FINAL REPORT

GEOLOGIC HAZARD ASSESSMENT PIPELINE SAFETY & RELIABILITY (PSR) PROJECT – RAINBOW METER STATION TO MCAS MIRAMAR SAN DIEGO COUNTY, CALIFORNIA

Prepared for:

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URS Project No. 27661428.10000

June 9, 2015

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Subject: Geologic Hazard Assessment – Pipeline Safety & Reliability (PSR)
Rainbow Meter Station to MCAS Miramar
San Diego County, California
URS Project No. 27661428.10000

Dear Mr. Ith:

URS Corporation Americas (URS) is presenting this final report that summarizes the results of our geologic hazard assessment for the proposed gas transmission pipeline. The Pipeline Safety & Reliability (PSR) project extends from the Rainbow metering station to MCAS Miramar. URS prepared this report in accordance with our original proposal dated July 30, 2014.

The proposed project is approximately 47 miles in length and is planned as a 36-inch diameter natural gas pipeline. Our hazards assessment is intended to provide preliminary geologic hazards information to support project planning, design, and permitting.

We appreciate the opportunity to work with you on this project. If you have any questions regarding this report, please contact us.

Sincerely,

URS CORPORATION

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SECTION 1 INTRODUCTION

This report presents a preliminary hazard assessment for the proposed natural gas transmission line. Our knowledge of the site and geologic conditions has been developed from a review of published and unpublished geology and geologic hazards information, an analysis of aerial imagery, a limited site reconnaissance and our experience in the general site area and in the geologic materials anticipated along the alignment.

1.1 PROJECT DESCRIPTION

The proposed project is a 36-inch line that would extend approximately 47 miles from the Rainbow meter station to MCAS Miramar. Our understanding of the proposed route as shown on Figure 1 is based on alignment information provided by San Diego Gas & Electric (SDG&E) and the Southern California Gas Company (SoCalGas).

1.2 PURPOSE AND SCOPE

The purpose of the geotechnical and geologic hazards assessment is to provide preliminary geologic and geotechnical information to support permitting, and to assist with route selection, site development planning, and preliminary engineering design. Specifically, the anticipated subsurface conditions and potential seismic and geologic hazards have been be evaluated with respect to the proposed pipeline route.

The purposes of this study were as follows:

- Characterize the various geologic formations present along the pipeline;
- Identify suspected landslides and areas of landslide susceptibility within the pipeline corridor and provide a preliminary characterization of these hazards;
- Identify areas having seismically-induced liquefaction potential and other geologic hazards based on geologic formations and published maps;
- Identify areas of possible hard rock where blasting or heavy ripping may be required to excavate the trench;
- Provide a ground motion assessment based on regional information.

The scope of work performed was developed to meet the purposes of the study described above. This investigation included the following key tasks:

- Literature review;
- Terrain analysis based on digital imagery and stereographic aerial photographs
- Preparation of a geologic strip map;
- Alignment reconnaissance;
- Preparation of this report.

No subsurface investigations or hydrological studies were completed as part of this study.

1.3 AVAILABLE INFORMATION

The primary sources of geologic information were obtained from published geologic and geologic hazard mapping from the California Geological Survey (CGS). The CGS has compiled regional geologic maps in a 30 minute by 60 minute format for the Oceanside and San Diego quadrangles (CGS, 2007; CGS, 2008). These geologic maps are the basis for the geologic mapping presented in the Site Plan and Generalized Geologic Map sheets, Figures 2b through 2j. Figure 1 present a map index showing the individual sheets which are presented at a scale of 1:24,000 and which extend along the route from north to south.

In addition, we have reviewed landslide hazard mapping at the 7.5 minute quadrangle scale published by the CGS (CGS, 1995). We have also reviewed regional fault hazard maps including the USGS Quaternary Fault and Fold Database and CGS Alquist Priolo Earthquake Fault Zone Maps.

To augment the published hazard mapping we have reviewed digital imagery of the site using terrain modelling software (Google Earth Pro) and we have reviewed historic stereographic vertical aerial photographs of selected areas along the alignment. Based on the compiled geologic mapping we have evaluated the route based on the geologic units mapped and we have evaluated geologic hazards and geotechnical considerations as presented in Table 1 for each geologic unit encountered along the route.

SECTION 2 GEOLOGIC SETTING

2.1 GENERAL SETTING

The proposed Pipeline extends southward through the central portion of San Diego County starting near the northern boundary with Riverside County. This area lies within the Peninsular Ranges physiographic province, which is characterized by northwesterly trending mountain ranges and intervening valleys. A series of major drainages traverse the area in a generally westerly direction and include the San Luis Rey and San Dieguito Rivers. Lesser drainages crossed by the project alignment include: San Clemente Canyon, Beeler Canyon, Upper Penasquitos Creek, and Moosa Canyon.

2.2 GEOLOGIC CONDITIONS

The geologic units encountered along the pipeline alignment consist of Mesozoic metamorphic and granitic rocks of the Peninsular Ranges batholith of southern California (about 23.2 miles of the alignment), and Tertiary (about 9.5 miles of the alignment) and Quaternary sedimentary rocks (about 17.0 miles of the alignment). The sedimentary rocks consist of nonmarine, marine, fluvial, and lacustrine strata. The sedimentary strata unconformably overlie the metamorphic and batholithic rocks in the Peninsular Ranges. The mapped locations of bedrock geologic units and surficial deposits present along the transmission line are based on published geologic mapping including the San Diego and Oceanside Quadrangles (CGS, 2008; CGS 2007).

The approximate areal extent of the soil and rock units encountered along the route is shown on Figures 2b through 2j with a geologic legend presented as Figure 2a. A summary of geologic conditions including anticipated geologic unit and potential geologic hazards is present in Table 1. Table 2 provides the lithologic descriptions of the geologic units encountered within the general project map area.

2.2.1 Quaternary Surficial Deposits (Qaf, Qw, Qya, Qyc, Qoa, Qls)

Holocene and late Pleistocene alluvial deposits are present locally in drainages throughout the project alignment. The most significant accumulations of young alluvial flood plain deposits (Qya) are in the San Luis Rey River valley and the San Dieguito River valley (San Pasqual Valley/Lake Hodges). Intermediate sized drainages with significant accumulations of alluvial deposits include Moosa Canyon, Penasquitos Creek, Beeler Canyon, and San Clemente Canyon. The alluvial materials consist mostly of poorly consolidated, poorly sorted, permeable flood plain deposits. Old alluvial flood plain deposits (Qoa) are exposed at some locations and typically underlie the younger alluvial deposits within most alluvial valleys. The older deposits are similar in composition to the younger alluvium but generally exhibit greater strength and may be slightly or even moderately cemented locally.

Large boulders that result from exfoliation and differential weathering processes are also present at the ground surface thought much of the area underlain by granitic terrain. Material from rocky outcrops in steep terrain is subject to some down slope movement; thus, some of the rock at the surface has been transported short distances by gravity.

Landslide deposits (Qls) and possible landslide deposits (Qls?) are present along and near the alignment as discussed in Section 3.4. These masses range from highly fragmented to largely coherent landslide deposits and may be unconsolidated to moderately well consolidated. Many of these features are Pleistocene age landslides that may have been reactivated to varying degrees in the Holocene.

Other surficial materials including young colluvial deposits (Qyc) are mapped in Figure 2. Artificial fill (Qaf) resulting from construction, mining or quarrying activities including compacted engineered and non-compacted non-engineered fill that has been placed along various portions of the alignment. These materials may not be shown on geologic maps even when present.

2.2.2 Older Quaternary Deposits (Qvop4, Qvop3, Qvop2)

Very old paralic deposits (Qvop) consisting of poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone, and conglomerate are exposed in the incised canyons (e.g., San Clemente Canyon) in the southern part of the alignment. These units are mapped in association with their deposition on ancient wave cut terraces with specific elevations, and are designated by numbers that increase with decreasing age of the deposit on geologic maps. Four discreet map units ranging from Qvop4 (the youngest unit on the lower terrace) to Qvop2 (the oldest unit on the highest terrace) are crossed by the alignment.

2.2.3 Tertiary Sedimentary Deposits (Tp, Tmv, Tst, Tf, Tt)

Eocene sedimentary deposits of the Poway and La Jolla Groups are present along the southern portion of the alignment. The Poway Group is comprised of conglomerate, nonmarine sandstone, and brackish water claystone and is subdivided into Pomerado Conglomerate (Tp), Mission Valley Formation (Tmv), Stadium Conglomerate (Tst), and Friars Formation (Tf), from youngest to oldest, respectively. The Pomerado Conglomerate and Stadium Conglomerate are lithologically similar and are composed of nonmarine massive cobble conglomerate with a coarse-grained sandstone matrix that is indurated with some sandstone interbedded tongues. The gravels, cobbles and rare boulders consist predominantly of rounded weakly metamorphosed volcanic and volcaniclastic rocks with lesser quartzite and granitic rock. The Mission Valley Formation is predominantly soft and friable fine to medium-grained marine and nonmarine sandstone with cobble conglomerate tongues. The Friars Formation is a medium-grained, massive, poorly indurated nonmarine and lagoonal sandstone and claystone with tongues of cobble conglomerate. The Friars Formation is also considered the upper part of the La Jolla Group, of which outcrops of the Torrey Sandstone (Tt) are present near the alignment.

2.2.4 Crystalline Rocks of the Peninsular Ranges Batholith of Southern California (Kis, Kmm, Kgd, Kwm, Kjd, Kr, Ki, Kt, Kgb, Mzu)

The pipeline alignment passes through the Peninsular Ranges of Southern California and thus encounters extensive granitic rock, where tonalite and granodiorite are the most abundant single rock types, although the composition ranges from gabbro to granite. The map unit designations apply to generic rock composition, such as granodiorite undivided (Kgd), tonalite undivided (Kt), and gabbro undivided (Kgb); or apply to localized references of geographic significance (e.g., granodiorite of Woodson Mountain [Kwm]).

For shallow excavations and foundation design in crystalline granitic rock, the degree of weathering and fracturing, rather than granitic rock composition, has a more significant effect on rock quality and engineering properties.

2.2.5 Metasedimentary and Metavolcanic Rocks (Mzu)

Metamorphic rocks found along the margins of the younger mid-Cretaceous crystalline batholithic rocks are crossed by the pipeline alignment. This map unit includes a wide variety of low to high-metamorphic grade metavolcanic and metasedimentary rocks that are mostly volcaniclastic breccia and metaandesitic flows, tuffs, and tuff-breccia.

2.3 TECTONIC SETTING

The current tectonic setting of southern California is controlled by its location within the plate boundary zone between the Pacific and North American Plates. The Pacific Plate is moving northwest relative to the North American Plate at a rate of about 50 millimeters per year (mm/yr) (deMets *et al.*, 1994). Most of this plate motion is accommodated on a series of strike-slip fault zones that constitute the San Andreas Fault System, which includes the San Andreas, San Jacinto, Elsinore, and Rose Canyon-Newport Inglewood fault zones. This crustal interaction of predominantly dextral (right-slip) faults spans from the Salton Trough across the Peninsular Ranges, and extends west approximately 60 miles offshore into the Continental Borderland Province. The site lies within this broad plate boundary and between the Elsinore and Rose Canyon-Newport Inglewood fault zones. Figure 3 presents a regional fault and epicenter map.

SECTION 3 GEOLOGIC HAZARDS

This section addresses potential geologic hazards along the proposed pipeline. A summary of our evaluations of geologic hazards including; fault rupture, seismic shaking, liquefaction and seismic settlement, and slope stability along the alignment is presented below.

3.1 FAULTS

The proposed Pipeline does not cross any active or potentially active faults. The northern end of the route lies within approximately 2 miles of the active Elsinore fault zone. The active Rose Canyon-Newport Inglewood fault lies to the west of the project alignment at distances of 8 miles or more. Figure 3 presents a regional fault and epicenter map and shows the locations of regional faults relative to the proposed project.

3.1.1 Elsinore Fault Zone

The Elsinore fault zone is a significant element of the San Andreas fault system and is classified as an active Earthquake Fault Zone (EFZ) over much of its length (Hart and Bryant, 2007). The fault zone is over 137 miles long, extending from near the Mexican border to the northwest end of the Santa Ana Mountains. It is comprised of multiple fault strands and is considered capable of generating maximum magnitude earthquakes ranging from Mw6.5 to 7.5 (SCEC, 2014). The nearest strands of the fault zone to the project are the Willard and Wildomar faults located in Temecula.

3.1.2 Rose Canyon – Newport Inglewood Fault Zone

The Newport-Inglewood – Rose Canyon Fault Zone is a major structural element within the Peninsular Ranges. The fault zone extends from Newport Mesa (and possibly further north) to south of the San Diego Bay. It may be capable of generating maximum moment magnitude (Mw) earthquakes ranging from Mw6.0 to 7.2; this estimate is uncertain due to the uncertainty in the continuity of the fault zone (SCEC, 2014).

The Rose Canyon fault zone portion dominates the seismic exposure of coastal San Diego. The primary faults comprising the Rose Canyon fault zone extend on land from La Jolla and continues south along the east margin of Mission Bay to the Old Town area. The Rose Canyon fault zone then continues south toward downtown San Diego, and branches and steps through San Diego Bay and south of the border roughly parallel to the coastline.

3.1.3 Historical Seismicity

The historical seismicity of central and western San Diego County has been relatively low. To the east and southeast of the site is the Salton Trough, a very active seismic zone that contains high slip rate faults including the southern San Andreas, Imperial and San Jacinto faults. The Imperial fault has ruptured twice in the last 70 years and the San Jacinto Fault has displayed the highest activity level of any fault in the State. The recent Mw7.2 Sierra El Major-Cucapah earthquake event occurred to the south of the Salton Trough in Mexico at a distance of approximately 100 miles or more from the route.

Closer to the route, the Elsinore fault has displayed a much lower rate of activity. There have been few historical surface-rupturing earthquakes on segments of the Elsinore fault zone. The 1910 M6 Temescal Valley earthquake ruptured the surface along about 9.3 miles of the Glen Ivy segment (north of Lake Elsinore), and the Laguna Salada fault (considered the southern end of the Elsinore fault zone, located in Mexico) may have produced an Mw7.8 earthquake in 1892 south of the International Border (Mueller and Rockwell, 1995). Paleoseismic studies have shown prehistoric fault rupture on the Temecula, Julian, and Coyote Mountain segments of the Elsinore fault zone.

To the west, the Rose Canyon-Newport Inglewood fault zone has been relatively quiet seismically. Some microseismicity occurred in San Diego Bay in the 1980s, but no major events have occurred in historic time. Paleoseismic studies suggest that the last large event on the Rose Canyon fault may have occurred on the order of 300 years ago.

3.2 SEISMIC SHAKING

Figure 4 is a generalized shaking hazard map presenting peak horizontal ground acceleration (PGA) as a percentage of the acceleration of gravity (g). The hazard level depicted represent the PGA associated with a 10 percent probability of being exceeded in 50 years (return period of 475 years) for bedrock conditions. The map is derived from seismic hazard curves calculated on a grid of sites across the southwestern United States that describe the frequency of exceeding a set of ground motions within delineated fault sources. The ground motions relate the source characteristics of the earthquake and propagation path of seismic waves through the ground at a particular site or vicinity. The predicted ground motion is typically quantified in terms of a median value (*i.e.*, a function of magnitude, distance, type of faulting, the geologic or subsurface characteristics, and other factors) and a probability density function of PGA (Peterson *et al.*, 2008). The strongest shaking at this hazard level is a result of potential earthquakes along the Elsinore fault.

Active faults pose an indirect hazard to structures such as pipelines through ground shaking generated by rupture of regional faults located at some distance from the facility. Burial of pipelines generally isolates them from the effects of inertial forces important in the design of above ground structures (e.g., buildings and bridges), but makes them susceptible to relative ground motions which cause distortions and strains. Pipeline systems can be designed to resist most, but not all potential earthquake loads and displacements. Seismic damage to underground piping systems has been caused by fault displacements, landslides, liquefaction and associated lateral spreading and seismic settlement, differences in dynamic properties of adjacent materials (e.g., soil and rock), and ground strains associated with traveling seismic waves. Pipelines traverse large areas and must often cross zones of potentially unstable soils. Careful planning in route selection, pipeline orientation, and location of critical components can promote good performance during earthquakes. Modern, welded ductile steel pipelines with adequate corrosion protection have a good performance record (FEMA, 1992).

3.3 LIQUEFACTION AND SEISMIC SETTLEMENT

Liquefaction and seismic settlement are secondary effects associated with seismic shaking. Liquefaction is a phenomenon in which loose to medium dense, saturated, granular materials undergo matrix rearrangement, develop high pore water pressure, and lose shear strength because of cyclic ground vibrations induced by earthquakes. This rearrangement and strength loss is followed by a reduction in bulk volume of the liquefied soils. The effects of liquefaction can include the loss of bearing capacity below foundations, settlement in level ground, and instability in areas of sloping ground (also known as lateral spreading). Liquefaction is generally considered to occur within 50 feet of the ground surface and is often limited to depths of 30 feet or less when evaluating more significant deformations. Seismic settlement results from the densification of granular soils during earthquake-induced shaking in dry or partially saturated soils. Where the pipeline passes from a non-liquefiable soil to a liquefiable soil, such as occurs when the alignment passes from bedrock into alluvium, differential settlement at the contact point can place stress on the pipeline.

The hazard liquefaction poses to a pipeline include the loss of support around the pipe, subjecting it to excessive stresses and the possibility of "floating" the pipe to the ground surface.

Based on our preliminary assessment and the anticipated conditions the potential for liquefaction and seismic settlement is considered low for the majority of the proposed alignment. Numerous minor drainages are crossed as noted in Table 1 where short stretches of young alluvium underlies the route. Shallow groundwater and thick sections of liquefying materials are not anticipated in these minor crossings and our preliminary hazard assessment characterizes these areas as having a low liquefaction and seismic settlement hazard potential relative to the pipeline. Intermediate and large drainages are also crossed by the route and liquefaction and seismic settlement hazards are present as noted by Milepost in Table 1 and described in general terms here.

Table 1 identified several locations along the proposed pipeline where relatively thick sequences of loose to medium dense alluvial soils may be present and where shallow groundwater conditions are anticipated. Specifically, a potential for liquefaction is present at the major river or canyon crossings, including the San Luis Rey River (MP 8.8) and the San Dieguito River (MP 30.0).

3.4 LANDSLIDES AND LANDSLIDE SUSCEPTIBLE ZONES

Landslides are a significant geologic hazard in southern California. Within San Diego County, the areas of greatest landslide hazard are generally located in the western and central portion of the county where layered sedimentary deposits are present. These sedimentary units contain inherently weak layers that may be exposed by natural erosion or grading activities. When unfavorable geologic and topographic conditions coincide, landsliding may result.

The northern portion of the proposed route is underlain by primarily by variably weathered crystalline rocks with lesser Quaternary deposits. Beginning at approximately MP 34 and extending southward to the end of the pipeline the route is underlain by a mix of Tertiary age sedimentary deposits, Mesozoic crystalline rocks and Quaternary age sediments. The Tertiary age sedimentary deposits include the Friars Formation, a landslide prone geologic unit that includes weak clay layers and localized occurrences of very weak bedding plane shears. Hill slopes underlain by this formation have a susceptibility to landslides. The mapped landslides and zones of greatest landslide susceptibility generally occur within or immediately adjacent to the mapped occurrence of the Friars Formation as shown on Figures 2h, and 2i.

The potential impact on the project from landslides can range from insignificant where the alignment passes near the toe of ancient, relatively stable landslides, to potentially more significant where it passes across or near the head of ancient landslides. There is no evidence of active landslides with the proposed alignment and the mapped and suspected landslides present along the route are considered ancient features and are primarily within areas already developed.

3.5 EXPANSIVE AND COLLAPSIBLE SOILS

Changes in moisture can cause shrinkage and expansion of clayey, fine-grained soils. Collapse can occur in dry or partially saturated soils that have unstable soil structure due to decomposition or irrigation processes, typically with a skeletal structure that is weakly cemented by clays or soluble salts. Increases in moisture content can cause the interparticle cementation to reduce, causing changes in volume (collapse), especially when loaded.

The soil conditions along the proposed route generally consist of granular deposits and variably weathered rock. Clayey soils, where encountered are likely to occur in relative shallow residual soil layers (upper 2 to 5 feet) and in the limited areas underlain by Friars Formation between approximately MP 34 and MP 39.5. The buried pipeline is not likely to be negatively impacted by the presence of shallow localized clayey residual soils or the weathered claystones of Friars Formation.

Collapsible soils are not a common occurrence in western or central San Diego County. In addition, the buried steel pipeline is not particularly sensitive to small scale or localized differential settlements of the kind anticipated if minor zones of collapsible soils were present. Based on our preliminary assessment, the soil and weathered rock units along the proposed route are unlikely to have significant expansion or collapse potential.

3.6 SCOUR

At any stream or river crossing there is the potential for scour during large runoff events or long-term degradation of the streambed that could potentially expose an insufficiently buried pipeline. The alignment crosses the San Luis Rey River, the San Dieguito River (near the upper reaches of Lake Hodges) and several smaller drainages. Where there could be movement of the streambed or of the channel during large events the pipeline must be placed at a depth sufficient to prevent exposure. This depth should be estimated by design level hydrologic studies using grain size, flow data, meteorological data and typical stream channel cross-section data.

SECTION 4 DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

This section presents a discussion of the general impacts to the proposed route as a result of geologic hazards, and conclusions and recommendations regarding geologic and seismic hazards.

4.1 FAULT RUPTURE HAZARDS

The proposed route does not cross any active or potentially active faults and therefore fault rupture is not considered a significant hazard.

4.2 SEISMIC SHAKING

Seismic shaking levels and the subsequent geologic hazard varies across the pipeline alignment. Figure 4 presents a regional ground shaking zonation representing probabilistic ground motions (peak ground acceleration – PGA) at the 10 percent probability of exceedance in 50 years. At this hazard level the central and southern portions of pipeline would be exposed to ground motions less than 0.3 g's (acceleration of gravity) or less. The northern end of the pipeline is potentially exposed to strongest ground motions for the hazard level depicted. Adherence to modern gas pipeline design and construction practices and applicable codes will mitigate the risk from seismic shaking.

4.3 LIQUEFACTION AND SEISMIC SETTLEMENT

Saturated alluvial deposits along creeks, streams, and drainages have the highest likelihood of presenting conditions where liquefaction can occur. Potential consequences of liquefaction include settlement, lateral spreading, loss of bearing capacity, and pipeline flotation. Based on preliminary screening of geologic conditions, we expect the most significant potential for liquefaction and seismic settlement along the alignment to be associated with the major river crossings described in Section 3.3 and tabulated in Table 1. Much of this hazard will be mitigated by the planned trenchless crossings at the San Luis Rey and San Dieguito River locations. Design level studies should provide estimated liquefaction-induced ground deformation for high hazard areas, and the pipeline designer can evaluate whether the pipeline can sustain the estimated ground deformations. If mitigations are warranted based on design level studies, consideration would be given to rerouting to avoid zones of potential liquefaction, or localized ground improvement methods (e.g., stone columns, dynamic compaction, jet grouting) may be considered to prevent liquefaction.

Trenchless technologies will be used to install the pipeline across major roadways and water crossings. These methods can also be used to cross environmentally sensitive sites. A summary of the anticipated trenchless crossings is provided in Table 3. Two methods are anticipated for trenchless crossings: bore-and-jack and HDD. Both methods require subsurface characterization at the design level to define soil, rock and groundwater conditions for the design of the crossing.

The bore-and-jack method involves installing a pipeline by pushing a string of pipes through the ground with large hydraulic jacks situated with a jacking pit located at either end of the drive. Soil excavation is conducted at the advancing end of the pipe string using a continuous flight auger that is powered by a horizontal boring machine (i.e., a one-pass system). Alternatively, an outer steel casing may be first installed and the carrier pipe subsequently placed inside the casing (i.e., a two-pass system). Bore-and-jack will likely be used for several roadway and waterway crossings.

Horizontal Directional Drilling (HDD) is a surface-launched process for boring beneath obstacles, such as roadways, rivers and wetland areas and installing a pipeline in the bore. A small-diameter pilot bore is drilled along the design alignment and stabilized by filling it with drilling fluid. The pilot bore is then enlarged by successive reaming passes, keeping the bore filled with drilling fluid. When the bore diameter is approximately 12 inches larger than the pipeline, the pipeline is pulled into the bore hole, displacing most of the drilling fluid. Jacking pits or shafts are not required, because HDD bores are installed along a sweeping vertical curve from surface to surface. A minimum cover is provided beneath the channel or environmentally sensitive feature to minimize the potential for drilling fluid to "frac out" of the bore hole and reach the ground surface somewhere between the two end points. HDD will likely be used for longer river and interstate highway crossings.

4.4 LANDSLIDES

Based on our review, ancient landslides and landslide susceptible zones are traversed by the route in two general areas along Pomerado Road as called out Table 1. The areas of possible concern are between approximate MP 34.2 and 36.2 and MP 38.1 and 39.4, respectively. These areas do not show evidence of movement in the recent geologic past and do not appear to represent a high level of risk to the proposed route based on our preliminary assessments. However, these areas should be further evaluated during design level geotechnical and geologic hazard investigations and feasible mitigations recommended, if needed. Such mitigations would be based on site specific information and may include, but would not be limited to: minor re-routes to align the pipeline outside of the limits of the landslide; placing the pipeline beneath the landslide; and placement of shutoff valves outside the area of concern.

4.5 SCOUR

While there is the potential for erosion or scour at the drainage crossings, the use of construction Best Management Practices (BMPs) for erosion control can be implemented to avoid significant impacts along the alignment.

At streams and rivers, the final pipeline design should consider potential scour and stream course migration to ensure that the pipeline is buried deep enough to avoid potential impact on the pipeline through erosion.

4.6 EXPANSIVE AND COLLAPSIBLE SOILS

Potentially collapsible soils are not commonly encountered with the majority of geologic units traversed by the route. Given the depth of buried for the pipeline and the general resilience of large diameter steel pipelines to minor settlement, collapsible soils are not a significant hazard with respect to pipeline performance.

4.7 OTHER GEOLOGIC HAZARDS

Other geologic hazards including tsunamis, volcanic eruption and seiches are not present in the project area and do not impact the project based on a review of the geologic and physiographic setting of the site.

4.8 GROUNDWATER

The depth to groundwater is generally expected to be well below the depth of the pipeline. In streambed areas, high rates of groundwater inflow are possible because of the presence of sands and gravels, and may occur within the pipeline trench or bore-and-jack pits. If dewatering is required during construction, the use of construction dewatering systems may be required to control groundwater inflow. Where construction dewatering is required, these systems may require review and approval by regulatory agencies.

4.9 EXCAVATION CHARACTERISTICS

Most of the pipeline alignment is located in weathered granitic rock, alluvial deposits, and sedimentary rock formations. Much of this material can be excavated using conventional excavation equipment typically used for pipeline construction in mountainous terrain. Portions of the route are underlain by nonrippable rock. Heavy ripping may be required to break up boulders or well cemented sandstone and conglomerate beds within some of the sedimentary rock to a manageable size. Heavy ripping and blasting may be required in less weathered granitic rock (see Table 1).

4.10 CONCLUSIONS

This geotechnical and geologic hazards assessment report maps and characterizes the various geologic materials and hazards present along the proposed route of the pipeline. Principal hazards include seismic shaking (as with any site in California) and landslides as well as areas of potential liquefaction and scour. General mitigation strategies for these hazards have been presented. Design level investigation of these hazards is recommended to confirm the presence or absence of the hazards that have been identified preliminarily in this study and to provide appropriate mitigation options, as needed.

Open cut trenches excavated with heavy duty equipment are feasible for much of the alignment, though localized areas of hard rock where heavy ripping, rock breaking or blasting may be required have been preliminarily identified. Geotechnical investigations are recommended to further define conditions along the pipeline to support planning, design and construction cost estimates for the project. The project appears feasible from a geotechnical and geologic hazards perspective, provided that standard design and construction practices are followed and that appropriate evaluation and mitigation measures are applied to the geologic hazards present.

SECTION 5 UNCERTAINTIES AND LIMITATIONS

The preliminary assessments made herein are based on the review of available information. We recommend that design level geotechnical studies be performed to support project design and that geologic hazards and geotechnical considerations be addressed. This would include evaluations of seismic hazards, liquefaction potential, landslides, faults and geotechnical considerations like trench wall stability and difficult excavation due to hard rock conditions.

Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgments presented herein are based partly on our understanding of the proposed construction, and partly on our general experience. Our engineering work and judgments rendered meet current professional standards; we do not guarantee the performance of the project in any respect.

The professional judgments and interpretations presented in this report are based on our current knowledge of the proposed project, our preliminary interpretations of the subsurface conditions in the project area, and our understanding of the geologic and tectonic setting of the project. This knowledge is based on the information provided to us, published literature, previous studies, and our assessments referenced in this report.

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Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
0.0	0.0	Kr	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipated relatively deep weathering - potential rock excavation
0.0	0.2	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
0.2	0.6	Kr	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible shallow hard rock -
0.6	0.7	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
0.7	0.7	Kr	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible shallow hard rock -
0.7	0.9	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
0.9	1.6	Kr	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible shallow hard rock -
1.6	1.6	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
1.6	1.9	Kr	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible shallow hard rock -
1.9	1.9	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
1.9	2.3	Kr	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible shallow hard rock -
2.4	2.6	Kgb	Crystalline Bedrock	Weathered gabbroic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
2.6	2.8	Mzu	Crystalline Bedrock	Weathered metamorphic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
2.8	3.3	Kgb	Crystalline Bedrock	Weathered gabbroic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
3.3	3.3	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
3.3	3.9	Kgb	Crystalline Bedrock	Weathered gabbroic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
3.9	4.3	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
4.3	4.3	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
4.3	4.4	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
4.4	4.4	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
4.4	4.5	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
4.5	4.5	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
4.5	4.7	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression

Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
4.7	5.5	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
5.5	6.1	Mzu	Crystalline Bedrock	Weathered metamorphic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
6.1	6.8	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Moderate potential for liquefaction/seismic settlement in tributary drainage to San Luis Rey River. Potential trench wall instability
6.8	6.9	Ki	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
6.9	7.0	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
7.0	7.1	Ki	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
7.1	7.4	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Trench wall stability, potential over sized material
7.4	7.5	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
7.5	8.3	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
8.3	8.4	Ki	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
8.4	8.7	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
					Crossing at Hwy 76 along Old Hwy 395 n/o San Luis Rey River - See Table 3
8.7	8.8	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	High potential for liquefaction/seismic settlement in San Luis Rey River Valley Potential trench wall instability
8.8	8.9	Qw	River Channel	Liquefaction/seismic settlement - loose or soft materials	High potential for liquefaction/seismic settlement in San Luis Rey River Valley
					Crossing of San Luis Rey River – See Table 3
8.9	9.3	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	High potential for liquefaction/seismic settlement in San Luis Rey River Valley
9.3	9.5	Mzu	Crystalline Bedrock	Weathered metamorphic bedrock - excavation considerations	Hard rock excavation conditions possible
9.5	10.4	Ki	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Hard rock excavation conditions possible - likely in areas of deeper road cuts
10.4	12.4	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Relatively deep weathering profile - low potential for hard rock where trench excavations are near original ground surface - increased potential for hard rock in trench traversing cut slope above freeway off ramp.
					Crossing of I15 at MP11.6 - See Table 3

Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
12.4	12.6	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
12.6	12.6	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
12.6	13.3	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
13.3	13.6	Kmm	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible hard rock conditions within trench depths.
13.6	13.8	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
13.8	13.9	Kmm	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible hard rock conditions within trench depths.
13.9	14.0	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Moderate potential for liquefaction/seismic settlement in Moosa Canyon. Potential trench wall instability
14.0	14.5	Kjd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible hard rock conditions within trench depths - definite hard rock in areas of deeper road cuts.
14.5	14.7	Kmm	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible hard rock conditions within trench depths.
14.7	14.9	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
14.9	15.0	Kmm	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible hard rock conditions within trench depths.
15.0	15.1	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
15.1	15.3	Kjd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible hard rock conditions within trench depths.
15.3	15.7	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
15.7	16.6	Kjd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Possible hard rock conditions within trench depths.
16.6	17.6	Kmm	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Localized potential for hard rock within trench depths
17.6	18.3	Kjd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
18.3	18.8	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Possible trench wall instability, potential over sized or deleterious material
					Crossing of Deer Springs Road – See Table 3
18.8	20.7	Kjd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
20.7	21.2	Kmm	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Localized potential for hard rock within trench depths

Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
21.2	21.3	Mzu	Crystalline Bedrock	Weathered metamorphic bedrock - excavation considerations	Localized potential for hard rock within trench depths
21.3	21.7	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
21.7	21.8	Mzu	Crystalline Bedrock	Weathered metamorphic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
21.8	22.0	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Trench wall stability, potential over sized material
22.0	22.3	Kis	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
22.3	22.4	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
22.4	22.4	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
					Crossing of flood channel – See Table 3
22.4	23.4	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
23.4	23.5	af	Artificial Fill	Trench wall stability, deliterious material potential	Potential trench wall instability, potential over sized material
23.5	24.1	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
24.1	24.2	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
					Crossing of flood channel – See Table 3
24.2	25.4	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
25.4	25.8	Kwm	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
25.8	26.1	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
26.1	26.6	Kwm	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
26.6	26.8	Qyc	Young Colluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
26.8	28.0	Kwm	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
28.0	28.2	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
28.2	28.2	Qyc	Young Colluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
28.2	29.0	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
29.0	29.3	Qyc	Young Colluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material

Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
29.3	29.6	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
29.6	29.9	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
29.9	30.2	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	High potential for liquefaction/seismic settlement in San Dieguito River Valley
					Crossing of San Dieguito River/Lake Hodges – See Table 3
30.2	30.5	Qoa	Older Alluvium	Potential for running sands and cobble or boulder sized clast	Trench wall stability, potential over sized material
30.5	30.6	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
30.6	31.0	Kgb	Crystalline Bedrock	Weathered gabbroic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
31.0	31.8	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
31.8	31.9	Qyc	Young Colluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
31.9	32.1	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
32.1	32.2	Qyc	Young Colluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
32.2	32.5	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
32.5	32.5	Qyc	Young Colluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
32.5	32.6	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
32.6	32.7	Qyc	Young Colluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
32.7	33.0	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
33.0	33.3	Qyc	Young Colluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
					Crossing of Flood Channel – See Table 3
33.3	33.5	Kt	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
33.5	33.7	Qyc	Young Colluvium	Potential for running sands and cobble or boulder sized clast	Potential trench wall instability, potential over sized material
33.7	34.2	Kgd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
34.2	34.6	Tf	Sedimentary Deposits - Claystones, Siltstone	Layered fine grained materials, weak bedding planes	Evaluate potential for slope instability

Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
34.6	34.9	Kgd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
34.9	34.9	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
34.9	35.3	Kgd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
35.3	35.6	Tf	Sedimentary Deposits - Claystones, Siltstone	Layered fine grained materials, weak bedding planes	Evaluate potential for slope instability
35.6	35.6	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
35.6	35.8	Tf	Sedimentary Deposits - Claystones, Siltstone	Layered fine grained materials, weak bedding planes	Evaluate potential for slope instability
35.8	36.1	Qls	Qls	Ancient Landslide	Evaluate potential for slope instability
36.1	36.2	Tf	Sedimentary Deposits - Claystones, Siltstone	Layered fine grained materials, weak bedding planes	Evaluate potential for slope instability
36.2	36.7	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
36.7	36.9	Kgd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
36.9	36.9	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
36.9	37.1	Kgd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
37.1	37.4	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
37.4	37.5	Kgb	Crystalline Bedrock	Weathered gabbroic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
37.5	37.6	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
37.6	37.8	Kgd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
37.8	38.1	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
					Crossing of Flood Channel – See Table 3
38.1	38.1	Kgd	Crystalline Bedrock	Weathered granitic bedrock - excavation considerations	Anticipate deeper weathering based on geomorphic expression
38.1	38.4	Tf	Sedimentary Deposits - Claystones, Siltstone	Layered fine grained materials, weak bedding planes	Evaluate potential for slope instability

Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
38.4	38.5	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
38.5	39.0	Tf	Sedimentary Deposits - Claystones, Siltstone	Layered fine grained materials, weak bedding planes	Evaluate potential for slope instability
39.0	39.1	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Moderate potential for liquefaction/seismic settlement in Beeler Canyon area. Potential trench wall instability
39.1	39.3	Tf	Sedimentary Deposits - Claystones, Siltstone	Layered fine grained materials, weak bedding planes	Evaluate potential for slope instability
39.3	39.3	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
39.3	39.4	Tf	Sedimentary Deposits - Claystones, Siltstone	Layered fine grained materials, weak bedding planes	Evaluate potential for slope instability
39.4	40.1	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
40.1	40.2	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation
40.2	40.5	Tp	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
40.5	40.9	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation
40.9	42.0	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
42.0	42.1	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
42.1	43.2	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
43.2	43.4	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
43.5	43.5	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening

Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
43.5	43.8	Qvop2	Pleistocene age terrace deposits	Minor potential for gravels and cobbles	Localized potential for trench wall instability
43.8	43.9	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
43.9	43.9	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
43.9	43.9	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
43.9	44.2	Qvop2	Pleistocene age terrace deposits	Minor potential for gravels and cobbles	Localized potential for trench wall instability
44.2	44.3	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
44.3	44.3	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
44.3	44.4	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
44.4	44.4	Qvop3	Pleistocene age terrace deposits	Minor potential for gravels and cobbles	Localized potential for trench wall instability
44.4	44.6	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
44.6	44.6	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
44.6	44.8	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
44.8	44.8	Qvop2	Pleistocene age terrace deposits	Minor potential for gravels and cobbles	Localized potential for trench wall instability
44.8	45.0	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
45.0	45.2	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability

Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
45.2	45.2	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
45.2	45.2	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation
45.2	45.2	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
45.2	45.4	Qvop4	Pleistocene age terrace deposits	Minor potential for gravels and cobbles	Localized potential for trench wall instability
45.4	45.5	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
45.5	45.5	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation
45.5	45.5	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
45.5	45.7	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation
45.7	45.7	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
45.7	45.7	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation
45.7	45.8	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
45.8	45.8	Qvop4	Pleistocene age terrace deposits	Minor potential for gravels and cobbles	Localized potential for trench wall instability
45.8	45.8	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
45.8	45.9	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation

Table 1
Geologic and Geotechnical Route Characterization

Milepost Start	Milepost End	Map Unit	Geologic Formation (Map Unit)	Potential Geologic Hazards or Geotechnical Consideration	Preliminary Hazard Assessment -Geotechnical Considerations
45.9	46.0	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
46.0	46.0	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation
46.0	46.2	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
46.2	46.3	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
46.3	46.4	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
46.4	46.4	Qya	Young Alluvium	Liquefaction/seismic settlement - loose or soft materials	Low potential for liquefaction/seismic settlement. Potential trench wall instability
46.4	46.6	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
46.6	46.7	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation
46.7	46.7	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening
46.7	47.0	Tmv	Sedimentary Deposits - sandstones	Minor potential for localized cementation	Localized potential for difficult excavation
47.0	47.0	Tst	Sedimentary Deposits - conglomerates	Potential for cobble and trace boulder sized clasts and localized cementation	Localized potential for difficult excavation, localized potential for oversized material unsuitable for trench backfill without screening

Table 2
Lithology of Geologic Units

Map Unit	Name	Age	Lithologic Description
Qaf	Artificial fill	late Holocene	Deposits of fill resulting from human construction, mining, or quarrying activities; includes compacted engineered and non-compacted non engineered fill. Some large deposits are mapped, but in some areas no deposits are shown.[a]
Qw	Wash deposits	late Holocene	Unconsolidated bouldery to sandy alluvium of active and recently active washes.[a]
Qls	Landslide deposits undivided	Holocene and Pleistocene	Highly fragmented to largely coherent landslide deposits. Unconsolidated to moderately well consolidated. Most mapped landslides contain scarp area as well as slide deposit. In some areas scarp is shown separately. Many Pleistocene-age landslides were reactivated in part or entirely during late Holocene.[b]
Qya	Young alluvial flood plain deposits	Holocene and late Pleistocene	Mostly poorly consolidated, poorly sorted, permeable flood plain deposits.[a]
Qyc	Young colluvial deposits	Holocene and late Pleistocene	Mostly poorly consolidated and poorly sorted sand and silt slope wash deposits.[a]
Qoa	Old alluvial flood plain deposits undivided	late to middle Pleistocene	Fluvial sediments deposited on canyon floors. Consists of moderately well consolidated, poorly sorted, permeable, commonly slightly dissected gravel, sand, silt, and clay-bearing alluvium.[a]
Qvop4	Very old paralic deposits, Unit 4	middle to early Pleistocene	Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 170-174 m Aqueduct terrace.[b]
Qvop3	Very old paralic deposits, Unit 3	middle to early Pleistocene	Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 181-185 m Aliso Canyon terrace.[b]
Qvop2	Very old paralic deposits, Unit 2	middle to early Pleistocene	Mostly poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 190-194 m Flores Hill terrace.[b]
Tp	Pomerado Conglomerate	middle Eocene	Massive cobble conglomerate with a dark-yellowish-brown, coarse-grained sandstone matrix.[b]

Table 2
Lithology of Geologic Units

Map Unit	Name	Age	Lithologic Description
Tmv	Mission Valley Formation	middle Eocene	Predominantly light-olive-gray, soft and friable, fine- to medium-grained marine and non marine sandstone containing cobble conglomerate tongues.[b]
Tst	Stadium Conglomerate	middle Eocene	Massive cobble conglomerate with a dark-yellowish-brown, coarse-grained sandstone matrix. The conglomerate contains up to 85% of slightly metamorphosed rhyolitic to dacitic volcanic and volcaniclastic rocks and up to 20% quartzite.[b]
Tf	Friars Formation	middle Eocene	Yellowish-gray, medium-grained, massive, poorly indurated non-marine and lagoonal sandstone and claystone with tongues of cobble conglomerate.[b]
Tt	Torrey Sandstone	middle Eocene	White to light-brown, medium to coarse-grained, moderately well indurated, massive and broadly cross-bedded, arkosic sandstone.[b]
Mzu	Metasedimentary and metavolcanic rocks undivided	Mesozoic	Wide variety of low- to high-metamorphic grade metavolcanic and metasedimentary rocks that are mostly volcaniclastic breccia and metaandesitic flows, tuffs and tuff-breccia.[a]
Kis	Granite of Indian Springs	mid-Cretaceous	Fine-grained biotite granite (Similar in appearance to Granite of Dixon Lake).[a]
Kmm	Monzogranite of Merriam Mountain	mid-Cretaceous	Massive, medium- to coarse-grained, leucocratic hornblende-biotite monzogranite.[a]
Kgd	Granodiorite undivided	mid-Cretaceous	Medium- to coarse-grained hornblende-biotite granodiorite.[b]
Kwm	Granodiorite of Woodson Mountain	mid-Cretaceous	Massive, coarse-grained, leucocratic hornblende granodiorite. Part of the Woodson Mountain Granodiorite of Larsen, 1948.[a]
Kjd	Granodiorite of Jesmond Dean	mid-Cretaceous	Massive, fine-grained, dark-gray and black granodiorite.[a]
Kr	Granodiorite of Rainbow	mid-Cretaceous	Massive, medium- to coarse-grained, leucocratic hornblende-biotite granodiorite.[a]
Ki	Granodiorite of Indian Mountain	mid-Cretaceous	Massive, medium-grained, leucocratic biotite granodiorite.[a]
Kt	Tonalite undivided	mid-Cretaceous	Mostly massive, coarse-grained, light-gray hornblende-biotite tonalite.[a]
Kqbd	Quartz-bearing diorite undivided	mid-Cretaceous	Mostly massive, medium-grained, dark-gray biotite-hornblende quartz-bearing diorite.[a]

Table 2
Lithology of Geologic Units

Map Unit	Name	Age	Lithologic Description
Kgb	Gabbro undivided	mid-Cretaceous	Mostly massive, coarse-grained, dark-gray and black biotite-hornblende-hypersthene gabbro.[a]

a Geologic Map of the Oceanside 30' x 60' Quadrangle, California, Michael P. Kennedy and Siang S. Tan, 2007.

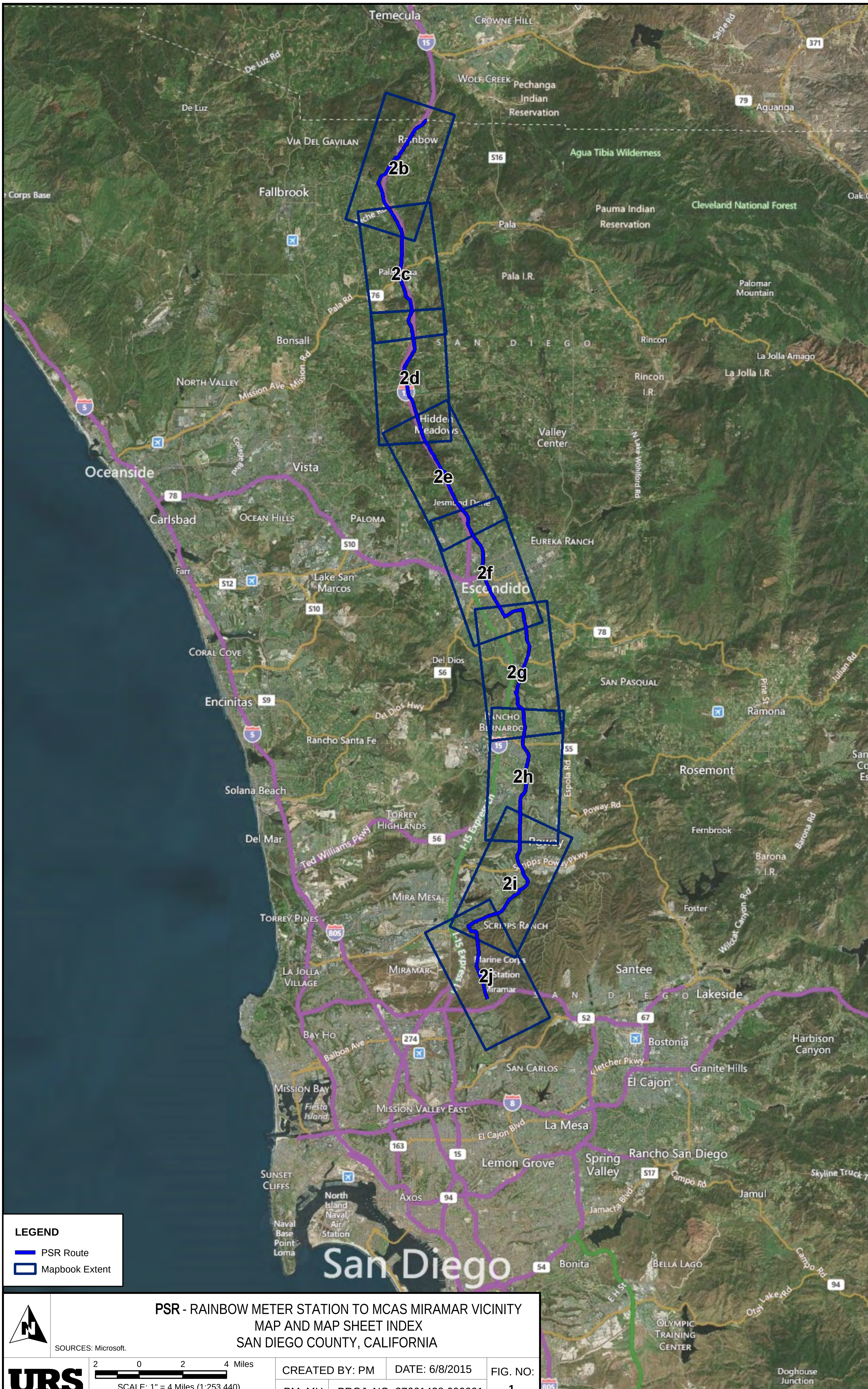
b Geologic Map of the San Diego 30' x 60' Quadrangle, California, Michael P. Kennedy and Siang S. Tan, 2008

Table 3
Geotechnical Considerations – Pipeline Crossings

Approx. MP	Geologic Unit/s	Construction Type	Crossing	Location/Description	Approx. Length (ft.)	Geotechnical Considerations
8.4	Tonalite	Bore	Highway	Hwy 76 along Old Hwy 395 N/o San Luis Rey River	200	Crossing underlain by weathered crystalline rock (granodiorite) in area of low relief; will likely require rock excavation techniques,hard rock conditions not anticipated, to be confirmed by geotechnical investigation
8.8	Tonalite and young alluvium	HDD	River	San Luis Rey River	3360	Major river crossing with the northern end of the alignment in highly weathered granitic rock transitioning to alluvium for most of the alignment. Shallow water table, granular alluvium with a potential for gravels, cobbles and boulders and a transition from weathered rock into weak alluvium are significant geotechnical considerations that may impact HDD design and construction.
11.6	Tonalite	HDD	Interstate	I-15 along Old Hwy 395 in Bonsall/Escondido	3000	Entire alignment appears to be underlain by variably weathered granitic rock (tonalite). Moderate terrain with potential for water inflow along fractures, geotechnical investigations needed to assess potential for hard rock based on depth of alignment
18.3	Granodiorite	Bore	Road	Deer Springs Rd Along Centre City Pkwy/Champagne Blvd (Possible bore; near freeway entrance with limitations to provide detours)	150	Short crossing underlain by weathered rock (granodiorite) with potential for localized shallow surficial deposits, geotechnical investigation needed to characterize conditions
22.4	Granite	Bore	Flood Channel	Along Centre City Pkwy N/o El Norte Pkwy	150	Short crossing mapped as underlain by weathered rock in area of relatively low relief, possible surficial deposits. Geotechnical investigation to verify material types and possible presence of perched water
24.1	Older Alluvium, alluvium	Bore	Flood Channel	Along Centre City Pkwy N/o Valley Pkwy	100	Short crossing underlain by alluvial deposits, possible low cohesion materials and perched water. Geotechnical investigation to verify material types and possible presence of perched water

Table 3
Geotechnical Considerations – Pipeline Crossings

Approx. MP	Geologic Unit/s	Construction Type	Crossing	Location/Description	Approx. Length (ft.)	Geotechnical Considerations
30.0	Young alluvium	Bore	Lake	San Dieguito River/Lake Hodges	2500	Long crossing with potential for shallow water, thick young alluvial deposits - low cohesion, possible gravels, cobbles, liquefaction potential, geotechnical investigation needed to characterize conditions.
33.0	Young Colluvium	Bore	Flood Channel	Along Pomerado Rd at Rancho Bernardo Rd	150	Surficial deposits, colluvium- potentially soft or loose, and possible sedimentary deposits (siltstone, claystone, sandstone -Friars Formation), possible perched water. Geotechnical investigation to verify material types and possible presence of perched water.
38.0	Young Alluvium	Bore	Flood Channel	Along Pomerado Rd at Robinson Blvd	150	Underlain by alluvial deposits, low cohesion, potential perched water, possible gravels and cobbles. Geotechnical investigation to verify material types and possible presence of perched water.



PSR - RAINBOW METER STATION TO MCAS MIRAMAR VICINITY MAP AND MAP SHEET INDEX
SAN DIEGO COUNTY, CALIFORNIA

SOURCES: Microsoft.

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SCALE CORRECT WHEN PRINTED AT 11X17

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Qaf, Artificial fill

Qls, Landslide deposits undivided

Qls?, Landslide deposits undivided, query denotes possilbe landslide

Qya, Young alluvial flood plain deposits

Qyc, Young colluvial deposits

Qoa, Old alluvial flood plain deposits undivided

Qw, Wash deposits

Qvop6, Very old paralic deposits, Unit 6

Qvop5, Very old paralic deposits, Unit 5

Qvop4, Very old paralic deposits, Unit 4

Qvop3, Very old paralic deposits, Unit 3

Qvop2, Very old paralic deposits, Unit 2

Qvop1, Very old paralic deposits, Unit 1

Tp, Pomerado Conglomerate

Tmv, Mission Valley Formation

Tst, Stadium Conglomerate

Tt, Torrey Sandstone

Tf, Friars Formation

Mzu, Metasedimentary and metavolcanic rocks undivided

Kqbd, Quartz-bearing diorite undivided

Kis, Granite of Indian Springs

Kmm, Monzogranite of Merriam Mountain

Kgd, Granodiorite undivided

Kwm, Granodiorite of Woodson Mountain

Kjd, Granodiorite of Jesmond Dean

Kr, Granodiorite of Rainbow

Ki, Granodiorite of Indian Mountain

Kt, Tonalite undivided

Kgb, Gabbro undivided

Water

Sources:

1) Modified from *Geologic Map of the San Diego 30x60 Quadrangle, California.* Michael P. Kennedy and Siang S. Tan. California Department of Conservation, California Geologic Survey. 2005.
2) Modified from *Preliminary Geologic Map of the El Cajon 30x60 Quadrangle, Southern, California.* V.R Todd. U.S Geologic Survey, OFR 2004-1361.
3) Alquist Priolo (EFZ) faults- Modified from California Geological Survey CD-ROM 2001-05 (2002), Official Map of Alquist-Priolo Earthquake Fault Zones. Various quads, various dates.
4) Quaternary/Pre-Quaternary Fault Data - *Digital Database of Fault from the Fault Activity Map of California and Adjacent Areas.* Charles W. Jennings. California Department of Conservation, California Geologic Survey. 2000.
5) Alignment – URS 2014.
6) Freeways/Interstates – ESRI.

PSR - RAINBOW METER STATION TO MCAS MIRAMAR GEOLOGIC LEGEND AND SOURCES
SAN DIEGO COUNTY, CALIFORNIA

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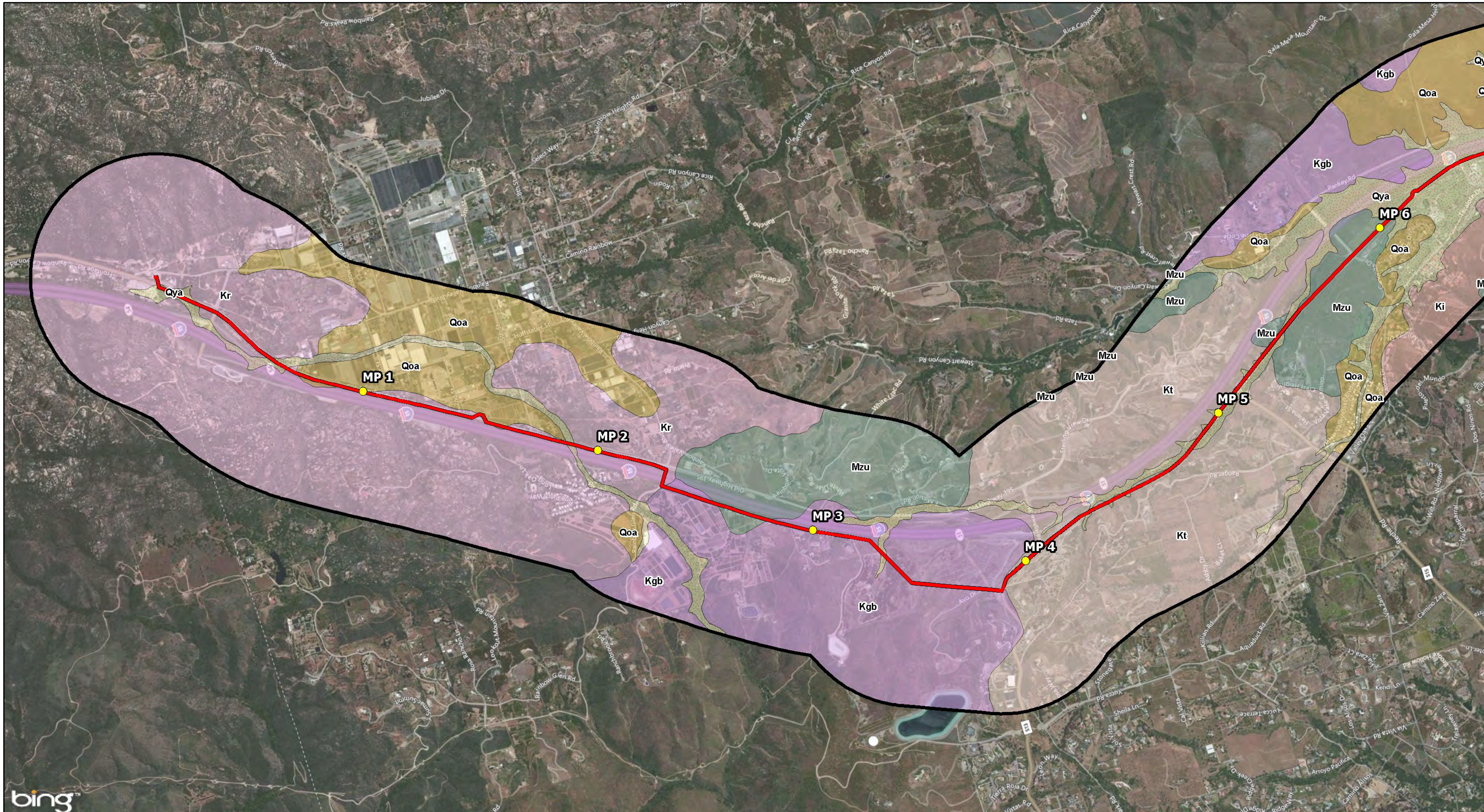

LEGEND

- Milepost
- PSR Route
- Half-mile Buffer

See Figure 2a for Geology Legend

SOURCES:
SDG&E,
California Geological Survey,
Bing.

PSR - RAINBOW METER STATION TO MCAS MIRAMAR
SITE PLAN AND GENERALIZED GEOLOGIC MAP
SAN DIEGO COUNTY, CALIFORNIA

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SCALE CORRECT WHEN PRINTED AT 11X17

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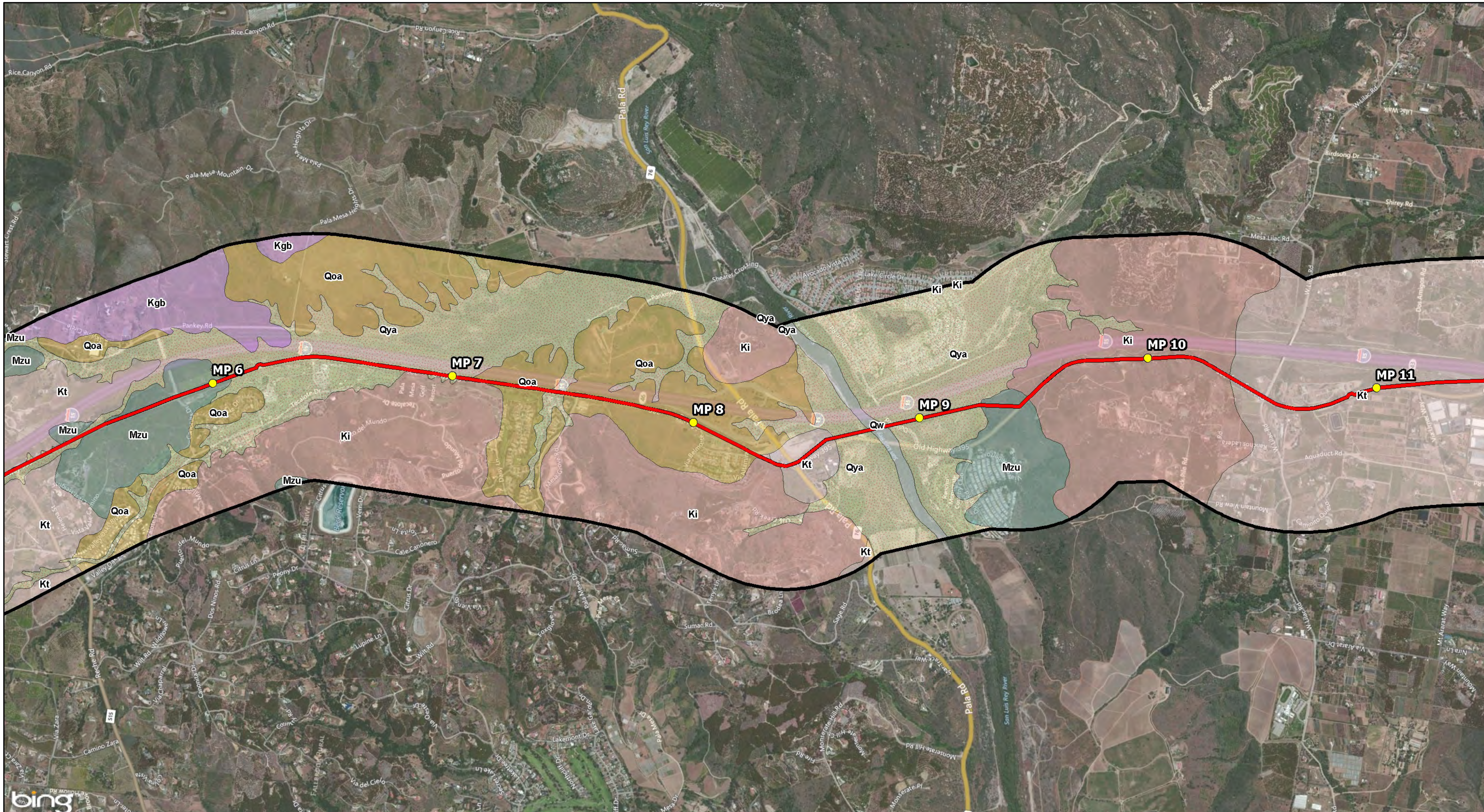

LEGEND

- Milepost
- PSR Route
- Half-mile Buffer

See Figure 2a for Geology Legend

SOURCES:
SDG&E,
California Geological Survey,
Bing.

PSR - RAINBOW METER STATION TO MCAS MIRAMAR
SITE PLAN AND GENERALIZED GEOLOGIC MAP
SAN DIEGO COUNTY, CALIFORNIA

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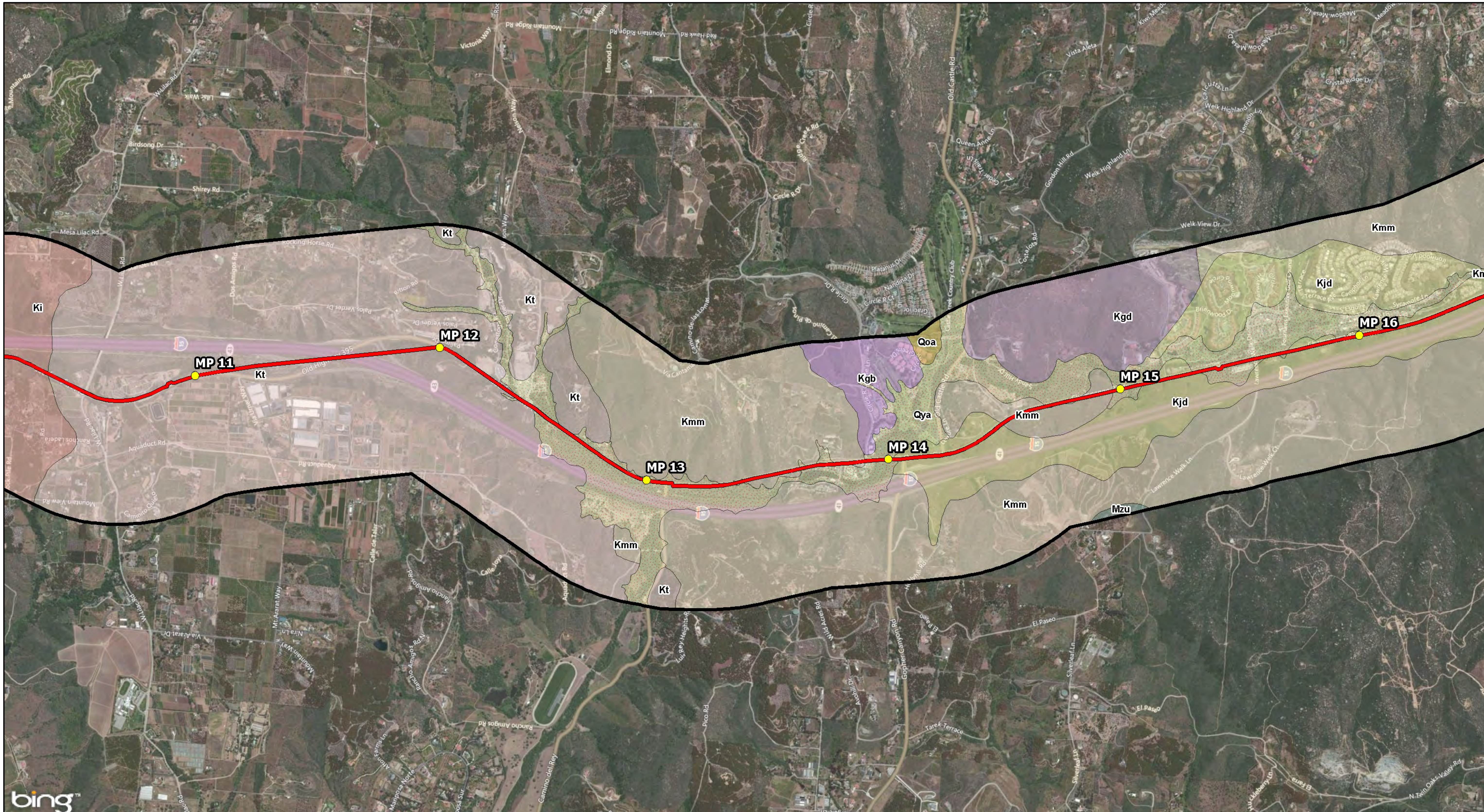

LEGEND

- Milepost
- PSR Route
- Half-mile Buffer

See Figure 2a for Geology Legend

SOURCES:
SDG&E,
California Geological Survey,
Bing.

PSR - RAINBOW METER STATION TO MCAS MIRAMAR
SITE PLAN AND GENERALIZED GEOLOGIC MAP
SAN DIEGO COUNTY, CALIFORNIA

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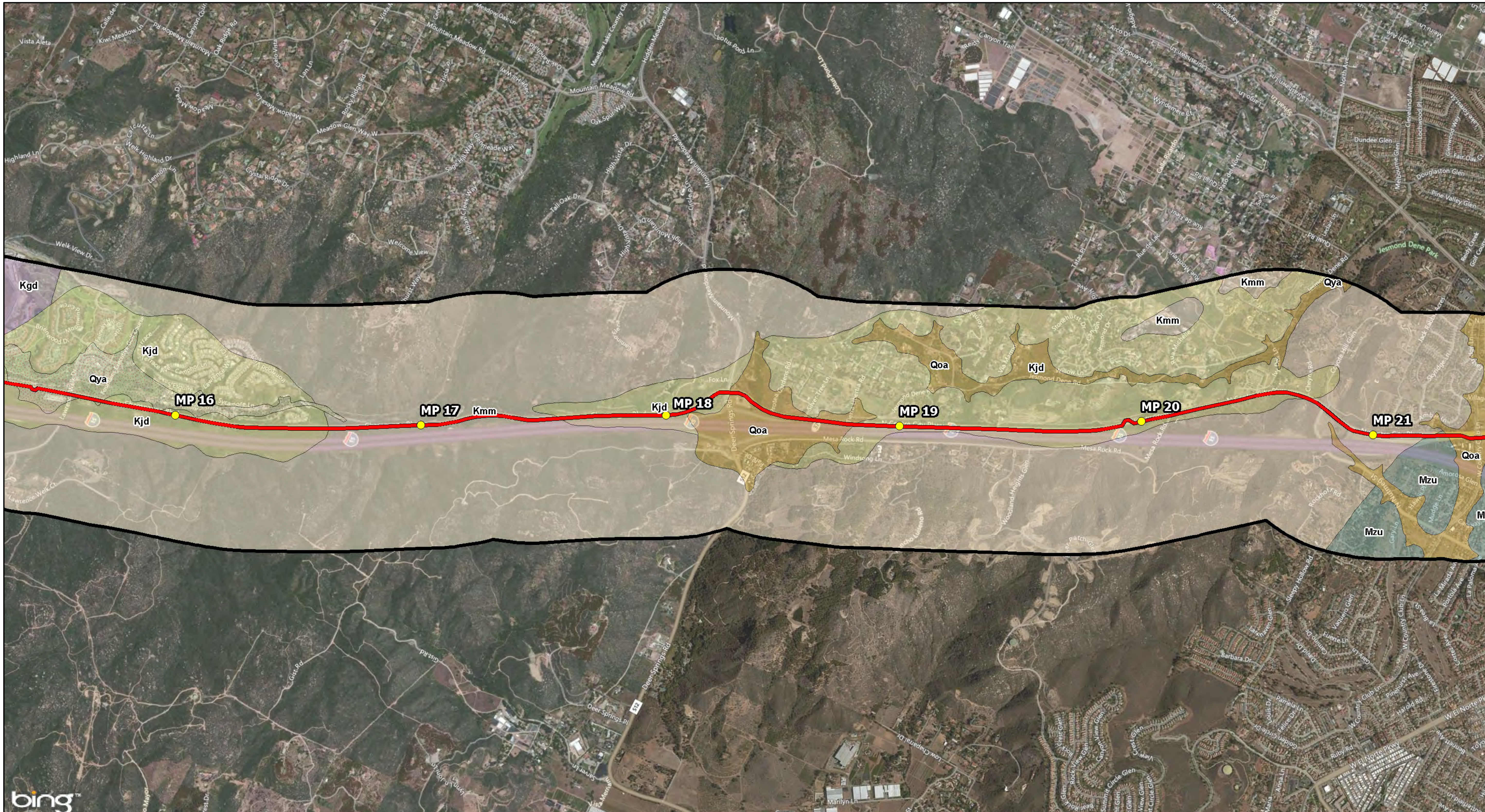

LEGEND

- Milepost
- PSR Route
- Half-mile Buffer

See Figure 2a for Geology Legend

SOURCES:
SDG&E,
California Geological Survey,
Bing.

PSR - RAINBOW METER STATION TO MCAS MIRAMAR
SITE PLAN AND GENERALIZED GEOLOGIC MAP
SAN DIEGO COUNTY, CALIFORNIA

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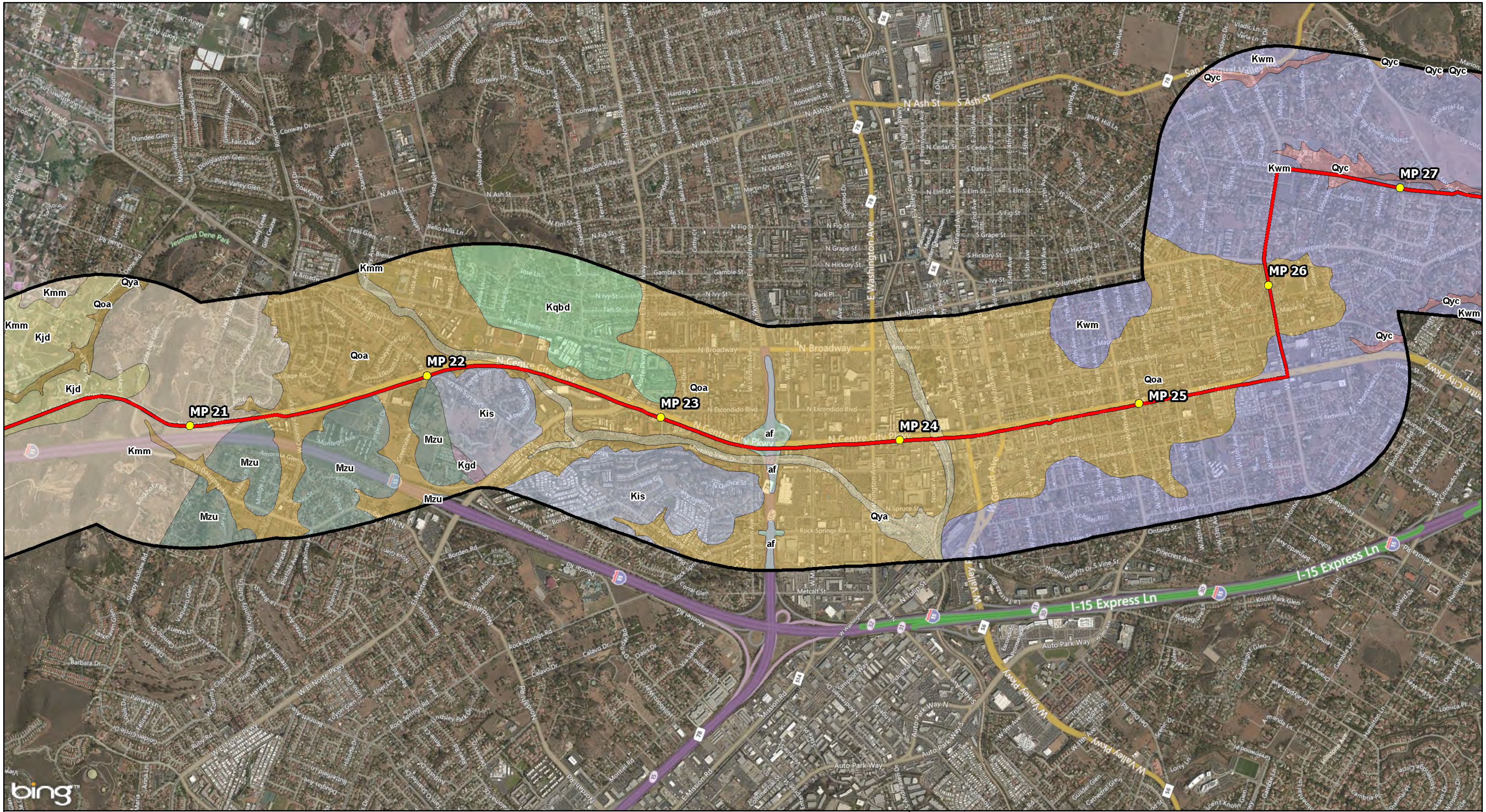

LEGEND

- Milepost
- PSR Route
- Half-mile Buffer

See Figure 2a for Geology Legend

SOURCES:
SDG&E,
California Geological Survey,
Bing.

PSR - RAINBOW METER STATION TO MCAS MIRAMAR
SITE PLAN AND GENERALIZED GEOLOGIC MAP
SAN DIEGO COUNTY, CALIFORNIA

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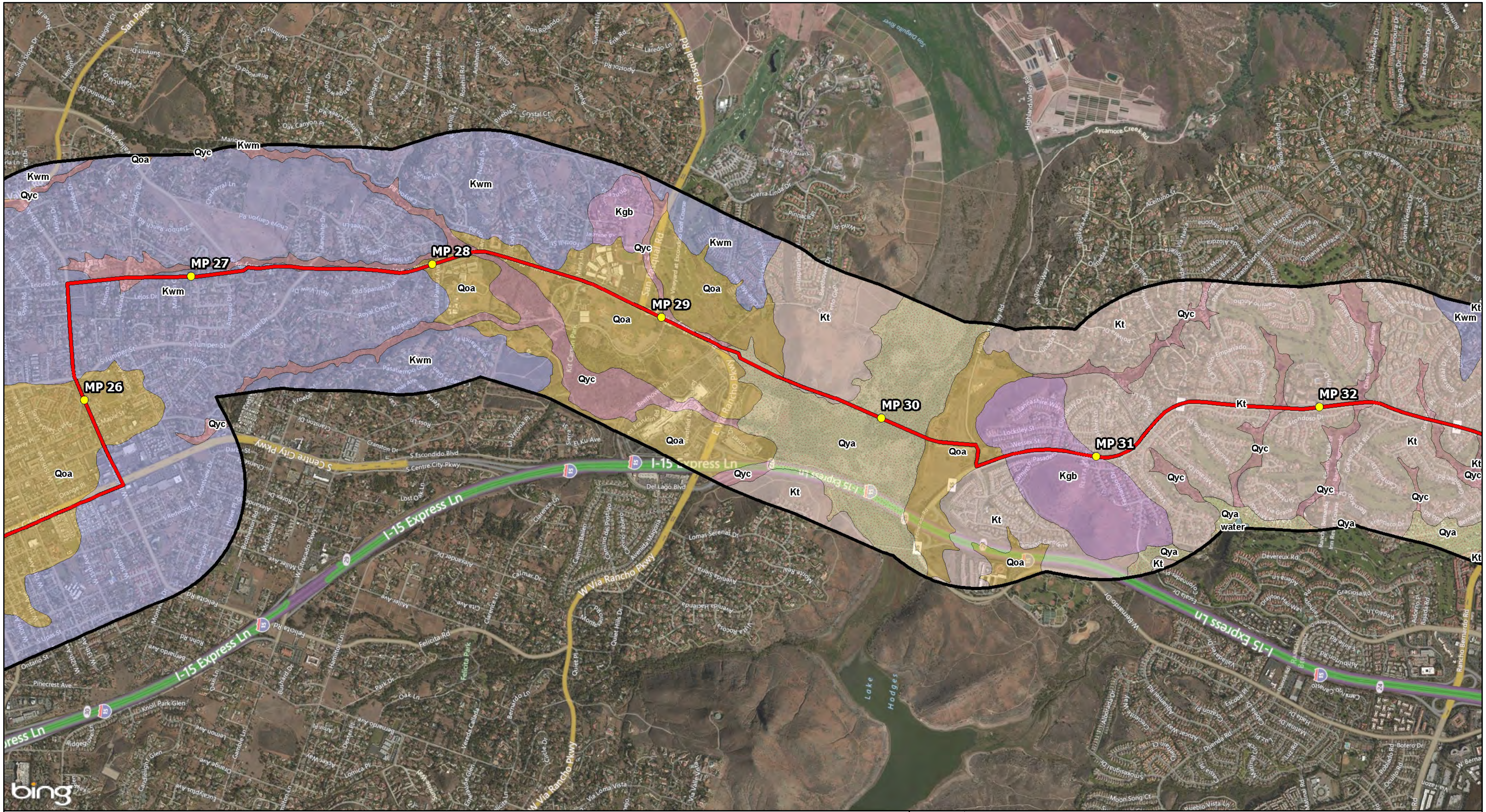

LEGEND

- Milepost
- PSR Route
- Half-mile Buffer

See Figure 2a for Geology Legend

SOURCES:
SDG&E,
California Geological Survey,
Bing.

PSR - RAINBOW METER STATION TO MCAS MIRAMAR
SITE PLAN AND GENERALIZED GEOLOGIC MAP
SAN DIEGO COUNTY, CALIFORNIA

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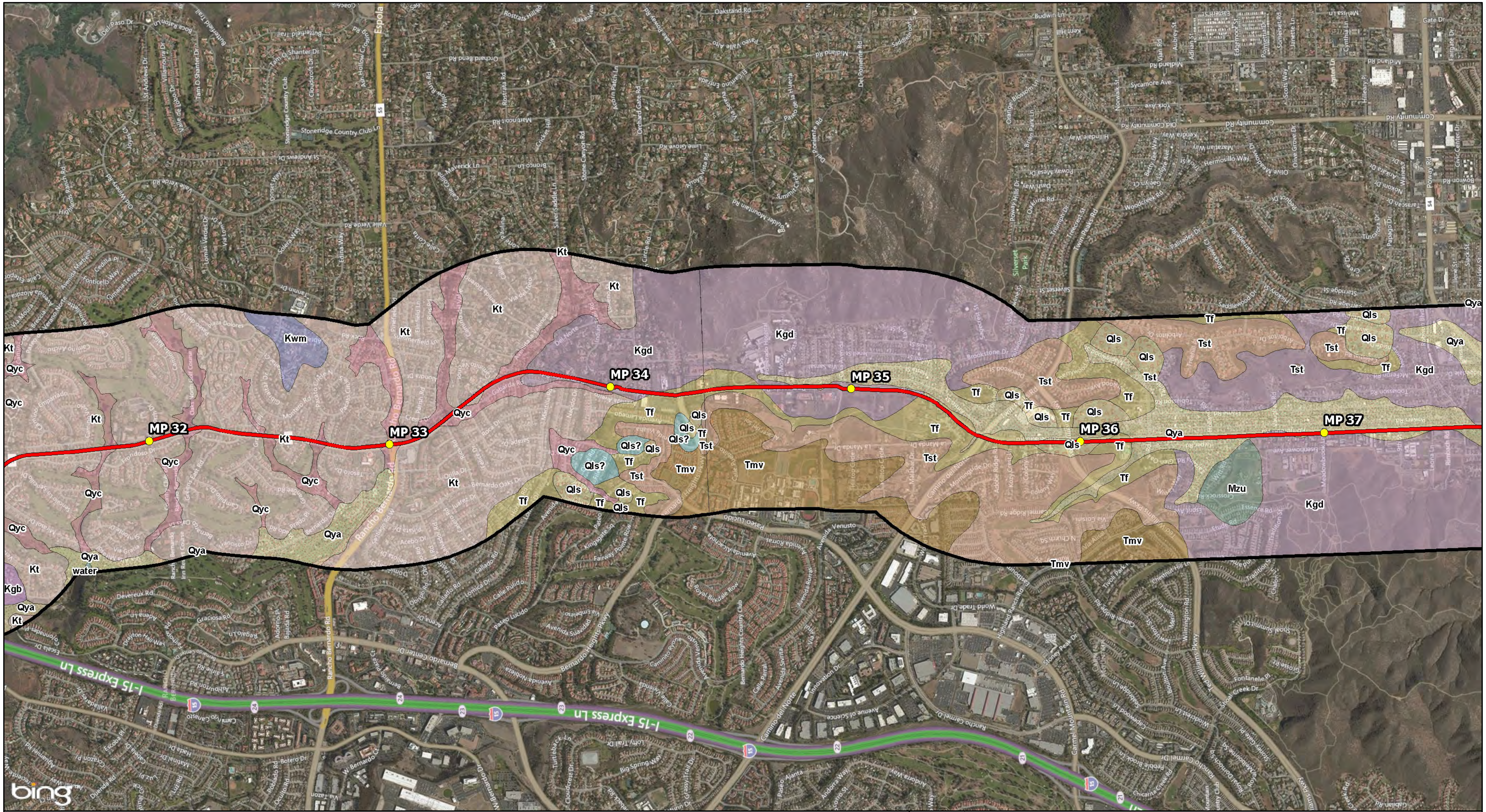

LEGEND

- Milepost
- PSR Route
- Half-mile Buffer

See Figure 2a for Geology Legend

SOURCES:
SDG&E,
California Geological Survey,
Bing.

PSR- RAINBOW METER STATION TO MCAS MIRAMAR
SITE PLAN AND GENERALIZED GEOLOGIC MAP
SAN DIEGO COUNTY, CALIFORNIA

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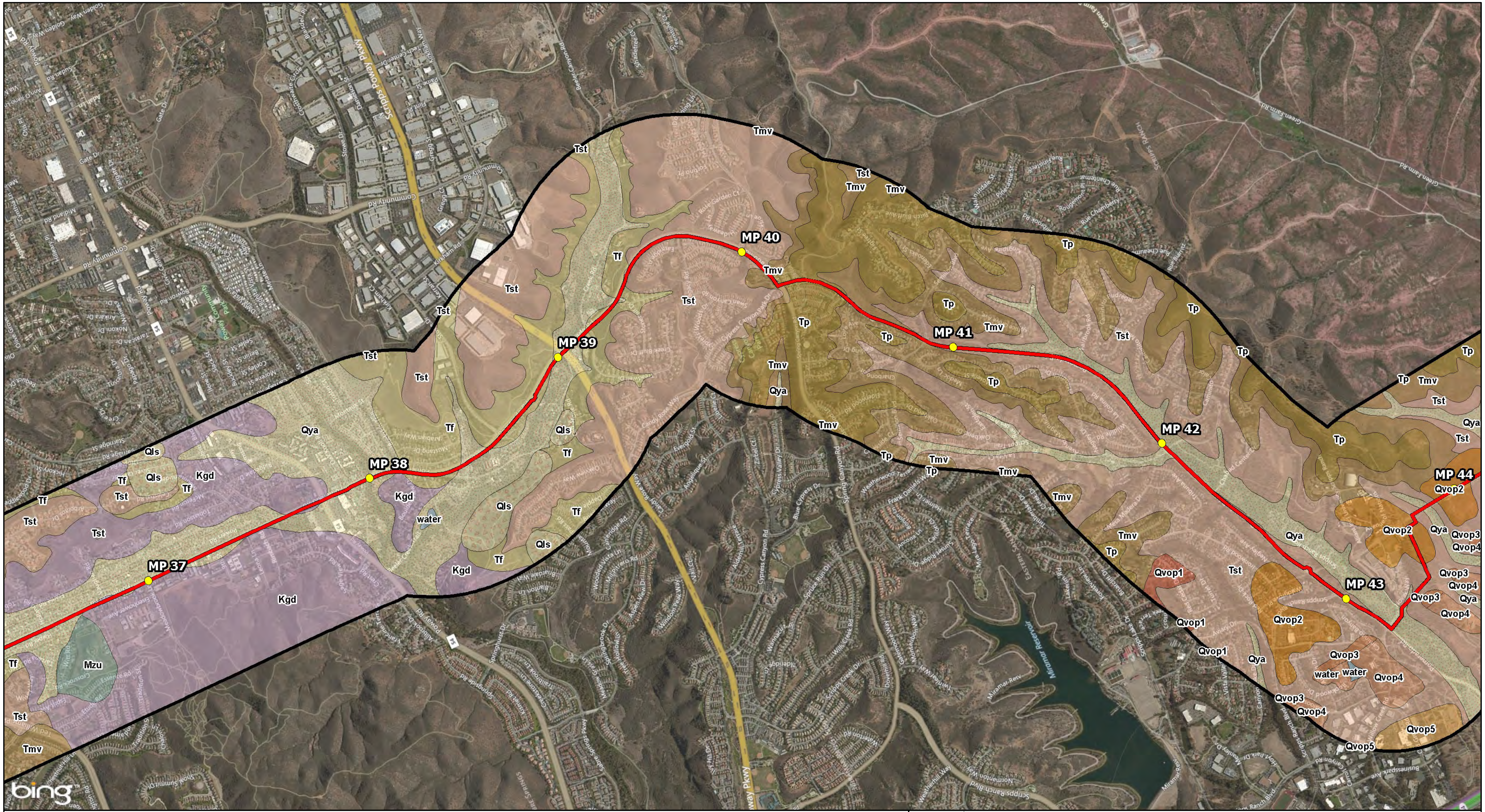

LEGEND

- Milepost
- PSR Route
- Half-mile Buffer

See Figure 2a for Geology Legend

SOURCES:
SDG&E,
California Geological Survey,
Bing.

PSR - RAINBOW METER STATION TO MCAS MIRAMAR
SITE PLAN AND GENERALIZED GEOLOGIC MAP
SAN DIEGO COUNTY, CALIFORNIA

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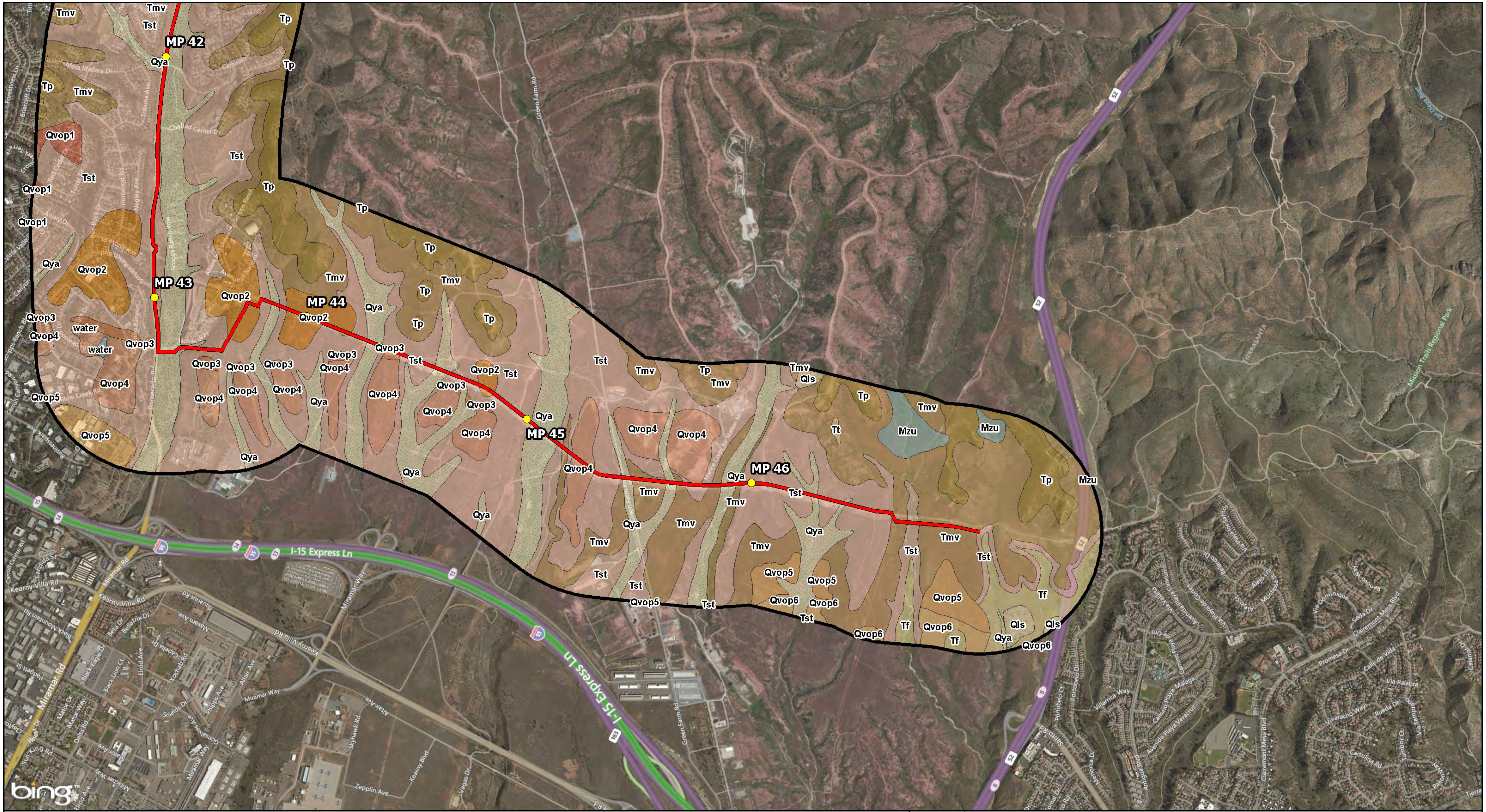

LEGEND

- Milepost
- PSR Route
- Half-mile Buffer

See Figure 2a for Geology Legend

SOURCES:
SDG&E,
California Geological Survey,
Bing.

PSR - RAINBOW METER STATION TO MCAS MIRAMAR
SITE PLAN AND GENERALIZED GEOLOGIC MAP
SAN DIEGO COUNTY, CALIFORNIA

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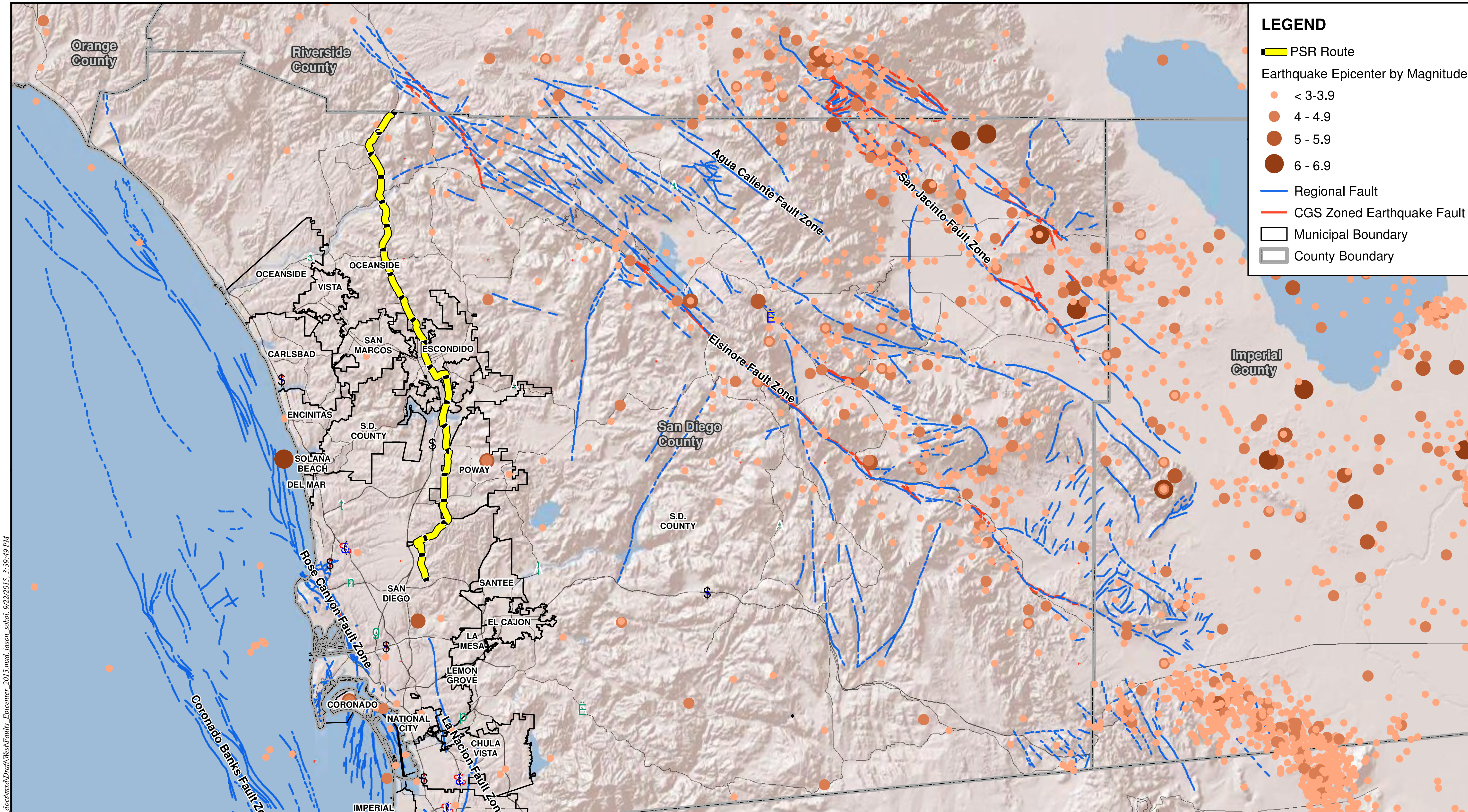

PSR - RAINBOW METER STATION TO MCAS MIRAMAR
FAULTS AND EARTHQUAKE EPICENTER LOCATIONS
SAN DIEGO COUTY, CALIFORNIA

SOURCES: Sandag, NEHRP;
Imagery (Microsoft 2012);
County Boundary (Esri 2012).

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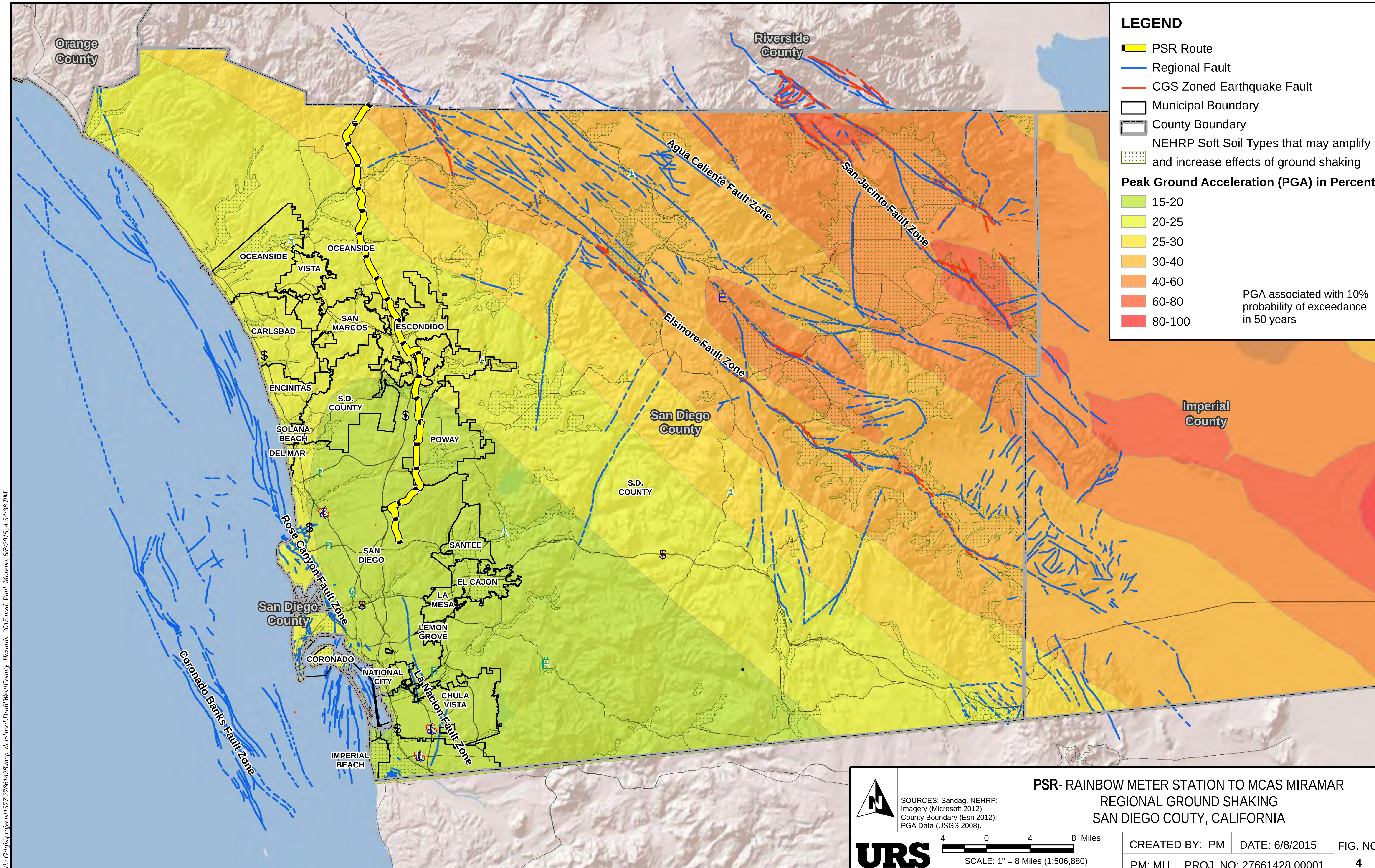

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