APPENDIX G

Geological Report

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GEOLOGICAL AND GEOTECHNICAL INPUT FOR ENVIRONMENTAL IMPACT REPORT, PROPOSED ETIWANDA HEIGHTS NEIGHBORHOOD AND CONSERVATION PLAN, RANCHO CUCAMONGA SPHERE OF INFLUENCE, SAN BERNARDINO COUNTY, CALIFORNIA

Prepared for:

MERIDIAN CONSULTANTS
706 South Hill Street, 11th Floor
Los Angeles, California 90014

Project No. 12281.001

March 25, 2019

DRAFT

March 25, 2019

Project No. 12281.001

To: Meridian Consultants
706 South Hill Street, 11th Floor
Los Angeles, California 90014

Attention: Mr. Tony Locacciato, AICP

Subject: Geological and Geotechnical Input for Environmental Impact Report, Proposed Etiwanda Heights Neighborhood and Conservation Plan, City of Rancho Cucamonga Sphere of Influence, San Bernardino County, California

In accordance with your request and authorization, Leighton and Associates, Inc. (Leighton) has conducted a geotechnical review of the proposed Etiwanda Heights Neighborhood and Conservation Plan (EHNCP, or "Plan"). Portions of EHNCP are located within unincorporated San Bernardino County, but within the City's sphere of influence adjacent to the northern area of the City. Other portions are within the city. The EHNCP is located generally north of Highway 210, east of Haven Avenue, west of Cherry Avenue and south of the San Gabriel Mountains (Figure 1).

The purpose of this study has been to provide geology and soils engineering input during preparation of the California Environmental Quality Act (CEQA) documents for the Plan. In performing the review, we have referred to California CEQA Checklists for preparation of Environmental Documents.

- Onsite earth units and their engineering characteristics
- Faulting and seismicity
- Secondary seismic hazards
- Slope stability
- Geologic structure
- Groundwater conditions and

- Erosion

This report summarizes our findings and conclusions, and presents possible mitigation measures for the potentially adverse geologic and geotechnical engineering constraints identified for the Plan. Our review has incorporated the findings encountered during our review of published geologic information, in-house data and previous field investigation reports for portions of the site done by us and others.

The most significant potential geologic and geotechnical engineering hazards affecting the Plan area are compressible soils, the potential for surface fault rupture and the effects of strong seismic shaking. These and other issues are discussed in the accompanying report.

We appreciate the opportunity to provide our services for this important Plan. If you have any questions, please contact this office at your convenience.

Respectfully submitted,

LEIGHTON AND ASSOCIATES, INC.

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1.0 INTRODUCTION

1.1 Purpose and Scope of Work

The purpose of this study has been to provide a preliminary assessment of the potential geologic, geotechnical engineering, and seismic impacts that may adversely affect the proposed Etiwanda Heights Neighborhood and Conservation Plan (EHNCP) as shown on Figure 1 (Site Location Map). The information provided herein is intended for use in environmental analysis during preparation of CEQA documents for the Plan. As part of our study, we have considered information you provided as well as the “Revised and Reissued Notice of Preparation Draft Environmental Impact Report” prepared by the City pf Rancho Cucamonga. Within this study, we identified several geologic and geotechnical conditions that may impact proposed uses within the EHNCP.

1.2 Methodology

This geologic and geotechnical study was conducted as follows:

- Available published reports and geologic maps were reviewed and the data analyzed with respect to the Plan. The literature search included review and analysis of aerial photographs from flights between 1955 and 1986 obtained from our in-house library. The references and aerial photographs reviewed are listed in Appendix A. We also reviewed aerial photographs available at *historicaerials.com* which included flights between 1938 and 2012.

- Review of geologic and geotechnical reports previously prepared for portions of the Plan and adjacent sites (Richard Mills, 1981, and Leighton, 1984, 1990a & b).

- Visits to the site to observe the site conditions and general distribution of earth units.

- Preparation of this report addressing the geologic, geotechnical engineering and seismic aspects of the site. This report is based on our experience in the general site vicinity, and the data obtained from the above-mentioned sources. The various geologic and geotechnical aspects of the site were evaluated, and where appropriate, potential mitigation measures were provided.

1.3 Site Location and Description

The EHNCP area (referred to herein as the Plan or site) is located along the northeastern edge of the city of Rancho Cucamonga at the base of the San Gabriel Mountains. The Plan is located west of Interstate 15 (I-15), north of Interstate 210 (I-210), south of the San Gabriel Mountains, and north of existing residential neighborhoods in the City of Rancho Cucamonga. The western edge and the southeast corner of the Plan are currently located within the City of Rancho Cucamonga, and the remainder consists of unincorporated area in the County of San Bernardino within the City's Sphere of Influence. The EHNCP area includes a total of 4,393 acres; the City identifies the northern 3,565 acres of the EHNCP area as the Rural/Conservation Area (RCA) and the lower 828 acres as the Neighborhood Area (NA); acreages have been rounded to the nearest acre herein. The approximate Plan boundaries, including the boundaries of the RCA and NA, are presented on the *Site Location Map,* Figure 1, along with the other figures of this report.

The majority of the Plan area is currently vacant. Occasional dirt access roads and trails cross the site. The RCA includes the majority of the existing North Etiwanda Preserve, with an existing rural residential development and the Limei Fang-Ling Yen Mountain Temple in the east and debris basins for Day and Deer Creeks in the west, along with the Day Creek Levee and the northern portions of the Deer/Day Separation Levee and Deer and Day Creek and Channels. The NA contains, Deer/Day Separation Levee, Day and Deer Creek Flood Control Channels, and a closed sand and gravel quarry.

Plant growth currently consists of an assortment of native grasses and brush, with heavy vegetation in the foothill canyon areas.

1.4 Proposed Plan

As previously noted, the Plan includes a total of 4,393 acres, including 3,565 acres in the northern portion of the EHNCP designated as the RCA. The lower 828 acres are designated as the NA. The EHNCP would allow a maximum of 100 single family homes on private property in the RCA, with limited site/home design specific grading.

Extensive new neighborhoods would be constructed in the NA, which would include significant grading, construction of streets, utilities, and other infrastructure. For the NA, development would include single-family neighborhoods, a K-8 school, neighborhood shops and restaurants, and a network of parks and open space areas linked by pedestrian/equestrian trails.

2.0 GEOTECHNICAL CONDITIONS

2.1 Regional Geologic Setting

This is a geologically complex area where the relatively northwest-moving Peninsular Range Province meets the relatively southeast-moving Transverse Ranges Province. The EHNCP is at the southern edge of the Transverse Ranges geomorphic province, which is characterized by east-west trending mountain ranges including the San Bernardino Mountains and the San Gabriel Mountains. Uplift of these mountains has occurred as a result of compressional forces caused by movements on the San Andreas Fault zone (U.S.G.S. 1987). These compressional forces have also resulted in the east-west trending thrust faults which are found at the base of the southern front of much of the Transverse ranges. The Cucamonga Fault, within the RCA, and the Sierra Madre Fault, to the west, are both examples of such thrust faults. Thrust faults are characterized by shallow dipping fault planes which result from compressional forces “thrusting” one land mass over another.

The San Gabriel Mountains immediately to the north of the RCA are composed of metamorphic “basement” rock, both Precambrian granulitic gneiss and Cretaceous Tonalite. The EHNCP area is underlain by granulitic gneiss in the northern portion of the RCA and by quaternary aged alluvial fan deposits in the southern portion of the RCA and within the NA (Morton, and Miller, 2006), see Figure 2.

The active San Jacinto Fault trends northwest to southeast located about 2.3 miles to the northeast of the EHNCP, within the Lytle Creek canyon. The San Andreas Fault is nearly parallel in this area, and is located about 5.2 miles to the northeast of the EHNCP. These two faults merge within the mountains to the north of the EHNCP. The San Andreas, San Jacinto, and Cucamonga faults have experienced significant activity in the recent geologic past.

2.2 Earth Units

Based upon our review of pertinent geotechnical literature and the previous subsurface studies of the Plan area and surroundings, the earth units in the Plan area consists of surficial deposits, including artificial fill, alluvial fan deposits, and landslide deposits, overlaying granulitic gneiss bedrock. The surficial units generally are composed of well graded silty sands and gravels with cobbles and boulders. Granulitic gneiss bedrock is exposed in outcrops across the northern portion of the RCA portion of the EHNCP.

Artificial Fill

The artificial fill observed within both the RCA and NA was generally seen as localized accumulations associated with unimproved dirt roads and locally infilled canyons and drainages at road crossings. The fill material in both areas is generally composed of sandy silt, and silty fine to coarse grained sand with cobbles and boulders. The inactive quarry within the NA is anticipated to contain significant quantities of artificial fill associated with past quarry activities.

Landslide Deposits

Young landslide deposits have been mapped in the northern limits of the EHNCP, entirely within the RCA. The deposits consist of chaotically mixed soil and rubble and (or) displaced bedrock blocks, most of which are debris slides and rock slumps or earth slumps. These landslides may or may not be active.

Alluvial Fan Deposits

Streams from the San Gabriel Mountains to the north carried alluvial deposits down into the valley, with coalescing deposits consisting of coarse gravels to fine-grained sands deposited over the course of the last 10,000 years or greater. The alluvial deposits are thin within the northern portions of the RCA, and as thick as 500 to 1,000 feet at the southern edges of the RCA and within the NA. The alluvial fan deposits within the RCA and NA typically consist of well graded silty sands and gravels with cobbles and boulders. Older alluvial fan deposits are described as moderately porous, well-consolidated, highly oxidized, sandy clay with gravel and abundant decomposed subangular cobbles and local decomposed boulders of granulitic bedrock.

Granulitic Gneiss Bedrock

Granulitic Gneiss metamorphic bedrock is mapped in the mountainous northern portion of the RCA. The bedrock is described as weathered, highly sheared and contorted cataclastic gneiss. Localized concentrations of quartzite and mica-rich zones were also observed, as are localized outcrops of marble. The bedrock can be hard and dense and difficult to excavate in fresh exposures. However, the near surface of the unit is weathered and fractured and, in some cases, highly fractured along faults and shears.

2.3 Regional Faulting and Seismicity

Southern California is a geologically complex area with numerous fault systems, including strike-slip, oblique, thrust and blind thrust faults. Any specific area of southern California is subject to seismic hazards of varying degree, depending on the proximity and earthquake potential of nearby active faults and the local geologic and topographic conditions. Seismic hazards include primary hazards from surface rupturing of rock and soil materials along active fault traces, and secondary hazards resulting from strong ground shaking.

2.3.1 Surface Rupture

Much of the RCA is located within a State of California designated Earthquake Fault Zone, established per the Alquist-Priolo (AP) Act of 1972 (CGS, 1995), and a County of San Bernardino designated Earthquake Fault Zone (San Bernardino County, 2010), see Figure 2. Based on the act, an active fault is one in which movement occurred along the fault in sometime within the past 11,700 years (within the Holocene). As such, if a fault is present at a site and is observed to offset Holocene aged soils, the fault is deemed active. The California Geological Society (CGS) Special Publication 42 includes the provisions of the Act and an index to maps of Earthquake Fault-Rupture Zones (formerly Alquist-Priolo Special Study Zones), (CGS, 2018). Special Publication 42 also provides state of the practice guidelines for permitting agencies and reviewers, as well as guidance for geoscience consulting practitioners conducting fault studies.

The NA is not located within a State of California designated Earthquake Fault Zone. However, the City of Rancho Cucamonga has extended the earthquake fault zone for the buried uncertain segment of the Red Hill Fault located in the southern portion of the NA, see Figure 2.

2.3.2 Seismic Shaking

Strong ground shaking can be expected at the EHNCP during moderate to severe earthquakes in this general region. This is common to virtually all of Southern California. Intensity of ground shaking at a given location depends primarily upon earthquake magnitude, site distance from the source, and site response (soil type) characteristics. Preliminary seismic coefficients based on the 2016 California Building Code (CBC) are provided in the tables below for rock outcropping areas and areas of deeper soil; these parameters will need to be updated for specific construction areas in both the RCA and NA as development plans progress.

Table 1. Preliminary CBC Site-Specific Seismic Coefficients – Rock (northern portion of RCA)

CBC Categorization/Coefficient	Value
Site Longitude (decimal degrees)	-117.4880
Site Latitude (decimal degrees)	34.1789
Site Class Definition	**C**
Mapped Spectral Response Acceleration at 0.2s Period, S_s	**3.204g**
Mapped Spectral Response Acceleration at 1s Period, S_1	**1.129g**
Short Period Site Coefficient at 0.2s Period, F_a	**1.0**
Long Period Site Coefficient at 1s Period, F_v	**1.3**
Adjusted Spectral Response Acceleration at 0.2s Period, S_{MS}	**3.204g**
Adjusted Spectral Response Acceleration at 1s Period, S_{M1}	**1.468g**
Design Spectral Response Acceleration at 0.2s Period, S_{DS}	***2.136g***
Design Spectral Response Acceleration at 1s Period, S_{D1}	***0.979g***
Maximum Considered Earthquake Geometric Mean (MCE_G), PGA	**1.254g**
MCE_G PGA Adjusted for Site Class Effects, PGA_M	**1.254g**

* g- Gravity acceleration

Table 2. Preliminary CBC Site-Specific Seismic Coefficients – Soil (southern portions of RCA and all of NA)

CBC Categorization/Coefficient	Value
Site Longitude (decimal degrees)	-117.4880
Site Latitude (decimal degrees)	34.1789
Site Class Definition	**D**
Mapped Spectral Response Acceleration at 0.2s Period, S_s	**3.204g**
Mapped Spectral Response Acceleration at 1s Period, S_1	**1.129g**
Short Period Site Coefficient at 0.2s Period, F_a	**1.0**
Long Period Site Coefficient at 1s Period, F_v	**1.5**
Adjusted Spectral Response Acceleration at 0.2s Period, S_{MS}	**3.204g**
Adjusted Spectral Response Acceleration at 1s Period, S_{M1}	**1.694g**
Design Spectral Response Acceleration at 0.2s Period, S_{DS}	***2.136g***
Design Spectral Response Acceleration at 1s Period, S_{D1}	***1.129g***
Maximum Considered Earthquake Geometric Mean (MCE_G), PGA	**1.254g**
MCE_G PGA Adjusted for Site Class Effects, PGA_M	**1.254g**

* g- Gravity acceleration

2.3.3 Nearby Active Faults

Numerous faults have been mapped within this area of southern California. The most significant and major active fault systems that could produce significant ground shaking at the Plan area include the Cucamonga, the Red Hill, the San Jacinto, and San Andreas faults. Characteristics of the known nearby, individual fault systems are discussed below.

The general information regarding the individual faults discussed below was gathered from the Southern California Earthquake Data Center website (http://www.data.scec.edu), as well as the referenced fault evaluation reports, the California Geological Society Special Publication 42, the City of Rancho Cucamonga General Plan, and the referenced previous onsite and nearby reports done by us and others.

Cucamonga Fault Zone

The Cucamonga Fault has been designated as a State of California designated Earthquake Fault Zone as shown on the Cucamonga Peak and Devore Quadrangle Earthquake Fault Zones Maps (CGS, 1995). It is approximately 30 km (19 miles) in length, and is located at the foothills of the San Gabriel Mountains. The fault generally extends from the Lytle Creek area in the east to the Claremont area to the west. The Cucamonga Fault Zone is located within and extends across the entire RCA portion of the EHNCP (it is not located on the NA). The fault offsets recent alluvial deposits along the northern edge of the City. Its presence can be seen on the surface as scarps or disruptions of the alluvial fan surface. The Cucamonga fault is a thrust fault uplifting the San Gabriel Mountains with respect to the valley below. It is estimated to be capable of generating a maximum credible earthquake of magnitude (Mw) 6.0 to 7.0.

Red Hill Fault Zone (also Etiwanda Avenue Fault)

The northeastern portion of the Red Hill Fault, known as the Etiwanda Avenue Fault Scarp, has been designated as a State of California designated Earthquake Fault Zone as shown on the Cucamonga Peak Quadrangle Earthquake Fault Zones Map (CGS, 1995); this portion of the fault is outside of the EHNCP. The entire Red Hill Fault Zone is approximately 25 km (16 miles) in length, and is a hyperbola-shaped feature that ‘wraps around’ Red Hill, a low hill with about 60 m of relief near the western border of the city of Rancho Cucamonga. Most of the fault is located on the basis of a fairly well-defined subsurface water barrier. The northeastern segment of the Red Hill Fault (mapped near Etiwanda Avenue, outside of the EHNCP) has been shown to be active and may be a splay of the Cucamonga fault. The most recent known movement along the Etiwanda Avenue section of this fault zone has occurred within the last few thousand years. A large number of small earthquakes (magnitudes [M] 1 to 3) have historically occurred beneath the City of Rancho Cucamonga, some which have epicenters on or near the trace of the Red Hill Fault. A maximum credible magnitude of 6.5 is possible on this fault. The inferred Red Hill Fault has been mapped across Planning Area 8 within the southern portion of the NA. The City of Rancho Cucamonga has adopted a more stringent standard than the AP Act to address this section of the fault and has extended the earthquake fault zone to include this section, see Figure 2 (City of Rancho Cucamonga, 2010). Fault Evaluation Report FER 40 (CGS, 1977b), pertaining to the Red Hill Fault has been reviewed in preparation of this report.

San Jacinto Fault Zone

The San Jacinto Fault has been designated as a State of California designated Earthquake Fault Zone (CGS, 1995).The San Jacinto Fault is located approximately 2.3 miles northeast of the EHNCP. The San Jacinto Fault is approximately 130 miles in length, and is made up of numerous individual fault strands, the eastern end of which joins with the San Andreas Fault system near Wrightwood. The most recent known surface movement along this fault zone has occurred within the last few hundred years. The Coyote Creek segment of the fault in the vicinity of Borrego Mountain experienced a magnitude (Mw) 6.5 earthquake in April 1968. The San Jacinto Fault, San Bernardino Valley segment is estimated to be capable of generating a maximum credible earthquake of magnitude (Mw) 6.5 to 7.5.

San Andreas Fault (Southern and San Bernardino Segments)

The San Andreas Fault has been designated as a State of California designated Earthquake Fault Zone (CGS, 1995). The San Andreas Fault is widely recognized as the longest and most active fault in the State of California. Its activity is known from historic earthquakes (some of which have caused rupture of the ground surface), and from many fault studies that have shown that the San Andreas offsets or displaces recently deposited sediments. The San Andreas Fault has been mapped from Cape Mendocino in Northern California to an area near the Mexican border, a distance of about 750 miles. Recent work indicates that large earthquakes have occurred along the fault at intervals averaging about 140 years, and that during these major earthquakes, the fault breaks along distinct segments. The Southern and San Bernardino segments of the San Andreas fault are located approximately 5.2 miles northeast of the EHNCP. These segments of the San Andreas Fault are thought to be capable of producing a maximum credible earthquake of magnitude (Mw) 6.8 to 8.0.

2.4 Existing Slope Stability

The northern portion of the RCA is within a moderate to high potential landslide susceptibility zone as depicted on the San Bernardino County, General Plan, Geologic Hazard Overlay (San Bernardino County, 2010). The presence of relatively steep topographic relief across this area of the EHNCP creates a moderate to high potential for both static and dynamic bedrock slope instability.

2.5 Groundwater

Based on our review of regional groundwater data (CDWR, 2019), groundwater is expected to be on the order of 350 feet below the ground surface in the general site vicinity. Historical high groundwater has been found to be on the order of 300 feet below the ground surface (Fife, 1976). The granitic bedrock is not generally considered water bearing. Groundwater is not generally expected to be a constraint to development of the EHNCP.

2.6 Soil Engineering Characteristics

2.6.1 Compressible and Collapsible Soil

Soil compressibility refers to a soil's potential for settlement when subjected to increased loads, such as from a fill surcharge or structural loads. Based on our previous experience in the vicinity of the site, the upper 5 feet of the alluvial soils onsite are generally considered to be slightly compressible. Uncontrolled artificial fill onsite is considered compressible throughout the entire depth.

Collapse potential refers to the potential settlement of the soil under existing stresses (loads) upon being wetted. Based on the type of soils observed and our experience in the area, the potential for significant collapse is considered slight to moderate and should be further evaluated during future geotechnical studies.

2.6.2 Expansive Soils

Expansive soils contain significant amounts of clay particles that swell considerably when wetted and shrink when dried. Foundations constructed on these soils are subjected to large uplifting forces caused by the swelling. Without proper measures taken, heaving and cracking of both building foundations and slabs-on-grade could result.

The alluvial soils across most of the EHNCP include sand gravel, cobbles and boulders that generally have a very low expansion potential. However weathered bedrock and clayey soils may be present within the northern portion of the RCA. Based on these soil types and our experience in the area, the soils within the RCA are expected to exhibit an Expansion Index in the very low to medium range (EI less than 90), and very low (less than 21) within the NA.

2.6.3 Corrosive Soils

Water-soluble sulfates in soil can react adversely with concrete. However, concrete in contact with soil containing sulfate concentrations of less than 0.10 percent are considered to have negligible sulfate exposure based on American Concrete Institute (ACI) provisions, adopted by the 2016 CBC (CBC, 2016, Chapter 19, and ACI, 2014).

Soil corrosivity to ferrous metals can be estimated by the soil's potential of hydrogen (pH) level, electrical resistivity, and chloride content. In general, soil having a minimum resistivity less than 2,000 ohm-cm is considered corrosive. Soil with a chloride content of 500 ppm or more is considered corrosive to ferrous metals. .

Soil corrosivity is not a visually discernable characteristic. The soil and bedrock units onsite may be detrimental to concrete and corrosive to metals. Site specific testing should be performed during future geotechnical studies.

2.6.4 Rippability and Oversized Rock

The granulitic gneiss bedrock is expected to be weathered and soft in the near surface, but dense and hard in fresh exposures. In deeper excavations it is likely that the bedrock will be difficult to rip with heavy equipment. The excavation characteristics of bedrock and the need for blasting depends on many factors, including the density of the rock, the amount and orientation of fractures, the size and quality of the equipment being used and the skill of the operators Heavy ripping and/or blasting in bedrock areas may be required for development of the hillside areas of the RCA underlain by bedrock, depending on project designs and conditions encountered.

The alluvial soil within the EHNCP includes cobbles and boulders up to several feet in dimension. The California Building Code requires that no oversize rock be placed within 10 feet of the surface of a structural fill and/or building pad. If insufficient deep fill areas are not available, size reduction processing or off-site disposal may be required. Other uses of resistant rock may include onsite riprap or crushing/processing for aggregate base materials.

Specific recommendations for placing oversized material should be provided as part of geotechnical studies for development projects within the EHNCP.

3.0 POTENTIAL GEOTECHNICAL IMPACTS AND MITIGATION MEASURES

This section summarizes the principal geotechnical conditions that occur in the EHNCP area. The potential impact that each condition may have on the site development is subjectively rated as less-than-significant or potentially significant. Review of these conditions should be undertaken by the CEQA consultant.

3.1 Seismic Hazards

3.1.1 Fault-Induced Ground Rupture

Earthquake Fault Zones established by the State of California along the Cucamonga Fault traverse the RCA (see Figure 2). Previous fault investigations of the Cucamonga Fault have observed onsite faulting and concluded that that fault was active with movement in the Holocene. Also an Earthquake Fault Zone established by the City of Rancho Cucamonga along the Redhill Fault traverses the southeastern portion of the NA, principally within a proposed open-space area (see Figure 2). Documented activity on the Redhill Fault is not clearly established.

Fault-induced ground rupture within the EHNCP (RCA and NA) area is possible. Current code (PRC Division 2, Chapter 7.5, Section 2621.5) prohibits constructing structures for human occupancy across the trace of active faults. In order to comply with code, project-level fault studies providing measures for fault-rupture mitigation will need to be conducted for development of structures planned within city and state established Earthquake Fault Zones (see California Geological Survey, Note 42); this includes State-established zones for the Cucamonga fault in the RCA, and a City-established zone for the Red Hill Fault in the southeastern portion of the NA.

By complying with existing code, this hazard will be mitigated on a project-level basis, such that this hazard is considered to be **less than significant**.

Mitigation Measures: Mitigation measures beyond complying with existing code are not required for this hazard.

3.1.2 Seismic Ground Shaking

The intensity of ground shaking at a given location depends on several factors, but primarily on the earthquake magnitude, the distance from the hypocenter to the site of interest, and the response characteristics of the soil and/or bedrock units underlying the site. The EHNCP includes and is surrounded by multiple faults that are capable of producing severe seismic ground shaking due to their locations and potential magnitudes.

In the EHNCP area, the hazard posed by seismic shaking is considered high, due to the proximity of known active faults. However, exposure to future ground shaking at the site is no greater than at many other sites in southern California.

In general, there is no realistic way in which the hazard of seismic shaking can be totally avoided. While it is not considered feasible to make structures totally resistant to seismic shaking, the existing code specifies that they be designed to not collapse, with specific levels of service as dictated by the California Building Code.

The effects of seismic shaking on structures can be reduced through conformance with the California Building Code, which requires a project-level geotechnical investigation to provide seismic design parameters. This will promote safety in the event of a large earthquake, with the purpose of reducing potential damage to code-acceptable levels. Design in accordance with these measures is expected to reduce the impact of ground shaking to **less than significant**.

By complying with existing code, this hazard will be mitigated on a project-level basis, such that this hazard is considered to be **less than significant**.

Mitigation Measures: Mitigation measures beyond complying with existing code are not required for this hazard.

3.1.3 Secondary Effects of Seismic Shaking

Secondary effects of seismic shaking are non-tectonic processes that are directly related to strong seismic shaking. Ground deformation, including fissures, settlement, displacement and loss of bearing strength, are common expressions of these processes, and are among the leading causes of damage to structures during moderate to large earthquakes. Secondary effects leading to ground deformation include liquefaction, lateral spreading, settlement, and landsliding. Other hazards indirectly related to seismic shaking are inundation, tsunamis, and seiches.

Liquefaction

Liquefaction occurs when loose, cohesionless, water-saturated soils (generally fine-grained sand and silt) are subjected to strong seismic ground motion of significant duration. These soils temporarily behave similar to liquids, losing bearing strength. Structures built on these soils may tilt or settle when the soils liquefy. Liquefaction more often occurs in earthquake-prone areas underlain by young sandy alluvium where the groundwater table is less than 50 feet below the ground surface.

The EHNCP has not been identified as being in an area potentially susceptible to liquefaction (County of San Bernardino). The historically highest groundwater has been estimated to be on the order of 300 feet below ground surface. Thus, the potential for liquefaction onsite is considered **less than significant.**

Mitigation Measures: No special precautions or restrictions are required.

Lateral Spreading

Lateral spreading is a phenomenon where large blocks of intact, nonliquefied soil move downslope on a liquefied substrate of relatively large aerial extent. The mass moves toward an unconfined area, such as a descending slope or stream-cut bluff, and is known to move on slope gradients as gentle as 1 degree. Lateral spreading only occurs in areas subject to liquefaction. As the EHNCP is not considered susceptible to liquefaction, the potential for lateral spreading onsite is considered **less than significant.**

Mitigation Measures: No special precautions or restrictions are required.

Seismically Induced Settlement

Strong ground shaking can cause settlement by allowing soil particles to become more tightly packed, thereby reducing pore space. Unconsolidated, loosely packed granular alluvial deposits are especially susceptible to this phenomenon. Poorly compacted artificial fills may also experience seismically induced settlement. The alluvial fan deposits across the majority of the EHNCP (RCA and NA) are not typically prone to significant seismic settlement, however unconsolidated native soils and artificial fill prone to seismic settlement may be present locally. As such, the hazard of seismically induced settlement is considered **potentially significant**.

Mitigation Measures: The potential for seismically induced settlement should be investigated during future geotechnical studies. Based on these studies, loose, compressible soils prone to seismic settlement should be identified. Recommendations for removal and replacement or mitigation of soil prone to seismic settlement should be provided as part of geotechnical reports submitted to the city as part of the review of specific projects. Correct implementation of remedial grading and design recommendations is expected to reduce the impact of seismically induced settlement to **less than significant.**

Seismically Induced Landslides

The northern portion of the RCA is within a moderate to high potential landslide susceptibility zone as depicted on the San Bernardino County, General Plan, Geologic Hazard Overlay (San Bernardino County, Undated). The presence of relatively high topographic relief across the northern portion of the RCA raises the potential hazards from both static and dynamic bedrock slope instability to be moderate to high. The potential for seismically induced landslides within the RCA is considered **potentially significant.**

Mitigation Measures: The potential for seismically induced landslides and slope instability should be investigated during future geotechnical studies. If the studies suggest slope instability is a concern, remedial recommendations to limit slope instability, such as construction of slope stability buttresses, installation of soil nails or anchors, or redesign of slopes, should be provided. Appropriate implementation of grading and slope stabilization recommendations is expected to reduce the impact of seismically induced landslides to **less than significant.**

Seismically Induced Inundation

Strong seismic ground motion can cause dams and levees to fail, resulting in damage to structures and properties located downstream. The Deer and Day Creek Debris Basins and the Day Creek Levee are within the subject property. However, the EHNCP is not mapped within a San Bernardino County Area of Dam Inundation zone, see Figure 5. As such, the potential for seismically induced inundation is considered **less than significant.**

Mitigation Measures: No special precautions or restrictions are required.

Tsunamis and Seiches

A tsunami, or seismically generated sea wave, is generally created by a large, distant earthquake occurring near a deep ocean trough. A seiche is an earthquake-induced wave in a confined body of water, such as a lake or reservoir. Damage from tsunamis is confined to coastal areas that are 20 feet or less above sea level. Since the EHNCP is not located near the coast or any confined bodies of water, the risk of inundation from a tsunami or seiche is **less than significant**.

Mitigation Measures: No special precautions or restrictions are required.

3.2 Slope Stability

3.2.1 Stability of Natural and Existing Slopes

The northern portion of the RCA has natural steep slopes and mapped landslides. While the bedrock is typically dense, steep slopes can fail along planes of weakness, such as joints or foliation, or where the rock is highly fractured and broken. The RCA also has areas that contain precariously balanced rocks that could potentially fall and/or be dislodged and roll downhill. The existing cut slopes of the inactive sand and gravel quarry within the NA will need to be evaluated if improvements are proposed near these slopes.

The City's Development Code, Article III, Chapter 17.30 (Hillside Residential) indicates that areas with slopes equal to or steeper than 8 percent are considered a "hillside", and alternative grading and structural design techniques are required. The code indicates that, "Hillside Development Review is required for any subdivision or development within the Hillside Residential District. As part of the Hillside Development

Review, environmental studies and investigations such as, but not limited to, geological, hydrological, seismic, slope and soil conditions…shall be conducted…" As such, project-level geotechnical investigations specifically addressing slope stability and providing requisite mitigation measures are required by city ordinance.

Future site-specific geotechnical investigations in areas of planned development are required to be conducted in order to evaluate the potential for slope instability. Implementation of slope stabilization measures based on these project-level required geotechnical studies will reduce the impact of natural slope instability and rockfall hazard to **less than significant.**

Mitigation Measures: Mitigation measures beyond complying with existing code as described above are not required for this hazard.

3.2.2 Stability of Proposed Slopes

Design slopes cut into the native soil can be prone to instability, depending on the nature of the earth material underlying the slope. Design fill slopes may also be prone to instability if poorly constructed or constructed of unsuitable earth materials. Consequently, the hazard posed by unstable manufactured slopes is considered to be **potentially significant**.

Mitigation Measures: Future site-specific geotechnical investigations of the planned development should be conducted. These investigations should analyze this potential for slope instability in light of the proposed grading and development plans and underlying earth materials, and present recommendations for construction and adequate stability of manufactured slopes.

Slopes should be constructed in accordance with the recommendations of the geotechnical engineer for individual projects, California Building Code and City and/or County guidelines. Implementation of slope stabilization measures during design and grading of the EHNCP will reduce the impact of slope instability in manufactured slopes to **less than significant**.

3.2.3 Stability of Temporary Slopes

Slope or sidewall failure in temporary excavations for underground utilities or other structures could occur in unconsolidated soils. The risk of failure in temporary slopes is higher because they are generally cut at a much steeper gradient versus permanent manufactured slopes. Consequently, the hazard from temporary slopes is considered to be **potentially significant**.

Mitigation Measures: Where excavations are made, the excavation wall may be shored, with shoring designed to withstand any additional loads, or the excavation walls may be flattened or “laid-back” to a shallower gradient. Excavation spoils should not be placed immediately adjacent to the excavation walls unless the excavation is shored to support the added load. Other measures used to reduce the potential for temporary slope failure include cutting and backfilling excavations in sections, and not leaving temporary excavations open for long periods of time. All Cal-OSHA regulations must be observed for excavations that will be entered by people. Following these measures is expected to reduce the impact posed by temporary slopes to **less than significant**.

3.3 Foundation Stability

3.3.1 Compressible Soils

When a load is placed, such as from fill soil or a building, the underlying soil layers undergo a certain amount of compression. This compression is due to the deformation of the soil particles, the relocation of soil, and the expulsion of water or air from the void spaces between the grains. As a result, settlement can occur. Some of this settlement occurs immediately after a load is applied, while some of the settlement occurs over a period of time after placement of the load. For engineering applications, it is important to estimate the total amount of settlement that will occur upon placement of a given load, and the rate of compression (consolidation).

Based on our experience and work in the general site vicinity, we expect the upper portion of the surficial soils onsite to be slightly to moderately compressible. Organic material and uncompacted fills are also compressible, and are unsuitable for foundation support.

Existing undocumented artificial fills of the inactive quarry are considered compressible and unsuitable for support of structures. Further, if deep fills are to be placed to backfill the quarry, these fills may be subject to significant settlement for a period of time.

Therefore, the impact posed by compressible soils is considered to be **potentially significant.**

Mitigation Measures: Future site-specific geotechnical investigations of planned development should be conducted. These investigations should identify potentially compressible soils. Implementation of the recommended removal and recompaction of the near surface soils should mitigate the significant portion of the soils that are prone to compression onsite. With the implementation of the recommended removals and overexcavation, the impact posed by compressible soils is expected to be **less than significant**.

If deep artificial fill is to be placed in the abandoned quarry (or in other areas), specific recommendations for placement and settlement monitoring of these fills will be required. Delay in construction while the settlement of the deep artificial fills reduces to acceptable limits may be necessary. Geotechnical studies with recommendations specifically addressing these issues will be required if deep fills are planned. With the implementation of such recommendations, the impact posed by settlement of deep artificial fill is expected to be **less than significant**

3.3.2 Expansive Soils

Expansive soils underlying a foundation or slab, if left untreated, can cause damage to the structure, including heaving, tilting and cracking of the foundation. Differential movement in the building can result in damage to floors and walls, as well as door and window frames. Based on our experience in the general site vicinity, we expect the onsite alluvial soils within the NA and within much of the RCA to have an Expansion Index of 20 or less. However, expansive soils may be present in hillside areas of the RCA. The impact posed by expansive soils within the RCA is considered to be **potentially significant.** The impact posed by expansive soils within the NA is considered to be **less than significant.**

Mitigation Measures: Testing within hillside areas of the RCA should be performed in planned development areas in order to evaluate the expansion potential of the near surface soil materials and prior to construction of the proposed foundations. Providing the results to the structural engineer will allow them to design a foundation system that is able to withstand the expansive potential of the near surface soil materials. Implementing these measures during the design and construction projects within the RCA is expected to reduce this impact to **less than significant**.

3.3.3 Corrosive Soils

Corrosive soils contain constituents or physical characteristics that react with concrete (water-soluble sulfates) or ferrous metals (such as chlorides, low pH levels, and low electrical resistivity). Based on our previous work and experience in the general site vicinity, the onsite soils are expected to have soluble sulfate contents in the negligible range. However, the onsite soils are expected to be mildly to moderately corrosive to ferrous metal. Consequently, the hazard to structures and underground improvements from corrosive soil within the RCA and NA is expected to be **potentially significant**.

Mitigation Measures: Testing should be performed prior to construction of the proposed improvements within the RCA and NA. All concrete in contact with the soil should be designed based on requirements of the California Building Code. All metals in contact with corrosive soil should be protected in accordance with the recommendations of the manufacturer or a corrosion engineer. Implementing these measures during the design and construction within the EHNCP is expected to reduce this impact to **less than significant**.

3.3.4 Erosion

The native soils within the RCA and NA, as well as fill slopes constructed with native soils, will have a moderate susceptibility to erosion. These materials will be particularly prone to erosion during site development, especially during heavy rains. Therefore, the impact of erosion within the RCA and NA is considered to be **potentially significant**.

Mitigation Measures: The potential for erosion can typically be reduced by appropriate paving of exposed ground surfaces, landscaping, providing terraces on slopes, placing berms or V-ditches at the tops of slopes, and installing adequate storm drain systems. Graded slopes should be protected until healthy plant growth is established. Typically, protection can be provided by the use of sprayed polymers, straw waddles, jute mesh or by other measures.

Temporary erosion control measures should be provided during construction, as required by current grading codes. Such measures typically include temporary catchment basins and/or sandbagging to control runoff and contain sediment transport within the individual project sites. Correct implementation of these erosion control measures is expected to reduce the impact resulting from erosion to **less than significant**.

3.3.5 Rippability and Oversized Rock

The onsite bedrock materials are generally anticipated to be rippable to depths of 5 to 10 feet below ground surface. However heavy ripping and or blasting may be required if deep cuts in bedrock are incorporated into development plans. Significant amounts of oversized materials (larger than 12 inches in dimension and ranging to several feet in dimension) are present within the alluvial soil. Such materials are generally not suitable immediately beneath planned structures and may require special handling and placement or disposal offsite during grading. Rippability and oversized rock disposal is considered to be a **potentially significant** impact.

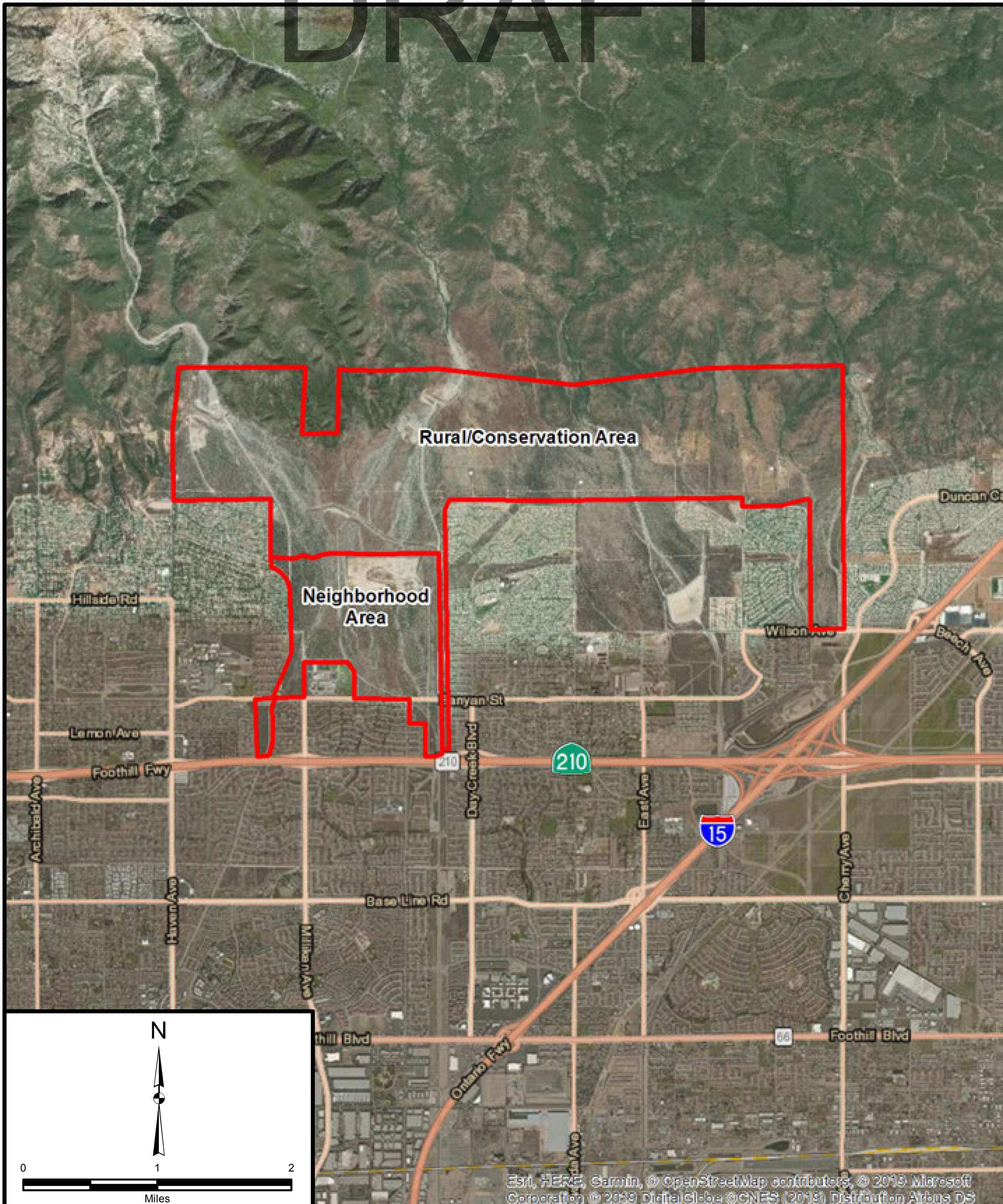
Mitigation Measures: Future site-specific geotechnical investigations of planned development should be conducted. These investigations should identify areas of hard rock and oversize rock. Adjusting the grades so as to not encounter the non-rippable rock will reduce the impact from the non rippable material to less than significant. Oversized rocks should be handled as recommended by the geotechnical consultants of the specific projects. Examples of oversized rock treatment includes placement in deeper fills, nonstructural areas, crushing, or disposed of offsite. Once the recommendations are implemented, mitigation measures such as these are expected to reduce the impact from oversized rock to **less than significant**.

3.3.6 Regional Subsidence

Regional ground subsidence generally occurs due to rapid and intensive removal of subterranean fluids, typically water or oil. It is generally attributed to the consolidation of sediments as the fluid in the sediment is removed. The total load of the soils in partially saturated or saturated deposits is born by their granular structure and the fluid. When the fluid is removed, the load is born by the sediment alone and it settles. No reports of regional subsidence have been reported in the site vicinity, and lack of intense removal of significant quantities of water or oil extraction in the area makes the potential for ground subsidence very low and **less than a significant impact**.

Mitigation Measures: None required.

DRAFT



Project: 12281.001	Eng/Geol: JDH/PB	Figure 1
Scale: 1 " = 1 miles	Date: March 2019	
Base Map: Bing Maps 2019		
Author: Leighton Geomatics (mmurphy)		

SITE LOCATION MAP

Etiwanda Heights Neighborhood and Conservation Plan Project Geology and Soils Study
City of Rancho Cucamonga, California

Leighton

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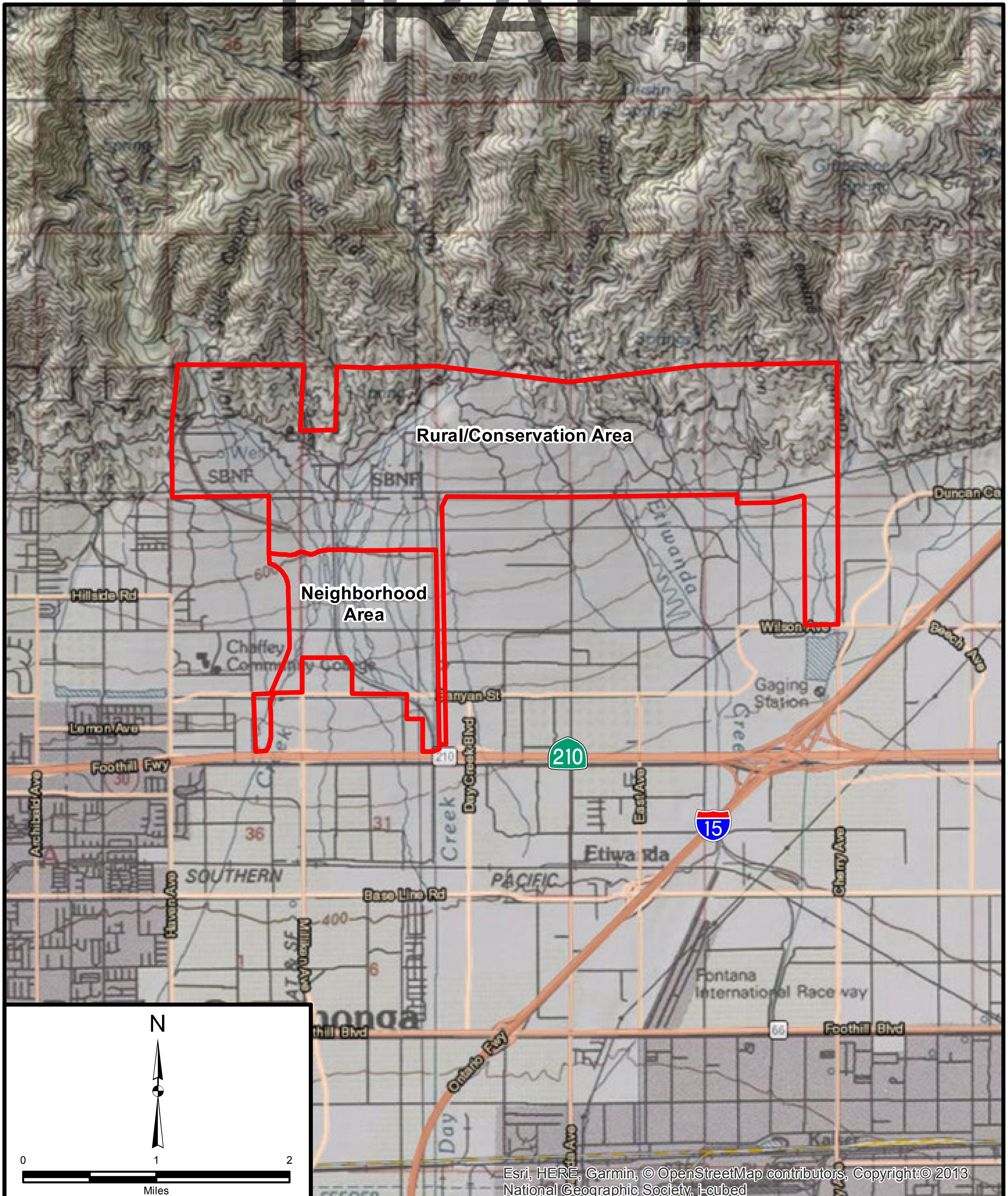


Project: 12281.001

Eng/Geol: JDH/PB

Scale: 1 " = 1 miles

Date: March 2019

Base Map: Bing Maps 2019

Author: Leighton Geomatics (mmurphy)

SITE LOCATION MAP

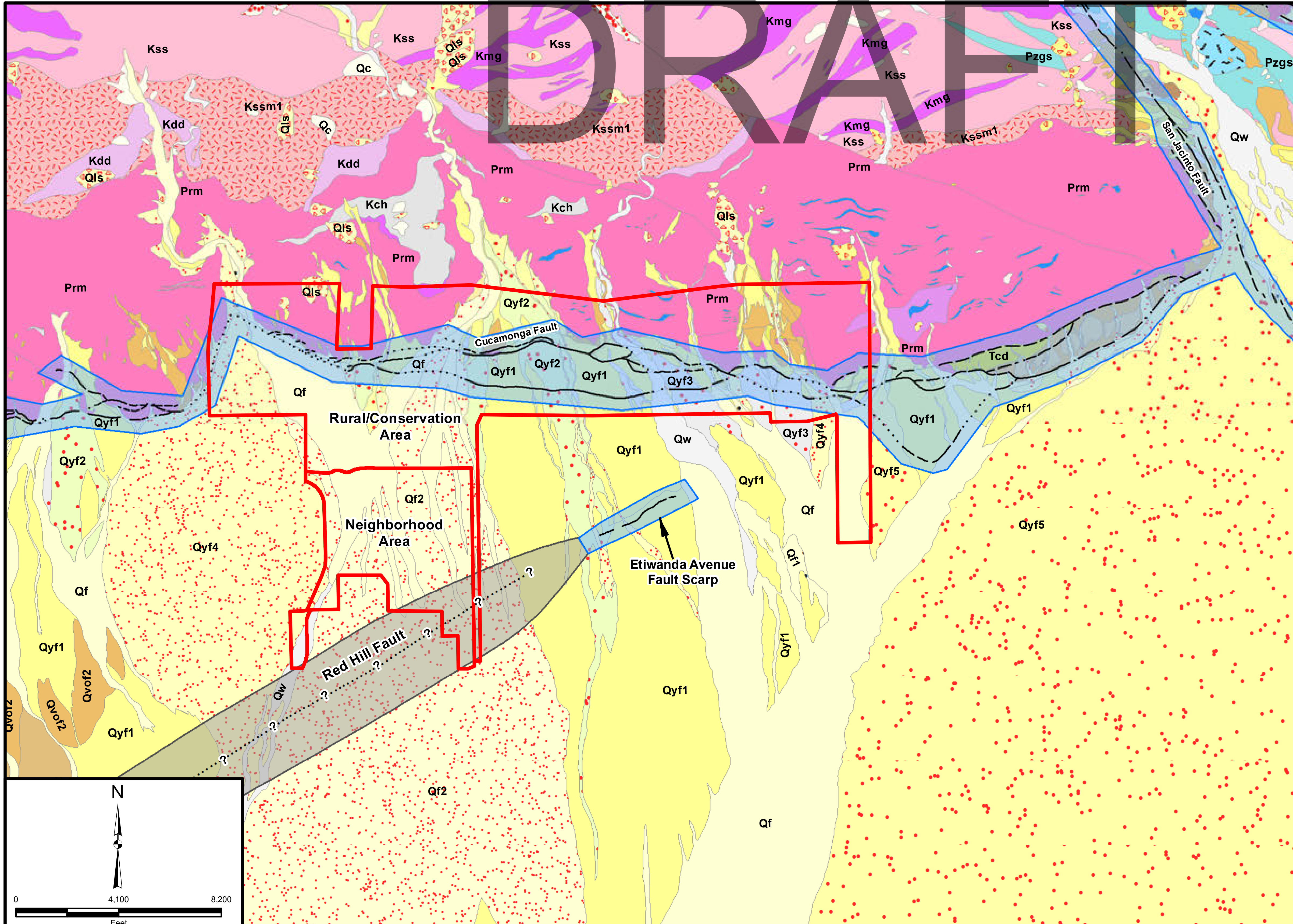
Etiwanda Heights Neighborhood and Conservation Plan Project Geology and Soils Study

City of Rancho Cucamonga, California

Figure 1a

Leighton

Map Saved as P:\Drafting\12281\001\Maps\12281-001_F01_SLM_2019-02-12.mxd on 3/21/2019 11:42:22 AM



Legend

- Approximate fault location, solid line where accurately located, long dash where approximately located, short dash where inferred, dotted where concealed
- City fault zone
- Alquist-Priolo Earthquake Fault Zone
- KPzst - Schist, gneiss, and tonalite
- Kch - Charnockite
- Kdd - Deer diorite of Alf
- Kmg - Monzogranite and granodiorite
- Kss - Tonalite of San Sevaine Lookout
- Kssm1 - Mylonitized tonalite of San Sevaine Lookout
- Prgu - Granulitic gneiss, mylonite, and cataclasite
- Prm - Granulitic gneiss, mylonite, and cataclasite, retrograde
- Pzgs - Metasedimentary schist and gneiss
- Pzmg - Marble, San Gabriel Mountains
- QTfz - Crushed rock in fault zones
- Qc - Very young colluvial deposits
- Qf - Very young alluvial-fan deposits
- Qf1 - Very young alluvial-fan deposits, Unit 1
- Qf2 - Very young alluvial-fan deposits, Unit 2
- Qls - Very young landslide deposits
- Qoa - Old axial-channel deposits
- Qof - Old alluvial-fan deposits
- Qof1 - Old alluvial-fan deposits, Unit 1
- Qof2 - Old alluvial-fan deposits, Unit 2
- Qof3 - Old alluvial-fan deposits, Unit 3
- Qsw - Very young slope-wash deposits
- Qt - Very young talus deposits
- Qvof - Very old alluvial-fan deposits
- Qvof1 - Very old alluvial-fan deposits, Unit 1
- Qvof2 - Very old alluvial-fan deposits, Unit 2
- Qw - Very young wash deposits
- Qya4 - Young axial-channel deposits, Unit 4
- Qya5 - Young axial-channel deposits, Unit 5
- Qye - Young eolian deposits
- Qyf - Young alluvial-fan deposits
- Qyf1 - Young alluvial-fan deposits, Unit 1
- Qyf2 - Young alluvial-fan deposits, Unit 2
- Qyf3 - Young alluvial-fan deposits, Unit 3
- Qyf4 - Young alluvial-fan deposits, Unit 4
- Qyf5 - Young alluvial-fan deposits, Unit 5
- Qyls - Young landslide deposits
- Qyt - Young talus deposits
- Tcd - Conglomerate and sandstone, San Sevaine Canyon area
- Tvc - Conglomerate and sandstone, San Sevaine Canyon area

Project: 12281.001	Eng/Geol: JDH/PB
Scale: 1 " = 4,115 '	Date: March 2019

Reference: USGS, 2006 Geologic map of the San Bernardino and Santa Ana 30'x60 quadrangle, California Version 1,0 Open File Report 2006-1217.
Author: Leighton Geomatics (mmurphy)

REGIONAL GEOLOGY MAP

Etiwanda Heights Neighborhood and Conservation Plan Project
Geology and Soils Study
City of Rancho Cucamonga, California

Figure 2

Leighton

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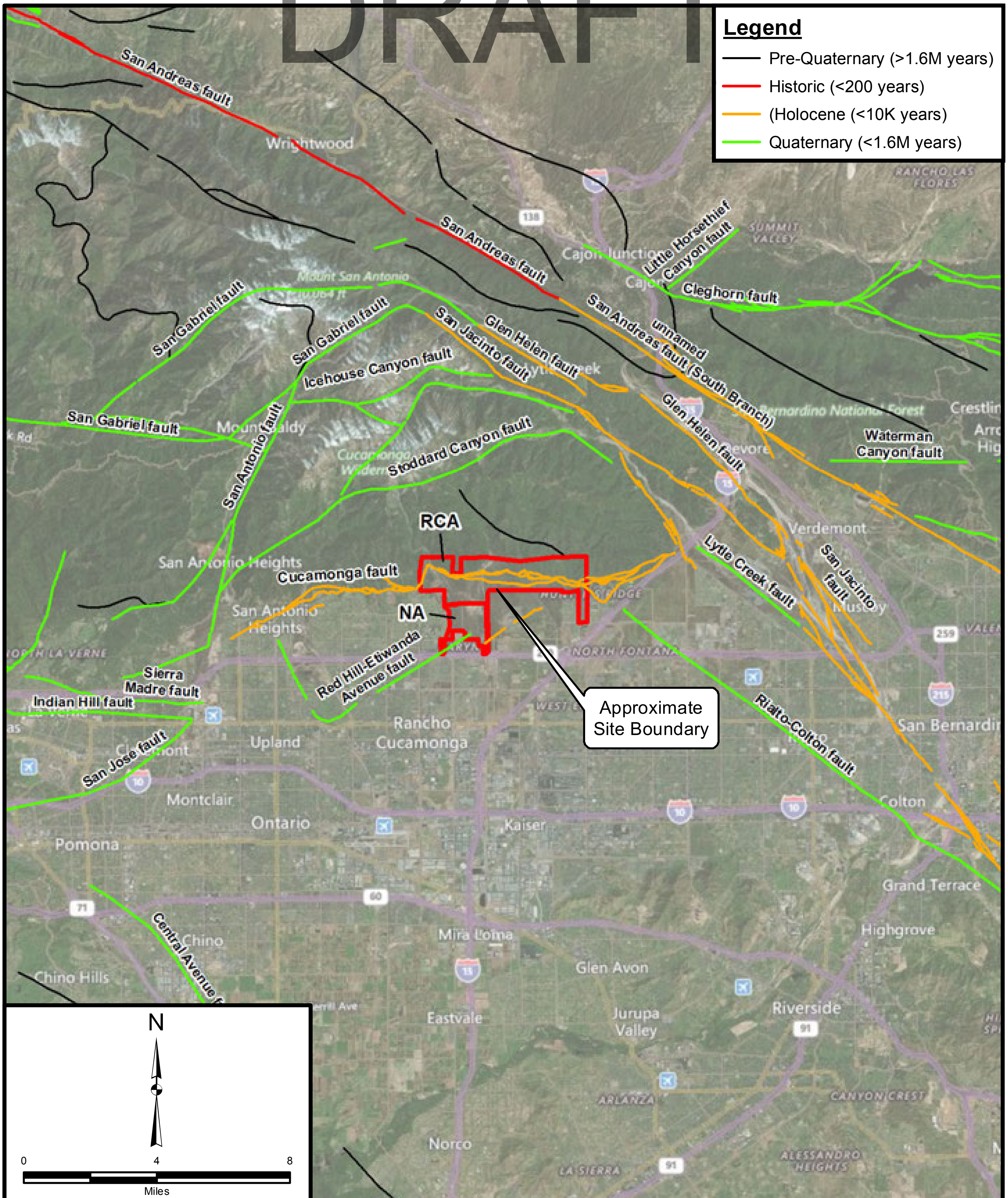

Project: 12281.001	Eng/Geol: JDH/PB
Scale: 1 " = 4 miles	Date: March 2019

Base Map: ESRI ArcGIS Online 2019
Thematic Information: Leighton, Bryant, W. A. (compiler), 2005, Digital Database of Quaternary and Younger Faults from the Fault Activity Map of California, version 2.0: CGS
Author: Leighton Geomatics (mmurphy)

REGIONAL FAULT MAP

Etiwanda Heights Neighborhood and Conservation Plan Project Geology and Soils Study
City of Rancho Cucamonga, California

Figure 3

Leighton

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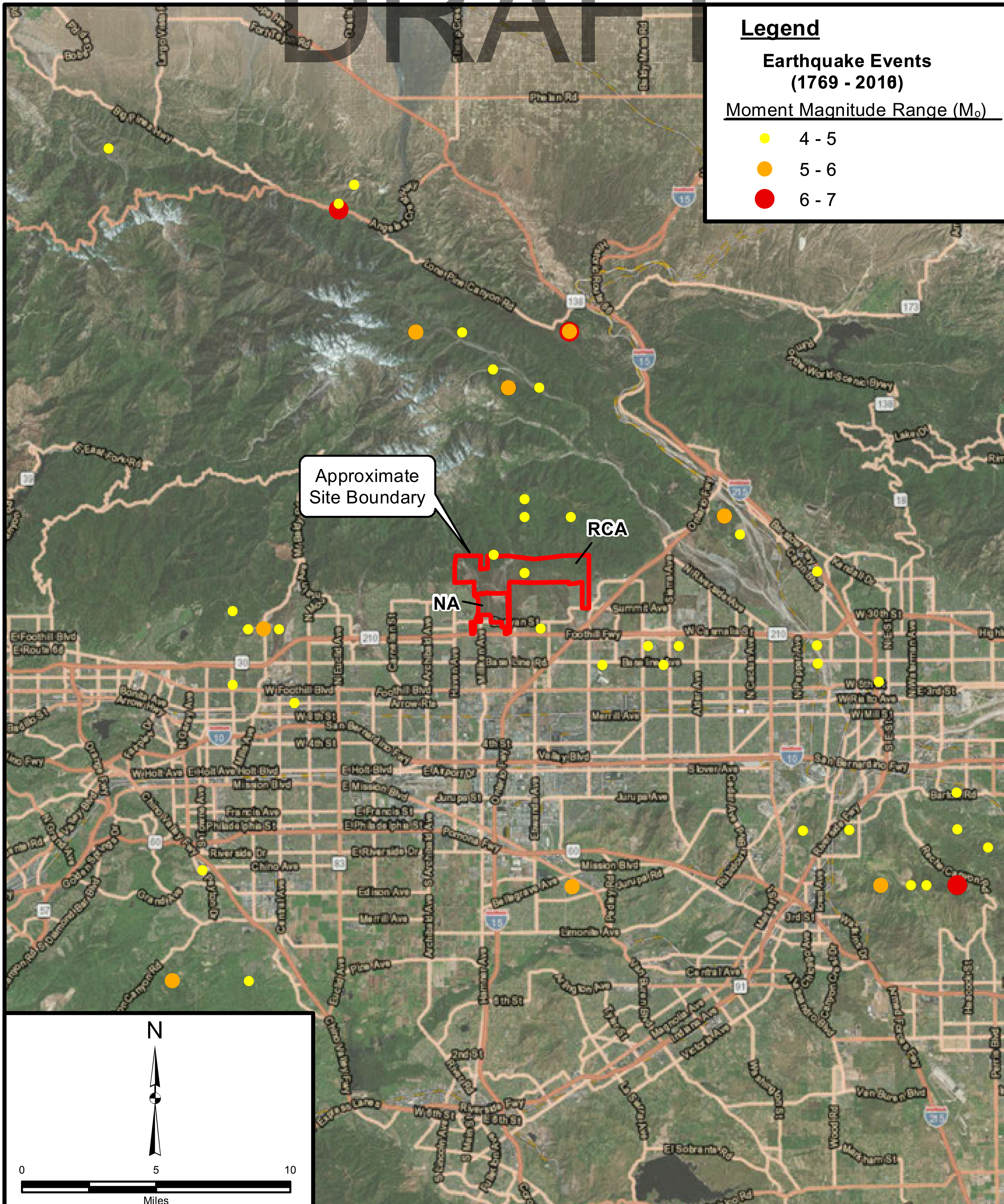

Project: 12281.001	Eng/Geol: JDH/PB
Scale: 1 " = 5 miles	Date: March 2019

Base Map: ESRI ArcGIS Online 2019
CGS, USGS, SCEC.

Author: Leighton Geomatics (mmurphy)

REGIONAL SEISMICITY MAP

Etiwanda Heights Neighborhood and Conservation Plan
Project Geology and Soils Study
City of Rancho Cucamonga, California

Figure 4

Leighton

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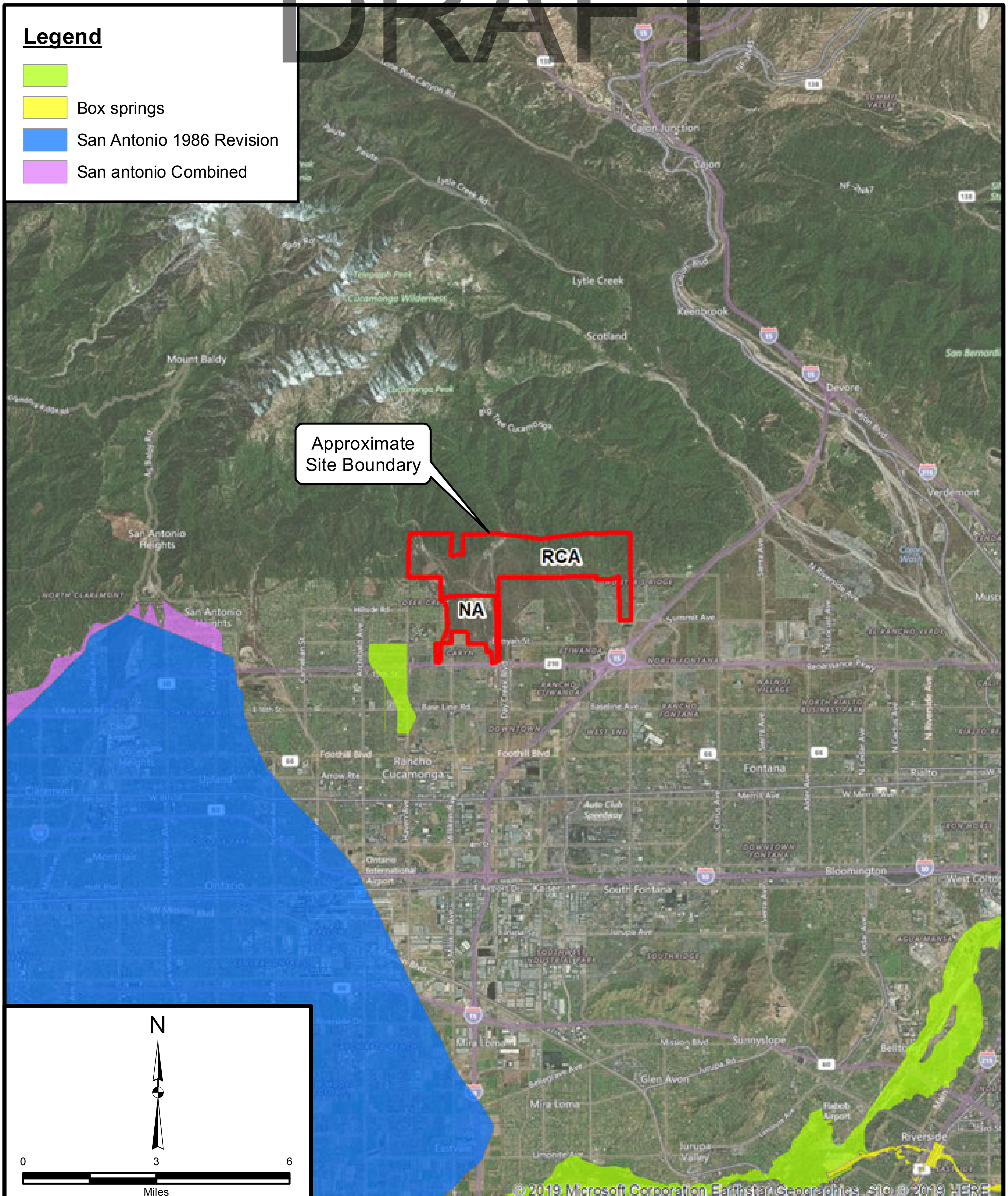

Project: 12281.001	Eng/Geol: JDH/PB
Scale: 1 " = 3 miles	Date: March 2019

Base Map: Bing Maps 2019

Author: Leighton Geomatics (mmurphy)

Figure 5

DAM INUNDATION MAP

Etiwanda Heights Neighborhood and Conservation Plan Project Geology and Soils Study
City of Rancho Cucamonga, California

Leighton

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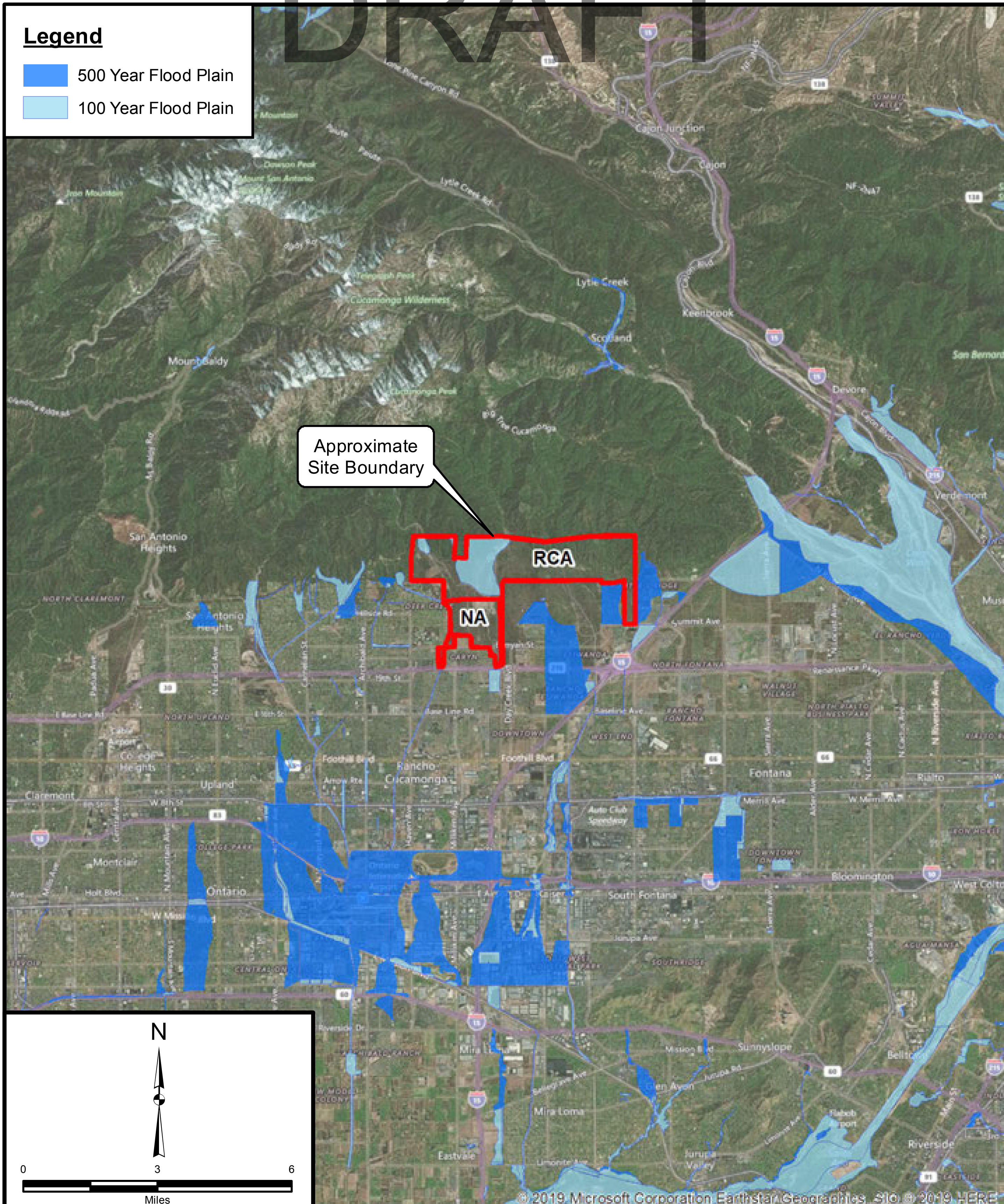

Project: 12281.001	Eng/Geol: JDH/PB
Scale: 1 " = 3 miles	Date: March 2019

Base Map: Bing Maps 2019
CA DWR, FEMA

Author: Leighton Geomatics (mmurphy)

FLOOD HAZARD MAP

Etiwanda Heights Neighborhood and Conservation Plan Project Geology and Soils Study
City of Rancho Cucamonga, California

Figure 6

Leighton

Map Saved as P:\Drafting\12281\001\Maps\12281-001_F06_FHM_2019-02-12.mxd on 2/12/2019 2:25:35 PM

APPENDIX A

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APPENDIX A

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Aerial Photos Reviewed:

Date:	Flight:	Frames:	Scale:	Source:
11/10/1955	22306	6-30 & 6-31	1:14,400	SBCFC
12/2/1965	C-140	63 & 64	1:24,000	SBCO
2/27/1969	C-295	19 & 20	1:24,000	SBCFC
2/25/1986	C-450	156 & 157	1:24,000	SBCFC