Bridgewater Equipment, Inc.
20075 Kendall Drive
San Bernardino, California 92407

**ENGINEERING GEOLOGY STUDY**
**PROPOSED INFILTRATION BASIN AND NEW STRUCTURE**
**APN 0266-012-10**
**20075 KENDALL DRIVE**
**SAN BERNARDINO, SAN BERNARDINO COUNTY**
**CALIFORNIA**

September 29, 2017



File No.: 12491-01
Doc. No.: 17-09-709

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Bridgewater Equipment, Inc.
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San Bernardino, California 92407

Attention: Lonnie D. Bridgewater

Project: **Proposed Infiltration Basin and New Structure**
APN 0266-012-10
20075 Kendall Drive
San Bernardino, San Bernardino County, California

Subject: **Engineering Geology Study**

Earth Systems Southwest [Earth Systems] is pleased to submit this engineering geology study report for the proposed infiltration basin and new building for Assessor Parcel No. 0266-012-10 located at 20075 Kendall Drive in San Bernardino, San Bernardino County, California. The intent of this report is to provide geologic constraints that may affect the planned site development.

This report completes our scope of services in accordance with our agreement (SWP-17-106) dated August 9, 2017. Other services that may be required, such as plan reviews, responses to agency inquiries, and grading observation are additional services and will be billed according to the Fee Schedule in effect at the time services are provided. Unless requested in writing, the client is responsible to distribute the report to the appropriate governing agency and other members of the design team.

We appreciate the opportunity to provide our professional services. Please contact our office if there are any questions or comments concerning this report or its recommendations.

Respectfully submitted,
**EARTH SYSTEMS SOUTHWEST**



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Senior Engineering Geologist

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## Section 1
## INTRODUCTION

### 1.1 Background

The proposed project will consist of the construction of a building and infiltration basin at 20075 Kendall Drive (APN 0266-012-10) in the northern part of San Bernardino, California. The proposed site development will include the construction of an approximately 12,800 square foot building on the northwest side of the lot, with paved parking and driveway between the building and Kendall Drive. In addition, an infiltration basin will be constructed on the south side of the lot adjacent to an existing hillside.

### 1.2 Site Description

The subject site is located along the southwest side of Kendall Drive in the City of San Bernardino, San Bernardino County, California. The central portion of the site is located at coordinates of approximately latitude 34.194354°N and longitude -117.367967°W. The site location is shown on Plate A-1.

Topographically, the site appears to have been previously sheet graded, with the surface drainage by sheet flow across the property, generally from north to south. Most of the project site is relatively flat with the highest elevation within the previously graded flat portion of approximately 1742 feet Mean Sea Level (MSL) located along Kendall Drive and a gradual gradient to the lowest elevation of 1736 feet MSL on the south side. The southern corner of the site extends into a natural hillside with an approximate high elevation at the property corner of 1770 feet MSL. The northwesterly end of the ridgeline (hill) has been modified with over-steepened, near-vertical cut slopes. The site has fencing along the front and back property lines and walls along the side property lines. A mobile structure and office is in the front eastern side of the site and numerous trucks, construction equipment, construction materials and other items are parked and stored at the site. Little to no vegetation is present in the flat portions of the site, small native bushes and grasses are present on the hillside in the southern corner of the site.

### 1.3 Purpose and Scope of Services

The primary purpose of this engineering geologic study is to address the concerns expressed by the County San Bernardino Geologist that was transmitted in an email dated April 12, 2017. The primary geologic issues to be addressed in this report are:

- Determine the approximate location of the Wiggins Hill fault with respect to proposed site improvements, based on published maps, a photo lineament analysis, and reconnaissance mapping.
- Evaluate the placement of the basin within a fault zone.
- Evaluate the existing slopes' stability.
- Evaluate the potential for the proposed basin to cut into the existing toe of slope.
- Evaluated if a restricted use zone for human occupancy structures is recommended for the Wiggins Hill fault.

The scope of services included:

A. Select literature and maps were reviewed with respect to readily available geologic data.
B. Select historical aerial photographs of the project area were reviewed to identify lineaments, which may be evidence for potential faulting related to the Wiggins Hill fault.
C. A general site reconnaissance was performed to observe existing conditions, map surficial geology and measure foliation, joints and shear planes within the bedrock exposures at the south corner of the property.
D. Samples of the surface bedrock materials were collected and returned to our laboratory.
E. Laboratory tests were performed on selected bedrock samples obtained from the site. Testing included unit densities and shear characteristics. These test results aided in the classification and evaluation of the pertinent engineering properties of the existing bedrock slope within the south side of the site.
F. Engineering geologic analysis of our research, field observations and laboratory data was performed.
G. A report was prepared summarizing our geologic findings and slope stability analysis and includes:
    - A description of the field exploration performed for this commission.
    - A general description of the geologic and fault conditions, based upon information obtained from this study.
    - Orientation of geologic discontinuities with respect to the existing slope faces.
    - Kinematic analysis of slopes adjacent to the proposed infiltration basin.
    - Slope stability conclusions and recommendations for the bedrock slope.
    - Discussions relating to seismic design parameters (per 2016 CBC).
    - Evaluation for structure setbacks based upon the assumed fault hazards and risks.

<u>Certain Items Not Contained in This Report</u>: The current scope of our services does not include:

- An environmental assessment.
- A geotechnical study.
- A study for the presence or absence of wetlands, hazardous or toxic materials in the soil, surface water, groundwater, or air on, below, or adjacent to the subject property.

## Section 2
## METHODS OF EVALUATION

### 2.1 Literature and Geologic Map Research and Review

Research of the California Geological Survey (CGS) and the United States Geologic Survey (USGS) websites yielded several geologic maps and reports which covered this northern portion of San Bernardino. A list of the literature and maps reviewed for this report are presented in the References section of this report. The Dutcher & Garrett (1963) and Morton (1974) maps have plotted the Wiggins Hill fault crossing through the subject site and have a similar alignment to lineaments observed. The Bortugno & Spittler 1986 map shows an un-named fault further to the northwest which doesn't cross the subject site. Plates A-3 and A-4 are enlarged copies of the Dutcher & Garrett and Morton maps which also has the subject site plotted.

### 2.2 Lineament Analysis

Our engineering geologist visited the County of San Bernardino's aerial photograph library and reviewed the following photographs:

| Date | Photo Nos. | Lineament Observations |
|---|---|---|
| 2/7/1970 | 87/88 | No lineaments observed |
| 1/30/1969 | 45/85 | No lineaments observed |
| 11/10/1955 | 7-30/7-31 | Faint lineament NW of the site, (see Plate A-5) |
| 7/9/1938 | AXL-63-80/63-81 | Faint lineament crosses the site, (see Plate A-5) |

These observed lineaments have been plotted on a copy of the 1995 Google Earth satellite image, see Plate A-5. The approximate location of the northeastern-most lineament is also plotted on Plate A-2. This lineament alignment is about 65 feet southwest of the planned building location.

We also reviewed historical satellite photographs on Google Earth dating from 1993 to 2017. The black and white Google Earth photo from 1995 had a faint tonal change which has been plotted on Plate A-5. However, review of older photos suggest that this particular tonal change might be associated with differential vegetation growth associated with manmade disturbances. Historical aerial photographs on the HistoricAerials website dating from 1938 to 2012 were also reviewed. The lineament observed in the previously mentioned 1938 photo was also observed on the 1938 photo at the HistoricAerials website and it appears that these were the same photograph.

The alignment and location of the 1955 and 1938 observed lineaments appear to be very similar in orientation with the mapped Wiggins Hill fault southwest of the project, but trend more northerly, northwest of the site. We suspect that the northwesterly lineaments have probable anthropic origins. It should be noted that the observed lineaments cross through a nearby relatively large commercial building that was constructed sometime between 2007 and 2009.

### 2.3 Geologic Site Reconnaissance

A senior engineering geologist from Earth Systems performed a site reconnaissance of the site on September 7, 2017. The surface geology was mapped and plotted on a copy of the precise grading plan, see Plate A-2. The strike and dip of observed foliation, joints, and shears exposed within the bedrock are documented. Portions of the site, as well as, the vacant property directly adjacent to the western property line were observed with respect to potential signs of shearing or tensional stresses possibly related to local faulting. No evidence of surficial signs of shearing or tensional stresses were observed.

Bulk samples of the bedrock materials were obtained from surface exposures of the bedrock exposed in the existing southern slopes.

### 2.4 Laboratory Testing

Bedrock bulk samples were collected to be analyzed further. Test results are presented in graphic and tabular form in Appendix B of this report. Testing was performed in general accordance with American Society for Testing and Materials (ASTM) or other appropriate test procedure.

Our testing program consisted of the following:

- Bulk Density of select bedrock samples collected (ASTM D 1188): 154 pcf
- Tilt Test for typical bedrock angle of repose: 39°

**Section 3**
**DISCUSSION**

## 3.1 Geologic Setting

Regional Geology: The site lies within the northern portion of the San Bernardino Valley, a part of the Peninsular Range geomorphic province. Significant features within the Peninsular Range geomorphic province include a series of northwest to southeast trending mountain ranges separated by longitudinal valleys generally parallel to the regional fault system that include the San Jacinto and San Andreas fault zones. Other features of this area include the San Gabriel and San Bernardino Mountains, the Chino Basin, the Perris Plain, and Bunker Hill-San Timoteo Basin (see Plate 3). Much of the San Bernardino Valley lies within the Bunker Hill-San Timoteo structural basin, an alluvial filled basin situated between the San Jacinto fault zone to the southwest and the San Andreas fault to the northeast.

Local Geology: The project site is in the northern portion of the San Bernardino Valley between the San Jacinto fault and San Andreas fault zones. Deep Holocene alluvial deposits (Qya) underlie much of the site. A relatively small topographic high or hill identified as "Verdemont" on USGS Quadrangle maps is located within the southern corner of the site. This hillside is comprised of the Mesozoic Pelona Schist (Mzps), which is a foliated and fractured, muscovite-chlorite-albite-quartz schist. Schist foliation is consistent across the ridge with a northeast strike and moderate dips to the southeast. A small shear within the schist was observed with apparent offsets on the order of 2 inches to 2 feet. The orientation (N39W/45SW) of the shear is oblique to the general trend of faulting in the region.

Two mapped traces of the Wiggins Hill fault cross the southern portion of the site, generally along the northern front of Wiggins Hills (Verdemont). The northernmost trace (Dutch & Garrett, 1953) is shown north of the hill, buried by alluvium. However, the southern trace (Morton, 1974) is inferred, based on scaling off the maps and transposing onto the site plan, within the hillside, and if actually present should be exposed in the existing cut face. While a minor shear was noted in the exposed rock face near the projected trend of the fault, the strike of the shear was oblique to the mapped fault trend. Based upon field mapping, the mapped trace of the Wiggins Hill fault, per Morton, 1974, is not corroborated by field mapping. If actually present, the Dutch & Garrett (1953) mapped trace is considered more likely.

It appears a minor amount of fill has been placed within the flat portion of the site and adjacent to the toes of the near vertical slopes cut into the hillside. Earth Systems was not provided a geotechnical or grading report for this fill, so all existing fill soils are considered undocumented.

## 3.2 Groundwater

The California Department of Water Resources website indicates that groundwater in a well (342060N1173880W001) located within Cajon Wash about 1.6 miles to the northwest of the site had groundwater at approximately 114 to 336 feet below the ground surface from 2012 to 2017.

## 3.3 Geologic Hazards

Geologic hazards that may affect the region include seismic hazards (ground shaking, surface fault rupture, soil liquefaction, and other secondary earthquake-related hazards), ground subsidence, slope instability, flooding, and erosion. A discussion follows on the specific hazards to this site.

### 3.3.1 Seismic Hazards

Seismic Sources: Several active faults or seismic zones lie within 40 miles (65 kilometers) of the project site (Table 1 in Appendix A). The primary seismic hazard to the site is strong ground shaking from earthquakes along the proximal and active San Jacinto, San Andreas and Elsinore fault zones.

The Wiggins Hill fault has been mapped by Dutcher & Garrett (1963) and Morton (1974) to cross the southern portion of the site. The Wiggins Hill fault is not considered to be active by the California Geological Survey. More recent geologic maps of this area have not mapped the Wiggins Hill fault. These maps are by Bortugno & Spittler (1986), Miller (1979) and Miller, Matti & Carson (2001), Morton & Miller (2003) and Jennings (2010). Other than the linear topographic orientation of several small hills, there is no readily observable evidence of active faulting across the site or specifically across the proposed building site. The Wiggins Hill fault, is buried by Holocene alluvium, and if truly present, projects near the proposed infiltration basin.

Surface Fault Rupture: The project site does not lie within a currently delineated State of California, *Alquist-Priolo* Earthquake Fault Zone (Bryant, 2007). Well-delineated fault lines cross through this region as shown on the referenced California Geological Survey [CGS] and United States Geological Survey (USGS) maps; however, no active faults are mapped crossing or in the immediate vicinity of the site. The closest active faults are the San Jacinto located approximately 0.8 miles to the west southwest and the San Andreas fault located 1.3 miles to the northeast.

The Wiggins Hill fault, if actually present, is mapped by others in the southern portion of the property (see Plate A-2). The fault projects near the northeast corner and southern limits of the planned retention basis and is well-south of the proposed building by approximately 80 feet. Effects of surface fault rupture near the basin would include disturbance to the below-grade 3:1 slopes. Catastrophic flooding due to slope failure is unlikely. The potential for surface fault rupture in the immediate proximity of the planned building is considered low.

A minor shear within the north-facing cut slope near the south corner of the property was observed. Apparent displacement of quartzite beds ranged from about 2 inches to two feet. No gouge was present indicative of repeated movement. This small-scale fault is thought to be related to deformation of the schist and not associated with regional active faulting.

Historic Seismicity: The site is located within an active seismic area in southern California where large numbers of earthquakes are recorded each year. Many of the major historic earthquakes felt in the vicinity of San Bernardino have originated from faults located outside the San Bernardino Valley area. These include the 1812 Wrightwood, 1857 Fort Tejon, 1910 Glen Ivy Hot Springs, 1933 Long Beach, 1992 Landers/Big Bear, 1994 Northridge, and 1999 Hector Mine earthquakes.

Locally, approximately 39 significant earthquakes of magnitude 5.5 or greater have occurred within 60 miles of the site since 1800 (see Table 2 in Appendix A). Historically, between 1812 and 1999, ten magnitude 5.5 to 7.5 earthquakes occurred within 20 miles of the project site. Many of these earthquakes are thought to have originated on the local segments of the San Jacinto fault. The San Jacinto fault is considered one of the most active faults in southern California.

Seismic Risk: While accurate earthquake predictions are not possible, various agencies have conducted statistical risk analyses. In 2002 and 2008, the California Geological Survey [CGS] and the USGS completed of probabilistic seismic hazard maps. We have used these maps in our evaluation of the seismic risk at the site. The recent Working Group of California Earthquake Probabilities (WGCEP, 2008) estimated a 31% conditional probability that a magnitude 6.7 or greater earthquake may occur between 2008 and 2038 along the San Jacinto fault. For the same time interval, there is 59% conditional probability for the San Andreas fault located northeast of the site. The primary seismic risk at the site is a potential earthquake along the San Jacinto and San Andreas faults that are considered fault Type A per the CGS. Estimated Modified Mercalli Intensity Scale ground shaking levels are VIII to IX for nearfield earthquake events (See Table A-3).

### 3.3.2 Secondary Hazards

Secondary seismic hazards related to ground shaking include soil liquefaction, ground subsidence, tsunamis, and seiches. The site is far inland, so the hazard from tsunamis is non-existent.

Dam Inundation: The Devils Canyon reservoir and dam is located up gradient and northeast of the site. Per the City of San Bernardino General Plan, Figure S-2, the project site is not located within the inundation area (City of San Bernardino General Plan, 2005) assuming dam failure.

Seiches: There are no reservoirs or tanks in the immediate vicinity of the project, such that the potential for flooding due to seiching (oscillation of water within the reservoir) and associated flooding is considered low.

Slope Instability: The 2005 City of San Bernardino General Plan, Figure S-7 has identified the southern slope area within the subject site to be an area of *Low Relief* with a *low to moderate susceptibility for landslides*. Modifications of the north facing and northwest facing ridge slopes has resulted in near-vertical cut slopes. These over-steepened slopes are positioned along the southern margin of the proposed infiltration basin.

Kinematic analysis of the Pelona Schist bedrock discontinuities (foliation and jointing) was performed to evaluate the potential for adverse conditions with respect to the near vertical graded cut slopes adjacent to the proposed infiltration basin. Foliation is consistent with northeast strikes and moderate dips to the southeast, and is not considered adverse with respect to the existing over-steepened slopes adjacent to the proposed infiltration basin. Multiple joints were observed to be adverse considering the near vertical conditions of the graded cut slopes. Wedge failures and block failures are considered likely. Simplified block analysis indicates static factors of safety of just above 1.0 for current conditions for the near-vertical cut faces. Seismic analysis factors of safety are less than 1.0 for current conditions. Raveling is also currently occurring. Strong seismic shaking could easily result in small wedge or block-type failures of the

over-steepened slopes. However, as the only development proposed is the shallow infiltration basin, hazards to structures, as proposed, is nil. Clean up and removal of rubble within the basin will be necessary to maintain basin capacity.

Flooding: The FEMA flood map that covers his site is Map No. 06071C7930J, Panel 7930 of 9400. The site is in a specially designated area which states the following:

> *Attention: The levee, dike or other structure that impacts flood hazards inside this boundary has not been shown to comply with Section 65.10 of the NFIP Regulations. As Such, is FIRM panel will be revised at a later date to update the flood hazard information associated with this structure.*
> *The flood hazard data inside this boundary on the FIRM panel has been republished from the previous effective (historic) FIRM for this area, after being converted from NGVD29 to NAVD88.*

The 2005 City of San Bernardino General Plan, Figure S-1 has designated the subject site is within a 500-year flood zone.

Liquefaction: According to the 2005 City of San Bernardino General Plan, Figure S-5, the site is within a High Liquefaction Susceptibility area. A liquefaction analysis was not within the scope services of this engineering geology study. Note that bedrock areas composing Verdemont are not subject to liquefaction.

### 3.3.3 Site Acceleration and Seismic Coefficients

Site Acceleration: The potential intensity of ground motion may be estimated by the horizontal peak ground acceleration [PGA], measured in "g" forces. Ground motions are dependent primarily on the earthquake magnitude and distance to the seismogenic (rupture) zone. Accelerations are also dependent upon attenuation by rock and soil deposits, direction of rupture, and type of fault. For these reasons, ground motions may vary considerably in the same general area. This variability can be expressed statistically by a standard deviation about a mean relationship.

Important factors influencing the structural performance are the duration and frequency of strong ground motion, local subsurface conditions, soil-structure interaction, and structural details.

The following tables provides the probabilistic estimate of the PGA based upon information provided by the California Geologic Survey Probabilistic Seismic Hazards Mapping Ground Motion website (www.quake.ca.gov/gmaps/PSHA/psha_interpoloator.html)

**Estimate of PGA from CGS**
**Probabilistic Seismic Hazard Ground Motion Interpolator (2008)**

| Risk | Equivalent Return Period (years) | PGA (g) |
|---|---|---|
| 2% exceedence in 50 years | 2475 | ≈ 1.20 |
| 10% exceedence in 50 years | 475 | ≈ 0.77 |

Note: Based on Site Class D.

Actual accelerations may be more or less than estimated. Vertical accelerations are typically ⅓ to ⅔ of the horizontal accelerations, but can equal or exceed the horizontal accelerations, depending upon the local site effects and amplification.

This site is subject to strong ground shaking due to potential fault movements along regional faults including the San Andreas and San Jacinto faults. Modified Mercalli Intensities of approximately VIII to X (see Table A-3 in Appendix A) should be anticipated. Engineered design and earthquake-resistant construction increase safety and allow development of seismic areas. The *minimum* seismic design should comply with the 2016 edition of the California Building Code [CBC] and ASCE 7-10 using the seismic coefficients given in the table below. Seismic parameters are based upon computation by the *Ground Motion Parameter Calculator* provided by the United States Geological Survey [USGS] at:

http://geohazards.usgs.gov/designmaps/us/application.php (Version 3.0.1).

**2016 CBC (ASCE 7-10) Seismic Parameters**

| | |
|---|---|
| Site Location: | 33.1079°N and 117.3119°W |
| Site Class: | D |
| **Maximum Considered Earthquake [MCE] Ground Motion** | |
| Short Period Spectral Response $S_s$: | 2.379 g |
| 1 second Spectral Response, $S_1$: | 1.136 g |
| **Design Earthquake Ground Motion** | |
| Short Period Spectral Response, $S_{DS}$ | 1.586 g |
| 1 second Spectral Response, $S_{D1}$ | 1.136 g |

The intent of the CBC lateral force requirements is to provide a structural design that will resist collapse to provide reasonable life safety from a major earthquake, but may experience some structural and nonstructural damage. A fundamental tenet of seismic design is that inelastic yielding is allowed to adapt to the seismic demand on the structure. In other words, *damage is allowed*. The CBC lateral force requirements should be considered a *minimum* design. The owner and the designer may evaluate the level of risk and performance that is acceptable. Performance based criteria could be set in the design. The design engineer should exercise special care so that all components of the design are fully met with attention to providing a continuous load path. An adequate quality assurance and control program is urged during project construction to verify

that the design plans and good construction practices are followed. This is especially important for sites lying close to major seismic sources.

Seismic Hazard Zones: The site lies in a "Moderately High to Moderate" liquefaction potential zone and Potential Ground Subsidence zone designated by the City of San Bernardino General Plan. This portion of San Bernardino County has not been mapped by the California Seismic Hazard Mapping Act (Ca. PRC 2690 to 2699). The project is not located within a designated City of San Bernardino "active" fault zone.

**Section 4**
**CONCLUSIONS**

The following is a summary of our conclusions and professional opinions based on the data obtained from a review of selected technical literature and the site evaluation.

General:

- From a geologic perspective, the site is suitable for the proposed development, provided the recommendations in this report are followed in the design and construction of this project.

Geologic Constraints and Mitigation:

- The primary geologic hazard is severe ground shaking from earthquakes originating on nearby active faults. A major earthquake above magnitude 7 originating on local segments of the nearby San Jacinto fault or San Andreas fault would be the critical seismic events that may affect the site within the design life of the proposed development. Peak ground accelerations may exceed 1 g. Engineered design and earthquake-resistant construction increase safety and allow development of seismic areas.
- The Wiggins Hill fault, if present based upon lineaments and aligned ridges, is projected across the southern portion of the site through the planned infiltration basin. **Surface fault rupture is not anticipated in the immediate proximity of the planned building.** Most noted lineaments are considered anthropic and do not pose a surface fault rupture hazard to the planned building. The nearest lineament is located approximately 65 feet south of the proposed building. Effects of fault rupture (considered a negligible potential) on the 3 feet high slopes (below grade basin) should not result in catastrophic failure of the basin.
- The underlying geologic condition for seismic design at the proposed building site is Site Class D. A qualified professional should design any permanent structure constructed on the site. The *minimum* seismic design should comply with the 2016 edition of the California Building Code.
- The site is about 0.8 and 1.3 miles from Type A seismic sources as defined by the California Geological Survey. A qualified professional should design any permanent structure constructed on the site. The *minimum* seismic design should comply with the 2016 edition of the California Building Code.
- As groundwater levels are anticipated to be in excess of 50 feet deep, the potential for damaging settlement from seismic induced settlement is considered low. Geotechnical evaluation of the soil conditions under the building site is recommended.
- Previous graded over-steepened cut slopes at the south portion of the site at the northwest terminus of the Wiggins Hill (Verdemont), are subject to instability. Raveling and small block and wedge failures should be anticipated. Rubble will fall into the proposed shallow detention basin.
- The proposed below-grade infiltration basin slopes are inferred to be excavated at the existing toe of the hillside. It is anticipated that the basin slopes will be excavated into

existing fills, alluvium and possibly schist bedrock. Foliation attitudes do not appear to be adverse where the basin slope are proposed. However, undocumented fills may be loose.

- Other geologic hazards, including, fissuring, seismically induced flooding, and dam inundation are considered low.
- Groundwater utilization is occurring in the San Bernardino Valley with depressed groundwater levels from historic highs. Groundwater overdrafting has contributed to the overall subsidence on the basin. It is important to stress that increased pumping and groundwater overdraft may lead to increased subsidence related settlement. It is impossible to predict the magnitude of future subsidence given the current level of information.

**Section 5**
**RECOMMENDATIONS**

Recommendations for site development from an engineering geology perspective are as follows:

- All proposed new structures should be designed in accordance with at least minimum building code standards as described in the 2016 California Building Code. Construction should allow for all plumbing and utility services to be connected with flexible connections and provided with convenient shutoffs.

- Structures intended for human occupancy should be located northeast of the designated Fault Setback line (see Plate A-2).

- The northwest terminus of Wiggins Hill (Verdemont) has been modified with over-steepened graded slopes that are, in our professional opinion, subject to slope instability by raveling and wedge failures. If left as is, rubble will need to be cleaned out of the infiltration basin. If slope instability is unacceptable, then the over-steepened slopes need to be regraded at 2:1 (horizontal to vertical) finished slopes.

- While not considered likely, in the event that surface fault rupture should occur along the assumed projections of the Wiggins Hill fault, disturbed slopes within the infiltration basin should be regraded and repaired in a prompt manner.

- The site should be designed and/or maintained to accommodate seasonal sheet flooding.

- The on-site soils are susceptible to erosion. Measures to minimize erosion should be incorporated into the overall project design.

- Project specific geotechnical recommendations (by others) for future site grading, remedial grading, foundation design, differential settlement, and other geotechnical considerations should be incorporated into site development and construction.

## Section 6
## LIMITATIONS AND ADDITIONAL SERVICES

### 6.1 Uniformity of Conditions and Limitations

Our evaluation of surface conditions at the site have considered soil, rock, and groundwater conditions present at the time of our study. The influence(s) of post-construction changes to these conditions such as introduction or removal of water into or from the subsurface will likely influence future performance of the proposed project. The magnitude of the introduction or removal, and the effect on the surface and subsurface soils/rock is currently unknown. It should be recognized that definition and evaluation of subsurface conditions are difficult. Judgments leading to conclusions and recommendations are generally made with incomplete knowledge of the subsurface conditions due to the limitation of data from field studies. The availability and broadening of knowledge and professional standards applicable to engineering services are continually evolving. As such, our services are intended to provide the Client with a source of professional advice, opinions and recommendations based on the information available as applicable to the project location and scope. Recommendations contained in this report are based on our field observations and subsurface explorations, select published documents (referenced), and our present knowledge of the proposed construction. If the scope of the proposed construction changes from that described in this report, the conclusions and recommendations contained in this report are not considered valid unless the changes are reviewed, and the conclusions of this report are modified or approved in writing by Earth Systems.

Recommendations contained in this report are based on our field observations and our present knowledge of the proposed construction. The scope of our services did not include observation of areas not accessible to a walking visual assessment nor any environmental site assessment for the presence or absence of hazardous/toxic materials. It is possible that soil conditions could vary between or beyond the points observed.

If during construction, soil/rock conditions are encountered which differ from those described herein, we should be notified immediately in order that a review may be made and any supplemental recommendations provided. In such an event, the contractor should promptly notify the owner so that Earth Systems can be contacted to confirm those conditions. We recommend the contractor describe the nature and extent of the differing conditions in writing and that the construction contract include provisions for dealing with differing conditions. Contingency funds should be reserved for potential problems during earthwork and foundation construction.

If the scope of the proposed construction changes from that described in this report, the conclusions and recommendations contained in this report are not considered valid unless the changes are reviewed, and the conclusions of this report are modified or approved in writing by Earth Systems.

This report is issued with the understanding that the owner or the owner's representative has the responsibility to bring the information and recommendations contained herein to the attention of the architect and engineers for the project so that they are reviewed for applicability and conformance to the current design and incorporated into the plans for the project. The

owner or the owner's representative also has the responsibility to take the necessary steps to see that the general contractor and all subcontractors follow such recommendations. It is further understood that the owner or the owner's representative is responsible for submittal of this report to the appropriate governing agencies.

Earth Systems has striven to provide our services in accordance with generally accepted engineering geology practices in this locality at this time. No warranty or guarantee, express or implied, is made. This report was prepared for the exclusive use of the Client and the Client's authorized agents. We make no representation as to the accuracy of the dimensions, measurements, calculations, or any portion of the design not under our responsible charge.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than one (1) year from the date of the report. Land use, site conditions (both on site and off site) or other factors may change over time, and additional work may be required with the passage of time.

Any party other than the client who wishes to use this report shall notify Earth Systems of such intended use. Based on the intended use of the report, Earth Systems may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release Earth Systems from any liability resulting from the use of this report by any unauthorized party.

-o0o-

Appendices as cited are attached and complete this report.

## REFERENCES

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Aerial Photographs Reviewed from County of San Bernardino

| **Date** | **Photo Nos.** |
|---|---|
| 2/7/1970 | 87/88 |
| 1/30/1969 | 45/85 |
| 11/10/1955 | 7-30/7-31 |
| 7/9/1938 | AXL-63-80/63-81 |

**APPENDIX A**

Plate A-1 – Site Location Map
Plate A-2 – Site Plan and Geology Map
Plate A-3 – Wiggins Hill Fault (Dutcher & Garrett, 1963)
Plate A-4 – Wiggins Hill Fault (Morton, 1974)
Plate A-5 – Observed Lineaments
Plate A-6 – Cross Section A-A'
Plate A-7 – Cross Section B-B
Plate A-8 – Kinematic Cut Slope Analysis
Table 1 – Fault Parameters
Table 2 - Historic Earthquakes
Table 3 – Modified Mercalli Intensity Scale


Base Map: Google Earth satellite image with USGS historical topographic map overlay.

**LEGEND**

Approximate Site Boundary

Approximate Scale: 1" = 185’

0 185’ 370’

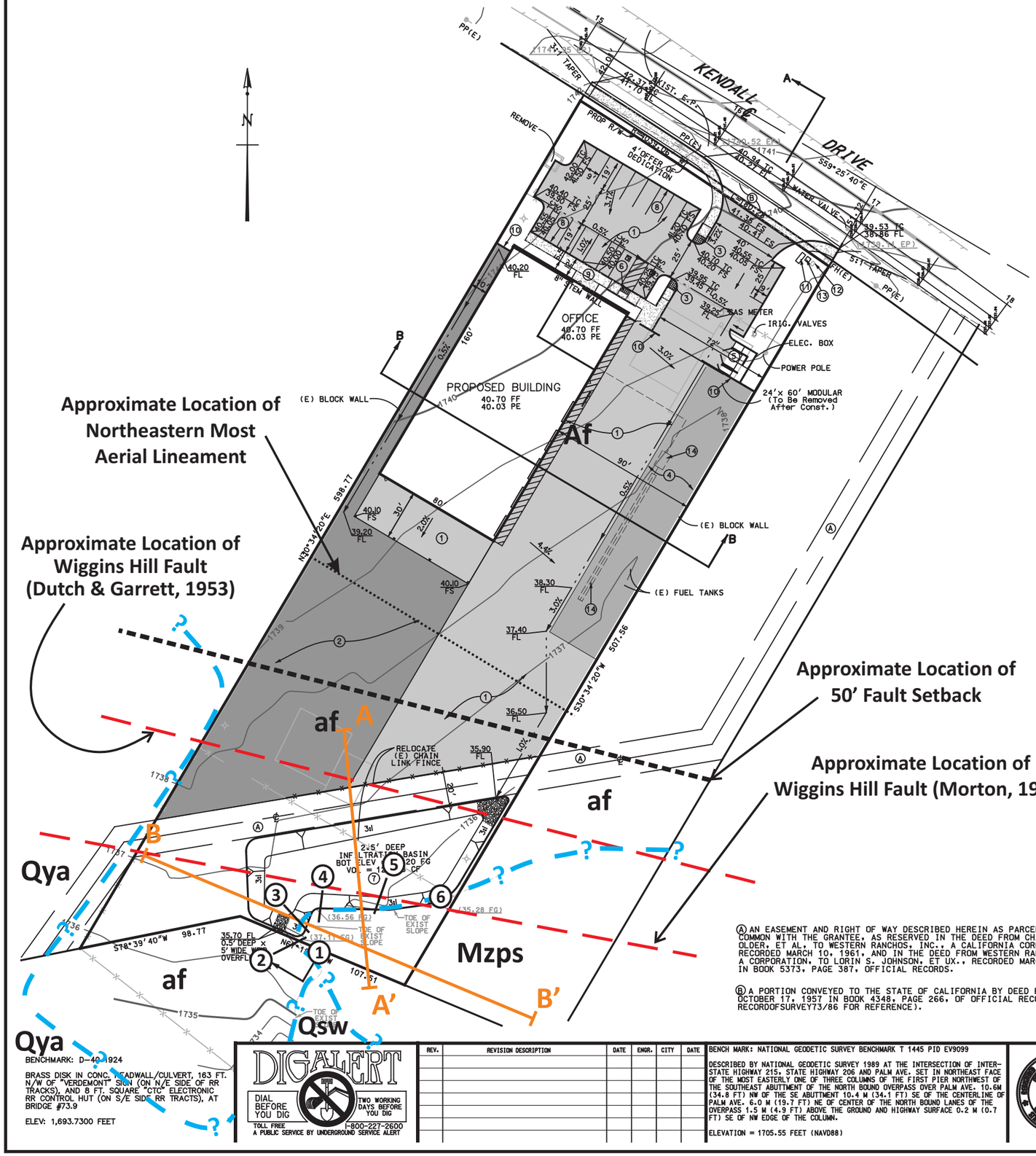
N

**Plate A-1**
**Site Location Map**

Proposed Infiltration Basin and New Structure
20075 Kendall Drive
North San Bernardino, San Bernardino County, California

**Earth Systems Southwest**

9/29/2017 | File No.: 12491-01




## LEGEND

Approximate Geologic Contact
? Where Uncertain

B — B' Approximate Location of Geologic Cross Section

Approximate Location of 50' Fault Setback

1. Foliation 105°/51°; Joint 304°/58°
2. Foliation 142°/58°; Joint 328°/54°
3. Foliation 129°/41°, 118°/43°; Joint 323°/49°
4. Foliation 132°/46°; Joint 280°/55°; Shear 302°/8°
5. Foliation 126°/34°; Joint 339°/72°, 187°/87°
6. Foliation 125°/30°; Shear 231°/45° (2" offset)

**af** Undocumented Fill

**Qsw** Slopewash

**Qya** Young Alluvial Fan Deposits

**Mzps** Pelona Schist

Ⓐ AN EASEMENT AND RIGHT OF WAY DESCRIBED HEREIN AS PARCEL 2, IN COMMON WITH THE GRANTEE, AS RESERVED IN THE DEED FROM CHARLES S. OLDER, ET AL, TO WESTERN RANCHOS, INC., A CALIFORNIA CORPORATION, RECORDED MARCH 10, 1961, AND IN THE DEED FROM WESTERN RANCHOS, INC., A CORPORATION, TO LORIN S. JOHNSON, ET UX., RECORDED MARCH 10, 1961 IN BOOK 5373, PAGE 387, OFFICIAL RECORDS.

Ⓑ A PORTION CONVEYED TO THE STATE OF CALIFORNIA BY DEED RECORDED OCTOBER 17, 1957 IN BOOK 4348, PAGE 266, OF OFFICIAL RECORDS.(SEE RECORDOFSURVEY73/86 FOR REFERENCE).

BENCHMARK: D-40-1924

BRASS DISK IN CONC. HEADWALL/CULVERT, 163 FT. N/W OF "VERDEMONT" SIGN (ON N/E SIDE OF RR TRACKS), AND 8 FT. SQUARE "CTC" ELECTRONIC RR CONTROL HUT (ON S/E SIDE RR TRACTS), AT BRIDGE #73.9

ELEV: 1,693.7300 FEET

DIGALERT — DIAL BEFORE YOU DIG — TWO WORKING DAYS BEFORE YOU DIG — TOLL FREE 1-800-227-2600 — A PUBLIC SERVICE BY UNDERGROUND SERVICE ALERT

| REV. | REVISION DESCRIPTION | DATE | ENGR. | CITY | DATE |
|---|---|---|---|---|---|

BENCH MARK: NATIONAL GEODETIC SURVEY BENCHMARK T 1445 PID EV9099

DESCRIBED BY NATIONAL GEODETIC SURVEY 1989 AT THE INTERSECTION OF INTER-STATE HIGHWAY 215, STATE HIGHWAY 206 AND PALM AVE. SET IN NORTHEAST FACE OF THE MOST EASTERLY ONE OF THREE COLUMNS OF THE FIRST PIER NORTHWEST OF THE SOUTHEAST ABUTTMENT OF THE NORTH BOUND OVERPASS OVER PALM AVE. 10.6M (34.8 FT) NW OF THE SE ABUTTMENT 10.4 M (34.1 FT) SE OF THE CENTERLINE OF PALM AVE. 6.0 M (19.7 FT) NE OF CENTER OF THE NORTH BOUND LANES OF THE OVERPASS 1.5 M (4.9 FT) ABOVE THE GROUND AND HIGHWAY SURFACE 0.2 M (0.7 FT) SE OF NW EDGE OF THE COLUMN.

ELEVATION = 1705.55 FEET (NAVD88)

Goodman & ASSOCIATES
2079 SKY VIEW DRIVE
COLTON, CA 92324
(909) 824-2775

DOUGLAS L. GOODMAN
RCE 28500, 3-31-2018
6-6-2017

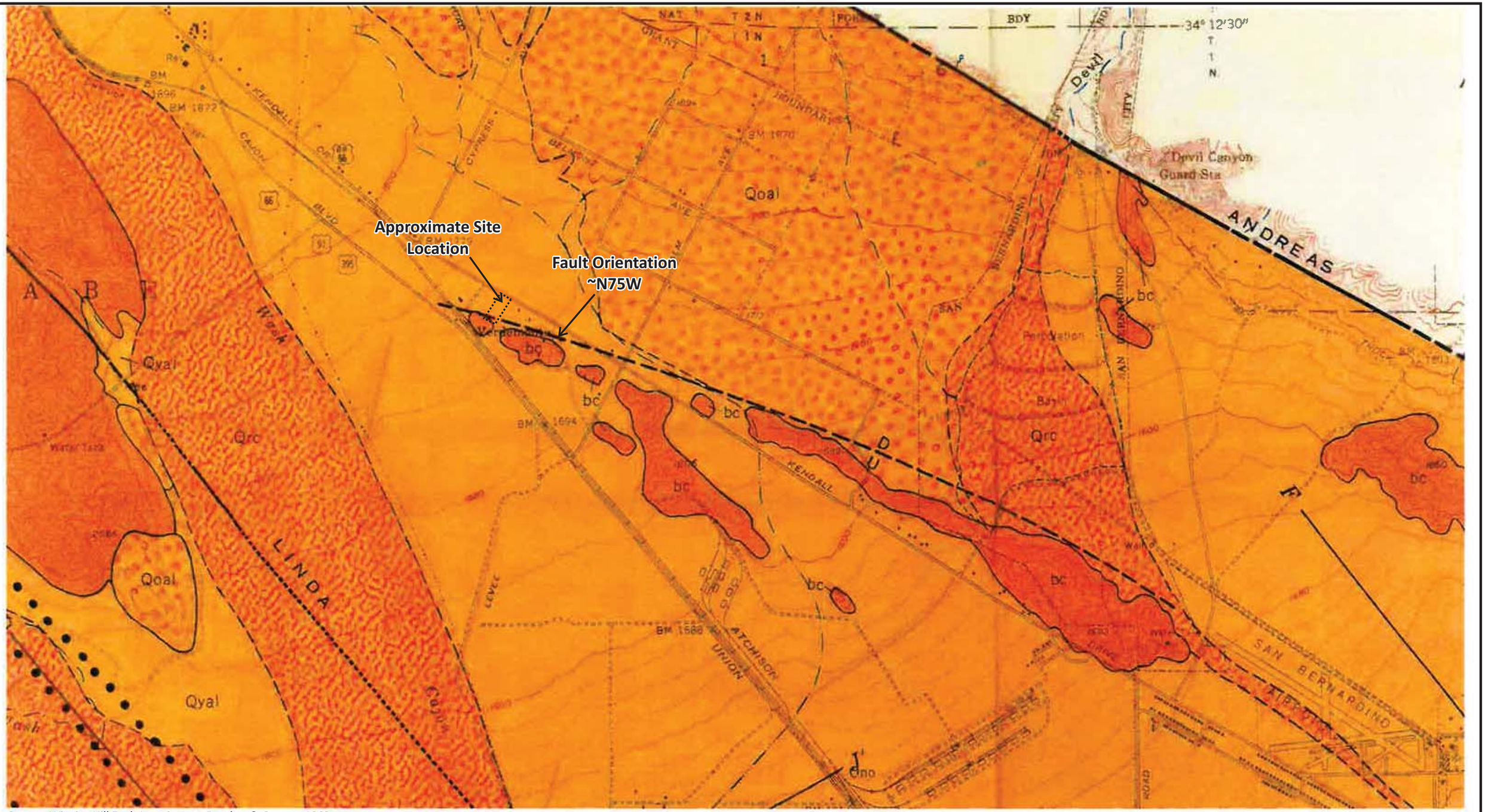
Source: Goodman & Associates Bridgewater Equipment Precise Grading Plan, drawing 2/4 dated June 2017.

**Plate A-2**
**Site Plan and Geology Map**

Proposed Infiltration Basin and New Structure
20075 Kendall Drive
North San Bernardino, San Bernardino County, California

Earth Systems Southwest

9/29/2017 | File No.: 12491-01




Source: Wiggins Hill Fault Location per Dutcher & Garrett, 1963

## LEGEND

Approximate Site Location

Approximate Scale: 1" = 1,600'

0 1,600' 3,200'

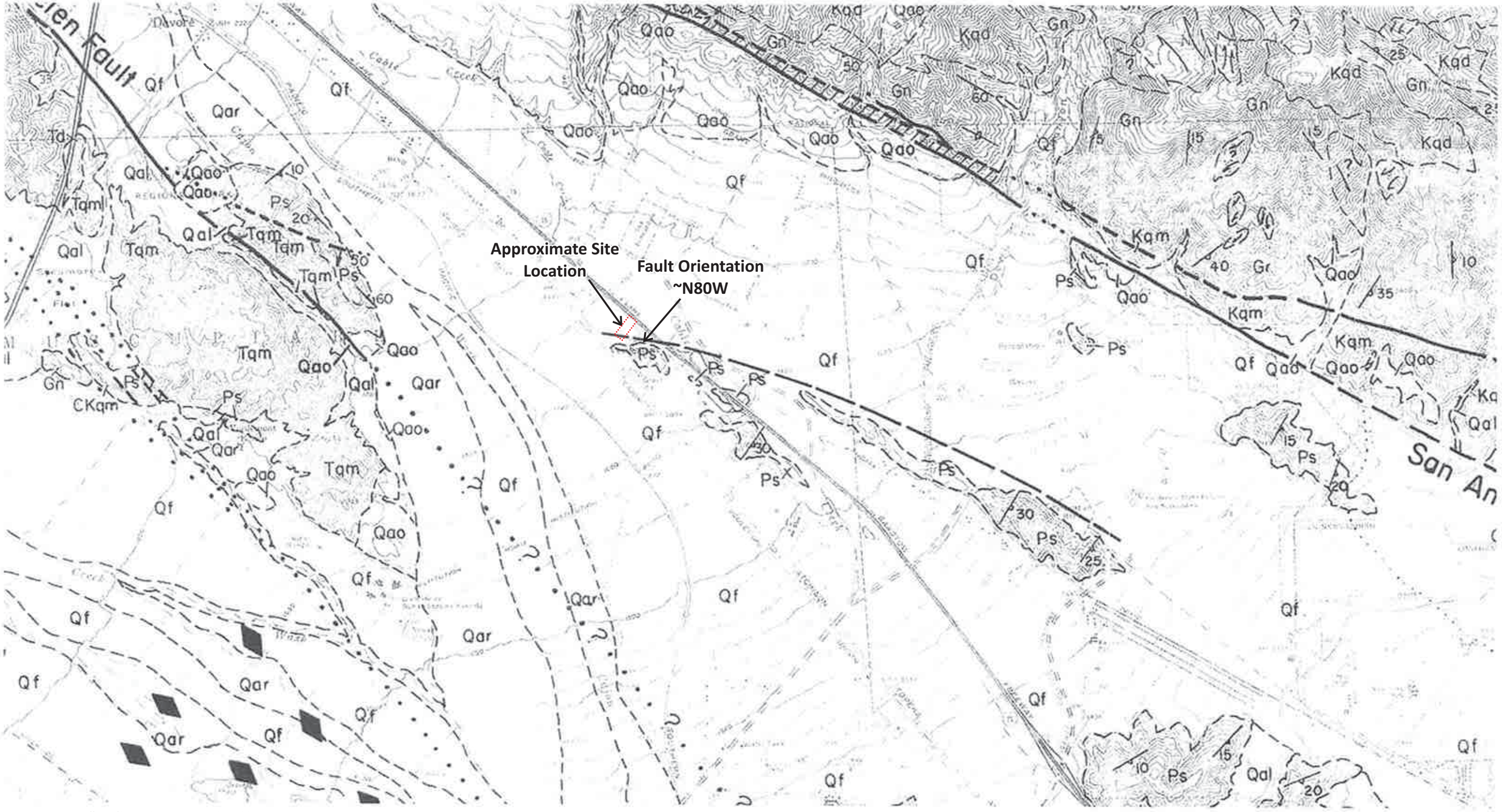
N

**Plate A-3**
**Wiggins Hill Fault Location per Dutcher & Garrett, 1963**

Proposed Infiltration Basin and New Structure
20075 Kendall Drive
North San Bernardino, San Bernardino County, California

**Earth Systems Southwest**

9/29/2017 | File No.: 12491-01




Source: Wiggins Hill Fault Location per Morton, 1974

## LEGEND

- Approximate Site Location
- **Qf** Younger Alluvial Fan Deposits
- **Ps** Pelona Schist

0 2,100’ 4,200’

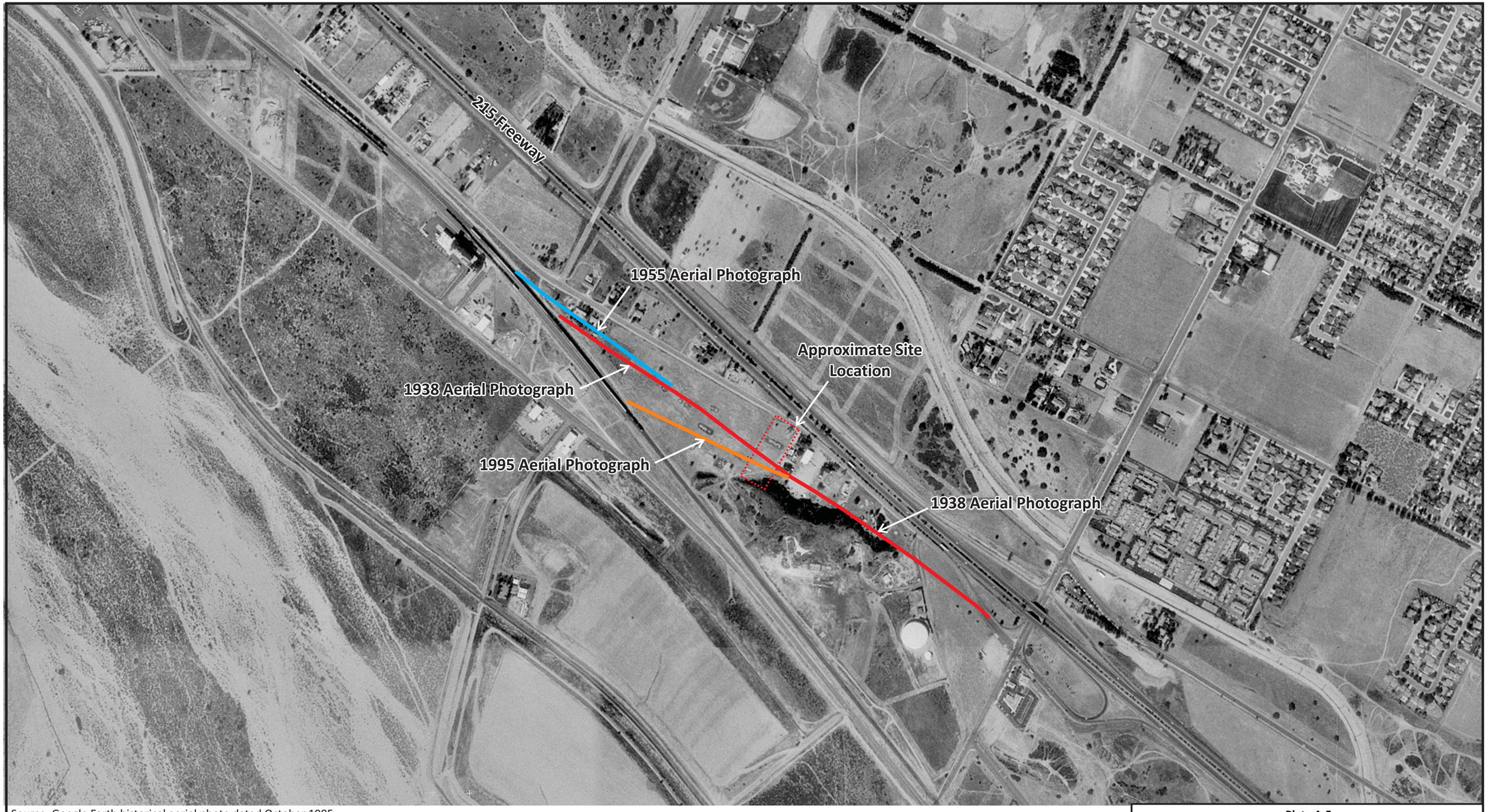
N

**Plate A-4**
**Wiggins Hill Fault Location per Morton, 1974**

Proposed Infiltration Basin and New Structure
20075 Kendall Drive
North San Bernardino, San Bernardino County, California

**Earth Systems Southwest**

9/29/2017 | File No.: 12491-01




Source: Google Earth historical aerial photo dated October 1995.

## LEGEND

Approximate Site Location

1955 Aerial Photograph

1938 Aerial Photograph

1995 Aerial Photograph

Approximate Scale: 1" = 650’

0 650’ 1,300’

Note: See references for all aerial photographs reviewed.

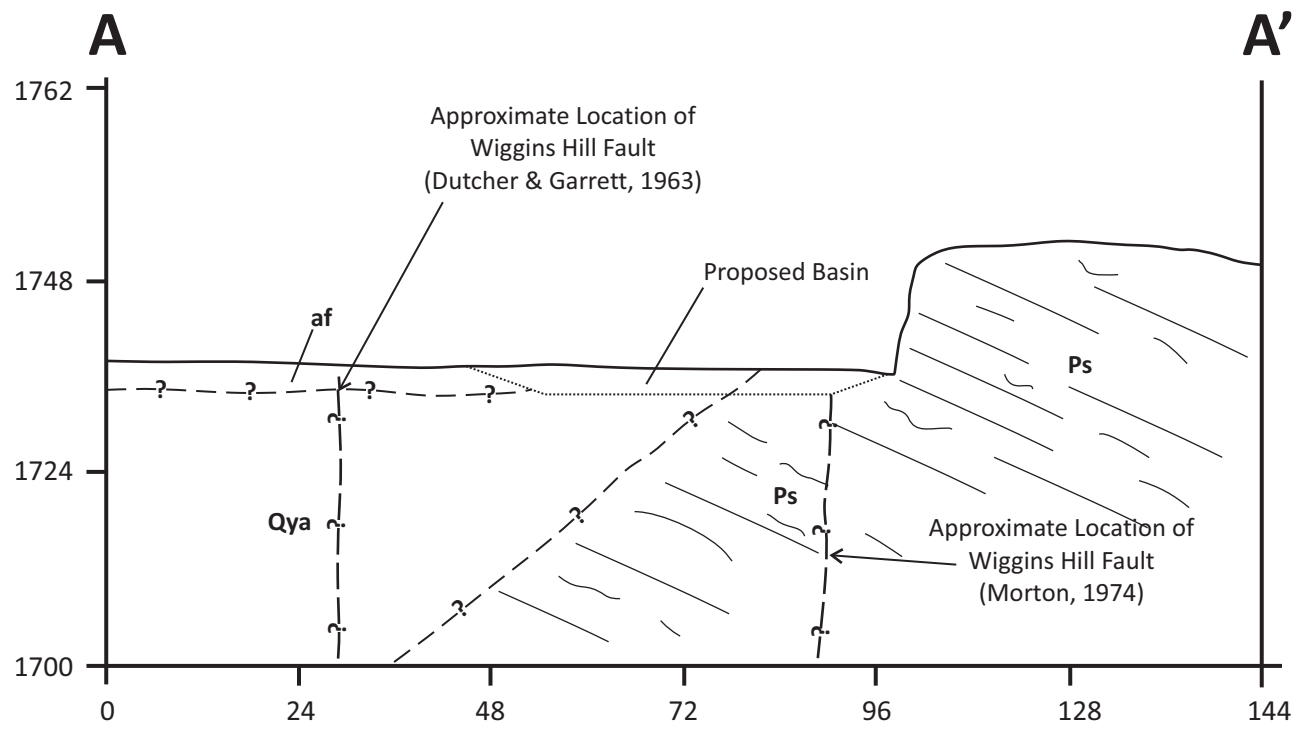
N

**Plate A-5**
**Observed Lineaments on Reviewed Historical Aerial Photographs**

Proposed Infiltration Basin and New Structure
20075 Kendall Drive
North San Bernardino, San Bernardino County, California

**Earth Systems Southwest**

9/29/2017 | File No.: 12491-01




**af** Undocumented Fill
**Qya** Younger Alluvial Fan Deposits
**Ps** Pelona Schist

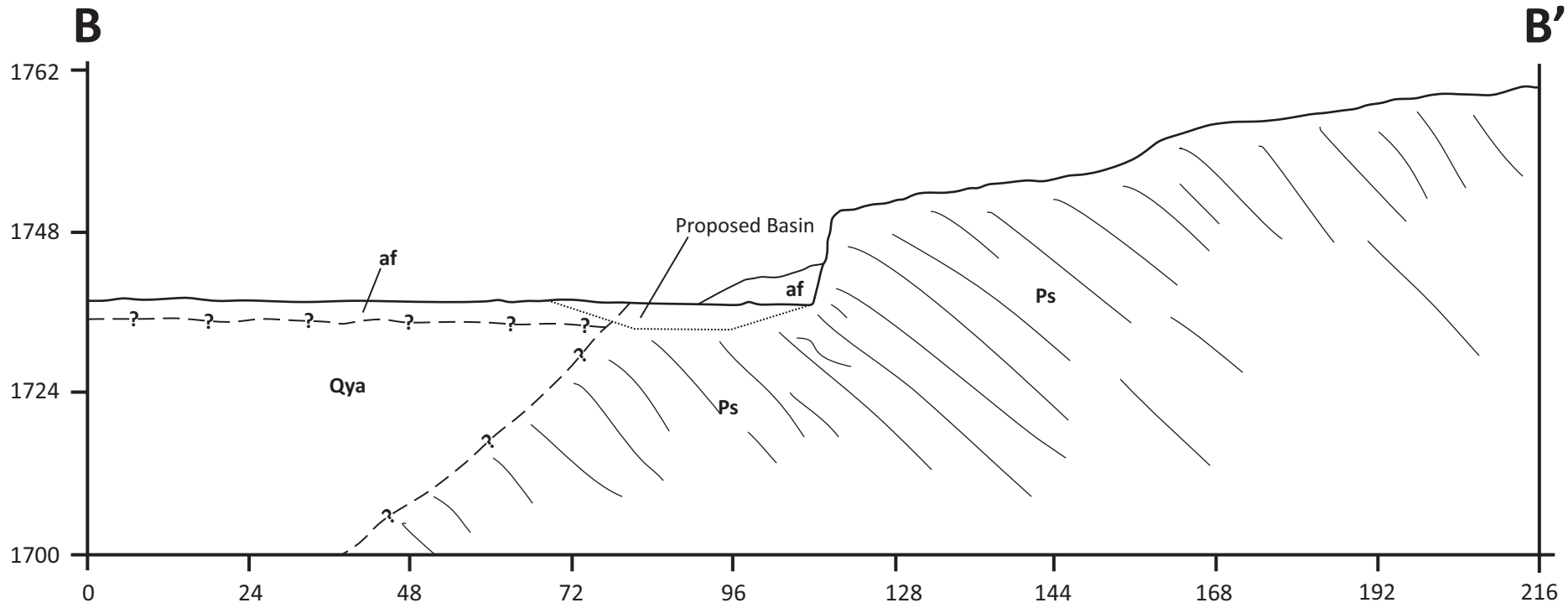
0 24' 48'

**Plate A-6**
**Cross Section A-A'**

Proposed Infiltration Basin and New Structure
20075 Kendall Drive
North San Bernardino, San Bernardino County, California

**Earth Systems Southwest**

9/29/2017 | File No.: 12491-01




**af** Undocumented Fill
**Qya** Younger Alluvial Fan Deposits
**Ps** Pelona Schist

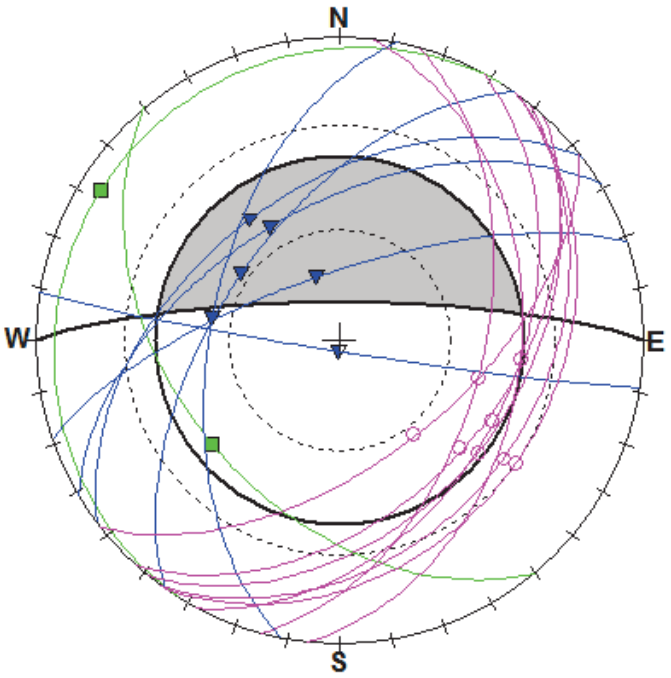
0 24' 48'

**Plate A-7**
**Cross Section B-B'**

Proposed Infiltration Basin and New Structure
20075 Kendall Drive
North San Bernardino, San Bernardino County, California

**Earth Systems Southwest**

9/29/2017 | File No.: 12491-01

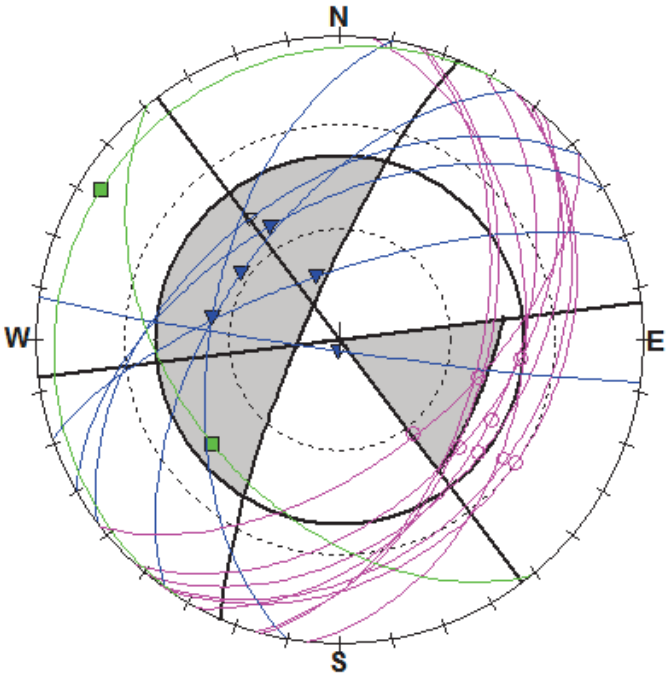



North Facing Cut Slope

Assumed phi: 39 Degrees

Pelona Schist

Adverse Joint Planes
Foliation Not Adverse




Northwest Facing Cut Slope

Assumed phi: 39 Degrees

Pelona Schist

Adverse Joint Planes
No Topple Hazard
Foliation Not Adverse

**Plate A-8**
**Kinematic Cut Slope Analysis**

Proposed Infiltration Basin and New Structure
20075 Kendall Drive
North San Bernardino, San Bernardino County, California

**Earth Systems**
**Southwest**

9/29/2017 | File No.: 12491-01

**Table A-1**
**Fault Parameters**

| Fault Section Name | Distance (miles) | Distance (km) | Avg Dip Angle (deg.) | Avg Dip Direction (deg.) | Avg Rake (deg.) | Trace Length (km) | Fault Type | **Mean Mag** | Mean Return Interval (years) | Slip Rate (mm/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| San Jacinto (San Bernardino) | 0.9 | 1.4 | 90 | 225 | 180 | 45 | A | **7.4** | 205 | 6 |
| San Andreas (San Bernardino N) | 1.3 | 2.1 | 90 | 212 | 180 | 35 | A | **7.5** | 103 | 22 |
| Fontana (Seismicity) | 4.2 | 6.7 | 80 | 313 | na | 24 | B' | **6.7** | | |
| Cucamonga | 4.3 | 6.9 | 45 | 347 | 90 | 28 | B | **6.6** | | 5 |
| San Andreas, (North Branch, Mill Creek) | 5.8 | 9.3 | 76 | 204 | 180 | 106 | A | **7.5** | 110 | 17 |
| Cleghorn | 6.4 | 10.3 | 90 | 187 | 0 | 25 | B | **6.7** | | 3 |
| San Andreas (San Bernardino S) | 8.9 | 14.3 | 90 | 210 | 180 | 43 | A | **7.6** | 150 | 16 |
| North Frontal (West) | 10.2 | 16.3 | 49 | 171 | 90 | 50 | B | **7.2** | | 1 |
| San Andreas (Mojave S) | 13.3 | 21.4 | 90 | 206 | 180 | 98 | A | **7.7** | 102 | 29 |
| San Jacinto (San Jacinto Valley) rev | 14.4 | 23.1 | 90 | 223 | 180 | 18 | A | **7.4** | 199 | 18 |
| San Gabriel (Extension) | 15.7 | 25.3 | 61 | 6 | 180 | 62 | B' | **7.2** | | |
| San Jose | 19.2 | 30.9 | 74 | 334 | 30 | 20 | B | **6.6** | | 0.5 |
| Sierra Madre | 21.8 | 35.1 | 53 | 19 | 90 | 57 | B | **7.2** | | 2 |
| San Gorgonio Pass | 22.5 | 36.2 | 60 | 11 | na | 29 | B' | **6.9** | | |
| Chino, alt 2 | 24.6 | 39.6 | 65 | 234 | 150 | 29 | B | **6.7** | | 1 |
| Chino, alt 1 | 24.6 | 39.6 | 50 | 236 | 150 | 24 | B | **6.6** | | 1 |
| San Jacinto (San Jacinto Valley, stepover) | 25.6 | 41.2 | 90 | 224 | 180 | 24 | A | **7.4** | 199 | 9 |
| San Jacinto (Stepovers Combined) | 25.6 | 41.2 | 90 | 229 | 180 | 25 | B' | **6.7** | | |
| San Jacinto (Anza, stepover) | 25.7 | 41.4 | 90 | 224 | 180 | 25 | A | **7.6** | 151 | 9 |
| Yorba Linda | 27.1 | 43.6 | 90 | 153 | na | 18 | B' | **6.5** | | |
| Clamshell-Sawpit | 27.5 | 44.2 | 50 | 334 | 90 | 16 | B | **6.6** | | 0.5 |
| Whittier, alt 1 | 28.2 | 45.5 | 70 | 24 | 150 | 46 | A | **7.1** | 530 | 2.5 |
| Whittier, alt 2 | 28.2 | 45.5 | 75 | 24 | 150 | 46 | A | **7.1** | 530 | 2.5 |
| Elsinore (Glen Ivy) rev | 28.3 | 45.5 | 90 | 218 | 180 | 26 | A | **7.0** | 222 | 5 |
| Mission Creek | 29.2 | 47.0 | 65 | 5 | 180 | 31 | B' | **6.9** | | |
| Helendale-So Lockhart | 29.4 | 47.4 | 90 | 51 | 180 | 114 | B | **7.4** | | 0.6 |
| Peralta Hills | 32.6 | 52.5 | 50 | 3 | na | 14 | B' | **6.5** | | |
| Richfield | 33.3 | 53.6 | 28 | 353 | na | 6 | B' | **6.2** | | |
| North Frontal (East) | 33.9 | 54.5 | 41 | 187 | 90 | 27 | B | **6.9** | | 0.5 |
| Puente Hills | 34.0 | 54.8 | 25 | 20 | 90 | 44 | B | **7.1** | | 0.7 |
| Puente Hills (Coyote Hills) | 35.2 | 56.6 | 26 | 358 | 90 | 17 | B | **6.8** | | 0.7 |
| Elsinore (Glen Ivy stepover) | 35.2 | 56.6 | 90 | 216 | 180 | 11 | A | **7.1** | 322 | 2.5 |
| Elsinore (Stepovers Combined) | 35.2 | 56.6 | 90 | 224 | 180 | 12 | B' | **6.3** | | |
| Raymond | 35.6 | 57.3 | 79 | 348 | 60 | 22 | B | **6.7** | | 1.5 |
| Elsinore (Temecula stepover) | 36.4 | 58.6 | 90 | 212 | 180 | 12 | A | **7.6** | 725 | 2.5 |
| San Andreas (San Gorgonio Pass-Garnet HIll) | 36.4 | 58.6 | 58 | 20 | 180 | 56 | A | **7.6** | 219 | 10 |
| Pinto Mtn | 38.2 | 61.6 | 90 | 175 | 0 | 74 | B | **7.2** | | 2.5 |
| Elsinore (Temecula) rev | 40.6 | 65.3 | 90 | 230 | 180 | 40 | A | **7.4** | 431 | 5 |
| Elysian Park (Lower, CFM) | 40.8 | 65.6 | 22 | 33 | na | 41 | B' | **6.8** | | |
| San Jacinto (Anza) rev | 40.9 | 65.9 | 90 | 216 | 180 | 46 | A | **7.6** | 151 | 18 |

Reference: USGS OFR 2007-1437 (CGS SP 203) Based on Site Coordinates of 34.194621 Latitude, -117.36793 Longitude

Mean Magnitude for Type A Faults based on 0.1 weight for unsegmented section, 0.9 weight for segmented model (weighted by probability of each scenario with section listed as given on Table 3 of Appendix G in OFR 2007-1437). Mean magntude is average of Ellworths-B and Hanks & Bakun moment area relationship.