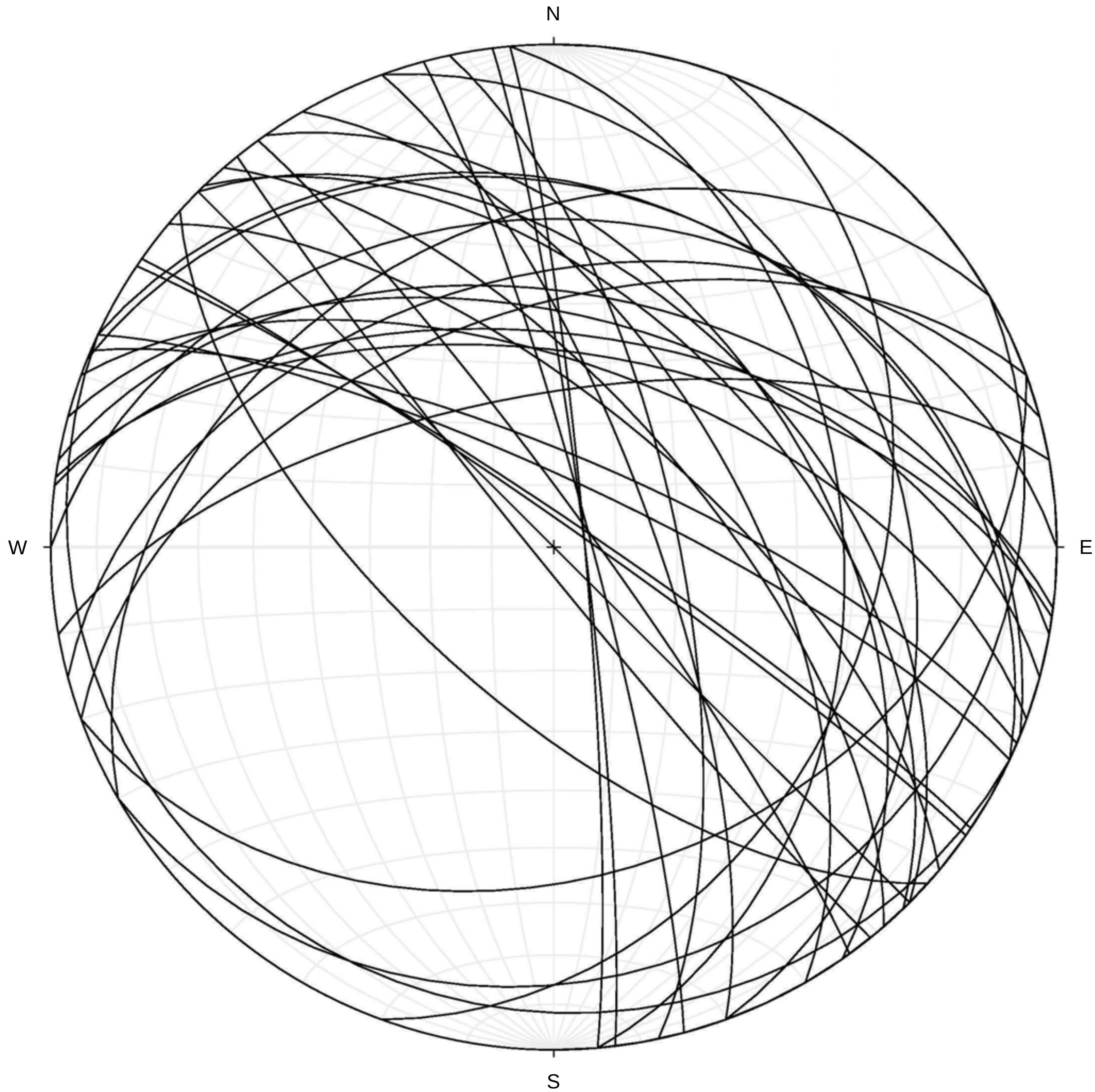

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STEREONET OF MINOR SHEARS

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APPENDIX A

APPENDIX A

INVESTIGATION PHOTOS

Photo 1: Trench 1 – Looking South

Photo 2: Trench 1 – Looking Southwest

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SITE PHOTOS 1 & 2		
Fault Rupture Hazard Investigation Hawthorne Blvd. & Via Valmonte, Torrance, CA		
A9201-06-01C		August 2015

Photo 3: Trench 1 – Looking West

Photo 4: Trench 1 – Looking Northwest

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SITE PHOTOS 3 & 4		
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A9201-06-01C		August 2015

Photo 5: Trench 2 – Looking North

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SITE PHOTO 5		
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Photo 6: Logging Trench 2 – Looking North

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SITE PHOTO 6		
Fault Rupture Hazard Investigation Hawthorne Blvd. & Via Valmonte, Torrance, CA		
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Photo 7: Clearing of Northwest Quarry Slope – Looking West-Southwest

Photo 8: Northwest Quarry Slope – Looking Northeast

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SITE PHOTOS 7 & 8		
Fault Rupture Hazard Investigation Hawthorne Blvd. & Via Valmonte, Torrance, CA		
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Photo 9: Clearing of Northwest Quarry Slope – Looking Northeast

Photo 10: Minor Faults Observed Along Northwest Quarry Slope

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SITE PHOTOS 9 & 10		
Fault Rupture Hazard Investigation Hawthorne Blvd. & Via Valmonte, Torrance, CA		
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Photo 11: Excavator Pot-Holing along North-Facing Slope

Photo 12: Depositional Contact - San Pedro Sand (or Terrace Deposit) over Monterey Formation

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SITE PHOTOS 11 & 12		
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Photo 13: San Pedro Sand over Monterey Formation Siltstone


Photo 14: Weathering Profile at Contact between San Pedro Sand and Monterey Formation Siltstone

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SITE PHOTOS 13 & 14		
Fault Rupture Hazard Investigation Hawthorne Blvd. & Via Valmonte, Torrance, CA		
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Photo 15: Trench 3 Looking East

Photo 16: Trench 3 Looking South (Intersection of Trench 1)

SITE PHOTOS 15 & 16		
Fault Rupture Hazard Investigation Hawthorne Blvd. & Via Valmonte, Torrance, CA		
A9201-06-01C		August 2015

Trench 1: Station 0+36 Closeup of Offset Beds

GEOCON
WEST, INC.
3303 N. SAN FERNANDO BLVD. – SUITE 100 – BURBANK, CA. 91504
PHONE 818 841-8388 – FAX 818 841-1704

SITE PHOTOS 17 & 18		
Fault Rupture Hazard Investigation Hawthorne Blvd. & Via Valmonte, Torrance, California		
A9201-06-01C		August 2015

Trench 1: Station 0+60 Closeup of Offset Beds

GEOCON
WEST, INC.
3303 N. SAN FERNANDO BLVD. – SUITE 100 – BURBANK, CA. 91504
PHONE 818 841-8388 – FAX 818 841-1704

SITE PHOTOS 19 & 20		
Fault Rupture Hazard Investigation Hawthorne Blvd. & Via Valmonte, Torrance, California		
A9201-06-01C		August 2015

Trench 1: Station 2+06

GEOCON
WEST, INC.
3303 N. SAN FERNANDO BLVD. - SUITE 100 - BURBANK, CA. 91504
PHONE 818 841-8388 - FAX 818 841-1704

SITE PHOTOS 21 & 22		
Fault Rupture Hazard Investigation Hawthorne Blvd. & Via Valmonte, Torrance, California		
A9201-06-01C		August 2015