4.9 GEOLOGY AND SOILS

This section describes current conditions relative to geology at the Resources Building Replacement Project site. It includes a description of soils and mineral resources, an analysis of environmental impacts, and recommendations for mitigation measures for any significant or potentially significant impacts. In addition to publicly available documentation, the primary source of information used for this analysis is the Preliminary Geotechnical Engineering Report prepared by Arup North America, Ltd. in 2017 (provided in Appendix I of this DEIR).

4.9.1 Regulatory Background

FEDERAL PLANS, POLICIES, REGULATIONS, AND LAWS

National Earthquake Hazards Reduction Act

In October 1977, the U.S. Congress passed the Earthquake Hazards Reduction Act to reduce the risks to life and property from future earthquakes in the United States. To accomplish this, the act established the National Earthquake Hazards Reduction Program (NEHRP). The mission of NEHRP includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improved building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improved mitigation capacity; and accelerated application of research results. The NEHRP designates the Federal Emergency Management Agency (FEMA) as the lead agency of the program and assigns several planning, coordinating, and reporting responsibilities.

STATE PLANS, POLICIES, REGULATIONS, AND LAWS

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act of 1972 (Public Resources Code [PRC] Section 2621-2630) intends to reduce the risk to life and property from surface fault rupture during earthquakes by regulating construction in active fault corridors, and by prohibiting the location of most types of structures intended for human occupancy across the traces of active faults. The act defines criteria for identifying active faults, giving legal support to terms such as active and inactive, and establishes a process for reviewing building proposals in Earthquake Fault Zones. Under the Alquist-Priolo Act, faults are zoned and construction along or across these zones is strictly regulated if they are “sufficiently active” and “well-defined.” A fault is considered sufficiently active if one or more of its segments or strands shows evidence of surface displacement during Holocene time (defined for purposes of the act as within the last 11,000 years). A fault is considered well defined if its trace can be clearly identified by a trained geologist at the ground surface or in the shallow subsurface, using standard professional techniques, criteria, and judgment (Hart and Bryant 2007). Before a project can be permitted in a designated Alquist-Priolo Earthquake Fault Zone, cities and counties must require a geologic investigation to demonstrate that proposed buildings would not be constructed across active faults. The law addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards.

Seismic Hazards Mapping Act

The intention of the Seismic Hazards Mapping Act of 1990 (PRC Section 2690–2699.6) is to reduce damage resulting from earthquakes. While the Alquist-Priolo Act addresses surface fault rupture, the Seismic Hazards Mapping Act addresses other earthquake-related hazards, including ground shaking, liquefaction, and seismically induced landslides. The act’s provisions are similar in concept to those of the Alquist-Priolo Act: The State is charged with identifying and mapping areas at risk of strong ground shaking, liquefaction, landslides, and other corollary hazards, and cities and counties are required to regulate development within mapped Seismic Hazard Zones. Under the Seismic Hazards Mapping Act, permit review is the primary mechanism for local regulation of development. Specifically, cities and counties are prohibited from issuing development permits for projects in Seismic Hazard Zones until appropriate site-specific geologic or geotechnical investigations have been carried out and measures to reduce potential damage have been incorporated into the development plans.

California Building Code

The California Building Code (CBC) (California Code of Regulations, Title 24) is based on the International Building Code (IBC). The CBC has been modified from the IBC for California conditions, with more detailed and/or more stringent regulations. Specific minimum seismic safety and structural design requirements are set forth in Chapter 16 of the CBC. The CBC identifies seismic factors that must be considered in structural design. Chapter 18 of the CBC regulates the excavation of foundations and retaining walls, while Chapter 18A regulates construction on unstable soils, such as expansive soils and areas subject to liquefaction. Appendix J of the CBC regulates grading activities, including drainage and erosion control. The CBC contains a provision that provides for a preliminary soil report to be prepared to identify "…the presence of critically expansive soils or other soil problems which, if not corrected, would lead to structural defects." (CBC Chapter 18 Section 1803.1.1.1).

LOCAL PLANS, POLICIES, REGULATIONS, AND LAWS

The Resources Building Replacement Project is located on State-owned property, has been authorized and funded by the State of California through the State Projects Infrastructure Fund, and would be implemented by the California Department of General Services (DGS). As explained in Section 4.2 "Land Use" of this EIR, under Section 4.2.1 "Local Plans, Policies, Regulations, and Laws," State agencies are not subject to local plans, policies, and zoning regulations. Nevertheless, in the exercise of its discretion, DGS does reference, describe, and address local plans, policies, and regulations that are applicable to the Resources Building Replacement Project. This evaluation is also intended to be used by local agencies for determining, as part of their permit process, the project's consistency with local plans, policies, and regulations.

City of Sacramento 2035 General Plan

The Environmental Constraints Element of the City of Sacramento 2035 General Plan outlines the City of Sacramento's (City's) goals and policies regarding seismic and geologic hazards. The following are those goals and policies most applicable to the Resources Building Replacement Project:

Goal EC 1.1 Hazards Risk Reduction. Protect lives and property from seismic and geologic hazards and adverse soil conditions.

- Policy EC 1.1.1 Review Standards. The City shall regularly review and enforce all seismic and geologic safety standards and require the use of best management practices (BMPs) in site design and building construction methods.

- Policy EC 1.1.2 Geotechnical Investigations. The City shall require geotechnical investigations to determine the potential for ground rupture, ground-shaking, and liquefaction due to seismic events, as well as expansive soils and subsidence problems on sites where these hazards are potentially present.

4.9.2 Existing Conditions

REGIONAL GEOLOGY

The Great Valley geomorphic province is an alluvial plain about 50 miles wide and 400 miles long in the central part of California, and is a trough in which sediments have been deposited almost continuously since the Jurassic Period. A "geomorphic province" is comprised of an area of similar geologic origin and erosional/depositional history. Its northern area is the Sacramento Valley, drained by the Sacramento River, and its southern area is the San Joaquin Valley, drained by the San Joaquin River. The project site is situated in the Sacramento Valley within the northern portion of the Great Valley geomorphic province of California.

The Sacramento Valley is bounded by the foothills of the Sierra Nevada mountain range to the east, the Coast Ranges to the west, and the Cascade Range and Klamath Mountains to the north. The geology of the Great Valley geomorphic province incorporates thick sequences of alluvial sediments derived primarily from erosion of the Sierra Nevada range to the east, and to a lesser extent from erosion of the Cascade and Klamath mountain ranges to the north. Sediments from these mountain ranges were transported downstream and laid down as river channel and floodplain deposits and alluvial fans.

The Sacramento Valley is an alluvial plain composed of a deep sequence of sediments derived from erosion of the Coast Ranges to the west and Sierra Nevada Mountains to the east, within the confines of a structural trough. The thickness of the alluvial deposits beneath the project site is approximately 8,000 feet (Hackel 1966: Figure 1); however, a minimum of 60,000 feet of Mesozoic sediments consisting of siltstone, claystone, and sandstone of predominantly marine origin were laid down in the area west of the present margin of the Sacramento Valley (Hackel 1966: 217), and west of the project site. The uppermost part of the alluvial plain is comprised of Holocene age Basin Deposits and Pleistocene age Riverbank Formation sediments, both alluvial in origin. These alluvial deposits are underlain by undifferentiated early Tertiary age marine deposits which overlie upper Cretaceous age deposits of the Great Valley Sequence. The sedimentary sequence rests on a basement complex composed of metamorphosed Paleozoic and Mesozoic sediments, volcanics, and granites extending west from the Sierra Nevada Mountains.

LOCAL GEOLOGY

The project site and immediate vicinity is underlain by Holocene age terraced riverine alluvium deposits, consisting of cobble, gravel, sand, silt, and clay (California Geological Survey [CGS] 1999a). These deposits were laid down by the present-day stream and river systems that flow through the Sacramento area. The Sacramento River and associated floodplain is located less than one mile west of the project site. Based on data provided in the November 30, 2016 EDR Radius Map Report (EDR 2016) and the NRCS Web Soil Survey (accessed 05/02/2017), the soil at and surrounding the project site is classified as Urban Land of variable surface texture, and as non-hydric.

A subsurface investigation was performed by Arup (Appendix I) to establish a general understanding of the geotechnical, geological, and geophysical properties of the site soils. The project site is located on alluvial deposits set down by the confluence of the Sacramento and American rivers. Based on the results of the geotechnical investigation and review of historical reports, the following were encountered at depth: stratigraphic layers of artificial fill, younger alluvium, and an older alluvial clay deposit. The younger alluvium includes distinct upper and lower layers of sands, silts, and clays separated by a layer of river cobbles and gravel. Bedrock was not encountered in the subsurface exploration.

GROUNDWATER

The Sacramento area is underlain by geologic formations that include an upper, unconfined groundwater/aquifer system (able to receive water that infiltrates from the surface) and a lower semiconfined groundwater/aquifer system (infiltration of water can be partially blocked by impermeable layers). Depth to groundwater in the downtown area varies seasonally, is relatively shallow (can be less than 10 feet to the water table), with no predominant direction of groundwater flow (Sacramento Central Groundwater Authority 2012). Depth to groundwater could not be conclusively determined because of the presence of drilling mud during preparation of the geotechnical engineering report (see Appendix I). It was estimated by the Arup field engineer based on observation of the soil samples that groundwater was encountered at approximately 12 to 15 feet, which is consistent with what is typical in the region.

SOILS

Borings were used to collect samples at the project site to identify subsurface soil characteristics and preliminary foundation design information. The following discussion summarizes the results of the soil investigations. The full preliminary geotechnical engineering report is attached as Appendix I of this EIR.

As of May 2017, Arup North American, Ltd. had completed two exploratory test borings located west and east along a transect across Opera Alley (mid-block on the P Street Block) in the parking lot area to depths of approximately 71.5 feet and 101.5 feet below ground surface (bgs), respectively (see Appendix I). The borings were advanced using hollow stem auger and mud rotary drilling technology. The soil conditions encountered in the boreholes consisted of interbedded layers of sands, silts, and gravels with shallow groundwater at a depth of approximately 12 to 15 feet bgs. Data from monitoring wells indicate depths to groundwater ranging from 12 to 17 feet, with an average depth of 15 feet. Seasonal variations range from approximately 10 feet in winter to approximately 18 feet in summer and fall. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual.

Based on data provided in the November 30, 2016 Environmental Data Resources, Inc. (EDR) Radius Map Report (EDR 2016), the soil at and surrounding the project site is classified as Urban Land type of variable surface texture and as non-hydric. Soils of this variety are characterized by heavy alteration from their natural character by urban land uses. Soil composition may have been altered during construction of structures and paved surfaces. Grading, excavation, and placement of fill are common construction practices and contribute to soil mixing and altered composition of soil.

Natural soil complexes that comprised the original, unaltered soil horizon have been truncated, mixed, or otherwise altered. The natural complexes most commonly associated with this soil type are soils that have proved to have characteristics amenable to urban development. In the Sacramento County area these include Americanos, Andregg, Argonaut, Auburn, Columbia, Cosumnes, Egbert, Fiddyment, Galt, Hedge, Kaseberg, Kimball, Lang, Laugenour, Liveoak, Natomas, Orangevale, Orthents, Red Bluff, Rossmoor, Sailboat, San Joaquin, Tinnin, Valpac soils, and Xerarents and Xerorthents (NRCS 2017). In their unaltered state, most of these soils have low to moderate shrink-swell potential, but rarely can have high shrink-swell characteristics. Taken together, these soils are susceptible to a variety of soil risk factors such as shallow hardpan, shallow bedrock, caving, flooding, and low strength. Construction on these soils generally requires design features that reduce or eliminate structural damage or failure risks. Soil textures are a varied mix of small soil particles: clay, silt, sand, and loam.

EROSION

Erosion is the process by which soil and rock at the earth’s surface is gradually broken down and transported to a different location. Erosive processes include rainfall, surface runoff, glacial activity, wind abrasion, chemical dissolution, and gravity in the form of mass wasting. Under normal conditions, these erosive processes control the rate at which erosion occurs, together with physical characteristics of the material being eroded. Human activities can accelerate that rate, causing excessive erosion and a wide variety of detrimental effects on the environment, including sedimentation of waterways, eutrophication of water bodies, slope instability, ground instability, loss of agricultural productivity through the removal of topsoil, or even desertification.

Because of the flat topography at the project site, the extensive pavement, and storm water collection and conveyance system, the potential for erosion is very low.

SUBSIDENCE

Land subsidence is the gradual settling or sinking of an area with very little horizontal motion. It occurs because of changes taking place underground. Subsidence can be induced by both natural and human phenomena. Natural phenomena include subsidence resulting from shifting of tectonic plates and dissolution of limestone resulting in sinkholes. Subsidence related to human activity includes pumping water, oil, or gas from underground reservoirs; collapse of underground mines; drainage of wetlands; and soil compaction. Although the project site and surrounding area is located in an area of potential subsidence associated with the principle groundwater basin (City of Sacramento 2014), there is no reported evidence of subsidence in the immediate area of the project site.

The results of preliminary findings of the geotechnical engineering investigation (Appendix I) concluded that only minor settlements may be expected beneath a proposed structure in the area investigated.

EXPANSIVE SOILS

Expansive soils (also known as shrink-swell soils) are soils that contain expansive clay minerals that can absorb significant amounts of water into their crystalline structure. The presence of these clay minerals makes the soil prone to large changes in volume in response to changes in water content. The quantity and type of expansive clay minerals affects the potential for the soil to expand or contract. When an expansive soil becomes wet, water is absorbed and it increases in volume, and as the soil dries it contracts and decreases in volume. This (often repeated) change in volume can produce enough force and stress on buildings and other structures to damage foundations and walls.

Where native soils still exist, soil types may be expected to be similar to those of the nearby areas. These soil types exhibit a range in shrink-swell potential from low to high (DGS 2005). However, potentially expansive soils were not identified in the preliminary geotechnical engineering investigation prepared for the project (see Appendix I).

MASS WASTING AND LANDSLIDES

Mass wasting refers to the collective group of processes that characterize down slope movement of rock and unconsolidated sediment overlying bedrock. These processes include landslides, slumps, rockfalls, flows, and creeps. Many factors contribute to the potential for mass wasting, including geologic conditions as well as the drainage, slope, and vegetation of the site. A landslide susceptibility database developed by CGS (2011) indicates that the project site is located in an area where land sliding is not expected because of the site being located on a topographically flat area on the valley floor within the floodplain of the Sacramento River. With such minor topographic relief, the probability of a landslide is considered nonexistent.

SEISMICITY

Most earthquakes originate along fault lines. A fault is a fracture in the Earth’s crust along which rocks on one side are displaced relative to those on the other side because of shear and compressive crustal stresses. Most faults are the result of repeated displacement that may have taken place suddenly and/or by slow creep (Hart and Bryant 2007: 3). The state of California has a classification system that designates faults as either active, potentially active, or inactive, depending on how recently displacement has occurred along them. Faults that show evidence of movement within the last 11,000 years (the Holocene geologic period) are considered active, and faults that have moved between 11,000 and 1.6 million years ago (comprising the later Pleistocene geologic period) are considered potentially active.

The project site is located along the eastern margin of the circum-Pacific earthquake zone, which is a result of the processes of plate tectonics, and is the most seismically active area in the United States. A major feature of the circum-Pacific earthquake zone associated with this region of California is the San Andreas Fault System which defines the boundary between the North American Plate to the east (on which the project area is located) and the Pacific Plate to the west. The San Andreas Fault System is generally expressed as a 40-mile wide elongated zone of fracturing and rock deformation that creates the general northwest-southeast trending valleys and ridges in the Coast Ranges, as well as the overall physiographic nature of California's Central Valley. Another consequence of its proximity to the project site is exposure to the earthquake activity that is common throughout California.

A review of available published geologic and seismic hazards maps indicates that there are no known active faults identified in or adjacent to the City of Sacramento and the Proposed Project area. In addition, there has been no documented movement on faults mapped in Sacramento County during the past 150 years. However, the region has experienced numerous instances of groundshaking originating from faults in the San Andreas Fault System.

There are no mapped faults in the immediate vicinity of the project area. The closest known potentially active fault mapped by the California Geological Survey is the Dunnigan Hills fault located about 20 miles northwest of Sacramento, with the closest branches of the seismically active San Andreas Fault System (Historic activity, i.e., within the last 200 years) being the Green Valley and Concord faults, 43 and 50 miles to the southwest, respectively. The main trace of the San Andreas Fault System is approximately 80 miles to the southwest. Active nearby faults identified within 100 miles of the Project area are listed on Table 4.9-1.

Table 4.9-1 Active Nearby Faults Within 100 Miles of the Project Area

Fault Name	Distance from Fault to Project Site (Miles)	Age of Movement	Characteristic Earthquake (moment magnitude)
Dunnigan Hills	20	Holocene (<11,000 years)	6.6[1]
Vaca	28	Quaternary	6.1[1]
Foothills, N central section	30	Quaternary (<130,000 years)	6.0[2, 3]
Foothills, S central section	36	Quaternary	6.0[2,3]
Greenville	43	Holocene	6.6
Green Valley	43	Recent (<150 years)	6.2
Cordelia	43	Holocene (<11,000 years)	NA
Concord	50	Recent	6.2
Healdsburg / Rogers Creek	56	Quaternary / Holocene	7.1
Hayward	61	Recent	6.9 – 7.1
Calaveras	61	Holocene	7.5
San Andreas	80	Recent	7.9

[1] Wesnousky, S.G., 1986
[2] General Plan, 2011
[3] Richter scale magnitudes
Source: Jennings and Bryant 2010

Seismic hazards resulting from earthquakes include surface fault rupture, ground shaking, liquefaction and lateral spreading, subsidence, and mass wasting. Each of these potential hazards is discussed below.

Surface Fault Rupture

Surface rupture is the surface expression of movement along a fault. Structures built over an active fault can be torn apart if the ground ruptures. The potential for surface rupture is based on the concepts of recency and recurrence. Surface rupture along faults is generally limited to a linear zone a few meters wide. The Alquist-Priolo Act (see the Regulatory Setting discussion above) was created to prohibit the location of structures designed for human occupancy across, or within 50 feet of, an active fault, thereby reducing the loss of life and property from an earthquake. The project site is not located within an Alquist-Priolo active fault zone (Hart and Bryant 2007), and there is no evidence of active faulting within or near the project site.

Ground Shaking

The intensity of seismic shaking, or strong ground motion, during an earthquake is dependent on the distance and direction from the epicenter of the earthquake, the magnitude of the earthquake, and the geologic conditions of the surrounding area. Ground shaking could potentially result in the damage or collapse of buildings and other structures. The project area is outside the zone of impact from active faults nearest to the project area (Table 4.9-1), and therefore these faults would be expected to produce minimal ground shaking in the area of the project.

The probable seismic ground shaking expected at the project site is anticipated to produce peak ground accelerations between 10 and 20 percent of the acceleration of gravity, 0.1 g and 0.2 g, respectively (DOC 2002). Earthquake intensities generally associated with this amount of ground shaking are typically between VI and VII on the Modified Mercalli Intensity Scale (MMI) (Table 4.9-2). An expected characteristic earthquake on the entire San Andreas Fault System is Moment Magnitude scale (Mw) of 7.9 and is probably the largest earthquake that would be felt in the project site. Given the distance between the San Andreas Fault and the project site, the felt intensity would be expected to be between MMI IV and V (light to moderate shaking). However, a felt intensity between MMI VII and VIII would be caused by a characteristic earthquake on the Dunnigan Hills fault of Mw 6.6 because it is much closer to the project area.

The project site is located in an area of low earthquake hazard and therefore experiences low levels of shaking on an infrequent basis (CGS 2003). Based on data from the CGS (2008), the project site would be expected to have 2 percent chance in 50 years to experience a ground motion of 0.318 g. However, based on the findings of the preliminary geotechnical engineering investigation (Appendix I), using the USGS web-based tool (USGS 2014) with the 2014 Seismic Hazard Update, the California Building Code-compliant seismic response spectrum for the project site is expected to experience a peak ground acceleration of 0.233 g.

Table 4.9-2 The Modified Mercalli Scale of Earthquake Intensities

If most of these effects are observed	Then the intensity is
Earthquake shaking not felt but people may observe marginal effects of large distance earthquakes without identifying these effects as earthquake-caused. Among them: trees, liquids, bodies of water sway slowly, or doors swing slowly.	I
Effect on people: Shaking felt by those at rest, especially if they are indoors, and by those on upper floors.	II
Effect on people: Felt by most people indoors. Some can estimate duration of shaking but many may not recognize shaking of building as caused by an earthquake; the shaking is like that caused by the passing of light trucks.	III
Other effects: Hanging objects swing. Structural effects: Windows or doors rattle. Wooden walls and frames creak.	IV
Effect on people: Felt by everyone indoors and by most people outdoors. Many now estimate not only the duration of shaking but also its direction and have no doubt as to its cause. Sleepers wakened. Other effects: Hanging objects swing. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Structural effects: Doors close, open or swing. Windows rattle.	V
Effect on people: Felt by everyone indoors and by most people outdoors. Many now estimate not only the duration of shaking but also its direction and have no doubt as to its cause. Sleepers wakened. Other effects: Hanging objects swing. Shutters or pictures move. Pendulum clocks stop, start, or change rate. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Structural effects: Weak plaster and Masonry D* crack. Windows break. Doors close, open, or swing.	VI
Effect on people: Felt by everyone. Many are frightened and run outdoors. People walk unsteadily. Other effects: Small church or school bells ring. Pictures thrown off walls, knickknacks and books off shelves. Dishes or glasses broken. Furniture moved or overturned. Trees, bushes shaken visibly, or heard to rustle. Structural effects: Masonry D* damaged; some cracks in Masonry C*. Weak chimneys break at roof line. Plaster, loose bricks, stones, tiles, cornices, unbraced parapets, and architectural ornaments fall. Concrete irrigation ditches damaged.	VII
Effect on people: Difficult to stand. Shaking noticed by auto drivers. Other effects: Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Furniture broken. Hanging objects quiver.	VIII

Table 4.9-2 The Modified Mercalli Scale of Earthquake Intensities

If most of these effects are observed	Then the intensity is
Structural effects: Masonry D* heavily damaged; Masonry C* damaged, partially collapses in some cases; some damage to Masonry B*; none to Masonry A*. Stucco and some masonry walls fall. Chimneys, factory stacks, monuments, towers, elevated tanks twist or fall. Frame houses move on foundation if not bolted down; loose panel walls thrown out. Decayed piling broken off.	
Effect on people: General fright. People thrown to ground. Other effects: Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. Steering of autos affected. Branches broken from trees. Structural effects: Masonry D* destroyed; Masonry C* heavily damaged, sometimes with complete collapse; Masonry B* is seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames cracked. Reservoirs seriously damaged. Underground pipes broken.	IX
Effect on people: General panic. Other effects: Conspicuous cracks in ground. In areas of soft ground, sand is ejected through holes and piles up into a small crate, and, in muddy areas, water fountains are formed. Structural effects: Mast masonry and frame structures destroyed along with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, and embankments. Railroads bent slightly.	X
Effect on people: General panic. Other effects: Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Structural effects: General destruction of buildings. Underground pipelines completely out of service. Railroads bent greatly.	XI
Effect on people: General panic. Other effects: Same as for Intensity X. Structural effects: Damage nearly total, the ultimate catastrophe. Other effects: Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air.	XII

* Masonry A: Good workmanship and mortar, reinforced, designed to resist lateral forces.
* Masonry B: Good workmanship and mortar, reinforced.
* Masonry C: Good workmanship and mortar, unreinforced.
* Masonry D: Poor workmanship and mortar and weak materials, like adobe.

Liquefaction and Lateral Spreading

Liquefaction is a phenomenon in which loose, saturated, granular soil deposits lose a significant portion of their shear strength because of excess pore water pressure buildup. Cyclic loading, such as an earthquake, typically causes the increase in pore water pressure and subsequent liquefaction. These soils are behaving like a liquid during seismic shaking and re-solidify when shaking stops. The potential for liquefaction is highest in areas with high groundwater and loose, fine, sandy soils at depths of less than 50 feet. Based on site-specific borehole data, the uppermost groundwater beneath the project site is estimated to be between 12 and 15 feet bgs (Appendix I). A geological and seismological study in 1972 in the downtown area indicated the potential for liquefaction (Sacramento County 2011). This study also concluded that potential liquefaction problems may exist throughout the downtown area where loose sands and silts are present below the ground water table. However, there have been no reported instances of liquefaction occurring in downtown Sacramento during major earthquake events, including the Loma Prieta earthquake in 1989, the Vacaville-Winters earthquake in 1982, or the San Francisco earthquake in 1906 (DGS 2005). Moreover, mapping conducted pursuant to the Alquist-Priolo Act indicates that the project site and surrounding area are not identified as located within an area of potential liquefaction (Hart and Bryant 2007).

Liquefaction may also lead to lateral spreading. Lateral spreading (also known as expansion) is the horizontal movement or spreading of soil toward an "open face," such as a streambank, the open side of fill embankments, or the sides of levees. It often occurs in response to liquefaction of soils in an adjacent area. The potential for failure from lateral spreading is highest in areas where there is a high groundwater table, where there are relatively soft and recent alluvial deposits, and where creek banks are relatively high, as in the case of the project site. The Sacramento River is located approximately one mile to the west of the project site and could offer a potential opportunity for lateral spreading. However, because the project site and vicinity are relatively flat and is relatively distant from the Sacramento River, lateral spreading caused by liquefaction is not expected to be a concern (DGS 2005).

According to the preliminary findings of the geotechnical engineering investigation (Appendix I), the effects of liquefaction would not contribute toward ground failure or manifest as more than minor settlements beneath a proposed structure in the area investigated.

MINERAL RESOURCES

The California Department of Conservation Division of Mines and Geology has developed guidelines for the classification and designation of mineral lands, known as Mineral Resource Zones (MRZs) and retains a list of publications of the Surface Mining and Reclamation Act Mineral Land Classification Project dealing with mineral resources in California. The project site is located within a mapped MRZ and is designated MRZ-1, areas where adequate information indicates that no significant mineral deposits are present, or where it is judged that little likelihood exists for their presence (CGS 1999b).

4.9.3 Environmental Impacts and Mitigation Measures

ANALYSIS METHODOLOGY

The examination of geology, soils, and mineral resources is based on information obtained from reviews of:

- the project description;
- available literature, including documents published by the City, the County of Sacramento, State and federal agencies, and published information dealing with geotechnical conditions in the Sacramento area;
- applicable elements from the County of Sacramento General Plan and the City of Sacramento General Plan; and
- Preliminary Geotechnical Engineering Report prepared for the Resources Building Replacement Project (Appendix I).

The analysis below does not address the proposed child care facility to be placed on the roof plaza of the Subterranean Building, located immediately north of the P Street Block (see Chapter 3, "Project Description"). This child care facility would not result in geology and soils impacts because it would be placed on the roof plaza of the existing building and would require no ground disturbing activities.

THRESHOLDS OF SIGNIFICANCE

A geology and soils impact is considered significant if implementation of the Resources Building Replacement Project would do any of the following:

- expose people or structures to potential substantial adverse impacts, including risk of loss, injury, or death through the rupture of a known earthquake fault, strong seismic shaking, seismic-related ground failure, soil liquefaction, or landslides;
- locate project facilities on a geologic unit that is unstable, or that would become unstable as a result of the Resources Building Replacement Project, and potentially result in on-site or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse;
- locate project facilities on expansive soil, creating substantial risks to property;

- result in substantial soil erosion or the loss of topsoil; or
- result in the loss of a known statewide, regional, or locally-important mineral resource.

ISSUES OR POTENTIAL IMPACTS NOT DISCUSSED FURTHER

The topography of the project site in downtown Sacramento is flat. Therefore, there is little to no potential for lateral spreading and landslides. Therefore, impacts associated with lateral spreading and landslides are not discussed further in this DEIR.

The project site is not located on soils susceptible to subsidence. No soft clay–type materials that would undergo long-term settlement were encountered in borings beneath the project site. Borehole data indicate medium stiff to hard silts and clays. On-site subsidence is not expected to occur and subsidence is not discussed further in this DEIR.

The project site is an urban site developed with an existing historic building (Heilbron House), impervious surfaces, and landscaping. Because of the developed conditions of the sites and their generally flat topography, the project would not generate the potential for substantial soil erosion or loss of topsoil. Grading, trenching, and excavation during construction can temporarily expose soil to erosive forces such as wind and stormwater. Such effects are addressed in Section 4.10, “Hydrology and Water Quality,” and are not addressed in this section.

The project site is located within a mapped MRZ and is designated MRZ-1, areas where adequate information indicates that no significant mineral deposits are present, or where it is judged that little likelihood exists for their presence (CGS 1999b). There is no evidence that there are important mineral resources underlying the project site and potential effects on mineral resources are not discussed further in this DEIR.

ENVIRONMENTAL IMPACTS

Impact 4.9-1: Seismic hazards

The project site is not located on any known faults or traces of active faults. Surface fault rupture, therefore, is extremely unlikely. Construction of the proposed facilities would conform to the current CBC, which contains specifications to minimize adverse effects on structures caused by ground shaking from earthquakes and to minimize secondary seismic hazards (i.e., ground lurching, liquefaction). Through conformance with the CBC and implementation of site-specific engineering measures developed in compliance with these codes, development of this project alternative would not result in exposure of people or structures to substantial adverse effects related to seismic hazards. This impact would be **less than significant.**

Although the Sacramento area is located between three seismically active fault regions, the project site would not be located on any known faults or traces of active faults. Surface fault rupture, therefore, is extremely unlikely.

In the event of a major earthquake, people and structures would be exposed to moderate to severe ground shaking. Potential secondary effects of ground shaking at the project site include seismic shaking and liquefaction.

The potential for seismic shaking and associated formation of cracks in the ground is considered greater at contacts between materials with substantially different properties, such as deep, soft soil and bedrock. These conditions were not found at the project site, and the probability of ground lurching and formation of cracks in the ground during a seismic event is considered low.

Construction of the project would conform to the current CBC, which contains specifications to minimize adverse effects on structures caused by ground shaking from earthquakes. Through conformance with the CBC and implementation of site-specific engineering measures developed in compliance with these codes, development of the project would not result in exposure of people or structures to substantial adverse effects related to seismic hazards. The impact would be **less than significant.**

Mitigation Measures

No mitigation is required.

Impact 4.9-2: Liquefaction

The project site is located in an area of potential liquefaction based on the findings of the geotechnical investigation prepared for the project and from previous investigations in the area. Construction of the proposed facilities would conform to the current CBC, which contains specifications to minimize adverse effects on structures caused by liquefaction. Through conformance with the CBC and implementation of site-specific engineering measures developed in compliance with these codes, development of this project alternative would not result in exposure of people or structures to substantial adverse effects related to liquefaction. This impact would be **less than significant.**

The soils beneath the project site may be susceptible to liquefaction, and potential liquefaction problems may exist throughout the downtown area where loose sands and silts are present below the ground water table. However, there have been no reported instances of liquefaction occurring in downtown Sacramento during past major earthquake events. According to the preliminary findings of the geotechnical engineering investigation (see Appendix I), the effects of liquefaction would not contribute toward ground failure or manifest as more than minor settlements beneath a proposed structure in the area investigated.

Lateral spreading occurs when soils liquefy and the overlying soils move horizontally or down a slope. Because the topography at the project site is relatively flat, the potential for lateral spreading is considered generally low.

Construction of the proposed project would conform to the current CBC, which contains specifications to minimize adverse effects on structures caused by liquefaction. Through conformance with the CBC and implementation of site-specific engineering measures developed in compliance with these codes, development of this project would not result in exposure of people or structures to substantial adverse effects related to liquefaction. The impact would be **less than significant.**

Mitigation Measures

No mitigation is required.

Impact 4.9-3: Expansive soils

The project site is located in an area where native soils may still exist, and these soil types exhibit a range in shrink-swell potential from low to high. However, potentially expansive soils were not identified in the preliminary geotechnical investigation beneath the project site. Through conformance with the CBC and implementation of applicable measures (if needed) to address shrink-swell soils, development of the project would not result in exposure of people or structures to substantial adverse effects from these soil types. This impact would be **less than significant.**

The soils beneath the project site are not susceptible to expansion. It is not expected that shrink-swell soils would adversely affect underground facilities associated with this project. However, construction of project facilities would conform to the current CBC, which contains specifications to address shrink-swell soils where they might occur.

Through conformance with the CBC and implementation of applicable measures (if needed) to address shrink-swell soils, development of the project would not result in exposure of people or structures to substantial adverse effects from these soil types. This impact is considered less than significant.

Mitigation Measures

No mitigation is required.