APPENDIX I

Preliminary Subsurface Investigation and Geotechnical Background Report

CV Link Project
Coachella Valley, Riverside County, California

Prepared by

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Federal Project No. ATPL-6164(022)
CVAG Project No. CVL-2015-0309
ALTA Project No. 2015-093

Mr. Deven Young
ALTA PLANNING + DESIGN
34935 Mission Hills Drive
Rancho Mirage, CA 92270

Subject: Preliminary Subsurface Investigation and Geotechnical Background Report, CV Link Project, CVAG, Coachella Valley, Riverside County, California

Dear Mr. Young:

Petra Geosciences, Inc. (Petra) is submitting this report presenting the results of our preliminary subsurface investigation, and background geological and geotechnical information for the subject project. This report provides our assessment of the impacts of geological conditions on the project design. This report also summarizes our findings to date, and provides additional geotechnical commentary with regard to site development.

In addition, this report presents the results of our background research, field investigation, and laboratory testing, as well as our engineering judgment, analyses, opinions, conclusions, and recommendations pertaining to the preliminary geotechnical design aspects of the proposed pathway improvements. This work was performed in accordance with our proposal P.N. 14-295P, dated November 5, 2014.

It is a pleasure to be of service to you on this project. Should you have any questions regarding the contents of this report, or should you require additional information, please do not hesitate to contact us.

Respectfully submitted,

PETRA GEOSCIENCES, INC.

Dr. Siamak Jafroudi, GE
President

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1.0 - INTRODUCTION

This report describes the general geological, seismological, and geotechnical properties along the CV Link Project (Project) routes and alignments. The portion of the overall route to be investigated, as described in the Executive Summary for the project prepared by Alta Planning + Design, traverses from dual western termini, at Highway 111 (North Palm Canyon Drive) in northern Palm Springs (the Palm Springs Visitor Center at Tramway Road – access point for the Aerial Tram) and in central Palm Springs at South Palm Canyon Drive and Tahquitz Creek. The eastern terminus is at Airport Boulevard (Avenue 56) in the City of Coachella and the unincorporated community of Thermal. The route under investigation is approximately 49± miles long and in some cases includes alternative routes or alignments. The general location of the principle alignment is shown on Figure 1. The project is to develop a pathway for bicycle, and neighborhood electric vehicles to link the various cities within the Coachella Valley.

This report is based on existing geologic and geotechnical information obtained for previous projects along the Project alignment such as street crossings across the Whitewater Wash and investigations conducted for improvements to the Whitewater Channel, as well as information obtained from subsurface exploratory borings conducted for this project to supplement or confirm the background data. A list of the references used is presented at the end of this report. Additional geotechnical studies will be conducted to provide more information as plans are developed. These future investigations will include geotechnical investigations to determine the engineering properties of site soils for foundation engineering in accordance with good engineering practice and existing building codes. The level of the completed investigations we have conducted is considered sufficient to indicate and does indicate that no immitigable environmental impacts will be discovered in future investigations.

This report provides specific background data, engineering analysis, and recommendations to support the development of the project environmental documents. Additional refinement and detailing of the provided recommendations should be expected as the project progresses through the design process. The assessment of the likely geological hazards to the project is provided within the report, additional supporting data, figures, analysis and recommendations are provided as attachments and appendixes. Data and findings such and logs, lab, seismic analysis and background report summaries are located in Appendixes A through E. Analysis and recommendations such as summaries of design considerations for project bridges, earthwork recommendations, corrosive soil guidelines and other preliminary general recommendations are provided in Appendixes F through N.

2.0 - OBJECTIVE AND SCOPE

The objective of our study is to provide support to the design team for development of the project Environmental Impact Report. To accomplish this objective we performed the following scope of work:

- Reviewed various published and unpublished geotechnical maps and literature pertaining to regional and local geologic conditions and potential geological hazards.

- Collected and reviewed previous engineering geotechnical investigation reports prepared by our firm and others for previous projects along the vicinity of the subject alignment. A reference list of reviewed reports in shown under the Literature Reviewed section at the end of this report. Summaries of relevant reports are listed in Appendix C. The locations where previous reports had boring and subsurface data useful to this investigation are shown on the Plates 1-?.

- Reviewed maps and reports published by the State of California Division of Mines and Geology (CDMG, now referred to as the California Geological Survey, CGS) to determine which segments may be within the boundaries of a designated Liquefaction Hazard Zone, Earthquake-Induced Landslide Hazard Zone, or an Alquist-Priolo Earthquake Fault Zone.

- Reviewed the requirements of local jurisdictional agencies in regard to geological hazards and concerns.

- Consulted and coordinated with the design team.

- Obtained encroachment permits for drilling from six local agencies.

- Coordinated with the local underground utilities locating service (Underground Service Alert) to obtain an underground utility clearance prior to commencement of the subsurface investigation.

- Drilled 26 exploratory borings along the proposed pathway alignment utilizing a hollow-stem auger drill rig. The purpose of the borings was to observe subsurface soil conditions and collect samples for laboratory testing. The hollow-stem auger borings were drilled to a maximum depth of 101.5 feet below the existing ground surface. Boring locations are depicted on the boring location maps Plates 1-?. Logs of the borings are attached in Appendix A.

- Advanced 11 Cone Penetrometer Test (CPT) soundings to a maximum depth of approximately 90 feet within the proposed pathway alignment. CPT locations are depicted on the boring location maps Plates 1-?. Logs of the CPT's are attached in Appendix A.

- Performed laboratory testing on soil samples considered representative of the locations investigated. Laboratory test results are shown in Appendix B.

- Prepared this report on the geological hazards and geological background suitable for use in the project EIR. The report will address the specific geological requirements of CEQA.

3.0 - SUBSURFACE EXPLORATION

3.1 - Subsurface Exploration - Pathway Alignment

Petra's subsurface exploration along the proposed pathway alignment was conducted in June and July 2016. The subsurface exploration consisted of the drilling, logging and sampling of 26 hollow-stem auger soil borings that were drilled to depths varying from 10.5 to 101.5 feet below the existing ground surface. The 26 borings are identified as B-3 to B-5, B-9, and B-13 to B-34. Additionally 11 CPT soundings were conducted. They ranged in depth from 32 to 90 feet below the ground surface. The CPT soundings were identified as CPT-1 to CPT-11. A description of exploration procedures and logs of the borings can be found in Appendix A. The location of the explorations is shown on the attached geotechnical maps (Plates 1 - ?).

4.0 - LABORATORY TESTING

Various laboratory tests were performed on selected samples of soil materials to determine their physical and chemical properties. These tests included:

- In situ dry density and moisture content
- Maximum dry density and optimum moisture content
- Expansion potential
- R-value
- Soluble sulfate content
- Chloride content
- pH
- Minimum resistivity
- Consolidation
- Direct shear
- Sieve analysis

A description of laboratory test procedures and summaries of the test data are presented in Appendix B. An evaluation of the test data is reflected throughout the report. Partial laboratory data test results relevant to the overall site assessment at the three Phase I bridge sites are included herein. The complete laboratory results for those bridges will be presented in the foundation design report for each bridge.

5.0 - GEOLOGIC SETTING

The proposed development lies within the northwestern Salton Trough that comprises a portion of the Colorado Desert Geomorphic Province. The Salton Trough region is well known for its exposures of the San Andreas and related faults that form the margin between the Pacific and North American Plates. In southern California, these plates move past each other along a somewhat diffuse array of faults comprising the San Andreas Fault System (Powell, 1993). The Salton Trough, however, formed as a major half-graben basin when regional crustal extension affected much of western North America in Miocene time prior to the development of the San Andreas Fault System.

The modern Salton Trough is the northern part of the Gulf of California rift basin formed by oblique strike-slip motion between the North American and Pacific plates. The basin itself continues to form, engendered mainly by activity of the San Andreas Fault System. Sediments deposited within the lowland area cause partial filling of the Salton Trough. The major contributors of sediments to the Salton Trough include erosion of the San Jacinto and Santa Rosa Mountains along the southwestern margin, the San Bernardino Mountains and Little San Bernardino Mountains to the north and northeast respectively, and the Orocopia Mountains to the east. Additionally, Colorado River delta sediments were deposited in the Salton Trough and eventually separated the Salton Trough from the ocean, which produced a region of interior drainage (a basin).

Three to five million year old sediments within the basin are typically associated with shallow seas (marine: Imperial Formation) and lakes (lacustrine: Palm Spring Formation). These deposits are typically composed of salt beds, fine-grained muds (silts and clays) and relatively minor sand and channel gravels. The fine-grained basin deposits typically pinch out and interfinger with coarser grained sediments along the trough margin. These units typically consist of sands, gravel and conglomerates, which, along the project route, include relatively young fluvial fan deposits. Geologic units along the western Project alignment (from the western termini to about Jefferson Street) are primarily young alluvial (stream-laid) sandy deposits. East of Jefferson Street to the east terminus, the geologic units are interlayered sandy alluvial and dune deposits, and fine sand, silts and clayey lake deposits.

The principal geologic formations in the eastern Coachella Valley are shown on Figure 2.

During historical periods, a large lake (Lake Cahuilla) would extend over much of the current Salton Trough. An estimated high water stand of approximately 43 feet above mean sea level occurred during one such period that prevailed from approximately 300 A.D. to about 1600 A.D. Ancient shorelines can be seen around the margins of the Salton Trough and are clearly visible in many aerial photographs. There have been approximately five to six high water stands of Lake Cahuilla in the area of the City of Coachella during the past twelve hundred years (Philibosian and others, 2011).

The trough may be greater than 8,000 feet deep toward the middle of the valley (Smith 1964). The hard crystalline bedrock associated with the adjacent mountain systems continues to descend at a steep angle away from the valley margins towards the middle of the valley. Deep sedimentary basins are prevalent in the southern California area and are known to amplify seismic shaking over areas where basement bedrock is at or near the surface.

5.1 - Regional Faults

Major faults in the region are listed on Table 1 and are shown on Figure 3. The major active fault in the Coachella Valley region is the San Andreas fault. The San Andreas fault extends about 750 miles from Bombay beach in Imperial County to the Cape Mendocino area of northern California. As the San Andreas extends southeasterly through the San Bernardino area, it changes orientation and splits into several branches, is intermingled with several thrust faults, and may lose continuity. This zone of complex faulting is commonly referred to as the San Bernardino tectonic knot. The San Andreas fault south of the San Bernardino Mountains has not experienced a large earthquake in historic time. In the northern Coachella Valley, the fault comprises the Garnet Hill, Banning and Mission Creek branches and several other smaller faults. These branches merge near the southern end of the Indio Hills and the fault continues northeast of the route area as a narrow, if not a single fault, to Bombay Beach at the Salton Sea where its surface expression disappears (Figure 3). This segment of the San Andreas fault is commonly referred to as the Coachella Valley segment.

The most recent surface-rupturing earthquake on the Mission Creek segment of the San Andreas fault likely occurred in the 1600's. Prior events occurred in about A.D. 825, 982, 1231, and 1502 based on trenching at Thousand Palms Oasis (Fumal, 2002). These data indicate that the average repeat time of surface-rupturing earthquakes on the southern San Andreas fault is about 215 y+/- 25 years but this may be misleading because the intervening time ranged from as short as a few decades to as long as 400 years (Fumal, 2002).

Table 5.1.1

Fault Parameters and Maximum Earthquakes

Fault Name	Fault Length (km)	Fault Dip (degrees)	Slip Rate (mm/yr)	Fault Type	Maximum Magnitude
Cucamonga	28	45 N	5.0	R	7.5
Elsinore-Glen Ivy	38	90	2.5	RL	7.0
Elsinore-Chino-Central Ave	28	65 SW	1.0	RL	7.0
Elsinore-Temecula	42	90	5.0	RL	7.0
Elsinore-Whittier	37	90	2.5	RL	7.0
San Andreas (Southern)	203	90	25.0	RL	8.0
San Andreas (Mojave/1857 rupture)	345	90	35.0	RL	8.0
San Andreas (San Bernardino)	107	90	25.0	RL	8.0

Fault Name	Fault Length (km)	Fault Dip (degrees)	Slip Rate (mm/yr)	Fault Type	Maximum Magnitude
San Jacinto (Anza)	90	90	12.0	RL	7.5
San Jacinto (Coyote Creek)	40	90	4.0	RL	7.5
San Jacinto (San Bernardino Valley)	35	90	10.0	RL	7.0
San Jacinto (San Jacinto Valley)	42	90	12.0	RL	7.5

Notes

RL = right lateral strike slip
R = reverse

5.2 - Seismicity

The route is located within the tectonically active southern California region. In spite of the active tectonic regime, earthquakes in the Coachella Valley region within historical times (i.e., the past couple hundred years) have been infrequent and of small magnitude. Figure 4 shows earthquake activity within recent historical time. Table 5.2.1 lists the notable earthquakes in the Salton Trough region.

Table 5.2.1

Notable Historical Earthquakes in the Salton Trough Region

Date	Location	Magnitude
2010	El Mayor-Cucapah	7.2
1999	Hector Mine, Mojave Desert	7.1
1992	Big Bear, San Bernardino Mountains	6.6
1992	Landers, Mojave Desert	7.3
1992	Joshua Tree, Mojave Desert	6.1
1987	Superstition Hills, Salton Trough	6.6
1986	Palm Springs, Salton Trough	5.9
1979	Imperial Valley, Salton Trough	6.4
1968	Borrego Mountain, Salton Trough	6.5
1948	Desert Hot Springs, Salton Trough	6.0
1944	San Gorgonio Pass	5.3
1940	Imperial Valley, Salton Trough	6.9
1934	Laguna Salada, Salton Trough	6.7
1934	Laguna Salada, Salton Trough	7.1
1923	Loma Linda, San Bernardino Valley	6.2
1915	Cerro Prieto, Salton Trough	6.0
1915	Cerro Prieto, Salton Trough	7.1
1907	Eastern San Bernardino Mountains	5.5-6
1899	Lytle Creek, Cajon Pass	6.5
1892	Laguna Salada, Salton Trough	> 7

Date	Location	Magnitude
1857	Fort Tejon, Transverse Ranges	7.8
1852	Cerro Prieto, Salton Trough	6.5

5.3 - Future Earthquake Probabilities

While accurate earthquake prediction is not presently possible, various agencies have conducted statistical seismic risk analyses in an effort to determine earthquake probabilities. The working group of California Earthquake Probabilities (WGCEP, 2013) has recently produced the UCERF3 model for earthquakes in California. For the Coachella Valley segment of the San Andreas fault, the following earthquake probabilities were determined for the next 30 years:

- There is a 22 percent conditional probability for a magnitude 6.7 or greater earthquake.
- There is a 21 percent conditional probability for a magnitude 7.0 or greater earthquake.
- There is a 12 percent conditional probability for a magnitude 7.5 or greater earthquake.
- There is a 3 percent conditional probability for a magnitude 8.0 or greater earthquake.

5.4 - Groundwater

5.4.1 - Hydrogeologic Units

The hydrogeologic setting of the Coachella Valley is very complex due to the various physiographic and subsurface geologic features situated within and adjacent to the Coachella Valley. In general, the Coachella Valley is located within the Whitewater hydrological unit, one of 27 hydrologic units based on barriers to water movement within the Colorado River Basin Region. The Whitewater hydrological unit includes the Coachella Valley Ground Water Basin and the surrounding subbasins. The Coachella Valley Ground Water Basin is generally bounded on the east and west by the non-water bearing crystalline and metamorphic rocks of the San Bernardino, Little San Bernardino, Santa Rosa, and San Jacinto Mountains. There is groundwater flow throughout the entire Coachella Valley Ground Water Basin; however, movement is constricted by fault barriers, basin profile, and areas of low permeability. Therefore, the basin has been subdivided into subbasins and sub areas. The Project area lies within the East and West Whitewater subbasins.

Depths to groundwater along the Project route ranges from a few hundred feet in the western portion to a few 10's of feet in the eastern portion. Groundwater within the Whitewater subbasins in the valley are artificially recharged by spreading basins located in Palm Springs at the head of the valley and spreading basins south of Lake Cahuilla in La Quinta. The eastern valley also has a perched, shallow water table that is comprised of agricultural runoff and is intercepted by agricultural drains and conveyed to the Coachella Valley Stormwater Channel.

Groundwater was not generally detected in our subsurface borings, or in the large majority of borings of others we reviewed within most of the project alignment. Groundwater levels where observed in subsurface explorations are noted in Table 5.4.1 below. The data shown are for the highest groundwater surface elevation within each data set.

Table 5.4.1

Groundwater Depths

Location	Depth	Groundwater Surface Elevation	Date	Organization
Miles Ave. and Whitewater, Indio	73	-55	January 2002	Earth Mechanics
Monroe Street and Whitewater, Indio	21	-18	February 1967	Caltrans
Jackson Street and Whitewater, Indio	19	-30	January 1967	Caltrans
Golf Center Parkway at Whitewater, Indio	10	-38	October 1967	Caltrans
Amistad H.S., Dillon Ave., Indio	50	-27	April 2009	Earthsystems
Dillon Road and Whitewater, Indio	0	-69	January 1969	Caltrans
Valle Del Sol E.S., 52nd and Education Way, Coachella	7	-91	September 2003	Earthsystems
Enterprise Way and Industrial Way, Coachella	15	-105	May 2008	Petra
54th and Fillmore, Coachella	5	-115	July 2008	Petra
Airport Blvd. and Whitewater, Coachella	7	-138	February 1969	Moore and Taber

Many of the groundwater levels noted in Table 5.4.1 above were based on data taken in the late 1960's. Current groundwater levels in those area may be deeper than noted in the table.

<u>5.4.2 - Historical High Groundwater Levels</u>

Before extensive farming began in the region, groundwater levels were quite high, and artesian conditions existed within the lower valley in the Indio and Coachella areas. A return to predevelopment conditions and groundwater levels is very unlikely in the future. However, with increased conservation and construction of underground storage improvements, an increase of groundwater levels from current conditions could be expected. For purposes of liquefaction evaluation a suitable historical high level of groundwater should be used. Figures 5.1 and 5.2 depict maps showing historical groundwater levels in the upper and lower valleys respectively.

Pumping of groundwater has lowered the levels of groundwater from historical highs and has resulted in settlement of the ground surface in several areas of the Coachella Valley. Further discussion of ground subsidence is addressed in Section 13.2 of this report.

5.5 - Surface Water

The Whitewater Channel carries stream flow intermittently as a result of storms in the Coachella Valley and in the Whitewater Watershed. Any surface water generated during non-storm events generally infiltrates to the subsurface of the watershed quickly due to the generally sandy nature of the channel bottom. The National Pollutant Discharge Elimination System (NPDES) implements the federal Clean Water Act of 1990. NPDES regulates polluted runoff by requiring the implementation of Storm water management plans and programs (SWPP) that reduce the discharge of pollutants from storm water systems into waters of the United States. The project will implement a SWPP program during construction to comply with storm water management requirements.

5.6 - Volcanic Activity

The nearest volcanic areas are within the Mojave Desert (Amboy, Pisgah) and Obsidian Buttes at the southern end of the Salton Sea.

The volcanic activity in the Salton Trough has been of the slow, low-energy type in contrast to explosive volcanism that typifies the Cascade Range or the Mono Basin/Long Valley area of northern and central California. There is little risk to the Project from the type of volcanism seen in the Salton Trough.

5.7 - Mineral Resources

Mineral resources can be defined as naturally occurring solid crystalline substances that consist of chemical elements or compounds formed from inorganic processes and organic substances, which are considered to be an economically valuable commodity.

Sand and gravel, collectively referred to as aggregate, are the primary mineral resources that are actively being mined in the Coachella Valley. Sand and rocks weathered and eroded from the surrounding mountains and hills are washed into the valley forming significant deposits of aggregate. There are several aggregate quarries throughout the valley and valley margins as well as other nearby sources such that there is an abundant and ready supply of aggregates for all foreseeable needs. The project alignment traverses areas where mineral resources may be located, but where they may be more economically prohibitive to access. As there is an abundant and economical supply for the foreseeable future already in use, the project is not expected to impair the availability of mineral resources.

5.8 - Energy Resources

Energy resources in the Coachella Valley region include abundant sunshine, wind, and geothermal. These resources can provide practical and cost-effective alternatives to conventional energy resources such as gas and oil. Wind energy resources are common in the Valley; these are presently being used in the northern part of the Valley and the San Gorgonio Pass to the northwest of the valley. The San Gorgonio Wind Resource Study has identified those portions of the wind resource area that offer an economically viable wind resource.

Geothermal resources occur at the south end of the Salton Sea where high ground water temperatures occur in association with volcanic activity. These resources are currently being developed.

The abundant sunshine makes solar energy a viable local resource but, at present, solar energy is utilized primarily on an individual or small business level. At present there are limited economic solar energy plants in the region.

6.0 - SITE GEOLOGY

The vast majority of the CV Link pathway will be located at the top of the earthen embankment's that form the channel and levees along the Whitewater Channel. Earth materials underlying the Project primarily consists of artificial fill placed in association with the Whitewater Channel embankment. The fill materials are typically loose to medium dense, dry in the near surface with moisture content increasing with depth.

The artificial fill typically consists of reworked local soils and is sandy in the western portion (upper valley) and fine sand and silts in the east (down valley).

Native soils may be exposed at the ground surface on occasion along the project alignment. These soils may be found in locations along the channel bottoms, or in areas where the channel has cut into native soils naturally and has not been graded to form the side slopes, or in alluvial areas where the path alignment is not located along the channel and not prior grading has occured. Native soils generally have the same consistency as the fill soils that were derived from them (as noted above), and are distributed similarly with more sandy soils in the upper valley, and more potential for finer grained soils in the lower valley. The boring logs located in Appendix A generally show the depth to native soils observed at the exploratory boring locations.

Geologic units consist primarily of sandy fluvial (stream-laid) deposits in the western portion and interbedded fluvial, aeolian (dune), and lake deposits consisting of sands, silts, and clays in the east.

7.0 - ENVIRONMENTAL IMPACTS AND MITIGATIONS

7.1 - Definition and Use of Significance Criteria

This section evaluates the potential impacts of the proposed project with regard to geologic and geotechnical features and processes. The proposed project is still in the design stage and site-specific geotechnical investigations are only partially completed, but information gathered to date has been incorporated in to this report.

Three publications were utilized as guides in identifying potential impacts; these were:

1. California Geological Survey; Note 46 Guidelines for Geologic/Seismic Considerations in Environmental Impact Reports.
2. Riverside County; Technical Guidelines for Review of Geotechnical and Geologic Reports.
3. Seismic and Geologic Technical Appendix to the Safety Element of the City of Coachella General Plan Update 2020.
4. Criteria established by the National Environmental Protection Act and the California Environmental Quality Act were also used to evaluate potential geologic impacts.

Generally speaking, geological and seismological impacts occur as two basic categories: natural events which may occur whether or not the project advances to the construction phase, and impacts that occur as a direct result of construction of the project. Examples of the former include fault displacement, earthquake shaking, liquefaction, and landslides. These can often be reduced to a level of insignificance through avoidance or by proper engineering design. Examples of potential geological impacts that can occur as a result of project construction are typically related to disturbance of surficial geologic formations and include induced hydroconsolidation of collapsible soils, induced slope instability, and increased soil erosion. Regardless of whether the impact is due to a natural event or a direct result of the proposed development, Section VI of Appendix G of the State CEQA Guidelines states that, implementation of the project would normally result in a significant impact if one or more of the following conditions is identified:

VI. GEOLOGY AND SOILS -- Would the project:

a). Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

   i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.

   ii) Strong seismic ground shaking?

   iii) Seismically-induced ground failure, including liquefaction?

   iv) Landslides?

b). Result in substantial soil erosion or the loss of topsoil?

c). be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?

d). Be located on expansive soil as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life and property?

e). Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

Generic examples of potentially significant impacts from natural geologic conditions include the following:

- Ground rupture occurs beneath proposed structures for human occupancy or support infrastructure as a result of surface displacement along active earthquake faults.

- Earthquake-induced ground shaking causes landslides, liquefaction, settlement, lateral spreading and/or surface cracking that damages project structures or facilities.

- Failure of construction excavations resulting from the presence of loose or saturated sand, soft clay, or highly fractured or weathered rock.

- Differential subsidence or hydroconsolidation of collapsible soil results in excessive differential settlement directly under project structures or facilities.

Examples of potentially significant impacts of a particular project on the geological environment include the following:

- Unique geologic features or geologic features of unusual scientific value for study or interpretation would be disturbed or otherwise adversely affected by the project or the associated construction activities.
- Adverse geological processes such as landslides would be triggered or accelerated by construction or disturbance of landforms.
- Substantial alteration of topography would be required or could occur beyond that which would result from natural erosion and deposition.
- Shallow, hard bedrock is encountered during grading that requires blasting.

The impacts of these on the proposed project can be reduced to a level that is not significant by avoidance or by proper engineering design. The potential geotechnical impacts of the project include construction that will disturb surficial geological formations, collapsible or expansive soils, and could contribute to increased erosion. These geotechnical issues can be mitigated to levels that are not significant. Mitigation measures include development and implementation of erosion control, slope stabilization measures (Stabilization/buttress fills or reinforced slopes), removal and recompaction of loose surficial soils or soil reinforcement, and establishing procedures for controlling erosion and runoff.

8.0 - GENERAL GEOLOGIC IMPACTS AND MITIGATION MEASURES

The following paragraphs provide our assessment of the potential geologic impacts of the proposed project in consideration of the significance thresholds described above. This assessment is based on our review of available geologic literature and maps, as well as our subsurface investigation, laboratory testing and engineering analysis completed to date. The range of potential impacts with respect to the proposed project are *No Impact, Less than Significant*, *Less than Significant with Compliance with Regulatory Standards*, and *Less than Significant with Mitigation*. Proposed mitigation measures are recommended where appropriate that would reduce the effect of potentially significant impacts to a less-than-significant level.

9.0 - POTENTIAL GEOLOGIC/GEOTECHNICAL HAZARDS

9.1 - Ground Rupture from Active Faulting

9.1.1 - Level of Significance: *No Impact*

9.1.2 - Nature of Concern

Surface rupture is one of the primary effects of an earthquake where displacement occurs along the fault zone and may produce ground surface uplift or subsidence. The Alquist-Priolo Earthquake Fault Zone Act (APEFZ), formerly called the Alquist-Priolo Special Studies Zone Act, was enacted in 1972 to mitigate the hazard of surface fault rupture along active faults in California. The California Geological Survey defines an active fault as that which has had surface displacement within Holocene time (about last 11,000 years).

Active Faulting has not been mapped at or trending toward the Project by the State of California or Riverside County or the cities that the Project traverses.

The only known fault to cross the Project alignment is Palm Canyon fault in the Palm Springs area (Figure 3). This fault is not considered active (Jennings, 1994).

9.1.3 - Impacts on Project

Ground displacement due to faulting can cause breakage of foundations, roads, and utility lines. In most cases, these ground ruptures cause damage that can be repaired, but in rare and extreme cases a rupture could cause collapse of buildings or structures that could cause injury and death.

9.1.4 - Mitigation Measures

In the absence of known active faulting at the Project alignment, mitigation for fault surface rupture is not expected.

9.2 - Earthquake Shaking/Strong Ground Motion

9.2.1 - Level of Significance: *Less than Significant with Compliance with Regulatory Standards*

9.2.2 - Nature of Concern

Strong ground shaking can cause building or structures that are not properly designed to resist the forces induced by the strong lateral and vertical ground motions to collapse. Collapse of a structure could cause severe injury or death to occupants. Building codes have been put into place by the State of California that in part require structures to be designed to resist seismic motions and to remain in such a state that occupants will not be killed and can be evacuated after a design level seismic event. However, the facilities or improvements are allowed to be damaged, and the damage may be to such an extent that the facility is not usable in the future and may require demolition or extensive repair. Only critical facilities such as police and fire stations, hospitals, and a few other critical structures are required to be design to be operational after a design seismic event. The proposed CV Link project does not have any critical facilities, and therefore will be designed in such a manner that damage after a design seismic event may be acceptable.

Estimates of the maximum earthquake for the Coachella Valley segment of the San Andreas fault range from about M=6 to M=8. The most likely maximum magnitude is in the 7 to 7.5 range. The faults may be capable of about M = 6.5 earthquakes based on empirical length-magnitude relationships of Wells and Coppersmith (1994). These earthquake estimates are based on indirect geologic data and comparison to other faults or fault segments because there have not been any surface ruptures on these faults in the Coachella valley area within historical time. Paleoseismic (ancient earthquakes) investigations have determine that there was a surface rupturing event in the Coachella Valley in A.D. 1690.

Geologic data exposed in trenches elsewhere in California (e.g., Pallett Creek, Wrightwood, Desert Palms Oasis) indicate the San Andreas Fault has ruptured several times in the past few thousand years (Fumal et al., 2002). Based on these data, the San Andreas Fault is expected to rupture in large events about every 200 to 300 years; however, as mentioned above, there has been no surface rupture on the San Andreas in the Coachella valley in historical time that is on the order of 250 years. This suggests that the geologic data are incomplete or that the fault is due for a major rupture.

The peak ground acceleration with a probability of 2 percent in 50 years (~ 2475 year return period) for 5 locations along the Project Alignment, by the California Geological Survey (2002), is given in Table 9.2.2 below.

Table 9.2.2

Peak Ground Acceleration at Various Project Areas

Location	Latitude, Longitude	Peak Ground Acceleration (g)
West (111/Palm Springs)	33.868205, -116.567940	0.84
West Central (Frank Sinatra)	33.772569, -116.444551	0.83
Central (Fred Waring)	33.736242, -116.365748	0.59
Northeast (Jackson St.)	33.735285, -116.216639	0.91
East (Ave 56)	33.642026, -116.136162	0.79

Additional ground acceleration data was analyzed at each bridge site, see Appendix G. Also, see the bridge design summaries in Appendix F. Full design response spectrums have been developed for the Phase I bridges and have been provided in our letter on July 25, 2016 (Petra 2016).

9.2.3 - Impacts

An earthquake on faults near (a few miles) the project alignment (e.g., the San Andreas) could generate shaking from earthquakes that could cause significant impacts along the alignment. Potential impacts include slope collapse, seismically (strong ground motions) induced ground cracking, or buckling of streets, parkways, pathways, bridges, or any other structure or improvement associated with soils settlement or collapse.

9.2.4 - Mitigations

The project will be designed according to the California Building Code (CBC) for buildings and other structures, and Caltrans design standards for bridges where appropriate in order to mitigate earthquake damage. Regulatory approval of the plans and specifications for this project requires compliance with all applicable State and local building codes. The design-phase geotechnical reports for the project will provide the required engineering geotechnical input to assist the project designers (including the architect, structural engineer and civil engineer) in achieving this regulatory compliance, provided that the structures proposed within the project are designed and constructed in accordance with the California Building Code as adopted by the relevant local agencies, or Caltrans design standards (bridges), and the site-specific recommendations.

10.0 - SEISMICALLY INDUCED GROUND FAILURE

10.1 - Liquefaction and Lateral Spreading

10.1.1 - Level of Significance: *Less than Significant with Mitigation*

10.1.2 - Nature of Concern

Liquefaction of soils may occur in areas where noncohesive, saturated, soils experience strong shaking by earthquakes. Geologic units most susceptible to liquefaction tend to be very young (generally late Holocene), unconsolidated alluvium. Areas with ground water less than 10 feet are most susceptible, but liquefaction can occur to deeper depths. Current scientific understanding of liquefaction is based on observation of liquefaction occurrences during past earthquakes. Liquefaction case history data sets are generally limited to observations conducted at the ground surface, and therefore liquefaction is generally understood to be observable within the upper 50 feet or so of the ground surface.

Liquefaction is not expected to occur in the western portion of the site where ground water is anticipated to be greater than 50 feet below the ground surface. Depth to groundwater in the eastern portion of the project can be less than 50 feet and liquefaction may occur. Figure 6 is modified from the County of Riverside Transportation and Land Management website and shows areas of low to high potential for liquefaction in the central Coachella Valley.

10.1.3 - Impacts

Liquefaction can cause settlement of the ground surface, settlement and tilting of engineered structures, flotation of buoyant buried structures and fissuring of the ground surface. A common surface manifestation of liquefaction is the formation of sand boils (short-lived fountains of soil and water that emerge from fissures or vents and leave freshly deposited conical mounds of sand or silt on the ground surface).

Lateral spreading occurs when shallow layers of liquefiable material are located in areas with sloping ground or where an open free face exists such as along the Whitewater Channel. Lateral spreading towards an open free face has generally not been observed where the liquefiable materials are located at a depth below two times the height of the open free face. Current groundwater levels are generally below this depth along the project alignment except at the very south east end near Avenue 52 and further south as noted below.

Our review of existing data and reports along the project alignment indicates that liquefaction has not been noted except within the Coachella Area. Reports from several schools in that area indicated the potential for liquefaction as noted below.

- At Amistad Wilson Continuation High School that is on Dillon Road just west of the Whitewater Channel, Earth Systems estimated liquefaction settlements of approximately 3 to 4 inches. This was based on a historical high groundwater level of 15 feet below the ground surface (groundwater at the time of exploration was noted at 48 feet bgs). They estimated settlements of approximately 1-½ inches for groundwater conditions existing at the time of exploration. They viewed the potential for lateral spreading to be low due to the unlikelihood that groundwater would rise in the future back to the historical high levels. With groundwater at historical high elevations they estimated a lateral spread potential of 3.3 feet (1 meter) towards the channel for the school site.
- At the Valle Del Sol elementary school located north of Avenue 52 near the Whitewater Channel, Earth Systems estimated liquefaction settlement of up to approximately 1-½ inches. Groundwater at the time of exploration was observed at depths of 7 to 15 feet. They did not consider lateral spreading at the site due to the level nature of the ground surface. However closer to the channel lateral spreading could be an issue.

Based on the review of data discussed and our knowledge of the area liquefaction effects are much less likely for those portions of project located to the west of Monroe Street. The potential for liquefaction increases as the project alignment traversed east and south of Monroe Street. From Avenue 52 south current groundwater levels are shallower and liquefaction effects at the surface are more likely, and the severity would be more. The potential for lateral spreading is further restricted to areas where the groundwater would be located closer to the surface. Whereas settlements from liquefaction may be felt if the groundwater was within 50 to 60 feet of the surface, lateral spreading of the levee would likely require groundwater to be within about 30 feet of the ground surface based on the depths of the channel below the adjacent ground.

If liquefaction occurs during the lifetime of the project settlement of the ground surface could result in cracking of the pavement and other improvements. Lateral spreading could breakup the surface of the levee and cause lateral movements of the ground surface towards the middle of the channel. The hazard of liquefaction and lateral spreading on the levee system is a current condition and will not be changed whether the project is constructed or not. The danger to human users of the project would likely be collapsing or falling structures if the structure were constructed without consideration of liquefaction and its associated phenomena. An example of such structures would be roof or wall collapse of restroom or other facilities. Lateral spreading causing cracking of the pathway pavement surface may cause disruption to the usage of the facility, but would not be expected to cause the loss of life.

10.1.4 - Mitigations

10.1.4.1 - Standards for Mitigation of Liquefaction Hazards

In April 1991, the State of California enacted the Seismic Hazards Mapping Act (California Public Resources Code, Division 2, Chapter 7.8, subsequently referred to herein as the "SHMA"). The purpose of the SHMA is to protect the public safety from the effects of strong ground shaking, liquefaction, landslides, or other ground failure. The SHMA defines mitigation as "… those measures that are consistent with established practice and that will reduce seismic risk to acceptable levels" (California Public Resources Code, Division 2, Chapter 7.8, Section 2693[c]). Acceptable level of risk is defined as "that level that provides reasonable protection of the public safety, though it does not necessarily ensure continued structural integrity and functionality of the project (California Code of Regulations Volume 18, Title 14, Article 10, Section 3721[a])." Within the context of the Act, mitigation of the project's potential liquefaction impact to an acceptable level of risk (to the extent that mitigation is required as described herein) can be accomplished through appropriate foundation design and subsurface soil improvement.

10.1.4.2 - Mitigation Assessments and Methods

Assessment of liquefaction potential for a particular site requires knowledge of a number of regional as well as site-specific parameters including the estimated design earthquake magnitude, the distance to the assumed causative fault and the associated probable peak horizontal ground acceleration at the site, subsurface stratigraphy and soil characteristics. Parameters such as distance to causative faults and estimated probable peak horizontal ground acceleration can be determined using published references and by utilizing online computer programs by the U.S. Geological Survey (USGS). Stratigraphy and soil characteristics are being determined by means of site-specific subsurface investigations combined with appropriate laboratory analysis of representative samples of onsite soils. The data from the site specific investigation are included as appendices in this report.

Site Specific geotechnical investigation will address liquefaction and lateral spreading potential and provide recommendation for mitigation, if necessary. Mitigation measures could include remedial grading, strengthened foundations, ground improvement, or deepened foundations. Remedial grading or various ground improvement methods can reduce the amount of differential settlement that will be felt at the surface by a structure. Strengthened or deepened foundations can resist the forces induced within a structure due to differential settlements, or deepened foundations may bypass the liquefiable layers and provide support for a structure by deriving bearing resistance from deeper layers. Specific levels of tolerable settlement or lateral movement for various types of building structures are outlined in the ASCE 7-16 guidelines for building loads.

Generally the amount of differential settlement from liquefaction that was noted by Earthsytems within their school reports had an angular distortion ratio of less than 1:360. Slab-on-grade foundations designed for expansive soils that are within the medium or high category would have resistance to similar levels of differential movement. Any building structures that are to be located within the Coachella City area of the project that are along the project alignment along the whitewater river should be further evaluated for the potential of lateral movements. Specific ground improvement or deepened foundations recommendations for those situations will be provided as the project design progresses. Distress to pavements or the channel slopes could occur as well but this is not expected to cause risks higher than the acceptable levels according to the state standards outlined above. Repair to such improvements should be expected after a strong shaking event. Building structures where a roof exists or where walls could collapse and seriously injure a person are designed to resist collapse. However these structures may be seriously damaged and not usable after the earthquake. Pavements and embankments even if damaged during the strong shaking would not be expected to collapse, thus the different level of risk that could be tolerable between the different improvements. Buildings and other structures will be designed to the tolerance required by the building code as adopted by the City of Coachella and other governments.

10.2 - Dynamic Settlement of Dry Sand

10.2.1 - Level of Significance: *Less than Significant with Mitigation*

10.2.2 - Nature of Concern

Settlement of dry sandy soils can occur during strong seismic events. The seismic shaking can induce shearing and reduction in volume of loose sandy deposits as the sand grains are rearranged and densified.

10.2.3 - Impacts

High shaking levels likely in the Coachella Valley can cause settlement of the ground surface and could result in distress to structures and foundations. We have evaluated the magnitude of dry sand settlement at many of the proposed bridge locations throughout the valley. See Appendix E, and F for results. Generally we have found that the magnitude of dry sand settlements that can be expected range from 2 to 7 inches of total settlement. It is our opinion that the magnitude of differential settlement that could be felt at the ground surface from dry sand would be less than 2 inches in a span of 40 feet. This can be expressed as an angular distortion ratio of 1:240. This is within the limits of tolerable settlement that building structure foundations can be designed for according to ASCE 7-16, and common practice within the area.

10.2.4 - Mitigations

Ground improvement, consisting of removal and recompaction of loose, near surface sandy soils, will likely be the most common mitigation employed. Other methods may include deep dynamic compaction, additives to the soils, such as cement or fiber (e.g., nylon) and flooding of in-place loose granular soils, can be accomplished to increase the density of the resultant compacted fill and thereby remove or reduce the tendency to settle under dynamic shaking. Deep foundation elements could also be used to bypass zones of loose sand subject to dynamic settlement. Deep foundations will be primarily used on bridge structures (see Appendix F for bridge recommendations). Other building structures can use strengthened foundations (either conventionally reinforced or post-tensioned). Building foundation recommendations are provided in Appendix K. Pavements may require some repair if excessive cracking occurs after a very strong earthquake.

10.3 - Tsunamis and Seiches

10.3.1 - Level of Significance: *No Impact*

10.3.2 - Nature of Concern

These hazards will not impact the site. Tsunamis are seismically generated sea waves and there are no bodies of water capable of producing Tsunamis at or near the site. Seiches are oscillating waves that may be generated in lakes by earthquake shaking.

10.3.3 - Impacts/ Mitigations

Several shallow ponds (e.g. golf course water traps) are located near the project but these features will generally be too shallow to generate seiches that would overtop the banks. No mitigations are anticipated.

11.0 - LANDSLIDES

11.1 - Slope Instability and Landslides

11.1.1 - Level of Significance: *Less than Significant with Mitigation*

11.1.2 - Nature of Concern

Large-scale landsliding/slope failures were not observed on Google earth imagery or the limited field reconnaissance conducted as part of this study. The vast majority of the project will be located within areas of relatively flat terrain. However, slopes associated with the Whitewater channel exist over the majority of the project. The slopes are on the order of a few feet to over 20 feet tall and are typically sloped at 2:1 (horizontal:vertical) to 4:1 (h:v) slope ratios. In the area of Indian Wells one section of channel slope is significantly higher. Portions of the slope are lined with concrete and the rest are earth materials. Only a very short portion of the project alignment is close to the slope at this location where Miles Ave., continuous away from the channel at the east abutment of the Miles Ave. Bridge.

11.1.3 - Impacts

Minor surficial slope failures can be expected in areas of the project next to unlined portions of the channel. Channel slopes could fail as a result of scour and removal of supporting soils during rapid flash flooding along the channel. We have conducted a basic slope stability analysis of the channel slope that represents the worst case design scenario. This is the slope along the north side of the channel in the city of Indian Wells south of the Miles Ave. Bridge. The slope is greater than 50 feet in height. The analysis is provided in Appendix G. The slopes are expected to remain grossly stable under static conditions. However some slope movement could occur during strong seismic shaking.

11.1.4 - Mitigations

Minor surficial slope failures are of a nuisance-level and are not significant. Hydrology analysis will be conducted by the project civil engineer, which will determine the extent of potential scour at areas where project improvements will occur. Scour and any resulting instability can be mitigated by installation of slope protection, cutoff walls, deepening of proposed foundations below the maximum depth of scour, and other measures. Some repairs to slopes may be required after strong seismic shaking however this is not expected to cause an unreasonable level of risk to the project.

11.2 - Rockfall

11.2.1 - Level of Significance: *Less than Significant with Mitigation*

11.2.2 - Nature of Concern

A very small portion of the project is located near existing bedrock outcrops or slopes that are a part of the mountains adjacent to the valley floor. Rockfall may occur where the path is near (closer than about 30 feet) to the toe of a bedrock slope. The area around Point Happy is the area that could be impacted.

11.2.3 - Impacts

Rockfall could occur onto the project in any areas located immediately below steep mountain slopes or bedrock outcrops.

11.2.4 - Mitigations

During project planning and construction, the potential for landsliding and rock falls along any adjacent bedrock outcrops or mountain slopes will be mapped and evaluated in detail. Mitigation of rockfall hazards could include scaling of loose rock from the surface of exposed slopes, or installation of rock catchment devices.

12.0 – SOIL EROSION OR LOSS OF TOPSOIL

12.1 - Soil Erosion

12.1.1 - Level of Significance: *Less than Significant with Compliance with Regulatory Standards*

12.1.2 - Nature of Concern

Erosion associated with fluvial processes does not appear to be a significant process within the project area, except along the channel bottom. The slope gradients within about 50% of the project area are low (<5 degrees). Under conditions where runoff from precipitation or uncontrolled irrigation is concentrated over an extended period of time, some localized erosion of graded areas could occur that would result in offsite transport of the non-cohesive (sandy) near-surface soils within the project site if the project did not comply with applicable regulatory standards relating to erosion control.

12.1.3 - Impacts

The constructed facilities of the project may alter natural drainage courses diverting runoff into areas not capable of handling the water flow. The impact of erosion could be increased.

12.1.4 - Mitigations

Mitigation measures include cessation of grading during rainstorms, installation of flow barriers during construction such as straw bales, silt fences, and temporary detention basins. The development plans will incorporate engineered drainage devices, such as street gutters, storm drains, culverts, and detention basins to control runoff and prevent erosion. Those portions of the Link that are located within drainage channels or floodplains shall be to minimize the potential damage associated with flooding in this/these facilities.

12.1.4.1 - Compliance with Regulatory Standards:

The localized soil erosion and loss of topsoil associated with the project would be less than significant because the project would be required to comply with applicable regulatory standards relating to erosion control and storm water management. Such standards include proper implementation of storm water Best Management Practices during earthwork operations within the project, as well as diligent maintenance of erosion control devices throughout the early phases of construction until such time as the permanent storm water conveyance is in place. A SWPP program will be implemented during construction. During the post-construction and occupancy period, the potential for soil erosion and loss of topsoil would remain less than significant through proper maintenance of irrigation systems, as well as though compliance with the local city's water quality ordinances.

12.2 - Wind-Blown Sand

12.2.1 - Level of Significance: *Less than Significant with Mitigation*

12.2.2 - Nature of Concern

Figure S-8 of the Riverside County General Plan Section 6.0 (County of Riverside 2003) reveals that the site is located in an area that is rated as "High" for susceptibility to wind erosion. Development plans should therefore account for the potential effects of windblown sand and dust.

12.2.3 - Impacts

Grading in conjunction with site development will loosen natural desert pavements and crusts that will enable wind erosion. Figure 7 shows the levels of wind erosion hazard that were mapped by the county in the area of the project. The figure is derived from Figure S-8 of the county general plan.

12.2.4 - Mitigations

Wind-blown sand can be mitigated during construction with conventional dust control measures during construction. Buildup of sand during the life of the project will be managed through a sand removal program.

13.0 - UNSTABLE GEOLOGICAL UNITS OR SOILS

13.1 - Collapsible Soils

13.1.1 - Level of Significance: *Less than Significant with Mitigation*

13.1.2 - Nature of Concern

Soils subject to collapse typically exhibit a high strength when dry, however when moisture is introduced, the grain structure is rearranged resulting in a relatively rapid volume reduction (collapse). The collapse phenomenon is relatively common in arid environments such as the Salton Trough. Collapsible soils generally result from rapid deposition close to the source of the sediment such as debris flows, but can occur in wind-blown sands also. When saturated, the grain structure of these soils condenses or collapses resulting in subsidence and settlement under relatively low loads. A rise in the groundwater table or an increase in surface-water infiltration, with or without the weight of structures can initiate settlement and cause the foundations and walls of constructed facilities to crack.

13.1.3 - Impacts

Collapsible soils have previously been found by this firm in areas within the City of La Quinta immediately adjacent to the project (Petra 2008). If not mitigated hydrocollapse can lead to excessive settlement of structures. Other design reports reviewed also indicated various levels of collapsible soils along the project alignment. See the summaries in Appendix C. Collapsible soils were primarily found in the near surface, and were noted in the mid and lower valley areas (Palm Desert, Indian Wells, La Quinta, Indio, and Coachella). Collapse potentials that are found to be less than 1 percent are generally considered minor. We have reviewed the existing geotechnical investigations along the project alignment, and locations where collapsible soils were noted are shown on Figure 10. Site No's. 5, 7, 10, 11, 13, 14, 15, & 16 on Figure 10 exhibited collapse potentials of 1 percent or greater. The maximum collapse potential noted was 6.6 percent at site No. 10.

13.1.4 - Mitigations

Laboratory testing on soil samples collected in-situ is the only reliable method to identify potentially collapsible soils. Collapse potential was observed as many locations throughout the valley as noted above. Hydrocollapse potential can be mitigated by removal and recompaction of susceptible soils, or by flooding and surcharging, or other ground densification techniques. The primary technique to be used on this project would be removal and recompaction. Flooding and surcharging or ground improvements such as deep dynamic compaction or stone columns may only be used where site constraints impinge on grading. In order to reduce the potential for collapsible soils to impact the project improvements, drainage and infiltration systems for stormwater management should be located away from structures and hardened improvements. Deep foundations can be used for bridge structures to bypass the zones of collapsible soils.

13.2 - Regional Subsidence and Fissuring

13.2.1 - Level of Significance: *Less than Significant with Mitigation*

13.2.2 - Nature of Concern

Fissuring has been known to occur in southern California largely as a result of ground water or other subsurface fluid (e.g. oil) withdrawals. Hydrocompaction is a common cause of subsidence but earthquakes may also cause subsidence. Ground water held in pore spaces between sediment grains maintains the open internal structure of the sediments; and when the water is extracted, grains compact causing subsidence at the surface. Subsidence has occurred widely in desert basins both as a result of natural dessication as the late Quaternary climate has become warmer and drier (post ice age), and as a result of groundwater extraction by man for agricultural purposes and drinking water. Subsidence caused by fluid withdrawal may only be partially reversible.

According to the County of Riverside Safety Element, Chapter 6.0 of the General Plan (adopted October 7, 2003), the site lies within a documented subsidence area. Figure S-7 of that document indicates that the area of the subject site has a subsidence categorization of "Susceptible". Policy S-3.8 of the General Plan requires a geotechnical evaluation of subsidence if a project site lies within a documented area or a susceptible area according to figure S-7. As stated in the General Plan, *"differential displacement and fissures occur at or near the valley margin, and along faults. In the County of Riverside, the worst damage to structures, as a result of regional subsidence, may be expected at the valley margins".*

13.2.3 - Impacts

Portions of the project alignment will lie near the valley margin were differential ground subsidence from groundwater extraction could be magnified. The site does lie within or near the active subsidence areas as documented by Sneed (Sneed 2001, 2007, 2014). The probability of subsidence due to groundwater extraction affecting the site is judged to be moderate.

Local subsidence depressions have been documented by Sneed in the Palm Desert and Indian Wells areas (see figures 9 through 12 of Sneed 2014). Figure 9 shows the subsidence areas observed whithin the valley that are in the approximate area of the CV Link project. Approximately 1-¼ feet of settlement has occurred along the alignment of Monterey Avenue in Palm Desert between Fred Waring and Country Club drive between 1996 and 2010. Figure 10 shows the general location of the project in the Palm Desert area in relation to the subsidence issues observed by Sneed. The maximum settlement occurred over a distance of approximately ½ mile, resulting in a differential settlement of approximately 2.5 feet per mile (or roughly 1 foot per 2000 feet). Wood frame building structures in California are generally designed to tolerate distortions from differential settlement where the angular distortion ratio is less than 1:480 to limit cosmetic or nuisance damage. Higher limits would be required for structural compromise. As noted the differential amount of ground deformation at the surface from subsidence in the project area is much less than the amount required to cause damage. Much greater levels of subsidence in the future would be required to begin to damage the proposed facilities.

Ground fissuring in the La Quinta area has been documented, approximately 3 miles south of the alignment, in the past from subsidence. However steps have been taken by CVWD in the form of groundwater recharge at the Tom Levy Groundwater Recharge Facility to arrest further movements.

Commonly the subsidence is slow and occurs over a wide area that is not noticeable and has no impact. In extreme cases it can cause reversal of drainage and distress to structures and lifelines. Because subsidence is generally spread over a wide area as discussed above, subsidence and fissuring should have a less than significant impact for the project.

13.2.4 - Mitigations

Regional subsidence is being actively monitored by the United States Geological Survey and the Coachella Valley Water District. Limitations on groundwater withdrawal by regional or state authorities can reduce the impacts of further subsidence. Standard building foundations constructed to usual settlement tolerances should be able to resist subsidence related deformations. Pavements could suffer minor cracking related to subsidence but the impact should be hard to distinguish from that caused by normal traffic and wear and tear. Therefore this potential impact would be less than significant.

13.3 - Expansive Soils

13.3.1 - Level of Significance: *Less than Significant with Mitigation*

13.3.2 - Nature of Concern

Relatively thin, rigid structural elements such as building floor slabs and exterior concrete flatwork and pavements may experience uplift, shifting, or cracking as a result of swelling or contraction of expansive soils. Expansive soils swell when they become wet and shrink when they dry. The expansion generally occurs in soils with large amounts of certain clay minerals. These types of soils are common in the lake sediments underlying the valley floor. Consequences of the expansion and contraction are cracked walls, foundations, and paved areas. Generally this type of cracking is only a nuisance but occasionally it can lead to structural distress.

13.3.3 - Impacts

Expansive soils are expected in the lower valley portion of the project area. Laboratory testing on soil samples collected by our firm indicate the potential exists for expansive soils. Tests such as the Expansion Index test and the Atterberg Limits test can be used to indicate the presence of expansive soils. The near surface soils noted during our drilling and exploration were primarily sandy, however some finer grained soils that could be subject to expansion were noted. Review of past reports by other firms also indicates the potential for expansive soils.

13.3.4 - Mitigations

Further laboratory testing for expansive soils should be conducted at the end of grading operations. The effects of expansive soils can be mitigated by standard geotechnical practices such as excavation of the expansive soils and replacement with nonexpansive compacted fill, by using additional steel reinforcing in foundations, the use of post-tensioned slabs, presoaking, and drainage control devices to maintain a constant state of moisture. Foundation and Flatwork recommendations for various levels of expansive soils that could be found along the project are found in Appendix K and L. These recommendations would reduce the level of impact from potential expansive soils to a less than significant level.

13.4 - Suitability of Site Soils to Support Wastewater Disposal Systems

13.4.1 - Level of Significance: *No Impact*

13.4.2 - Discussion

The proposed development along the project alignment would be served by the local municipal sewer systems. Therefore, the project would not include the use of private on-site septic systems or alternative wastewater disposal systems.

14.0 - OTHER GEO-RESOURCE IMPACTS

14.1 - Flooding Not Related to Seismicity

14.1.1 - Level of Significance: *Less than Significant with Mitigation*

14.1.2 - Nature of Concern

Flooding not related to seismicity may occur rarely as a result of locally concentrated winter storms or summer monsoons. Flooding of this type involves short-term, low volume, high velocity flow downslope generally within existing drainages.

<u>14.1.3 - Impacts</u>
Any alterations to the natural drainages would impact runoff and could cause local flooding.

<u>14.1.4 - Mitigations</u>
These impacts can be mitigated to a level of non-significance by engineered drainage controls.

14.2 - Mineral and Energy Resources

<u>14.2.1 - Level of Significance</u>: *Less than Significant*

<u>14.2.2 - Nature of Concern</u>
The materials comprising and underlying the proposed project alignment are entirely young sediments rocks of the type that generally do not have economic minerals. There is no documentation of economic mineral deposits within the proposed project alignment. Many of the sands and gravels along the project alignment may be suitable for aggregate.

<u>14.2.3 - Impacts/Mitigations</u>
Loss or reduced access to aggregate mineral resources could occur as a result of construction of the proposed project. However, there is nothing unique or unusual about these materials that would make them of significant importance. Existing commercial aggregate sources are adequate to meet existing and future needs, and there are abundant undeveloped local sources to supply the unforeseen needs of the community. Therefore this impact is considered less than significant.

The project will not have a significant impact on the wind resources of the San Gorgonio Wind Resource area or on the geothermal resources at the southern end of the Salton Sea. These impacts are considered less than significant.

15.0 - CONSTRUCTION ACTIVITIES

Grading and construction of foundations may involve the use of heavy construction equipment. Noise and vibration could be caused by drilling equipment used for ground improvement or installation of piles, and vibratory compaction equipment used to densify subgrade soils etc. Seismic shear wave velocity tests were conducted in each CPT sounding (see Appendix A for results). Study of the significance of these potential activities is beyond our expertise and is referred to the other qualified design team members.

16.0 - RECOMMENDATIONS FOR ADDITIONAL STUDY

Once an engineering level grading plan has been developed for the proposed project, a design-phase engineering geotechnical investigation will be prepared. The results of the exploratory work discussed in this report will form the basis of a comprehensive site-specific geotechnical engineering report that provides detailed recommendations for site grading and ground improvement, design of structural foundations and floor slabs for the proposed buildings, structures, improvements, roadways, and pavement surfaces.

17.0 - CONCLUSIONS

Based on the results of our review of available geotechnical literature and maps, it is our opinion that development of the subject project is feasible from a geotechnical standpoint. In addition, with the implementation of the mitigation measures/performance standards described in this study and the final recommendations to be provided in the comprehensive design-phase geotechnical reports, the potentially significant geologic and seismic impacts identified in this report would be reduced to a less-than-significant level.

18.0 - CLOSURE

It should be noted that our site evaluation and professional opinion reported herein are based on limited subsurface data collected to date from previous investigations conducted in the area, as well as existing published geological literature, and limited time for analysis. As such, further subsurface exploration and evaluation is warranted, which subsequently could change conclusions and recommendations provided herein. The materials encountered on the project site, described in other literature, and utilized in our laboratory investigation are believed representative of the total project area, and the conclusions and recommendations contained in this report are presented on that basis. However, soils can vary in characteristics between points of exploration, both laterally and vertically, and those variations could affect the conclusions and recommendations contained herein. As such, observation and testing by a geotechnical consultant during the construction phase of the project are essential to confirming the basis of this report. To provide the greatest degree of continuity between the design and construction phases, consideration should be given to retaining Petra Geosciences, Inc., for construction services. The data obtained and reviewed as part of this EIR level report are considered adequate for this stage of study, however as additional data is collected in future studies, and during construction revised recommendations may be provided as necessary to assure compliance with required regulatory and engineering standards.

This report has been prepared consistent with that level of care being provided by other professionals providing similar services at the same locale and time period. The contents of this report are professional opinions and as such, are not to be considered a guarantee or warranty. This report should be reviewed and updated after a period of one year or if the general project design concept changes from that described herein.

The opportunity to be of continued service to your firm is greatly appreciated. Should you have any questions, please do not hesitate to call.

Respectfully submitted,

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JMS/AP/lmv

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