3.7 Geology and Soils

3.7.1 Introduction

This section describes the regulatory and environmental setting for geology, soils, and paleontological resources in the vicinity of the Proposed Project and the Atwater Station Alternative.[1] It also describes the impacts from geology and soils and on paleontological resources that would result from implementation of the Proposed Project and the Atwater Station Alternative and mitigation measures that would reduce significant impacts, where feasible and appropriate.

Cumulative impacts from geology and soils and on paleontological resources, in combination with planned, approved, and reasonably foreseeable projects, are discussed in Chapter 4, *Other CEQA-Required Analysis*.

3.7.2 Regulatory Setting

This section summarizes the federal, state, regional, and local regulations related to geology, soils, and paleontological resources and applicable to the Proposed Project and the Atwater Station Alternative*.* This section also includes a summary of industry design standards and guidelines that would be adhered to during project design and construction.

3.7.2.1 Federal

Geology and Soils

Federal Railroad Administration

Section 213.239, Special Inspections, of 49 Code of Federal Regulations (C.F.R.) Part 213 requires that, in the event of a natural disaster, such as an earthquake or flooding, the Federal Railroad Administration (FRA) and the rail operator will conduct a special inspection of the track involved as soon as possible after the occurrence, and, if possible, before the operation of any train over the track.

Paleontological Resources

Paleontological Resources Preservation Act

The federal Paleontological Resources Preservation Act of 2002 was enacted to codify the generally accepted practice of limiting the collection of vertebrate fossils and other rare and scientifically significant fossils to qualified researchers. These researchers must obtain a permit from the appropriate state or federal agency and agree to donate any materials recovered to recognized public institutions, where they will remain accessible to the public and to other researchers.

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[1] *Paleontological resources* include vertebrate, invertebrate, and plant fossils.

3.7.2.2 State

Geology and Soils

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was enacted as the Special Studies Zones Act in 1971 to prevent land development and construction of structures for human occupancy directly across the trace of active faults. The law required the State Geologist to delineate approximately 0.25-mile-wide zones along surface traces of active faults. The act defines an *active* fault as one that has ruptured the ground surface within the past 11,000 years. Prior to approving construction of structures for human occupancy, permit authorities must require a project's applicant to submit a fault investigation report for review and approval by the local jurisdiction. Although the Alquist-Priolo Act does not regulate transit or transportation projects, it provides relevant information about areas that would be susceptible to ground rupture from an earthquake.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act was enacted in 1990 to control land development and construction of structures for human occupancy in areas with a potential for ground deformation related to seismic activity. The Seismic Hazards Mapping Act requires that the State Geologist issue Official Seismic Hazard Zones Maps that delineate zones within which there may be a potential for earthquake-induced landslides or liquefaction. Prior to approving specific types of development, local permit authorities require a project's applicant to submit a geotechnical investigation report for review and approval by the jurisdiction.

Surface Mining and Reclamation Act

The state Surface Mining and Reclamation Act (SMARA) was enacted in 1975 (revised in 2007) to address the need for a continuing supply of mineral resources and to prevent or minimize the adverse impacts of surface mining on public health, property, and the environment. SMARA requires the State Geologist to issue maps that delineate mineral resources and establish zones in which special requirements are imposed upon land use. The State Mining and Geology Board has adopted policies and regulations for the reclamation of surface-mined lands and conservation of mineral resources (California Code of Regulations [Cal. Code Regs.], Title 14, Division 2, Chapter 8, Subchapter 1).

International Building Code 2012 and American Society of Civil Engineers 7 (2010)

These codes and standards provide minimum design loads for buildings and other structures. They would be used for the design of the maintenance facilities and stations. Sections in the International Building Code and American Society of Civil Engineers (ASCE) provide minimum requirements for geotechnical investigations, levels of earthquake ground shaking, minimum standards for structural design, and inspection and testing requirements.

California Building Standards Code

Cal. Code Regs., Title 24, the California Building Standards Code, governs the design and construction of buildings, associated facilities, and equipment and applies to most buildings in California. Standards cover general building design and construction requirements related to fire and life safety, structural safety, and access compliance.

Paleontological Resources

California Environmental Quality Act and California Environmental Quality Act Guidelines for Protection of Paleontological Resources

The California Environmental Quality Act (CEQA) (California Public Resources Code [Cal. Public Res. Code] 21000 et seq.) and CEQA Guidelines (14 Cal. Code Regs. 15064.7) provide specific guidance for determining the significance of impacts on historic and unique archaeological resources. Under CEQA, these resources are called *historical resources* whether they are of historic or prehistoric age.

The CEQA Guidelines define procedures, types of activities, persons, and public agencies required to comply with CEQA. Section 15064.7(b) prescribes that project effects that would "cause a substantial adverse change in the significance of an historical resource" are significant effects on the environment. Substantial adverse changes include physical changes to both the historical resource and its immediate surroundings.

Appendix G of the CEQA Guidelines provides an environmental checklist of questions that a lead agency should normally address if relevant to a project's environmental impacts. One of the questions to be answered in the Environmental Checklist (Section 15023, Appendix G, Section V, part c) is: "Would the project directly or indirectly destroy a unique paleontological resource or site?" Although CEQA does not define what constitutes "a unique paleontological resource or site," Section 21083.2 defines *unique archaeological resources* as

> any archaeological artifact, object, or site about which it can be clearly demonstrated that, without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:
>
> - Contains information needed to answer important scientific research questions and show that there is a demonstrable public interest in that information.
> - Exhibits a special and particular quality, such as being the oldest of its type or the best available example of its type.
> - Is directly associated with a scientifically recognized important prehistoric or historic event or person.

This definition is equally applicable to recognizing a unique paleontological resource or site. CEQA Section 15064.7(a)(3)(D) provides additional guidance, indicating that "generally, a resource shall be considered historically significant if it has yielded, or may be likely to yield, information important in prehistory or history."

The CEQA lead agency having jurisdiction over a project is responsible for ensuring that paleontological resources are protected in compliance with CEQA and other applicable statutes. Cal. Public Res. Code Section 21081.6, *Mitigation Monitoring Compliance and Reporting*, requires that the CEQA lead agency demonstrate project compliance with mitigation measures developed during the environmental impact review process.

California Public Resources Code

Section 5097.5 of the Cal. Public Res. Code protects artifacts at paleontological sites, including fossilized footprints, that are situated on public lands, except with the permission of the public agency with jurisdiction over the lands. *Public lands* are defined as lands owned by the state, any city, county, district, authority, or public corporation.[2] Disturbing paleontological resources on public lands under this section of the Cal. Public Res. Code is a misdemeanor.

3.7.2.3 Regional and Local

The San Joaquin Regional Rail Commission (SJRRC), a state joint powers agency, proposes improvements inside and outside of the Union Pacific Railroad (UPRR) right-of-way (ROW). The Interstate Commerce Commission Termination Act (ICCTA) affords railroads engaged in interstate commerce[3] considerable flexibility in making necessary improvements and modifications to rail infrastructure, subject to the requirements of the Surface Transportation Board. ICCTA broadly preempts state and local regulation of railroads, and this preemption extends to the construction and operation of rail lines. As such, activities within the UPRR ROW are clearly exempt from local building and zoning codes and other land use ordinances. However, facilities located outside of the UPRR ROW, including proposed stations, the proposed Merced Layover & Maintenance Facility, and the Atwater Station Alternative would be subject to regional and local plans and regulations. Though ICCTA does broadly preempt state and local regulation of railroads, SJRRC intends to obtain local agency permits for construction of facilities outside of the UPRR ROW even though SJRRC has not determined that such permits are legally necessary and such permits may not be required.

Appendix G of this EIR, *Regional Plans and Local General Plans*, provides a list of applicable goals, policies, and objectives from regional and local plans of the jurisdictions in which improvements associated with the Proposed Project and the Atwater Station Alternative would be located. Section 15125(d) of the CEQA Guidelines requires an environmental impact report to discuss “any inconsistencies between the proposed project and applicable general plans, specific plans, and regional plans.” These plans were considered during the preparation of this analysis and were reviewed to assess whether the Proposed Project and the Atwater Station Alternative would be consistent with the plans of relevant jurisdictions.[4] The Proposed Project and the Atwater Station Alternative would be generally consistent with the applicable goals, policies, and objectives related to geology, soils, and paleontological resources identified in Appendix G.

3.7.2.4 Industry Design Standards and Guidelines

The design and construction of the Proposed Project and the Atwater Station Alternative would conform to industry-wide engineering design guidelines and standards. These guidelines and standards define the parameters for the design and construction of facilities that protect the users of the facilities and others that may be affected by public use of the facility. Each improvement associated with the Proposed Project and the Atwater Station Alternative would be designed to handle normal operating loads from the weight of the structure or train, as well as loads from environmental conditions, such as seismic shaking and wind forces. At locations where geologic conditions present a hazard, the guidelines and standards identify minimum requirements for characterizing the geologic conditions and then addressing the design issue, such as the stability of

[2] Lands within the existing rail ROW and acquired for rail ROW fall within the definition of public lands used for this section of the Cal. Public Res. Code.
[3] Altamont Corridor Express (ACE) operates within a ROW and on tracks owned by UPRR, which operates interstate freight rail service in the same ROW and on the same tracks.
[4] An inconsistency with regional or local plans is not necessarily considered a significant impact under CEQA, unless it is related to a physical impact on the environment that is significant in its own right.

slopes, the corrosion of materials, and best management practices (BMPs) for water and wind erosion, stream sedimentation, or dust control.

These guidelines and standards provide requirements for evaluating soil conditions, defining seismic loads, and evaluating the response of the foundation systems. Minimum performance requirements are also provided. The guidelines and standards also provide direction when minimum performance requirements are not met.

Engineering geologists and geotechnical engineers who assist in the design of the Proposed Project and the Atwater Station Alternative are obligated to use these guidelines and standards. To meet professional licensing requirements, contract design documents would have to be signed and stamped by engineering geologists, civil engineers, and geotechnical engineers registered in California, certifying that the designs have been completed in a manner that meets minimum standards and is protective of the public.

Primary guidelines and standards that would be incorporated as part of the Proposed Project and the Atwater Station Alternative design to reduce risks associated with geology, soils, and seismicity are highlighted in this section.

2012 American Association of State Highway and Transportation Officials Load and Resistance Factor Design Bridge Design Specifications (6th Edition) and the 2011 American Association of State Highway and Transportation Officials Guide Specifications for Load and Resistance Factor Seismic Bridge Design

These documents provide guidance for characterization of soils, as well as methods to be used in the design of bridge foundations and structures, retained cuts and retained fills, at-grade segments, and buried structures. These design specifications would provide minimum specifications for evaluating the seismic response of soil and structures.

Federal Highway Administration Circulars and Reference Manuals

These documents provide detailed guidance on the characterization of geotechnical conditions at sites, methods for performing foundation design, and recommendations on foundation construction. These guidance documents include methods for designing retaining walls used for retained cuts and retained fills, foundations for elevated structures, and at-grade segments. Some of the documents include guidance on methods of design to reduce the risk of geologic hazards that are encountered during design.

American Railroad Engineering and Maintenance-of-Way Association Manual

The American Railroad Engineering and Maintenance-of-Way Association (AREMA) guidelines deal with rail systems. Although these guidelines cover many of the same general topics as the American Association of State Highway and Transportation Officials (AASHTO), they are more focused on best practices for rail systems. The manual includes principles, data, specifications, plans, and economics pertaining to the engineering, design, and construction of railways.

Union Pacific Railroad Design and Construction Standards

These guidelines are specific to any work that will take place within or affect facilities owned and operated by UPRR. In general, UPRR relies on the current guidance provided by the most recent version of AREMA, while applying its own criteria to be applied to its assets as it deems necessary. Where a conflict between the current UPRR criteria and the AREMA guidelines arises, the UPRR criteria will govern for facilities or resources within its ROW.

California Department of Transportation Design Standards

The California Department of Transportation (Caltrans) has specific minimum design and construction standards for all aspects of transportation system design, ranging from geotechnical explorations to construction practices. Caltrans design standards include state-specific amendments to the AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications and Guide Specifications for LRFD Seismic Bridge Design. These amendments provide specific guidance for the design of deep foundation used to support elevated structures, for design of mechanically stabilized earth walls used for retained fills, and for design of various types of cantilever (e.g., soldier pile, secant pile, and tangent pile) and tie-back walls used for retained cuts.

American Society for Testing and Materials International

American Society for Testing and Materials (ASTM) International has developed standards and guidelines for all types of material testing, from soil classifications to pile load testing or compaction testing through to concrete strength testing. The ASTM standards also include minimum performance requirements for materials. Most of the guidelines and standards cited in the preceding sections use ASTM or a corresponding series of standards from AASHTO to achieve the required and intended quality in the constructed project.

Society of Vertebrate Paleontology

The Impact Mitigation Guidelines Revisions Committee of the Society of Vertebrate Paleontology has published Standard Guidelines (Society of Vertebrate Paleontology 2010) that include procedures for the investigation, collection, preservation, and cataloguing of fossil-bearing sites. The Standard Guidelines are widely accepted among paleontologists and are followed by most investigators.

3.7.3 Environmental Setting

This section describes the environmental setting related to geology, soils, and paleontological resources for facilities associated with the Proposed Project and the Atwater Station Alternative. For the purposes of this analysis, the study area for geology, soils, and paleontological resources is defined as follows.

- Underlying geology and soils within 2 miles of the footprint of the Proposed Project and the Atwater Station Alternative.
- Seismicity up to 62 miles (100 kilometers) from improvements associated with the Proposed Project and the Atwater Station Alternative.
- Paleontological resources within 150 feet of the Proposed Project and the Atwater Station Alternative environmental footprint (horizontal study area), and extending below-ground to the maximum depth of disturbance to include all geologic units below the horizontal study area that could be encountered during construction or operation (vertical study area).

Information presented in this section related to geology, soils, and paleontological resources was obtained from the following sources. Locations of undisturbed land were determined through the use of geographic information systems (GIS).

- Geology, soils, and seismicity: U.S. Geological Survey (USGS) topographic maps; USGS, California Geological Survey (CGS) and other geologic, landslide, and liquefaction susceptibility maps; Natural Resources Conservation Service (NRCS) soils maps; CGS Seismic Hazard Zone maps; USGS and CGS potential ground shaking maps; and CGS Alquist-Priolo earthquake fault zone (EFZ) maps; USGS and State of California mineral resource zone (MRZ) maps.
- Paleontological resources: Peer-reviewed scientific literature (Marchand and Allwardt 1981; Hilton et al. 2000); geologic mapping (Wagner et al. 1991); and records searches from the University of California Museum of Paleontology database (University of California Museum of Paleontology 2020a, 2020b).

3.7.3.1 Soils, Seismicity, and Groundwater

Soils

Soil type is one criterion used to evaluate potential impacts of development on the environment, as well as potential impacts of the environment on a project. Depending on type, some soils are susceptible to erosion or expansive behavior, while others are more suitable for construction. Soil-type mapping, emphasizing a soil's agricultural and engineering properties, is conducted typically on a countywide (or geographic) basis using nomenclature that changes with time.

Soils in the study area vary from well-drained soils present on the alluvial fans and younger stream terraces to highly clayey soils on the basin floor or uplands developed on fine-grained sedimentary rocks. Many of the soils in some parts of the study area are urbanized and have been disturbed, paved over, or replaced with artificial fill. Figure 3.7-1 includes a map of the soil survey units, which illustrates the generalized soil associations in the study area. The soil survey units underlying the Proposed Project and the Atwater Station Alternative generally consist of sand and loam, with 0 to 3 percent slopes, as well as clay in the southern portions of the segment.

Seismicity

In the past, numerous moderate to large earthquakes have originated from some of the active faults in Central California, where the Proposed Project and the Atwater Station Alternative are located. It is anticipated that seismic events will continue to occur within the region at approximately the same rate and on some of the same faults as in the past. There are no Alquist-Priolo EFZs in the vicinity of the Proposed Project and the Atwater Station Alternative. The closest EFZ to the Proposed Project and the Atwater Station Alternative is the Vernalis Fault, located approximately 25 miles northwest of Ceres. Although there are no EFZs in the vicinity of the Proposed Project and the Atwater Station Alternative, the Proposed Project and the Atwater Station Alternative would be subject to groundshaking as a result of nearby earthquakes, depending on magnitude. Figures 3.7-2, 3.7-3, and 3.7-12 include maps depicting fault locations and activity near the Project site and the peak ground acceleration (PGA) that could be experienced in the vicinity of the Proposed Project and the Atwater Station Alternative.

Groundwater

The alluvial sediments that fill the San Joaquin Valley contain groundwater. The depth to groundwater varies across the region. Figure 3.7-4 includes a map depicting the depths to groundwater in the study area. Beneath the portion of the San Joaquin Valley where the Proposed

Project and the Atwater Station Alternative would be located, the depths to the groundwater table range from 10 to 80 feet, and generally are deeper in the southern portions of the study area.

3.7.3.2 Geologic Hazards

Landslides and Debris Flows

Landslides occur when the force of gravity overcomes the strength of the soil or rock within a hillside or a built embankment. The presence of groundwater can reduce the shear strength of the subsurface materials. Excavation or erosion of material at the toe of a slope can destabilize the slope above it. Placement of fill on the upper portion of a slope can overload the soil or rock within the slope and cause it to fail. Landslides can be of several types: falls, slides, slumps, or flows. They can move very rapidly (within seconds or minutes), or slowly (over days or years). Landslide movements often result in significant deformation of the ground surface, producing open cracks, with vertical and horizontal displacements measured in a few inches to multiple feet. All or portions of an existing landslide can be reactivated by any of the landslide causes. New landslides can occur on slopes with geologic conditions similar to those within existing landslides. Therefore, the extent of past landslides can be a guide to understanding the potential for slope failures that could affect the Proposed Project and the Atwater Station Alternative.

The probability for landslides and debris flow in the vicinity of the Proposed Project and the Atwater Station Alternative is low because there are no previous landslide occurrences, and the areas are relatively flat.

Land Subsidence

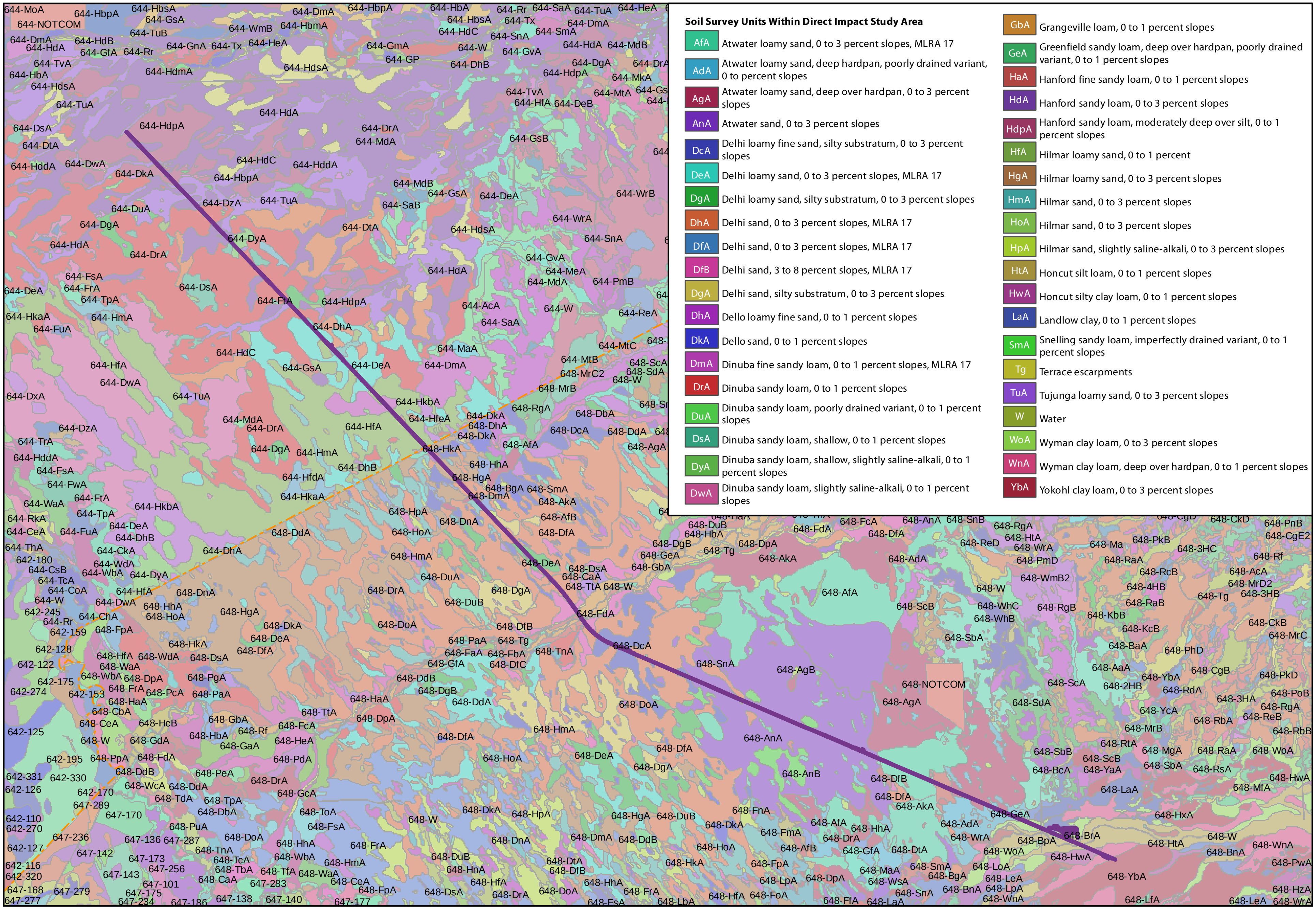
Land subsidence is the lowering of the ground surface elevation as a result of volume-reducing changes that take place underground. Common causes of land subsidence are pumping of water, oil, or gas from underground reservoirs; dissolution of limestone aquifers and collapse of the overlying soils into the resulting caves (sinkholes); collapse of underground mines; oxidation of organic soils; and initial wetting of certain sensitive soils (hydro-compaction). Land subsidence can cause many problems, including: (1) changes in elevation and slope of streams, canals, and drains; (2) damage to bridges, roads, railroads, storm drains, sanitary sewers and pipelines, canals, and levees; (3) damage to private and public buildings; and (4) failure of well casings.

In recent years, drought-related withdrawal of groundwater and the associated amount of subsidence of the ground surface in the southern San Joaquin Valley have increased. Subsidence due to withdrawal of groundwater can be arrested by artificially recharging the aquifers with enough water to compensate for the amount being pumped out of them.

Figure 3.7-5 includes a map depicting the extent of subsidence in the San Joaquin Valley (Farr et al. 2015). It appears likely that ongoing groundwater overdrafting (extraction exceeding recharge) will cause subsidence to increase.

Poor Soil Conditions

This section provides descriptions of soil properties in Proposed Project and the Atwater Station Alternative study area that can be detrimental to civil construction projects, including expansive soils, corrosive soils, collapsible soils, erodible soils, and areas of difficult excavation.



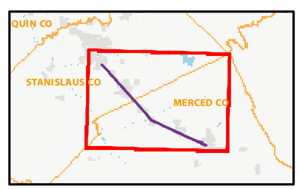
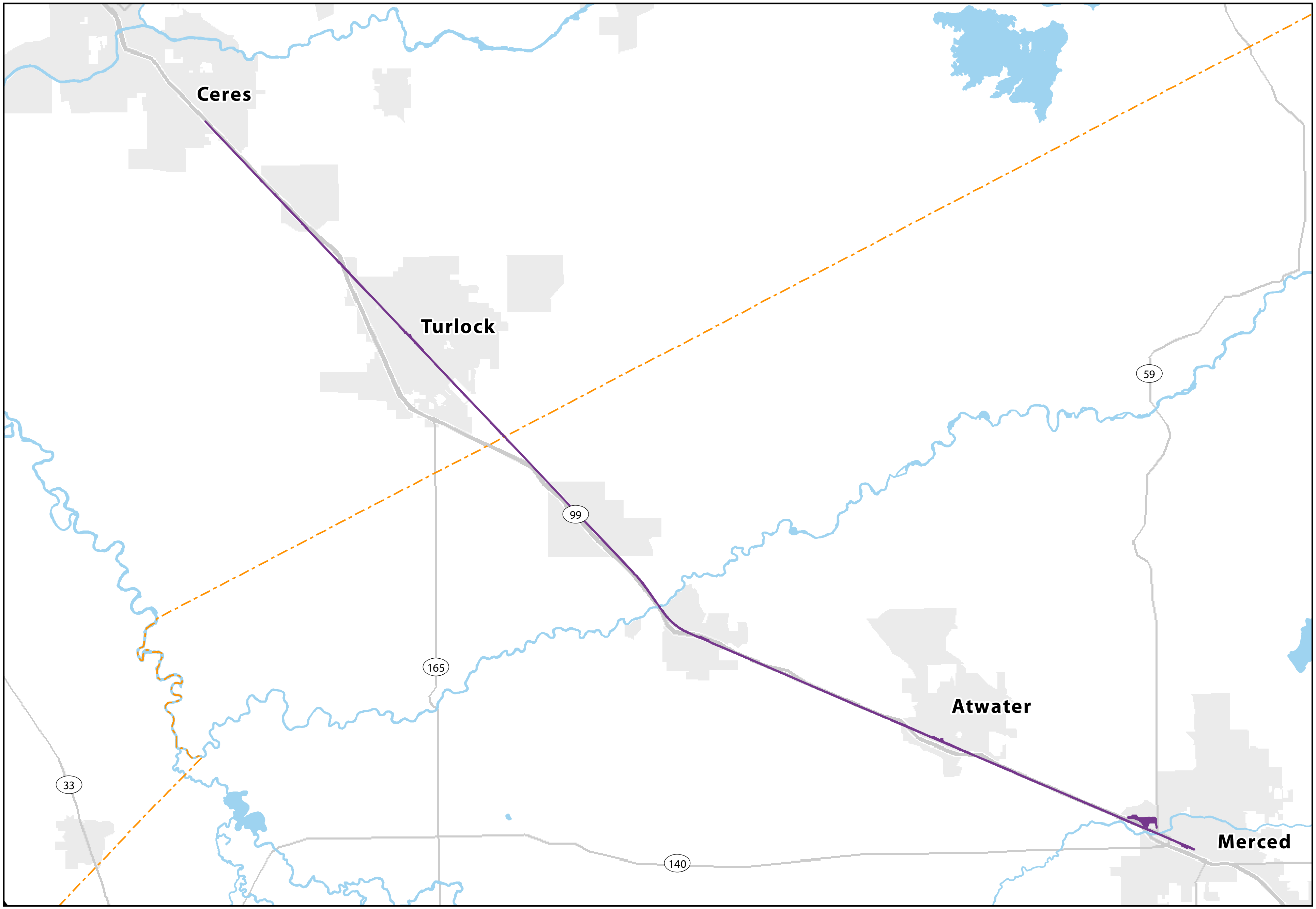


Figure 3.7-1
Soil Survey Units
ACE Ceres-Merced Extension Project



Direct Impact Study Area

State Faults (None in Map Area)

N

0 1 2 Miles

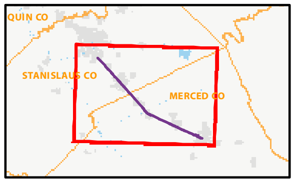


Figure 3.7-2
Fault Map
ACE Ceres-Merced Extension Project

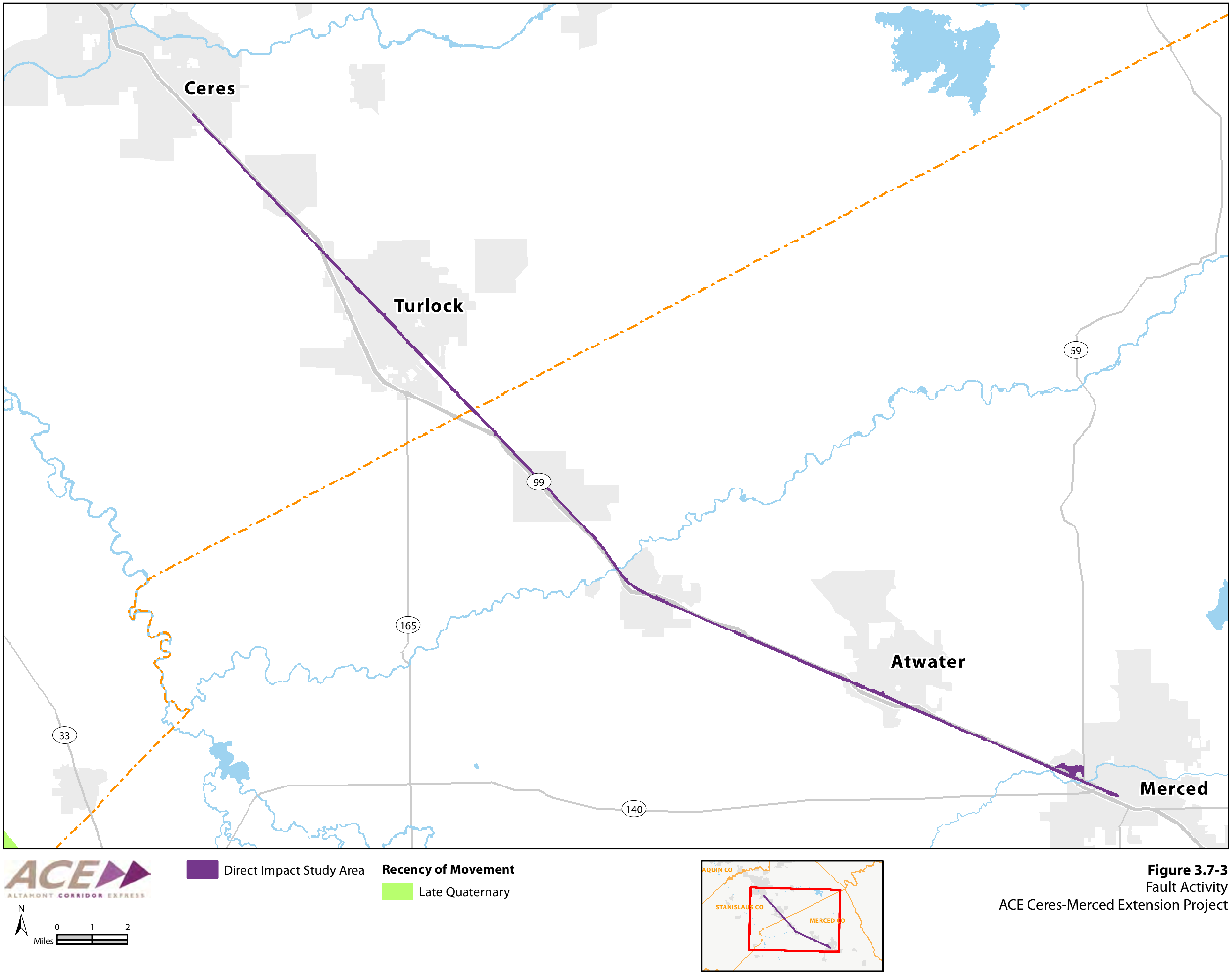


Figure 3.7-3
Fault Activity
ACE Ceres-Merced Extension Project

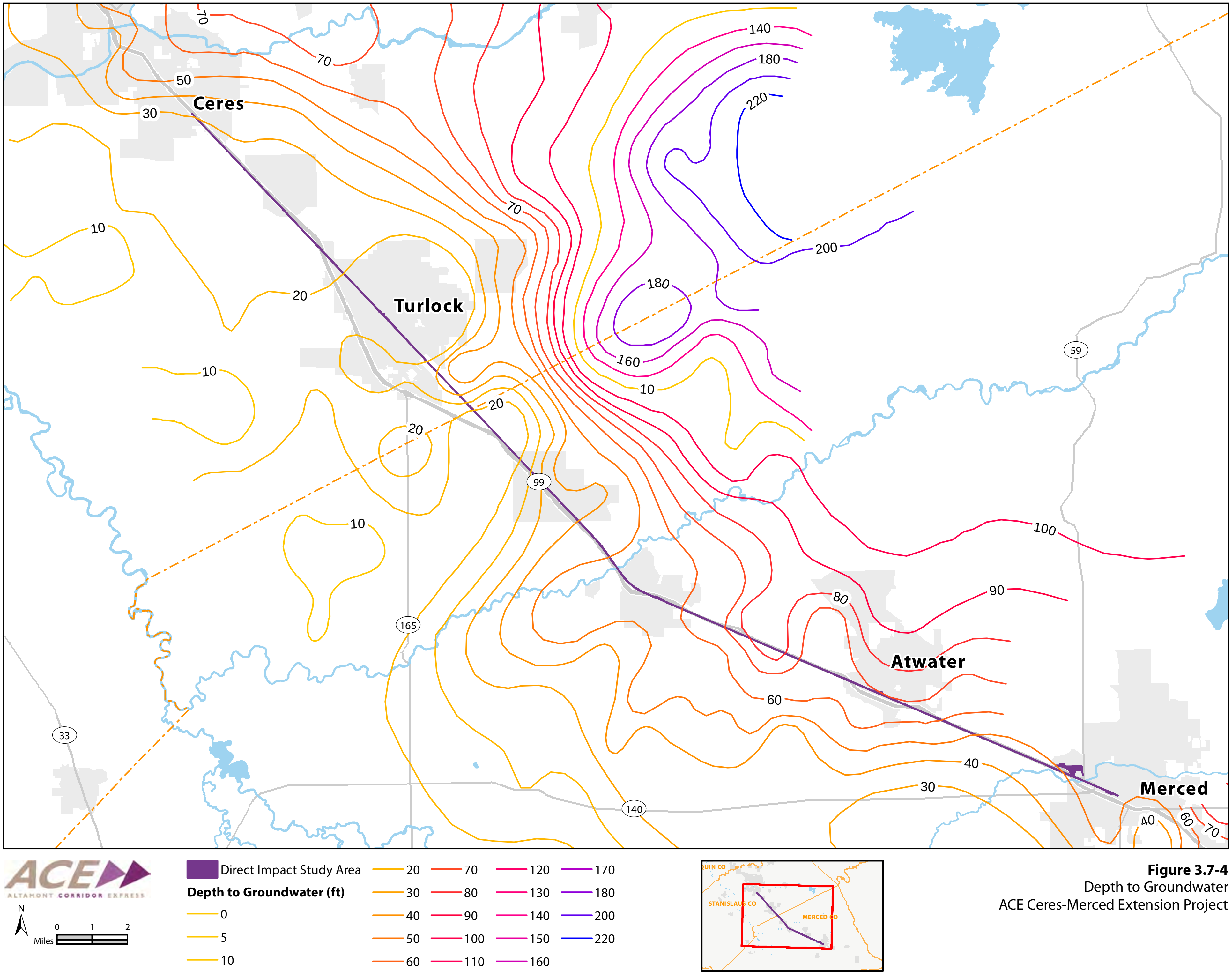
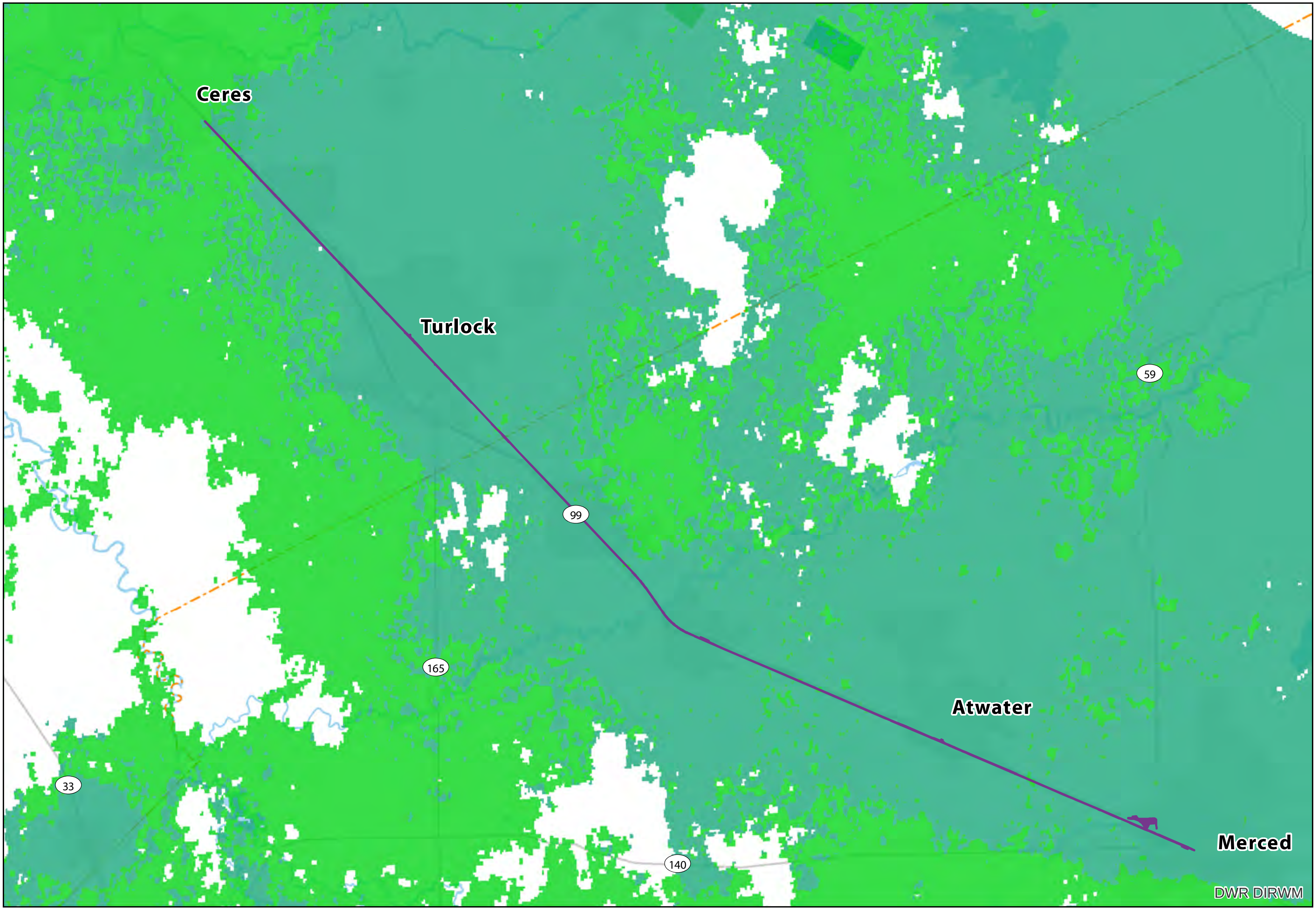


Figure 3.7-4
Depth to Groundwater
ACE Ceres-Merced Extension Project



ALTAMONT CORRIDOR EXPRESS

N

0 1 2
Miles

Direct Impact Study Area

Subsidence (ft)

-3 to 0 (inches)

0 to 3 (inches)

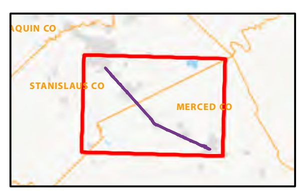


Figure 3.7-5
Subsidence
ACE Ceres-Merced Extension Project

Expansive Soils

The shrink-swell potential is a reflection of the ability of some soils with high clay content to change in volume with a change in moisture content. Shrink-swell potential poses a less significant hazard, where soil moisture is relatively constant (either always wet or always dry). Shrink-swell potential poses a significant hazard to sites that undergo seasonal variation in soil moisture content, such as hillsides or flatlands with a seasonally fluctuating water table. Plasticity Index (PI) is used to infer the potential for soils to swell when wetted and shrink when dried. NRCS has determined the PI for each soil unit. Low PI corresponds to a low shrink-swell potential. High PI corresponds to a high shrink-swell potential.

Figure 3.7-6 depicts the Proposed Project and the Atwater Station Alternative overlaid on the derived maps of the soil PI. Soil underlying the Proposed Project and the Atwater Station Alternative consists of generally very low and low soil PI, with medium soil PI in the southern portions of the segment in Merced.

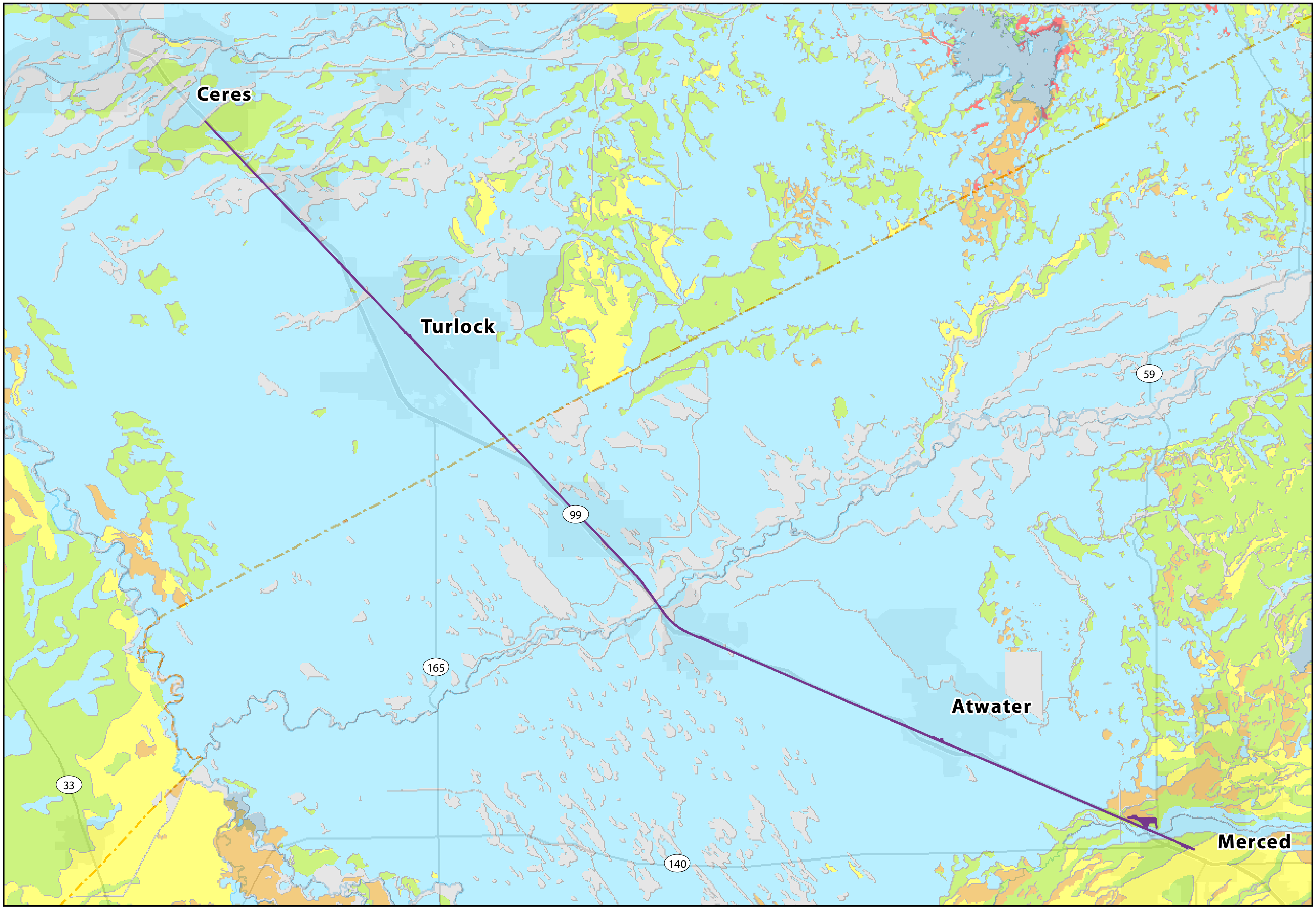
Corrosive Soils

Soil corrosivity measures the potential for corrosion of concrete and steel caused by contact with some types of soil. Knowledge of potential soil corrosivity is often critical for the effective design parameters associated with cathodic protection of buried steel and concrete mix design for plain or reinforced concrete buried project elements. Several factors—including soil composition, soil and pore water chemistry, moisture content, and pH—affect the response of concrete and steel to soil corrosion. Soils with high moisture content, high electrical conductivity, high acidity, and high dissolved salts content are most corrosive. In general, sandy soils have high resistivity and are the least corrosive. Clayey soils, including those that contain interstitial saltwater, can be highly corrosive.

Figures 3.7-7 and 3.7-8 include a map depicting the potential corrosivity between native soils in the study area and buried concrete and buried, uncoated steel. Corrosivity to concrete in the footprint of the Atwater Station Alternative is generally low to moderate. In the Proposed Project footprint, high soil corrosivity to steel is identified in areas between north of Turlock and north of Livingston and in Merced; the remaining portions of the Proposed Project footprint have generally low soil corrosivity to steel.

Collapsible Soils

Collapsible soils are soils that undergo volume reduction or settlement upon the addition of water, which weakens or destroys soil particle bonds of loosely packed structure, reducing the bearing capacity of the soil. Other mechanisms for soil collapse include the sudden closure of voids in a soil, whereby the sudden decrease in volume results in loss of the soil's internal structure, causing the soil to collapse. Specific soil types, such as loess and other fine-grained aeolian soils, are most susceptible to collapse, although certain coarser-grained, rapidly deposited alluvial soils can also be susceptible. Laboratory testing during the field investigation phases of the Proposed Project and the Atwater Station Alternative would be required to identify soils susceptible to collapse.



N

Miles 0 1 2

Direct Impact Study Area

Plasticity Index

Not Rated

Very Low (PI=0 - 10)

Low (PI=10-15)

Medium (PI=15-25)

High (PI=25-35)

Very High (PI>35)

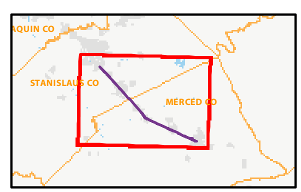
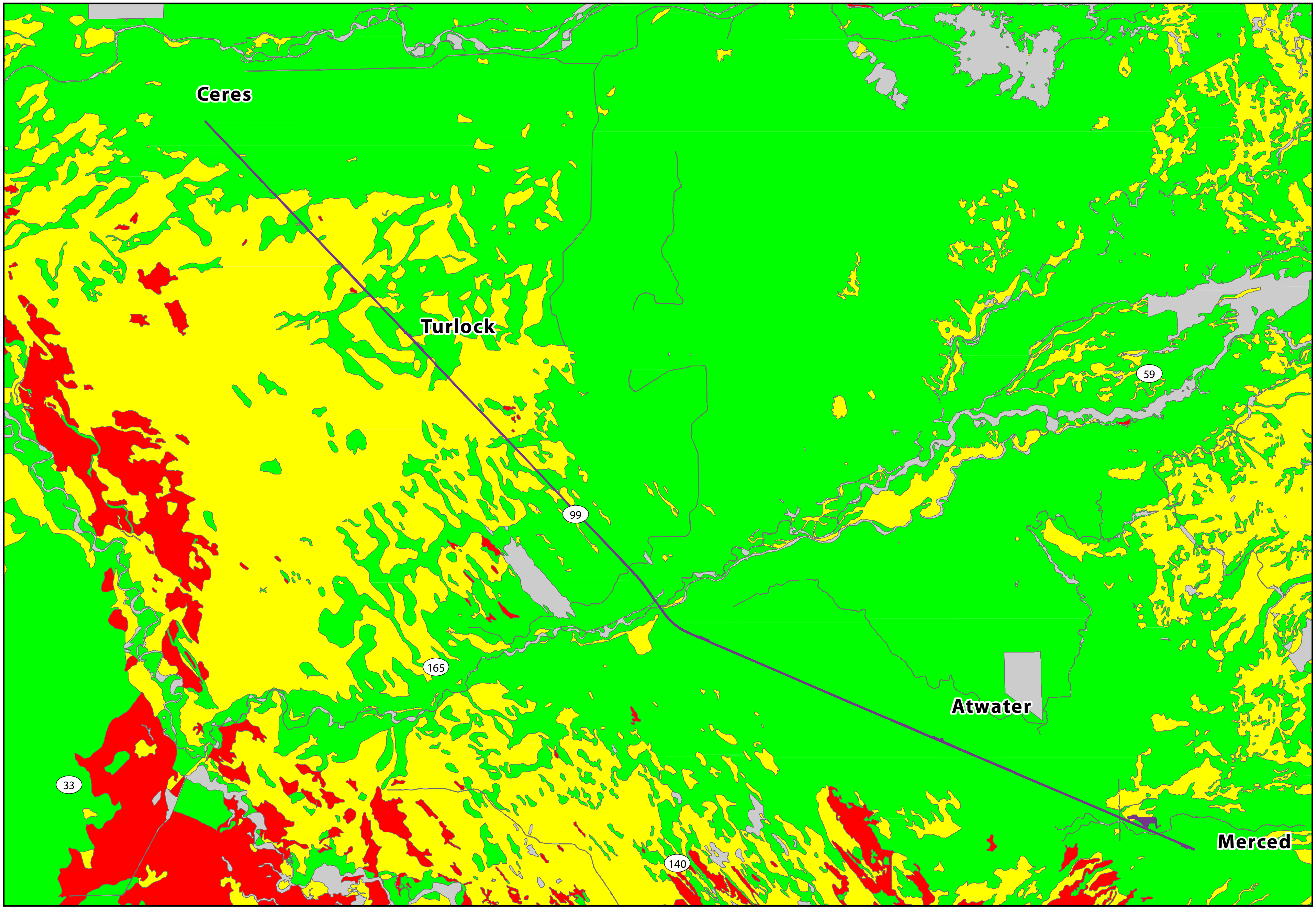


Figure 3.7-6
Plasticity Index
ACE Ceres-Merced Extension Project



Direct Impact Study Area

Soil Corrosivity to Concrete

High

Moderate

Low

Not Determined

N

Miles 0 1 2

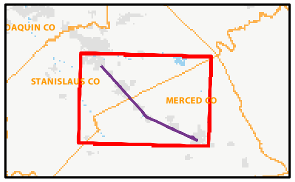


Figure 3.7-7
Corrosivity to Concrete
ACE Ceres-Merced Extension Project

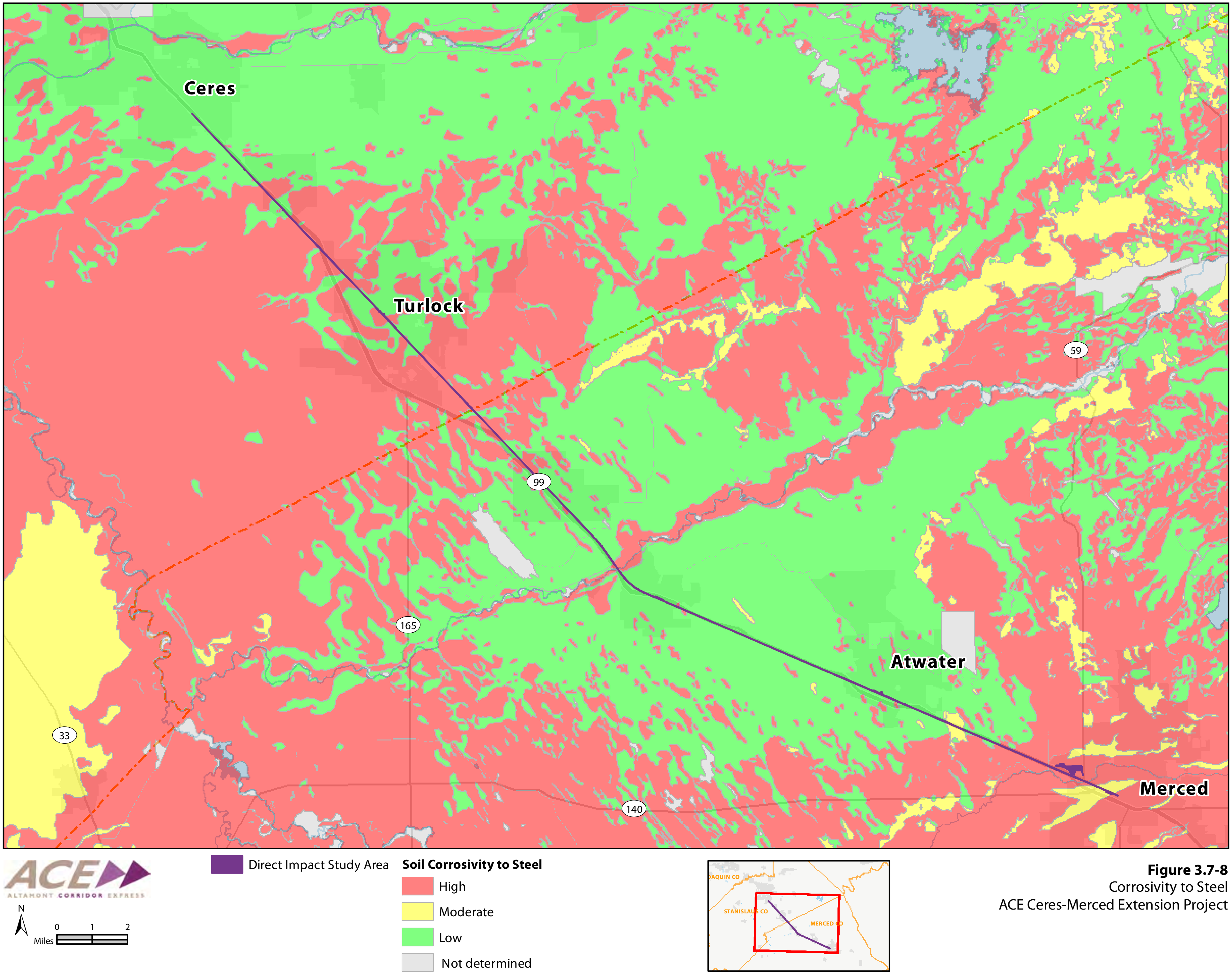


Figure 3.7-8
Corrosivity to Steel
ACE Ceres-Merced Extension Project

Erodible Soils

The potential for erosion by water or wind is a function of the cohesiveness of the soil particles. The NRCS has quantified the potential for erosion by water with the *k factor*, with lower k factor values indicating soils resistant to detachment and not easily susceptible to erodibility and high k factor values indicating soils are easily detached and are most erodible. Soils on steep slopes are often erodible, especially during heavy rain events. Soils and alluvial deposits present in stream channels are susceptible to erosional scour, especially around foundation elements where erosive forces can be concentrated. According to the United States Department of Agriculture, the wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion - the higher the wind erodibility index, the higher susceptibility to wind erosion (United States Department of Agriculture 2017). In addition, a wind erodibility group (WEG) consists of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to WEG 1 are the most susceptible to wind erosion (and have a higher wind erodibility index), and those assigned to WEG 8 are the least susceptible.

Figures 3.7-9 and 3.7-10 depict the potential for soil erodibility by water and wind. Soils in the Proposed Project and the Atwater Station Alternative study area have a generally moderate soil erodibility by water and wind between Ceres and Turlock, low soil erodibility by water and high erodibility by wind between Turlock and Atwater, and high soil erodibility by water with low wind erodibility to wind south of Atwater to Merced.

Areas of Difficult Excavation

Due to the presence of predominantly uncemented Quaternary sediments in the San Joaquin Valley, areas of difficult excavation due to hard or strong rock at shallow depths in the study area are not expected to be widespread. Figure 3.7-11 includes a map depicting areas of difficult excavation in the study area. The study area is identified as being very limited or somewhat limited in shallow excavation difficulty. However, substantial excavation is not anticipated with construction of the Proposed Project and the Atwater Station Alternative.

3.7.3.3 Primary Seismic Hazards

Surface Fault Rupture

When an active fault ruptures, the displacement of one rock mass relative to an opposing rock mass may extend to the ground surface. The resulting surface rupture can produce a variety of effects including the shearing of structures that were built across the fault's surface traces. Such surface fault ruptures can measure a few inches or several feet.

CGS has issued Official EFZ Maps (known as Special Studies Zones Maps prior to 1995) that show roughly 0.25-mile-wide zones along both sides of the mapped surface traces of active faults across the entire state. There are no official EFZ maps that have been issued for areas in the vicinity of the Proposed Project and the Atwater Station Alternative. The closest EFZ is the Vernalis Fault, located approximately 25 miles northwest of Ceres.

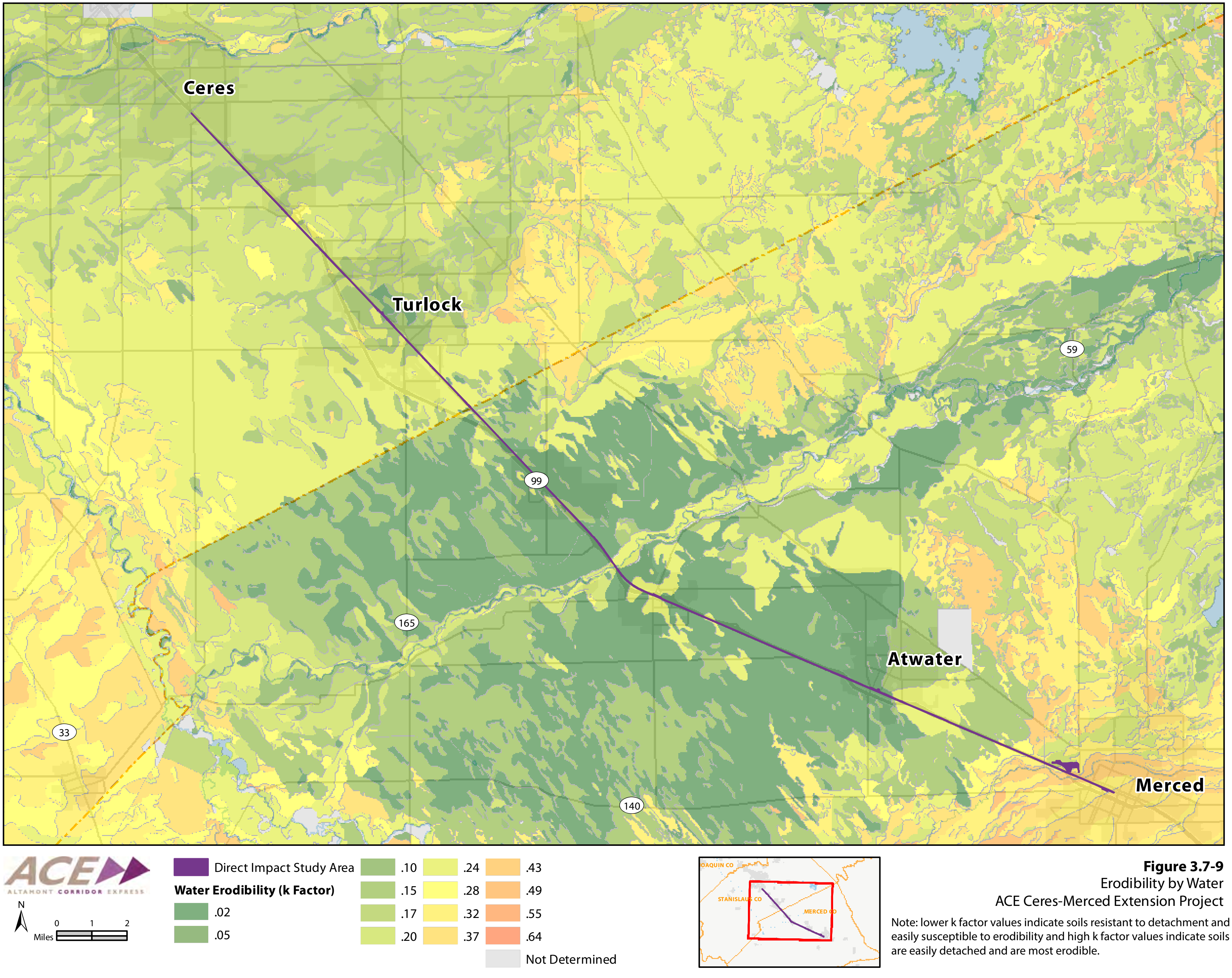
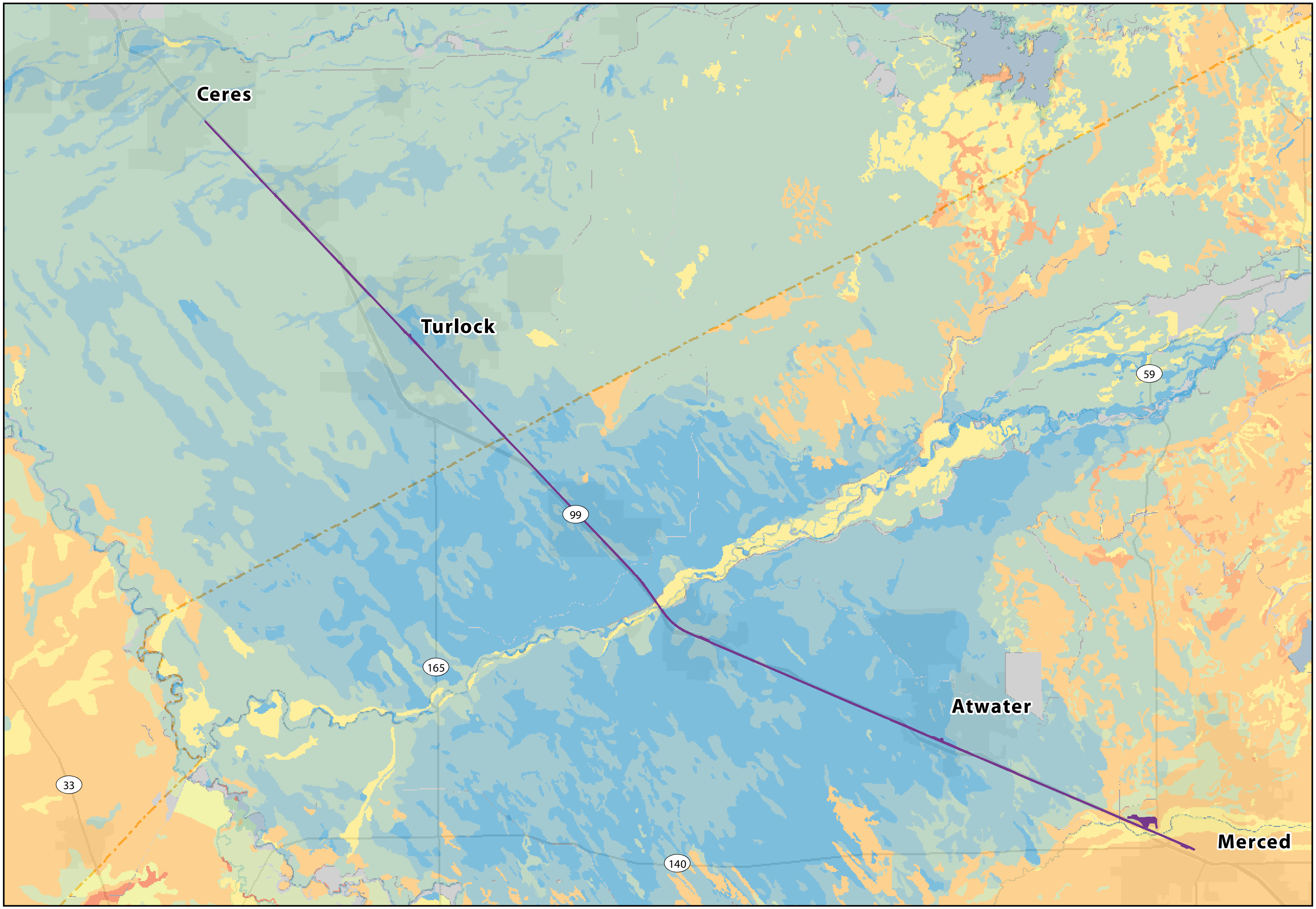
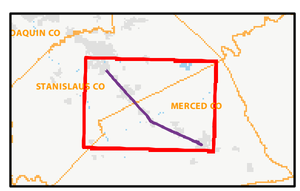


Figure 3.7-9
Erodibility by Water
ACE Ceres-Merced Extension Project

Note: lower k factor values indicate soils resistant to detachment and not easily susceptible to erodibility and high k factor values indicate soils that are easily detached and are most erodible.





ACE ALTAMONT CORRIDOR EXPRESS

N

0 1 2 Miles

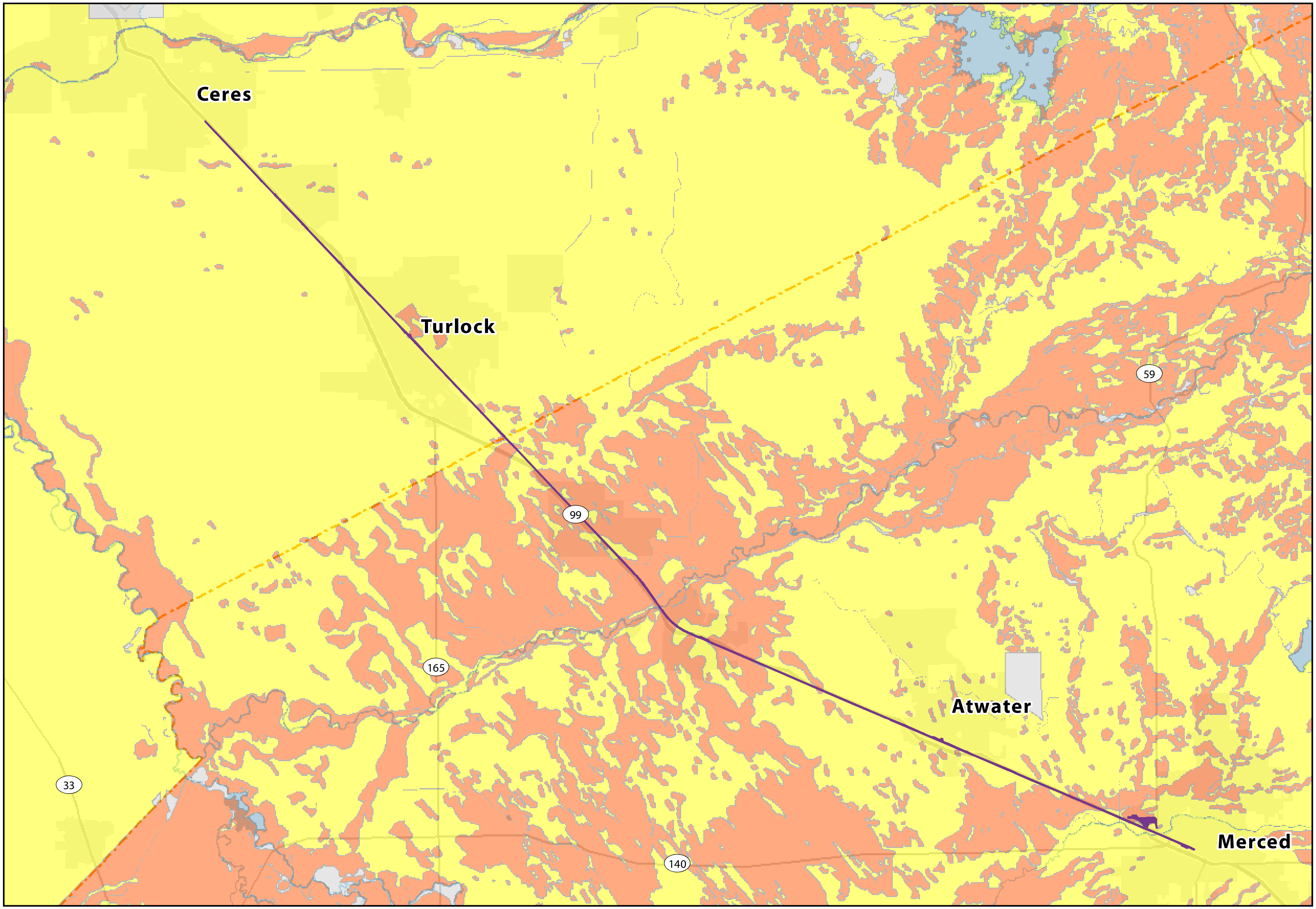
Direct Impact Study Area

Wind Erodibility Group

1
2
3
4
4L
5
6
7
8
Not determined

Figure 3.7-10
Erodibility by Wind
ACE Ceres-Merced Extension Project

Note: The soils assigned to wind erodibility group 1 are the most susceptible to wind erosion and those assigned to wind erodibility group 8 are the least susceptible.



ACE
ALTAMONT CORRIDOR EXPRESS

N

Miles 0 1 2

Direct Impact Study Area

Shallow Excavation Difficulty

- Very limited
- Somewhat limited
- Not rated or not available

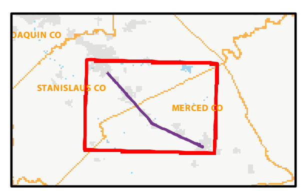


Figure 3.7-11
Difficult Excavation
ACE Ceres-Merced Extension Project

Seismic Ground Motion

The Proposed Project and the Atwater Station Alternative would likely be subjected to strong groundshaking during earthquakes on nearby faults. Groundshaking occurs when the elastic energy stored in strained bedrock is suddenly released. The strength of the shaking can be measured in terms of its percentage of the acceleration due to earth's gravity. Strong earthquake groundshaking can make slopes fail, cause liquefaction with related ground deformation, and can damage built structures that were not designed and constructed to resist or accommodate the shaking.

USGS has estimated the PGA likely to occur with a 2 percent probability within 50 years at bedrock sites throughout the United States and published a map showing these PGAs. Figure 3.7-12 includes a map depicting the 2014 USGS 2 percent probability of exceedance in 50 years contours of PGA (Peterson et al. 2015). The PGA contours run essentially parallel with the surface traces of the Hayward and Calaveras faults located in the San Francisco Bay Area, and the estimated PGAs decrease away from the causative faults. In the San Joaquin Valley, PGAs range between 0.22 and 0.60 g (where g = acceleration of gravity).

3.7.3.4 Secondary Seismic Hazards

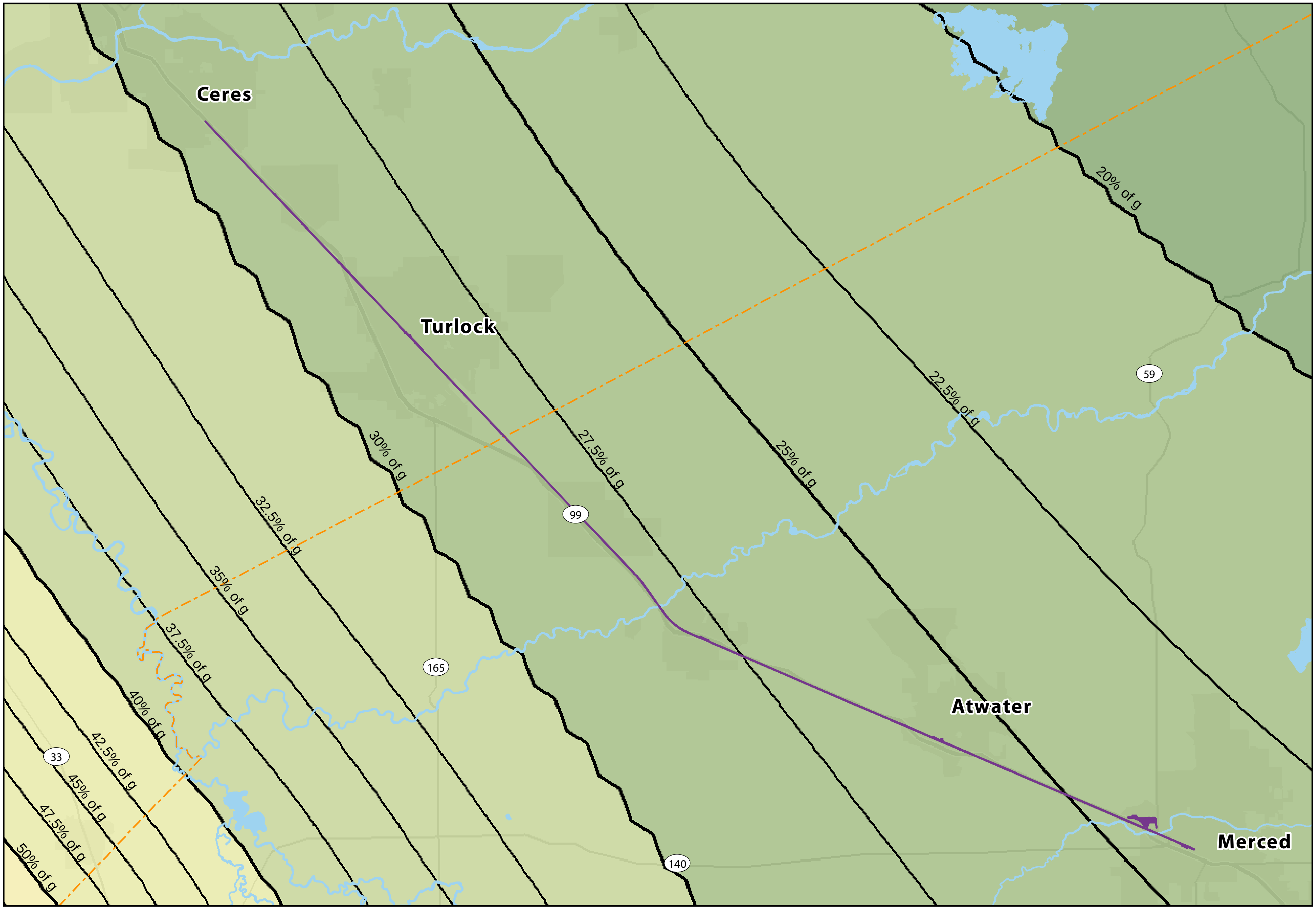
Liquefaction and Lateral Spreading

Soil liquefaction is the process by which the shear strength of granular-saturated soils is reduced because of an increase in pore pressure during seismic shaking or human-induced events. Requisite conditions for liquefaction include saturated granular soils that are not free-draining with a loose-packed grain structure capable of progressive rearrangement of grains during repeated cycles of seismic loading. When liquefaction occurs, the particles rearrange to a denser state, but excess pore pressure is not dissipated; therefore, the shear strength of the soil decreases, thus reducing the soil's ability to support foundations for buildings, bridges, and other structures. One of the consequences of seismic liquefaction in sloping ground areas is lateral spreading, which refers to the translation of ground laterally after the loss of support due to liquefaction. For this to occur, the liquefied area must be relatively near a free face, a vertical or sloping face such as a road cut or stream/riverbank.

There are no USGS Liquefaction Susceptibility or CGS Seismic Hazard Zones maps for the Proposed Project and the Atwater Station Alternative study area because these areas are currently not affected by liquefaction hazards or lateral spreading.

Seismically Induced Landslides

Landslides triggered by earthquakes have historically been a significant source of damage in California. Areas that are most susceptible to earthquake-induced landslides are steep slopes in poorly cemented or highly fractured rocks, areas underlain by loose, weak soils, and areas on or adjacent to existing landslide deposits. The probability for earthquake-induced landslides in the study area is low because there are no previous landslide occurrences, and the areas are relatively flat.



ACE ALTAMONT CORRIDOR EXPRESS

N

Miles 0 1 2

Direct Impact Study Area

Peak Ground Acceleration (PGA)

- 12.75 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60

Note: g = acceleration of gravity

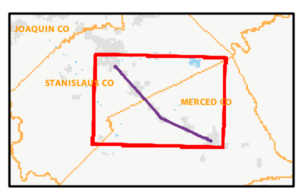


Figure 3.7-12
Peak Ground Acceleration (PGA)
ACE Ceres-Merced Extension Project

3.7.3.5 Geologic Resources

Mineral Resources

Information on the mineral resource potential in the study area was obtained from CGS publications (Jensen and Silva 1988; California Department of Conservation 1993). SMARA directs the State Geologist to classify the non-fuel MRZs of the state to show where economically significant mineral deposits occur based on scientific data. Land studied by the CGS is classified as MRZs 1 through 4.

- 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.
- MRZ-2: Areas where adequate information indicates that significant mineral deposits are present, or where it is judged that a high likelihood exists for their presence.
- MRZ-3: Areas containing mineral deposits, the significance of which cannot be evaluated from available data.
- MRZ-4: Areas of no known mineral occurrences where geologic information does not rule out either the presence or absence of significant mineral resources.

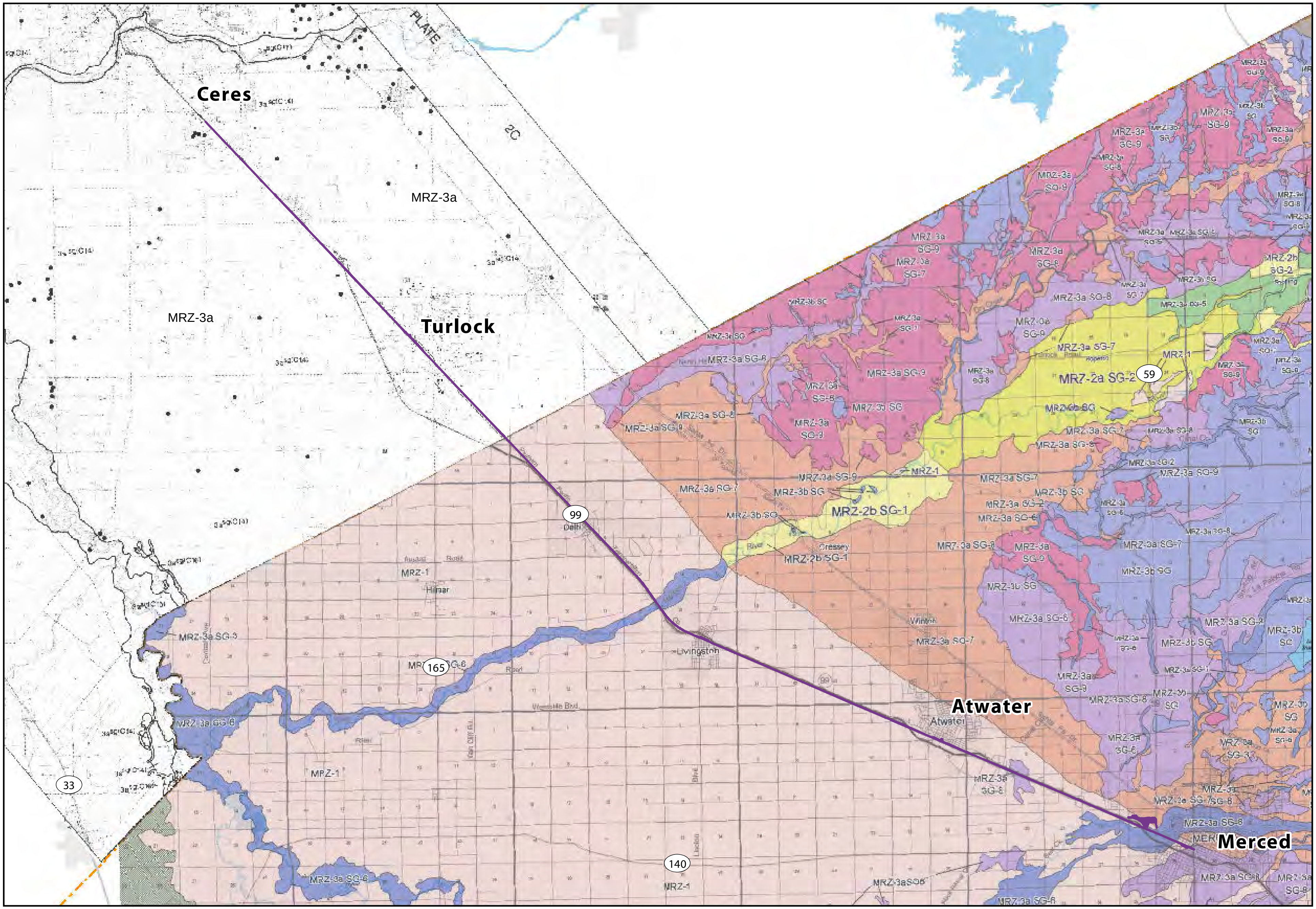
The MRZs are further subdivided with the suffixes “a” and “b.” An “a” suffix indicates demonstrated mineral reserves, and a “b” suffix indicates inferred mineral reserves. For example, MRZ-2a represents that there is adequate information to indicate that demonstrated reserves of significant mineral deposits exist.

Figure 3.7-13 includes a map depicting the MRZs in the vicinity of the Proposed Project and the Atwater Station Alternative. According to CGS, the major mining and mineral products present near the rail alignment consist of sand and gravel aggregate.

As shown in Figure 3.7-13, the Proposed Project is located on areas classified as MRZ-3a in Stanislaus County; and MRZ-1 and MRZ-3a in Merced County. The Atwater Station Alternative is located in an area classified as MRZ-1. The Stanislaus County General Plan and the Merced County General Plan EIR identify the location of the aggregate resource areas in Stanislaus County (County of Stanislaus 2015 and County of Merced 2012). The Proposed Project would not be located within an area identified as an aggregate resource area County (County of Stanislaus 2015 and County of Merced 2012).

Fossil Fuel Resources

The Central Valley has produced trillions of cubic feet of natural gas and millions of barrels of oil since the discovery of these resources more than 100 years ago. Figure 3.7-14 depicts the locations of dry holes, idle wells, plugged wells, and active wells vicinity of the Proposed Project and the Atwater Station Alternative (California Division of Oil, Gas, & Geothermal Resources 2019). The majority of wells are not active.



Direct Impact Study Area

Mineral Land Classification

- Drill Holes
- Mineral Resource Zone (MRZ) Boundary
- SG (C#) Areas Classified for Concrete Aggregate (Sand and Gravel)

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.

MRZ-2b: Areas underlain by mineral deposits where geologic information indicates that significant inferred resources are present.

MRZ-3a: Areas containing known minerals occurrences of undetermined mineral resource significance.

MRZ-3b: Areas containing inferred minerals occurrences of undetermined mineral resource significance.

N

Miles 0 1 2

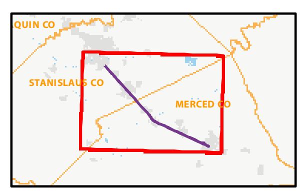
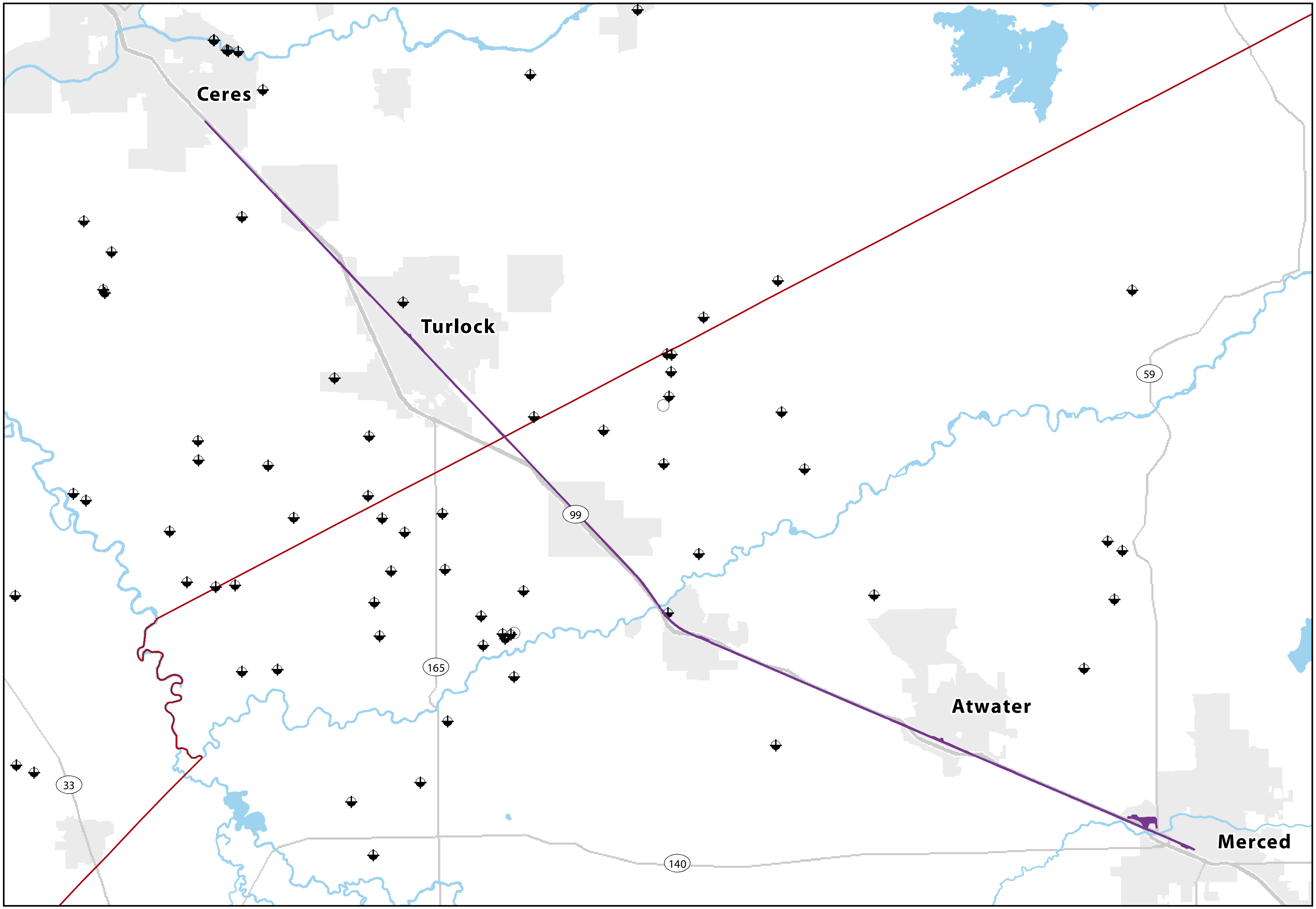
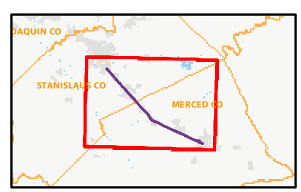


Figure 3.7-13
Mineral Land Classifications
ACE Ceres-Merced Extension Project

Note: The MRZ in Stanislaus County is indicated by the first number and letter shown on the map. This map shows the area surrounding the Proposed Project within Stanislaus County as having a MRZ of MRZ-3a.





ACE ALTAMONT CORRIDOR EXPRESS

N

0 1 2 Miles

Direct Impact Study Area

Well Status/Type

- Idle
- Idle/Dry
- Dry Hole

Figure 3.7-14
Oil and Gas Wells
ACE Ceres-Merced Extension Project

Geothermal Resources

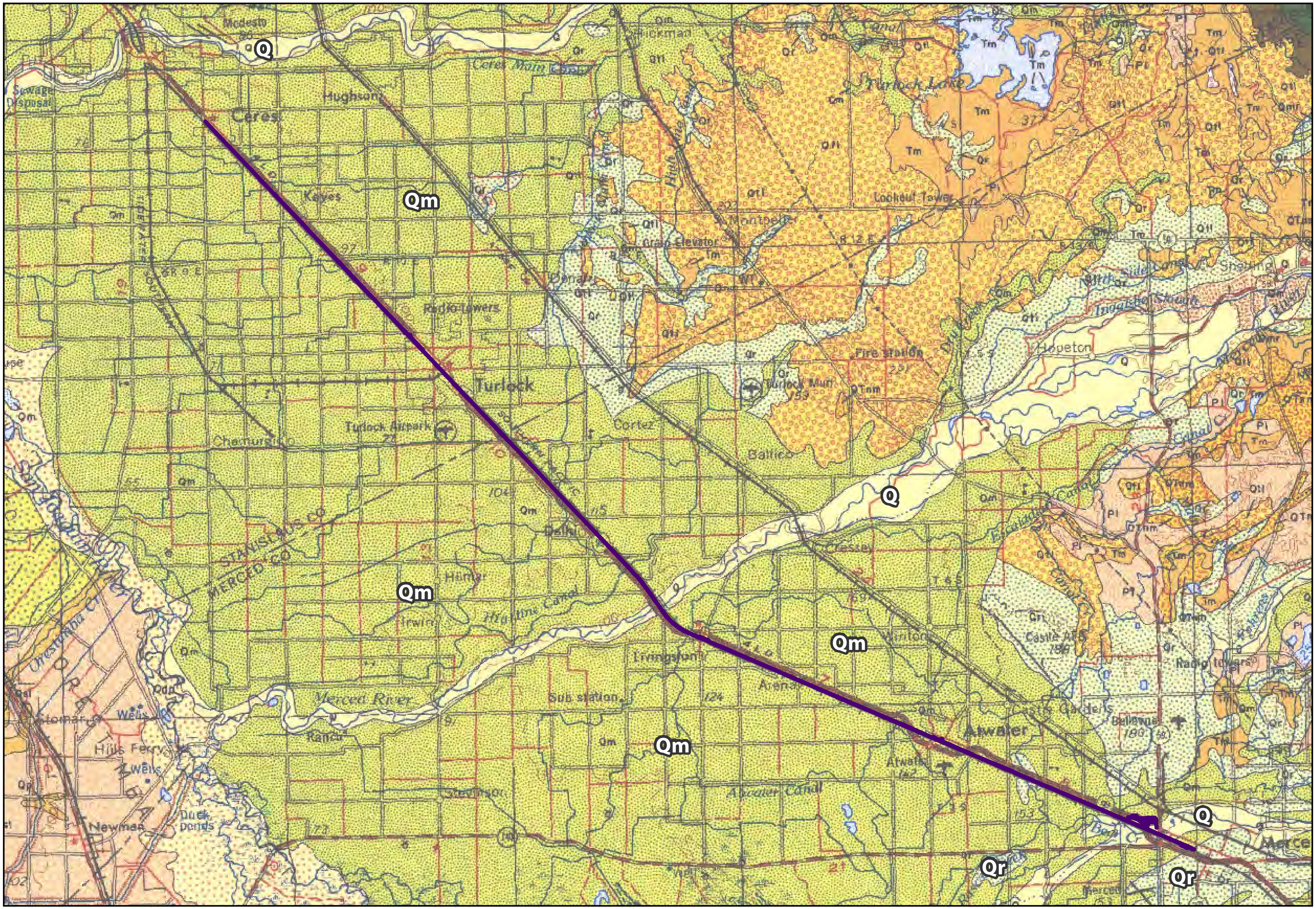
Review of the California Division of Oil, Gas, & Geothermal Resources (DOGGR) California Geothermal Map (California Department of Conservation 2001) and Geothermal Map of California (California Department of Conservation 2002) indicate that there are no geothermal resource areas as classified by DOGGR in the vicinity of the study area. Additionally, no producing or abandoned geothermal wells or geothermal springs have been identified in the study area.

3.7.3.6 Paleontological Resources

Paleontological Sensitivity

Paleontological sensitivity is an indicator of the likelihood of a geologic unit to yield fossils, and is defined and discussed in Section 3.7.4.1, *Methods for Analysis*. Unlike archaeological sites, which are narrowly defined, paleontological sites are defined by the entire extent (both areal and stratigraphic) of a unit or formation. Once a unit is identified as containing vertebrate fossils, or other rare fossils, the entire unit is a paleontological site (Society of Vertebrate Paleontology 2010). For this reason, the paleontological sensitivity of geologic units is described and analyzed broadly, rather than being limited to county boundaries.

Table 3.7-1 provides the paleontological sensitivity of the geologic units exposed at ground surface in the study area for the Proposed Project and the Atwater Station Alternative. Figure 3.7-15 includes a map depicting the geological units, three of which are in the study area. A description of geologic units located in the study area with high potential to contain fossils is provided following the table.



Direct Impact Study Area

Geologic Units

Q	Alluvium	Qr	Riverbank Formation	Pl	Laguna Formation
Qdp	Dos Palos Alluvium	Qm	Modesto Formation	Qtl	Turlock Lake Formation
		QTnm	North Merced Gravel	Tm	Mehrten Formation

N

Miles 0 1 2

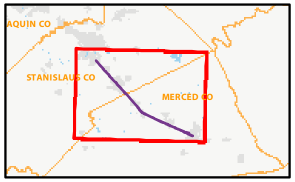


Figure 3.7-15
Paleontological Study Area
ACE Ceres-Merced Extension Project

Note: The following geological units within the environmental footprint of the Proposed Project have high paleontological sensitivity: Modesto Formation (Qm) and Riverbank Formation (Qr)

Table 3.7-1. Geologic Units in the Paleontological Study Area

Symbol	Geologic Unit	Epoch	Paleontological Sensitivity	Proposed and Alternative Facilities
Q	Alluvium	Holocene	*Low*: in most areas, units are likely too young to yield fossils[a]	Ceres to Merced Extension Alignment
Qm	Modesto Formation	Pleistocene	*High*: this unit has produced vertebrate fossils from a number of localities	Ceres to Merced Extension Alignment Turlock Station Livingston Station Merced Station Merced Layover & Maintenance Facility Atwater Station Alternative
Qr	Riverbank Formation	Pleistocene	*High*: this unit has produced vertebrate fossils from a number of localities	Merced Station

Sources: Society of Vertebrate Paleontology 2010; Wagner et al. 1991; Marchand and Allwardt 1981, Hilton et al. 2000, University of California Museum of Paleontology 2020a, 2020b.

[a] Geologic units younger than 5,000 years are generally not considered old enough to contain fossils (Wagner et al. 1991).

Modesto Formation (Qm)

The Modesto Formation consists of primarily arkosic sediments in the San Joaquin Valley, west of the Riverbank Formation, characterized by oxidized and weathered well sorted sand and gravel that transitions to fine sand and silt. The origin of the materials is primarily the Sierra Nevada. Locally derived material, such as andesite or a metamorphic rock, also appears in the Modesto Formation. The age of the Modesto Formation is approximately 14,000 to 42,000 years (Marchand and Allwardt 1981). Vertebrate fossils documented from the Modesto Formation include extinct mammals (giant ground sloth, mastodon, bison, and camel) and reptiles (University of California Museum of Paleontology 2020a). This unit is considered sensitive for paleontological resources.

Riverbank Formation (Qr)

The Riverbank Formation consists primarily of arkosic sediments in the San Joaquin Valley, characterized by well sorted sand and silts with pebbly lenses. Its origin is the Sierra Nevada. The age of the Riverbank Formation ranges from approximately 130,000 to 450,000 years (Marchand and Allwardt 1981). Vertebrate fossils documented from the Riverbank Formation include extinct mammals (mastodon, bison, wolf, coyote, horse, camel, and ground sloth), birds, reptiles (snake, turtle, and tortoise), and bony fish (University of California Museum of Paleontology 2020b; Hilton et al. 2000). This unit is considered sensitive for paleontological resources.

3.7.4 Impact Analysis

This section describes the environmental impacts of the Proposed Project and the Atwater Station Alternative on geology, soils, and paleontological resources. It describes the methods used to evaluate the impacts and the thresholds used to determine whether an impact would be significant. Measures to mitigate significant impacts are provided, where appropriate.

3.7.4.1 Methods for Analysis

Geology, Soils, and Seismicity

Impacts related to geology, soils, and seismicity are analyzed qualitatively, based on a review of published geologic and soils information for the study area and on professional judgment, in accordance with the current standard of care for geotechnical engineering and engineering geology. The analysis focuses on the potential of the Proposed Project and the Atwater Station Alternative, both during construction and operation, to increase the risk of personal injury, loss of life, and damage to property as a result of existing geologic conditions in the study area.

For the purposes of this analysis, the potential for Proposed Project and the Atwater Station Alternative to be affected by each geologic, soil, and seismic conditions are ranked low, moderate, or high. Areas in which information was not available are not ranked. The rankings are defined as follows for each geologic, soil, and seismic condition.

- Risks associated with expansive soils were ranked low if the PI of the soil is very low or low (PI 0–15), moderate if the PI is medium (PI 15–25), and high if the PI is high (25–35).
- Risks associated with corrosive soils were ranked based on the presence of soil types with the low, moderate, or high potential to result in corrosion to concrete or steel.

- Risks associated with erosion were ranked based on the erodibility of the underlying soil, with the lowest four values classified as low hazard, the middle four classified as moderate hazard, and the highest three values classified as high hazard.
- Risks associated with areas of difficult excavation were ranked moderate if shallow excavation would be somewhat limited and high if shallow excavation would be very limited.
- Strong groundshaking was classified as representing a high hazard everywhere because all segments can be expected to experience at least 0.25 g horizontal ground acceleration.
- Ranking of liquefaction susceptibility corresponds to the USGS determination.
- Landslides and earthquake-induced landslides were classified as high hazard if landslides have been mapped along a segment, moderate if the segment is in hilly terrain where landslides might occur, and low if the segment is in flat terrain where landslides are unlikely to occur.
- Subsidence was classified as low if it was mapped as less than 4 inches, moderate if between 4 inches and 12 inches, and high if greater than 12 inches.
- Effects on oil resources were analyzed based on the proximity of active extraction facilities to the improvements. Where facilities would be located within areas designated MRZ-2, the impact analysis indicates the potential presence of mineral resources.

Paleontological Resources

The fossil-yielding potential of geologic units in a particular area depends on the geologic age and origin of the units, as well as on the processes they have undergone, both geologic and anthropogenic.[5] The methods used to analyze potential impacts on paleontological resources and to develop mitigation for the identified impacts involved the following steps.

- Assess the likelihood of sediments affected by implementing improvements associated with the Proposed Project and the Atwater Station Alternative to contain scientifically important, nonrenewable paleontological resources that could be directly affected.
- Identify the geologic units in the paleontological study area.
- Evaluate the potential of the identified geologic units to contain significant fossils (their *paleontological sensitivity*).
- Identify the geologic units that would be affected by each improvement associated with the Proposed Project and the Atwater Station Alternative, based on each improvement's depth of excavation—either at ground surface or below ground surface, defined as at least 5 feet below ground surface.
- Identify and evaluate impacts on paleontologically sensitive geologic units as a result of construction and operations that involve ground disturbance.
- Evaluate impact significance.
- According to the identified degree of sensitivity, formulate and implement measures to mitigate potential impacts.

[5] *Anthropogenic* means caused by human activity.

The potential of improvements associated with the Proposed Project and the Atwater Station Alternative to affect paleontological resources is related to ground disturbance. Ground disturbance caused by improvements associated with the Proposed Project and the Atwater Station Alternative would take place during construction phases; therefore, this impact analysis addresses construction impacts.

The *Geologic Map of the San Francisco-San Jose Quadrangle* (Wagner et al. 1991) was consulted to identify the geologic units in the paleontological study area. To evaluate the paleontological sensitivity of the geologic units, the University of California Museum of Paleontology database was searched for records of fossils in these geologic units (University of California Museum of Paleontology 2020a, 2020b). Based on data from the University of California Museum of Paleontology database, each geologic unit in the study area was assigned a paleontological sensitivity according to the Society of Vertebrate Paleontology's (SVP's) Standard Guidelines.

The Impact Mitigation Guidelines Revisions Committee of the SVP has published Standard Guidelines (Society of Vertebrate Paleontology 2010) that include procedures for the investigation, collection, preservation, and cataloguing of fossil-bearing sites. The Standard Guidelines are widely accepted among paleontologists and are followed by most investigators. The Standard Guidelines identify the two key phases of paleontological resource protection as (1) assessment and (2) implementation. Assessment involves identifying the potential for a project site or area to contain significant nonrenewable paleontological resources that could be damaged or destroyed by project excavation or construction. Implementation involves formulating and applying measures to reduce such adverse effects. SVP defines the level of potential as one of four sensitivity categories for sedimentary rocks: high, undetermined, low, and no potential (Society of Vertebrate Paleontology 2010). The levels of potential defined in the SVP Standard Guidelines are defined as follows:

- **High Potential**. Assigned to geologic units from which vertebrate or significant invertebrate, plant, or trace fossils have been recovered; and sedimentary rock units suitable for the preservation of fossils ("e.g., middle Holocene and older, fine-grained fluvial sandstones…fine-grained marine sandstones"). Paleontological potential consists of the potential for yielding abundant fossils, a few significant fossils, or "recovered evidence for new and significant taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data."
- **Undetermined Potential**. Assigned to geologic units "for which little information is available concerning their paleontological content, geologic age, and depositional environment." In cases where no subsurface data already exist, paleontological potential can sometimes be assessed by subsurface site investigations.
- **Low Potential**. Field surveys or paleontological research may allow determination that a geologic unit has low potential for yielding significant fossils (e.g., basalt flows). Mitigation is generally not required to protect fossils.
- **No Potential**. Some geologic units have no potential to contain significant paleontological resources, such as high-grade metamorphic rocks (e.g., gneisses and schists) and plutonic igneous rocks (e.g., granites and diorites). Mitigation is not required.

To identify and evaluate impacts on paleontologically sensitive geologic units, GIS was used to identify ground-disturbance areas, including depth of ground disturbance, with respect to the location of geologic units with high potential and undetermined potential.

Measures for adequate protection or salvage of significant paleontological resources are applied to areas determined to contain geologic units with high or undetermined potential to contain significant paleontological resources. In areas determined to have high or undetermined potential for significant paleontological resources, an adequate program for mitigating the impact of development must include specific conditions: surveying; monitoring by a qualified paleontological resource monitor; salvage, identification, cataloguing, curation, and provision for repository storage; and reporting. All phases of mitigation must be overseen by a qualified paleontologist.

3.7.4.2 Thresholds of Significance

CEQA Guidelines Appendix G (14 Cal. Code Regs. 15000 et seq.) has identified significance criteria to be considered for determining whether a project could have significant impacts related to geology, soils, and paleontological resources.

An impact would be considered significant if construction or operation of the Proposed Project and the Atwater Station Alternative would have any of the following consequences.

- Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - 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.
  - Strong seismic ground shaking.
  - Seismic-related ground failure, including liquefaction.
  - Landslides.
- Result in substantial soil erosion or the loss of topsoil.
- 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.
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.
- Result in the loss of availability of a known mineral resource that would be a value to the region and the residents of the state.
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land-use plan.
- Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.

Septic tanks or alternative wastewater disposal systems are not part of the Proposed Project and the Atwater Station Alternative and, thus, are not discussed further in this section.

3.7.4.3 Impacts and Mitigation Measures

Impact GEO-1	Construction or operation of the Proposed Project would not directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving surface fault rupture, strong seismic ground shaking, liquefaction, seiches, landslides, subsidence and settlement, expansive soils, corrosive soils, and erosion.
Level of Impact	**Less than significant impact**

Impact Characterization and Significance Conclusion

Construction or operation of the Proposed Project could expose people or infrastructure to geologic hazards from expansive and corrosive soils, difficult excavation, landslides, subsidence and settlement, surface faulting, strong seismic groundshaking, liquefaction, and earthquake-induced landslides. Table 3.7-2 shows the potential geologic hazards for the Proposed Project and the Atwater Station Alternative.

Proposed Project

The Proposed Project would be constructed in areas associated with difficult excavation (moderate to high) and strong groundshaking (high). The potential for expansive soils is low to moderate for the Proposed Project**.** The potential for corrosive soils to be present in the Proposed Project is high, except at the Livingston Station, which has a low potential. Erosion potential is low, moderate, and high for the Proposed Project. In addition, the potential for landslides, subsidence, liquefaction, and earthquake-induced landslides for the Proposed Project is low because there are no previous occurrences, and the areas are relatively flat.

Table 3.7-2. Potential Geologic Hazards

	Geologic Hazards							
Proposed and Alternative Facilities	**Expansive Soils**	**Corrosive Soils**	**Erosion**	**Difficult Excavation**	**Strong Groundshaking**	**Liquefaction**	**Landslides & Earthquake-Induced Landslides**	**Ground Subsidence**
Ceres to Merced Extension Alignment	m	h	h	h	h	nr	l	l
Turlock Station	l	h	l	h	h	nr	l	l
Livingston Station	l	l	m	m	h	nr	l	l
Atwater Station Alternative	l	l	l	m	h	nr	l	l
Merced Layover & Maintenance Facility	l	h	h	m	h	nr	l	l
Merced Station	m	h	h	m	h	nr	l	l

Notes:
Estimated hazard rating listed is the highest that exists along a given improvement.
If a portion of an improvement was not evaluated for a given hazard, and the hazard rating could not be estimated, it was left as "nr".
l = low; m = moderate; h = high; nr = not rated; N/A = not applicable.

Construction-related activities for the Proposed Project would be temporary and limited in duration. Active fault rupture, large earthquakes, seismically induced ground failures, landslides, rockfalls, and debris flows are relatively infrequent events in the vicinity of the Proposed Project. Similarly, fault creep, subsidence, consolidation of unstable soils, expansion of expansive soils, corrosion to steel and concrete, and erosion are relatively slow processes. Loss of topsoil during construction activities would be prevented by standard measures required as part of the National Pollutant Discharge Elimination System program, as described in Section 3.10, *Hydrology and Water Quality*. Consequently, the probability of geologic hazards adversely affecting construction of the Proposed Project is relatively low.

Construction-related activities for the Proposed Project may be affected in some areas by difficulty of excavations due to the presence of shallow groundwater or shallow bedrock. The presence of shallow groundwater may require pumping, shoring, sloping, or benching of excavations, or other measures to maintain a safe working environment and allow construction to proceed. Shallow bedrock may require the use of standard heavy equipment measures (excavator with hoe ram or bulldozer with ripper teeth) or blasting to perform required excavations.

During operation of the Proposed Project, geologic hazards, including seismic events or ground failure, could occur, which could potentially affect the operation of trains, cause structural damage, and result in the injury or death of persons. However, SJRRC and UPRR have practices in place for routine track inspections, as required by FRA. Inspectors verify the integrity of the track prior to the operation of trains on the track. Routine inspection and special inspections pursuant to 49 C.F.R. Section 213.239 would ensure train operators were notified in advance of damage to the tracks associated with natural disasters, such as an earthquake. These procedures would prevent hazards associated with these events and any secondary seismic effects.

The following industry design standards and guidelines would be implemented in accordance with regulations.

- **Expansive Soils**—Treat soil to reduce expansive characteristics, excavate expansive soil, and replace with non-expansive soil.
- **Corrosive Soils**—Provide cathodic protection and/or increase dimensions of foundation elements, and coat buried steel.
- **Erosion**—Protect sloping embankment fill surfaces, armor stream banks, and control surface runoff in concrete V-ditches.
- **Landslides**—Excavate and/or stabilize (e.g., with retaining walls, tie backs, soil nails, buttress, dewater, control of surface runoff) unstable materials.
- **Subsidence**—Raise track elevation through re-ballasting.

As mentioned above, construction and operation of the Proposed Project would be located in areas with known geologic hazards, including difficult excavation and strong groundshaking. However, the Proposed Project would be designed and constructed in accordance with industry design standards, guidelines, and regulations, which would ensure that geological hazards do not compromise the structural integrity of the Proposed Project. Thus, impacts associated with geologic hazards would be less than significant due to implementation of standard design and construction measures as required by California Building Code and AREMA standards.

Atwater Station Alternative

Similar to the Proposed Project, the Atwater Station Alternative would be constructed in areas associated with difficult excavation and potential for strong groundshaking. Conversely, erosion potential along with impacts associated with corrosive and expansive soils is considered low. Additionally, the potential for landslides, subsidence, liquefaction, and earthquake-induced landslides within the footprint of the Atwater Station Alternative is also considered low. The Atwater Station Alternative would also be designed and constructed implementing all applicable industry design standards, guidelines, and regulations (as mentioned for the Proposed Project), minimizing potential impacts associated with geologic hazards. As such, impacts associated with geologic hazards would be less than significant for the Atwater Station Alternative due to implementation of standard design and construction measures as required by California Building Code and AREMA standards.

As described above, geologic conditions are similar under both the Livingston Station and the Atwater Station Alternative (with the exception of erosion potential, which is higher within the Livingston Station footprint). Thus, implementation of the Atwater Station Alternative instead of the proposed Livingston Station would result in the same less-than-significant impact due to geologic hazards.

Impact GEO-2	Construction or operation of the Proposed Project would not affect geologic resources, including oil and gas wells, mineral resources, or geothermal resources, and would not result in a loss of availability of regionally or locally important mineral resources.
Level of Impact	**No impact**

Impact Characterization and Significance Conclusion

The Proposed Project is not located in an area supporting significant aggregate resources. In addition, there are no active oil and gas wells or geothermal resources in the vicinity of the Proposed Project. Thus, there would be no impacts on aggregate mineral resources, oil or gas wells, or geothermal resources, and the Proposed Project would not result in the loss of availability of regionally or locally important mineral resources.

Likewise, the Atwater Station Alternative is not located in an area supporting significant aggregate resources, and there are no active oil and gas wells or geothermal resources in the vicinity. Thus, the Atwater Station Alternative would result in no impact on aggregate mineral resources, oil or gas wells, or geothermal resources and would not result in the loss of availability of regionally or locally important mineral resources. There would be no difference between the impacts of the Atwater Station Alternative and the proposed Livingston Station (both would have no impact).

Impact GEO-3	Construction of the Proposed Project could directly or indirectly destroy a unique paleontological resource or site or unique geological feature.
Level of Impact	**Potentially significant impact**
Mitigation Measures	GEO-3.1: Monitor for discovery of paleontological resources, evaluate found resources, and prepare and follow a recovery plan for found resources.
Level of Impact after Mitigation	**Less than significant impact**

Impact Characterization

The potential for impacts on paleontological resources is associated with the paleontological sensitivity of the geologic units involved in construction-related ground disturbance—that is, their potential to produce significant (scientifically important) fossil materials. The Proposed Project and the Atwater Station Alternative would be located in areas that are underlain by geologic units that have yielded abundant, diverse, and scientifically important fossil finds, including numerous vertebrate remains.

Where geologic units with high paleontological sensitivity are present, construction-related ground disturbance, particularly excavation, could result in disturbance, damage, or loss affecting other significant (scientifically important but non-unique) paleontological resources. Impacts are possible in two situations.

- Where strata with high paleontological sensitivity are exposed at the ground surface in areas subject to ground-disturbing activities.
- Where highly sensitive units are not surface exposed, but ground disturbance would extend deep enough to involve underlying highly sensitive materials.

Where geologic units with low paleontological sensitivity are adjacent to units with undetermined or high paleontological sensitivity, the units with low sensitivity are assumed to overlie the adjacent unit at a shallow depth; any shallow disturbance (greater than 5 feet) would encounter the unit of undetermined or high paleontological sensitivity.

While pile driving would disturb geologic units, any disturbance, damage, or loss affecting paleontological resources would not be identifiable. Furthermore, pile driving affects smaller areas than excavation. Therefore, excavation is of concern, whereas pile driving is of less concern.

The Proposed Project and the Atwater Station Alternative would not result in disturbances of previously undisturbed soils and, thus, would not affect paleontological resources by affecting undisturbed soils. Table 3.7-3 identifies geologic units that would be affected at ground surface or below ground surface by each improvement.

Proposed Project

Ceres to Merced Extension Alignment

The Ceres to Merced Extension Alignment would be constructed on Holocene alluvium (Q), Modesto Formation (Qm), and Riverbank Formation (Qr). All of the construction would take place on previously disturbed land, so no surficial disturbance would affect paleontological resources. Where geologic units with low paleontological sensitivity (Holocene alluvium [Q]) are adjacent to units with undetermined or high paleontological sensitivity (Modesto Formation [Qm] and Riverbank Formation [Qr]), the units with low sensitivity are assumed to overlie the adjacent unit at a shallow depth; any shallow disturbance would encounter the unit of undetermined or high paleontological sensitivity. The new bridge structures over the Merced River, State Route 99 in Livingston, Canal Creek, Weber Canal, irrigation canal, cross-swale drainage, Black Rascal Canal, and Bear Creek and modifications to 14 existing undercrossings for the Ceres to Merced Extension Alignment would involve disturbance below ground surface, and would potentially affect the Modesto Formation (Qm) and Riverbank Formation (Qr). The below-ground-surface construction for the Ceres to Merced Extension Alignment could encounter geologic units of high paleontological sensitivity, as shown in Table 3.7-3, with potential to damage or destroy significant paleontological resources. This impact would be potentially significant.

Turlock Station

The Turlock Station would be constructed on the Modesto Formation (Qm). Construction for this station would take place on previously disturbed land, so no surficial disturbance would affect paleontological resources. Below-ground-surface disturbances would be required for the Turlock Station. The new pedestrian bridge and drainage trenching activities for the Turlock Station would involve disturbance below ground surface and would potentially affect the Modesto Formation (Qm). Excavation associated with this below-ground-surface construction could encounter geologic units of high paleontological sensitivity, as shown in Table 3.7-3, with potential to damage or destroy significant paleontological resources. This impact would be potentially significant.

Livingston Station

The **Livingston Station** would be constructed on the Modesto Formation (Qm). Construction for this station would take place on previously disturbed land, so no surficial disturbance would affect paleontological resources. Below-ground-surface disturbances would be required for the Livingston Station. The new pedestrian tunnel and drainage trenching activities for the Livingston Station would involve disturbance below ground surface and would potentially affect the Modesto Formation (Qm). Excavation associated with this below-ground-surface construction could encounter geologic units of high paleontological sensitivity, as shown in Table 3.7-3, with potential to damage or destroy significant paleontological resources. This impact would be potentially significant.

Merced Station

The Merced Station would be constructed on the Modesto Formation (Qm) and Riverbank Formation (Qr). Construction for this station would take place on previously disturbed land, so no surficial disturbance would affect paleontological resources. Below-ground-surface disturbances would be required for the Merced Station. Drainage trenching activities for the Merced Station would involve disturbance below ground surface and would potentially affect the Modesto Formation (Qm) and Riverbank Formation (Qr). Excavation associated with this below-ground-surface construction for the Merced Station could encounter geologic units of high paleontological sensitivity, as shown in Table 3.7-3, with potential to damage or destroy significant paleontological resources. This impact would be potentially significant.

Merced Layover & Maintenance Facility

The Merced Layover & Maintenance Facility would be constructed on Modesto Formation (Qm) and Holocene alluvium (Q). All construction would take place on previously disturbed land, so no surficial disturbance would affect paleontological resources. Although Holocene alluvium (Q) is a geologic unit with low paleontological sensitivity, this unit is assumed to overlie the Modesto Formation (Qm), a unit with high paleontological sensitivity. The new maintenance building and facilities associated with the Merced Layover & Maintenance Facility would involve disturbance below ground surface and would potentially affect the Modesto Formation (Qm). Excavation associated with this below-ground-surface construction for the Merced Layover & Maintenance Facility could encounter geologic units of high paleontological sensitivity, as shown in Table 3.7-3, with potential to damage or destroy significant paleontological resources. This impact would be potentially significant.

Atwater Station Alternative

The Atwater Station Alternative would be constructed on the Modesto Formation (Qm). The construction for this station would take place on previously disturbed land, so no surficial disturbance would affect paleontological resources. Below-ground-surface disturbances would be required for the Atwater Station Alternative. The new pedestrian tunnel and drainage trenching activities for the Atwater Station Alternative would involve disturbance below ground surface and would potentially affect the Modesto Formation (Qm). Excavation associated with this below-ground-surface construction for the Atwater Station Alternative could encounter geologic units of high paleontological sensitivity, as shown in Table 3.7-3, with potential to damage or destroy significant paleontological resources. This impact would be potentially significant.

Table 3.7-3. Summary of Impacts on Geologic Units/ Paleontological Resources

Proposed or Alternative Facility	Improvements	Depth of Disturbance	Type of Disturbance[a]	Geologic Units
Ceres to Merced Extension Alignment	New or upgraded tracks	Less than 5 feet bgs	Surface	Holocene alluvium (Q) **Modesto Formation (Qm)** **Riverbank Formation (Qr)**
	Modify existing overhead structure undercrossing	Excavation of abutment fill for a retaining wall from 5 to 15 feet bgs Foundations for pier protection, depth is not specified at this level of design	Surface Below ground surface	
	Modify existing at-grade crossings	Less than 5 feet bgs	Surface	
	New culverts crossing over irrigation canal and drainage	Less than 5 feet bgs	Surface	
	New bridge structure over roadways and waterways (Merced River, SR 99, Canal Creek, Weber Canal, irrigation canal, cross-swale drainage, Black Rascal Canal, and Bear Creek)	Piles driven to depths greater than 5 feet bgs, depth is not specified at this level of design	Surface Below ground surface	
Turlock Station	New station platform, fence between main tracks, and surface parking	Less than 5 feet bgs	Surface	**Modesto Formation (Qm)**
	New pedestrian bridge	Foundations greater than 5 feet bgs	Surface Below ground surface	
	Drainage trenching	Slightly greater than 5 feet bgs	Surface Below ground surface	
Livingston Station	New station platform, fence between main tracks, and surface parking	Less than 5 feet bgs	Surface	**Modesto Formation (Qm)**
	Drainage trenching	Slightly greater than 5 feet bgs	Surface Below ground surface	
	Pedestrian tunnel	Excavation to depth of 15–20 feet bgs	Surface Below ground surface	

Proposed or Alternative Facility	Improvements	Depth of Disturbance	Type of Disturbance[a]	Geologic Units
Merced Layover & Maintenance Facility	New tracks, support facility areas, and fence, and surface parking	Less than 5 feet bgs	Surface	Holocene alluvium (Q) **Modesto Formation (Qm)**
	New facilities, including train wash facility and maintenance building	Up to 20 feet bgs	Below ground surface	
Merced Station	New station platform, fence between main tracks, and surface parking	Less than 5 feet bgs	Surface	**Modesto Formation (Qm) and Riverbank Formation (Qr)**
	Drainage trenching	Slightly greater than 5 feet bgs	Surface Below ground surface	
Atwater Station Alternative	New station platform, fence between main tracks, and surface parking	Less than 5 feet bgs	Surface	**Modesto Formation (Qm)**
	Modify Atwater Boulevard	Less than 5 feet bgs	Surface	
	Drainage trenching	Slightly greater than 5 feet bgs	Surface Below ground surface	
	Pedestrian tunnel	Excavation to depth of 15–20 feet bgs	Surface Below ground surface	

Note: Geologic units in **bold** have high paleontological sensitivity.
bgs = below ground surface.
SR = State Route.
[a] Surface disturbances are defined as disturbances up to 5 feet and below-ground-surface disturbances are defined as disturbances more than 5 feet below ground surface.
[b] The Holocene alluvium (Q) is likely underlain by a more sensitive unit—Modesto Formation—depending on location. The Modesto Formation is therefore is also identified in these columns.

Mitigation Measures

Mitigation Measure GEO-3.1 would apply to the Proposed Project (including the Ceres to Merced Extension Alignment, Turlock Station, Livingston Station, Merced Station, and Merced Layover & Maintenance Facility).

Likewise, Mitigation Measure GEO-3.1 would apply to the Atwater Station Alternative.

Mitigation Measure GEO-3.1: Monitor for discovery of paleontological resources, evaluate found resources, and prepare and follow a recovery plan for found resources

Given the potential for paleontological resources to be present in construction areas at ground surface and at excavation depths in sensitive geologic units in the study area, the following measures will be undertaken to avoid any potentially significant effect from the improvements on paleontological resources.

Before the start of any drilling or pile-driving activities, SJRRC's contractor will retain a qualified paleontologist, as defined by SVP, who is experienced in teaching non-specialists. The qualified paleontologist will train all construction personnel involved with earthmoving activities, including the site superintendent, regarding the possibility of encountering fossils, the appearance and types of fossils that are likely to be seen during construction, and proper notification procedures should fossils be encountered. Procedures to be conveyed to workers include halting construction within 50 feet of any potential fossil find and notifying a qualified paleontologist, who will evaluate the significance.

The qualified paleontologist will also make periodic visits during earthmoving in high-sensitivity sites to verify that workers are following the established procedures.

If paleontological resources are discovered during earthmoving activities, the construction crew will immediately cease work near the find and notify SJRRC. Construction work in the affected areas will remain stopped or be diverted to allow recovery of fossil remains in a timely manner. SJRRC's contractor will retain a qualified paleontologist to evaluate the resource and prepare a recovery plan in accordance with SVP Standard Guidelines (Society of Vertebrate Paleontology 2010). The recovery plan may include a field survey, construction monitoring, sampling and data recovery procedures, museum storage coordination for any specimen recovered, and a report of findings. Recommendations in the recovery plan that are determined by SJRRC to be necessary and feasible will be implemented before construction activities can resume at the site where the paleontological resources were discovered. SJRRC's contractor will be responsible for ensuring that the monitor's recommendations regarding treatment and reporting are implemented.

The final disposition of paleontological, archeological, and historical resources recovered on state lands under the jurisdiction of the California State lands Commission must be approved by SJRRC.

Significance with Application of Mitigation

Mitigation Measure GEO-3.1 requires training for construction crews to recognize paleontological resources by a qualified paleontologist, stopping work in case of discovering such resources, evaluating those resources by a qualified paleontologist and, as appropriate, preparing and implementing a recovery plan. This measure would ensure that excavation would not result in destruction of significant paleontological resources, and potential construction impacts would be less than significant for the Proposed Project.

Likewise, with implementation of Mitigation Measure GEO-3.1, construction-period impacts on paleontological resources from the Atwater Station Alternative would be less than significant.

Comparison of the Proposed Livingston Station and Atwater Station Alternative

Implementation of the Atwater Station Alternative instead of the proposed Livingston Station would result in the disturbance of the same geologic unit with high paleontological sensitivity (Modesto Formation [Qm]). Both the Atwater Station Alternative and the proposed Livingston Station would include construction of a pedestrian tunnel and drainage trenching, both of which involve excavation below ground surface. Thus, construction of the Atwater Station Alternative and the proposed Livingston Station would result in the same impact on paleontological resources (less than significant after implementation of Mitigation Measure GEO-3.1).

Impact GEO-4	Operation and maintenance of the Proposed Project would not directly or indirectly destroy a unique paleontological resource or site or unique geological feature.
Level of Impact	**No impact**

Routine operations and maintenance activities associated with the Proposed Project are not expected to require disturbance of previously undisturbed substrate materials. With no ground disturbance in previously undisturbed materials, there would be no disturbance, damage, or loss of paleontological resources. Thus, there would be no impact related to paleontological resources associated with operation and maintenance of the Proposed Project.

Likewise, for the same reasons listed above, there would be no impact related to paleontological resources associated with operation and maintenance of the Atwater Station Alternative. There would be no difference in the impact between the proposed Livingston Station and the Atwater Station Alternative (both would have no impact).

3.7.4.4 Overall Comparison of the Proposed Livingston Station and Atwater Station Alternative

The proposed Livingston Station would have a slightly greater impact on geology and soils than the Atwater Station Alternative because the potential for erosion is higher within the Livingston Station. Overall, there would be no substantial difference in geology and soils impacts between implementation of the Atwater Station Alternative or the proposed Livingston Station (both are expected to result in less than significant impacts after mitigation).