## 3.4 GEOLOGY, SOILS, AND SEISMICITY

This section describes the geology, soils and seismicity of the proposed project site, and assesses their impact in relation to the operation of the railroad, construction activities associated with Bakers Creek, Foss Creek, Black Point Bridge, and the Lombard Siding, and routine maintenance activities. The study area is Napa, Sonoma, Marin and Mendocino counties for regional geology and seismicity, and railroad right-of-way for geologic hazards.

In 2005 an EIR prepared for the SMART project analyzed impacts from the construction and operation of a proposed passenger line between Novato and Cloverdale. Much of the information discussed in the following existing environmental setting section for the proposed project along this segment of the rail line was collected from the SMART document and verified during several reconnaissance hy-rail project site visits with Kleinfelder geologists and engineers. The existing environmental setting between Lombard and Novato, and between Cloverdale and Willits (the part of the line not analyzed in the SMART EIR), was collected from additional sources, previous knowledge by Kleinfelder geologists, and inspections during the reconnaissance hy-rail trips.

### 3.4.1 Regulatory Setting

The regulatory setting is based on the information that was available in 2008 when the March 9, 2009 DEIR was under preparation.

#### *3.4.1.1 Federal Regulations*

The Code of Federal Regulations (CFR) include specific requirements pertaining to railway safety and emergency response. Rules regarding freight rail operations are included in Title 49, Subtitle B, Chapter II, Part 200-268.

The general condition of the track grade, including embankments, cuts and fills, is included in a required weekly track inspection that will be performed by the operator's track inspector in accordance with the Federal Railroad Authority (FRA) regulations contained in 49 CFR Part 213. Any exceptions must be noted on the inspector's report and follow-up action will be taken as required.

Special inspections are necessary if derailments, fires, floods, earthquakes, or other events occur that may affect the stability of the track grade or embankments (including both cuts and fills). If erosion is observed, the operator is required to take the actions necessary to control the erosion to the extent possible. Qualified railroad and/or marine contractors will be utilized to perform these repairs, except where railroad forces are able to place rip-rap or make repairs using railroad equipment. Some circumstances may require that permits be obtained in accordance with applicable regulations.

#### *3.4.1.2 State Regulations*

The principal state guidance relating to the impact and mitigation of geologic hazards in California is the Alquist-Priolo Earthquake Fault Zoning Act (P.R.C. § 2621 et. Seq.), and in the Seismic Hazards Mapping Act of 1990 (P.R.C. § 2690-2699.6). The Alquist-Priolo Act prohibits locating many types of occupied structures across active faults. In addition, the Act regulates construction in the corridors along active faults.

The Seismic Hazards Mapping Act of 1990 addresses hazards related to strong ground shaking, liquefaction, and seismically induced landslides. The state is required to identify and map areas at risk of strong ground shaking, liquefaction, and landslides for use by cities and counties in preparing their general plans, adopting land use policies, and reducing and mitigating potential seismic hazards.

The Uniform Building Code (UBC) is the structural code used to design buildings to withstand seismic hazards. In California it is referred to as the California Building Code (CBC). Seismic site factors are derived from the UBC/CBC and are required by state and local agencies in geotechnical investigations for critical structures in areas of high seismicity.

#### *3.4.1.3 Rail-Specific Standards*

The American Railway Engineering and Maintenance-of-Way Association (AREMA) is the governing body to provide rules and procedures that guide and facilitate the development of materials for the design, construction and maintenance of railway infrastructure. Rail-specific improvements such as bridges, rail line embankments, drainage culverts, and signals are designed, built, inspected, and rated in accordance with AREMA standards.

## 3.4.2 Environmental Setting

The environmental setting is based on the information that was available in 2008 when the March 9, 2009 DEIR was under preparation.

### *3.4.2.1 Physiographic and Geologic Setting*

The proposed project's southern terminus begins at Lombard in Napa County, extending northwestward through Schellville and then southwestward into Ignacio along Highway 101 (Figure 2-1). At Ignacio the rail line trends north-northwest along Highway 101 northward through Novato, Petaluma, Cotati, Rohnert Park, Santa Rosa, Windsor, Healdsburg, Cloverdale, Ukiah and ending in Willits, CA. Elevations along the rail alignment range from nearly sea level in Napa County, to approximately 300 feet above Mean Sea Level (MSL) at Cloverdale, and a maximum of approximately 2,000 feet MSL in the hill area of Willits on the north end.

The proposed project is located within the Coast Range geomorphic province of California, which is characterized by northwest trending mountain ranges and intervening valleys that reflect the dominant northwest structural trend in bedrock of the region. The dominant basement rocks in the northwest portion of this province are a mélange of sedimentary, metamorphic and volcanic rock of the Franciscan Complex of Upper Jurassic to Cretaceous Age (Figure 3.4-1). Within the Franciscan complex are localized exposures of serpentinites and ultramafic rocks that may contain naturally occurring asbestos (NOA). The potential impacts related to NOA are described in section 3.6: Hazardous Materials.

The geomorphology of the Coast Ranges is an expression of basement rock structure, which is primarily the result of older (Jurassic-Cretaceous) compressional tectonics and superimposed younger (recent) transpressional faulting and folding. The principal fault in northern California is the San Andreas fault (Figure 3.4-2), but it is recognized that virtually all of the major active left-lateral strike-slip faults south of Point Mendocino are considered to be a part of the San Andreas fault system, a broad active transform tectonic plate boundary located between the Pacific Plate to the west and the North American Plate to the east. Uplift due to transpressional forces along these faults has created the Coast Ranges. Rainfall and surface runoff have dissected the ranges to create the rugged and varied topography that exists today.

### *3.4.2.2 Bedrock Geology*

Basement rocks of the Jurassic-Cretaceous age Franciscan Complex and Great Valley Sequence outcrop at various locations throughout the project area. Younger bedrock units that overlay the basement rocks are generally volcanic or marine in origin. Rhyolitic tuff, basalt, fluvial gravel, silt, sand, clay, siltstone, and pyroclastic rocks of the Pleistocene age Huichica and Glenn Ellen Formation are found from the hills east of Santa Rosa north to Healdsburg. Older marine siltstones, sandstones, mudstones and conglomerates (mostly non-marine) of the Petaluma Formation outcrop in Petaluma and northern Marin County. North of Cloverdale are ultramafic outcroppings and non-marine alluvium (Figure 3.4-1).

### *3.4.2.3 Soils and Surficial Deposits*

Soils throughout the project corridor vary considerably. The geological parent material from which the soils derive and climatic factors that are important to soil formation vary along the project site, resulting in a wide range of soil materials along the rail line. These range from well drained loamy organic silts in alluvial valleys to impermeable swelling clays.

The rail line is built on intertidal deposits between Lombard and Petaluma (often referred to as Bay Mud). The intertidal deposits consist of soft compressible silts, clays and occasionally peat. These materials are very weak and susceptible to settlement when loaded with fill. A geotechnical investigation by Kleinfelder (2007) south of Petaluma indicates that these sediments have been compressed as much as 6.5 feet from the loading of the railroad embankment. Progressive compression and resulting subsidence is a common occurrence when heavy loads, such as an embankment, is placed above.

North of Petaluma the rail line crosses areas of Holocene alluvium and Pleistocene older alluvium deposits. The alluvium is present along large areas of the proposed project from Petaluma north to Cloverdale, near Hopland, and again in the Ukiah and Willits areas (Figure 3.4-1).

### *3.4.2.4 Landslides*

Damage to the rail line and track bed caused by mass movement during severe storms has occurred along the railroad. Much of the present damage is due to major storm events that occurred in 1993 and 1998 (CAR, 2005). During the storms, intense and prolonged rainfall saturated the ground. The groundwater pressures increased to the point that slopes failed. At the same time, rivers swollen by the heavy rain eroded the lower toes of these slopes, which contributed to landslides along the rail line in and around the Russian River area and the high relief areas along the rail line. Ground movement along the rail line has created sag ponds, closed depressions, and open cracks that intercept or trap water.

Different types of landslides are observed along the alignment include rotational and translational slides, earthflows, debris flows and rockslides. In rotational slides the head of the slide mass moves vertically downward with relatively little horizontal movement. Translational slides displace downslope and horizontally and move over the top of the ground located below their toe. An earthflow is a landslide that flow or creeps downslope as a semi-viscous earth mass. They are common in the Franciscan Complex where comprised locally of highly sheared rock and weak soils. Debris flow consists of soil, rock and other debris (i.e. vegetation) that move rapidly downslope. Rock slides include wedge failures, plane failures, topples, falls and rock avalanches.

Issues arising from slope movement and landsliding along the rail line are as follows:

- Vertical and horizontal displacements of the track;
- Loss of track subgrade support;
- Encroachment on or complete burial of the track by soil and rock slide debris; and
- Complete loss of roadbed (hanging track).

### *3.4.2.5 Faults and Seismicity*

Faults in Northern California are categorized as active, potentially active, and inactive faults, based on criteria developed by the California Geological Survey (CGS) for the Alquist-Priolo Earthquake Fault Zoning Program. By definition, an active fault is one that exhibits surface displacement within Holocene time (last 11,000 years). A potentially active fault is a fault that exhibits surface displacement of Quaternary age deposits (within the last 1.6 million years). Inactive faults have no displacement within the last 1.6 million years.

A list of nearby active faults and the distance in kilometers between the nearest point on the project to the fault, the maximum magnitude, and the slip rate for the fault are shown in Table 3.4-1. A list of historic seismicity of earthquakes that exceeded Richter magnitude of 5.0 and that caused shaking in the vicinity of the project corridor is presented in Table 3.4-2. Large historic earthquakes (greater than magnitude 6.0) within the region are shown on Figure 3.4-3.

The project corridor crosses three Alquist-Priolo Earthquake Zones (Figure 3.4-2):

- West Napa Fault west of Lombard in Napa County;
- Rodgers Creek-Healdsburg fault in Healdsburg and west of Lombard; and
- Several crossings of the Maacama fault zone north of Cloverdale in the Ukiah and Willits areas.

### *3.4.2.6 Seismic and Other Geologic Hazards*

Liquefaction

Liquefaction is defined as the transformation of solid subsurface soils into a liquid state due to build up of pore pressures and subsequent loss of shear strength generally by excitation by earthquake waves. Areas underlain by young, shallow (less than 50 feet) loose, saturated, granular soils with low clay content are most susceptible to liquefaction. Secondary effects of liquefaction are lateral spreading and differential settlement. Soil liquefaction, lateral spreading, and differential settlement may cause ground failure that can damage the rail line.

Settlement

Settlement is the consolidation of bearing soil when a load, such as that of a building or new fill material, is placed upon it. Soil that settles at different rates and by varying amounts depending on the load weight and relative thickness of soil is referred to as differential settlement. Areas are susceptible to differential settlement if underlain by compressible sediments, such as poorly engineered artificial fill or intertidal deposits.

**Table 3.4-1**
**Major Faults Considered to be Active**
**In Northern California**

| Fault | Maximum Moment Magnitude (Mw) | | Slip Rate (mm/yr.) | Distance From Project (kilometers) | Direction From Project |
|---|---|---|---|---|---|
| Rodgers Creek – Healdsburg [1] | 7.0 | SS | 9.0 | 0-2 | Crosses |
| Maacama | 6.9 | SS | 9.0 | 0-4 | Crosses |
| West Napa | 6.5 | SS | 1.0 | 0-28 | Crosses |
| San Andreas | 7.9 | SS | 24.0 | 16 | Southwest |
| Concord – Green Valley | 6.9 | SS | 6.0 | 38 | East |
| Hayward (North) | 6.9 | SS | 9.0 | 13 | East |
| San Gregorio (Seal Cove) | 7.3 | SS | 5.0 | 50 | North |
| Calaveras (North of Calaveras Reservoir) | 6.8 | SS | 6.0 | 54 | Southeast |

Source: California Geological Survey, 1996 and SMART EIR, 2005.

Notes: SS = Strike-slip. A strike-slip fault is an approximately vertical fault plane where the rock on one side of the fault slides horizontally past the other.

[1] = A potentially active segment of the Healdsburg fault crosses the project corridor in Healdsburg.

**Table 3.4-2**
**Historic Earthquakes in Region Greater**
**Than Magnitude 5.0**

| Earthquake (Oldest to Youngest) | Date of Earthquake | Magnitude | Direction to Epicenter [1] |
|---|---|---|---|
| Oakland | June 10, 1836 | 7.0 | Southwest |
| San Francisco Peninsula | June, 1839 | 6.8 | South-southeast |
| Hayward | October 21, 1868 | 6.8 | Southeast |
| Vacaville | April 19, 1891 | 6.4 | Southeast |
| San Francisco | April 18, 1906 | 7.8 | Southwest |
| Concord | October 24, 1954 | 5.4 | Southeast |
| Santa Rosa | October 2, 1969 | 5.7 | Northeast |
| Livermore Valley | January 24, 1980 | 5.8 | Southeast |
| Livermore | January 27, 1980 | 5.4 | Southeast |
| Loma Prieta | October 17, 1989 | 6.9 | South-southeast |
| Yountville | September 3, 2000 | 5.2 | East-southeast |

Source: Toppozada et. Al., 1994 and USGS, 2000 – "The September 3, 2000, Yountville Earthquake", online report by U.S. Geological Survey, Earthquake Hazards Program, released December 7, http://quake.wr.usgs.gov/recent/reports/napa, SMART EIR 2005.

[1] Direction to epicenter of the earthquake event from the closest point along the proposed project corridor.

Earthquake-Induced Settlement

Settlement of underlying bearing materials can occur during earthquakes as a result of compaction and settling of subsurface materials, particularly loose, non-compacted, and variable sandy sediments. Settlement can occur both uniformly and differentially (i.e. where adjoining areas settle at different rates). Areas susceptible to earthquake-induced settlement would include those underlain by thick layers of colluvial material or non-engineered fill.

Expansive Soils

Expansive soils are clay-rich soils that absorb water and expand, then contract when dry, resulting in cyclic shrinking and swelling. Structural damage may occur over a long period of time, usually the result of inadequate soil and foundation engineering where structures are placed directly on expansive soils.

#### *3.4.2.7 Environmental Setting at Specific Rehabilitation and Construction Sites*

Bakers Creek

Bakers Creek is an intermittent stream that flows down McGee Canyon, a fault-controlled valley formed by erosion of fractured rock along the trace of the active Maacama fault. The fault trace lies directly beneath the railroad embankment where it crosses the valley.

In December 2005 blockage of the culvert during heavy storms led to the impoundment of water behind the embankment, resulting in failure of the embankment and flooding as far as one mile downstream.

In early January 2006 the California Department of Forestry (CDF) investigated the flooding, and observed that only the top of the embankment failed, and approximately five million gallons of water remained impounded. As a result, the CGS recommended a controlled breaching of the embankment. On January 24th, 2006 a multi-agency team that included NCRA, planned, directed, and executed operations to drain the ponded water. Water currently flows freely through the engineered breach.

On February 27, 2006 the CGS sent to the CDF a memorandum that summarized the causes and emergency breaching of the embankment. The memorandum noted several observations and made three recommendations for repair, including evaluation by a consulting geotechnical engineer and engineering geologist to determine a permanent repair that eliminates risk of hazard to downstream properties and residents, and mitigates the potential for future debris flows, culvert plugging, and flooding.

Foss Creek

Foss Creek flows southward and subparallel to the railroad right-of-way toward the Russian River near Healdsburg. The railroad embankment was constructed of fill placed on floodplain deposits adjacent to an abandoned creek channel approximately 30 feet east of the modern channel.

High runoff from heavy storms in the winter of 2005-2006 caused Foss Creek to meander eastward and become captured within the channel adjacent to the embankment. High flows severely damaged a 200 foot section of the embankment, ballast, and track. The creek currently remains captured adjacent to the embankment.

Black Point Bridge

The Black Point Bridge is situated within the Petaluma River about a half mile north of where it discharges into San Pablo Bay. Beneath the river are deposits of sediments derived from the transport of silts and clays from the watershed that extends to north Petaluma. On either side of the river are silts and bay muds derived from the interaction of annual flooding and overbank deposition and tidal influenced marshes and wetlands. Uplands to the west are composed of Cretaceous greywacke sandstones of the Franciscan complex. The river has been channeled by historic dredging sediments from the river bottom.

Lombard Siding (MP 1.0 – MP 2.0)

This proposed new siding will be 5,300 feet long located between MP 1.0 and MP 2.0 just before the interchange at Lombard. The right-of-way is 60 feet wide for the first 3,600 feet, then 110 feet wide the remaining 1,700 feet at this location. The proposed siding will be located 15 feet south of and parallel to the mainline.

At the western end of the proposed siding along this stretch of right-of-way, mudflats/diked historic baylands extend from the toe of the slope of the railroad bed beyond the limits of the right-of-way. Historically, these areas occurred within the floodplain of the Napa River, and are underlain by fine-grained interbedded bay mud and floodplain deposits.

Further east of the road crossing at MP 1.8, seasonal wetland habitat occurs sporadically along both sides of the railroad bed and generally extends an average of 6-12 feet into the right-of-way from the toe of slope of the bed. Most of the seasonal wetlands appear to be artificial in origin and function as drainage ditches that parallel the mainline with the exception of a 15' wide swale that drains under the track at MP 1.37.

*Novato Consent Decree (MP 35.5 – MP 18.7)*

Improvements required by the Novato Consent Decree include establishing quiet zones involving improvements at fourteen or more crossings, welding of rails, fencing as required for safety, and landscaping to reduce the effects of glare from trains running after dusk. The existing crossings identified in the Novato Consent Decree include paved public roads, private crossings, and pedestrian or trail crossings. An unspecified number of additional crossings may also be required or recommended by the regulatory agencies (see Section 2.0, Project Description, for specific descriptions and mile posts).

The crossings are either developed (paved roads) or unpaved roads and trails where the ground has been disturbed by vehicular or pedestrian traffic. Specific improvements at crossings related to potential geologic hazards include construction of short mountable medians, 3-feet wide medians, quad gates, short pedestrian gates and swing gates. Except for part of a 200 feet median strip that extends off of the railroad ROW at Hanna Ranch Road, road improvements, gates, and signage will be constructed on existing roads or disturbed areas adjacent to the crossings.

The geologic materials vary with location. Rock formations may range from coherent Franciscan sandstone to unconsolidated alluvium or bay mud.

<u>Maintenance and Repair Activities Associated with the Operation of the Railroad</u>

The proposed project includes routine maintenance and repairs. These activities typically involve replacement and/or repair within five principal categories: signals, culverts, tunnels, track, and bridges.

Virtually all of the signals are located adjacent to roads on disturbed ground. Typical repair or replacement activities include replacement or upgrades of electrical systems, lights, and arms, full replacement of signals on existing foundations, or construction of new foundations involving local removal of existing roadway pavement, repair of the track bed, and replacement of the road surface.

Many of the culverts are located in ephemeral channels or historic drainages where water has been diverted for agricultural use. Some culvert repair work may involve minor excavation of non-native material and backfilling.

Five tunnels are located between Cloverdale and Willits. Typical repair work involves replacement of some timber lagging and sets, adding additional support, removal of rockfall, and clearing ditches to improve drainage.

Track repair along the line typically involves working within the railroad right-of-way to maintain ballast and embankment slope, as well as maintain rail components such as railroad ties, switches, and rail.

Most of the bridges are constructed of wood on wood supporting piles. The bridges are found throughout the rail line and span all types of crossings, such as swales, ephemeral channels, rivers, roadways, highways, farm roads, and cattle passes. Repair work is typically minor involving the replacement of bridge components such as decking, deck ties and timber guards, struts, bents, bracing, handrails, and piles.

## 3.4.3 Impacts and Mitigation Measures

This section describes the potential environmental impacts to or from the proposed project related to geology, soils, and seismicity. A description of the criteria used to determine the level of significance for potential impacts is provided. For impacts that are considered to be significant, mitigation measures are prescribed to reduce the impact to a less than significant level.

### *3.4.3.1 Significance Criteria*

The significance of the proposed project impacts were evaluated based on the following criteria:

- Expose people or structures to potential substantial adverse effects from slip along a known active fault that crosses the rail line, strong seismic ground shaking, seismic-related ground failure or liquefaction, or earthquake-induced landslides.
- Result in substantial soil erosion.
- The rail line or supporting structures are 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 significant on- or off-site landslide, lateral spreading, subsidence liquefaction or collapse.
- The rail line or supporting structures are located on expansive soil that creates a substantial risk to life or property.

### *3.4.3.2 Impact Assessment Methodology*

Impacts related to geology and seismicity were assessed by reviewing existing reports, documents, governmental databases, and field reconnaissance. This information was then analyzed against the significance criteria to assess whether significance thresholds were exceeded. The following is a list of activities that were performed:

- Review of previously prepared documents.
- Review of current seismic and fault data from the USGS and CGS, soils map from the U. S. Department of Agriculture (USDA), groundwater maps and reports from the California Department of Water Resources (DWR), and slope maps from the CGS.
- Review of the Alquist-Priolo Fault Zone Maps.
- Review of data contained in the SMART EIR.
- Field reconnaissance of geologic conditions.

### *3.4.3.3 Impacts and Mitigations*

Rehabilitation and Construction Activities

Two of the rehabilitation projects, Bakers Creek and Foss Creek, involve the placement of fill to repair the damaged line, and one, Black Point Bridge, involves mechanical work that will fully mechanize the bridge. A fourth proposed project activity involves construction of a new siding near Lombard. Potential impacts from these rehabilitation and construction activities as well as the minor rehabilitation activities, ongoing maintenance that are necessary to bring and keep the rail line into compliance with FRA Class 2/3 Standards were assessed.

*Bakers Creek*

Rehabilitation activities at Bakers Creek involve the replacement of a culvert and rail embankment across the existing creek by constructing a 20-foot concrete arch that will allow Bakers Creek to flow through more naturally than the previous culvert. It will also prevent the conditions that led to the failure of the embankment. Although the structure will be built across the trace of the active Maacama fault, it is unlikely that an earthquake focused beneath the structure will occur during construction. In addition, although several landslides have been mapped in McGee Canyon, it is unlikely that workers will be exposed to mass movement of soil because construction will occur outside periods of rainfall. Therefore, impacts related to seismicity during rehabilitation are not anticipated.

**Impact GEO-BC1:** Fill material may be released to Bakers Creek if not placed and managed properly during construction, leading to siltation at the site and downstream from the site. ***[Less Than Significant With Mitigation Measure GEO-BC1]***

**Mitigation GEO-BC1a:** Agency approved operations plans and BMPs for construction and the management of earthen materials shall be implemented during the rehabilitation activities. These BMPs shall include storm water control measures such as silt fences, contractor training for work in sensitive areas, and project controls to prevent the spill of excess soil from the embankment as it is being constructed.

**Mitigation GEO-BC1b:** Planning and construction activities shall be conducted in coordination with the appropriate permitting agencies, and adhere to permitting requirements.

Additional mitigation measures regarding potential impacts to biological and water resources are provided in Section 3.2: Biological Resources, and Section 3.11: Water Resources.

*Foss Creek*

Rehabilitation of the damaged segment will consist of driving sheet piles parallel to the creek, backfilling, replacement of ballast and track, and placement of rip rap at the base to prevent scour. It is unlikely that a significant earthquake on one of the region's active faults will occur during construction, and there are no significant potential geologic hazards along the right-of-way. Therefore, impacts related to seismicity are not anticipated.

**Impact GEO-FC1:** Fill material may be released to Foss Creek if not placed and managed properly during rehabilitation activities, leading to siltation at the site and downstream from the site. ***[Less Than Significant With Mitigation Measure GEO-FC1]***

**Mitigation GEO-FC1a:** Agency approved operations plans and BMPs for construction and the management of earthen materials shall be implemented during the rehabilitation activities. These BMPs shall include storm water control measures such as silt fences, contractor training for work in sensitive areas, and project controls to prevent the spill of excess soil from the embankment as it is being constructed.

**Mitigation GEO-FC1b:** Planning and construction activities shall be conducted in coordination with the appropriate permitting agencies, and adhere to permitting requirements.

Additional mitigation measures regarding potential impacts to biological and water resources are provided in Section 3.2: Biological Resources, and Section 3.11: Water Resources.

*Black Point Bridge*

Rehabilitation of the Black Point Bridge will not involve modification of foundations or other support structures that are anchored within geologic materials. Materials and equipment will be transported in by rail, and all repairs will occur out of the water. Impacts related to geologic or seismic hazards are not anticipated.

*Lombard Siding (MP 1.0 – MP 2.0)*

Construction of the siding from MP 1.0 to MP 2.0 will include grading, placement of track ballast and clean fill, placement of 5,300 feet of new track, extending a culvert, reestablishing drainage ditches, widening an existing timber deck bridge, the embankment, and constructing culverts. The Siding from MP 1.0 to MP 2.0 is located in open grasslands with commercial development occupying the adjacent properties on the south side.

**Impact GEO-LS1:** If not controlled, conducted in dry weather, or improperly engineered, grading operations and the resulting new siding may leave the site to be susceptible to erosion from surface runoff. ***[Less Than Significant With Mitigation Measure GEO-LS1a and GEO-LS1b]***

**Mitigation GEO-LS1a:** Agency approved operations plans and BMPs for construction and the management of earthen materials shall be implemented during the rehabilitation activities. These BMPs shall include storm water control measures such as silt fences, contractor training for work in sensitive areas, and project controls to prevent the spill of excess soil from the embankment as it is being constructed.

**Mitigation GEO-LS1b:** Planning and construction activities shall be conducted in coordination with the appropriate permitting agencies, and adhere to permitting requirements.

Additional mitigation measures regarding potential impacts to biological and water resources are provided in Section 3.2: Biological Resources, and Section 3.11: Water Resources.

*Novato Consent Decree (MP 35.5 – MP 18.7)*

Specific improvements at crossings vary depending on the type of crossing (public road vs. private or pedestrian), size of the street, and volume of traffic. They include construction of short mountable medians, 3-feet wide medians, quad gates, short pedestrian gates and swing gates, and signage. These improvements are relatively routine construction projects, and the resulting structures are not occupied by persons, nor are they likely to injure persons by failure during an earthquake. Therefore, impacts arising from geologic hazards are considered to be less than significant.

Operations

Impacts that may occur during the long-term operation of the railroad are identified below:

**Impact GEO-OP1:** Parts of the rail line are susceptible to erosion from surface runoff, particularly sloping areas adjacent to drainage swales, creeks and rivers that feed the Russian, Napa, and Petaluma Rivers.

The rail line is most susceptible to impacts where it is located against hill slopes and runoff flows to the tracks. If the rail embankment has not been graded properly or the drainage system (ditches and culverts) has not been properly engineered or maintained, water can pond and run off the slope, causing severe erosion.

Embankment fill slopes leading to bridge crossings are more susceptible to long-term erosion. Portions of the alignment in northern Marin County and southern Sonoma County cross marshlands, and are adjacent to creeks and bridge crossings. In general, these areas are stable; however, flooding caused by high storm runoff coupled with high tides can cause localized erosion and loss of fill beneath the rail bed.

Debris that accumulates against bridge piles in creeks may impede flow and dam the creek. This may cause water to rise to the level of the embankment, overtop, and severely erode the rail line.

In addition, portions of the proposed project may be subject to landslides and slope movement that could cause damage to the rail line and bridges.

The hill areas north of Cloverdale are susceptible to landslides and slope movement. These slopes are inherently unstable due to weak underlying materials, or due to over steepening or loading of existing stable slopes. Along the rail line, several areas have been identified with these conditions including the slopes immediately adjacent to tunnels along the line, which presently exhibit rockfalls and shallow slumping. ***[Less Than Significant with Mitigation Measure GEO-OP1]***

**Mitigation GEO-OP1:** Drainage ditches, culverts, embankments, and the entire rail line shall be regularly inspected and maintained and immediately after significant storms.

Inspections shall be performed in accordance with AREMA standards, FRA regulations, and agency-approved operation plans (described in Section 3.6, Hazardous Materials).

**Impact GEO-OP2:** The rail line and bridges are susceptible to significant ground shaking and liquefaction from earthquakes that could damage the line. In addition, the rail line could be damaged by displacement where active faults cross the line along the Lombard to Novato segment and in Bakers Creek (Figure 3.4-2). Potential impacts vary based on a number of factors including distance to the epicenter, magnitude of the earthquake, duration of ground shaking, nature of the underlying soils, and the construction of the structures. ***[Less Than Significant with Mitigation Measure GEO-OP2]***

**Mitigation GEO-OP2:** Operations shall be stopped and the rail line and bridges shall be immediately inspected after a significant earthquake. Inspections shall be performed in accordance with AREMA standards, FRA regulations, and the agency-approved operation plans (described in Section 3.6, Hazardous Materials).

**Impact GEO-OP3:** Fill material may be released to streams, creeks, and rivers if not placed and managed properly during repair of culverts or embankments that may be damaged during earthquakes or storms, leading to siltation at the site and downstream from the site. ***[Less Than Significant With Mitigation Measure GEO-OP3]***

**Mitigation GEO-OP3a:** Agency approved operations plans and BMPs for maintenance activities and the management of earthen materials shall be implemented during the rehabilitation activities. These BMPs shall include storm water control measured such as silt fences, contractor training for work in sensitive areas, and project controls to prevent the spill of excess soil from the embankment as it is being constructed.

**Mitigation GEO-OP3b:** Routine maintenance and repair activities shall be conducted in coordination with the appropriate permitting agencies, and adhere to permitting requirements.

Additional mitigation measures regarding potential impacts to biological and water resources are provided in Section 3.2: Biological Resources, and Section 3.11: Water Resources.

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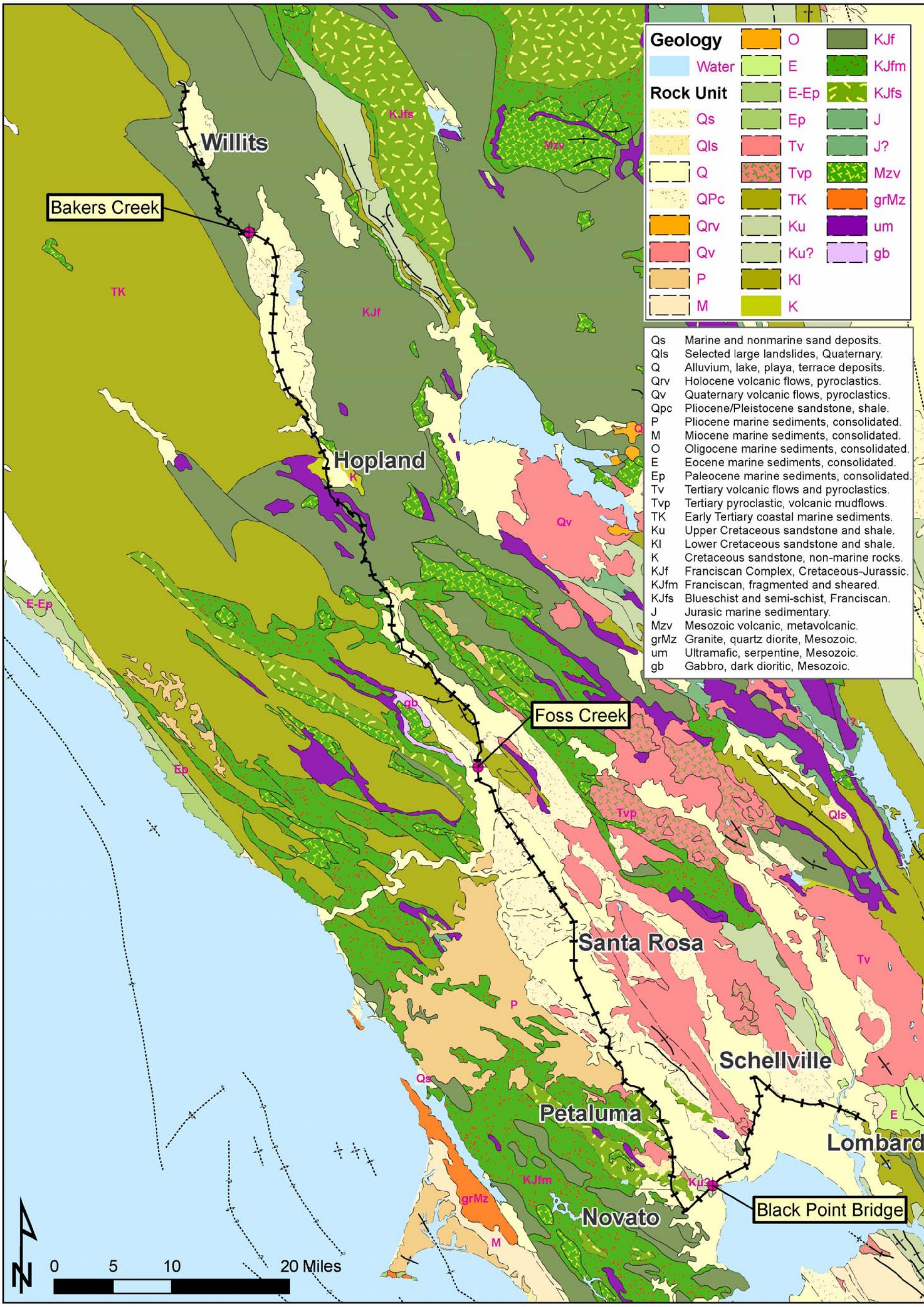


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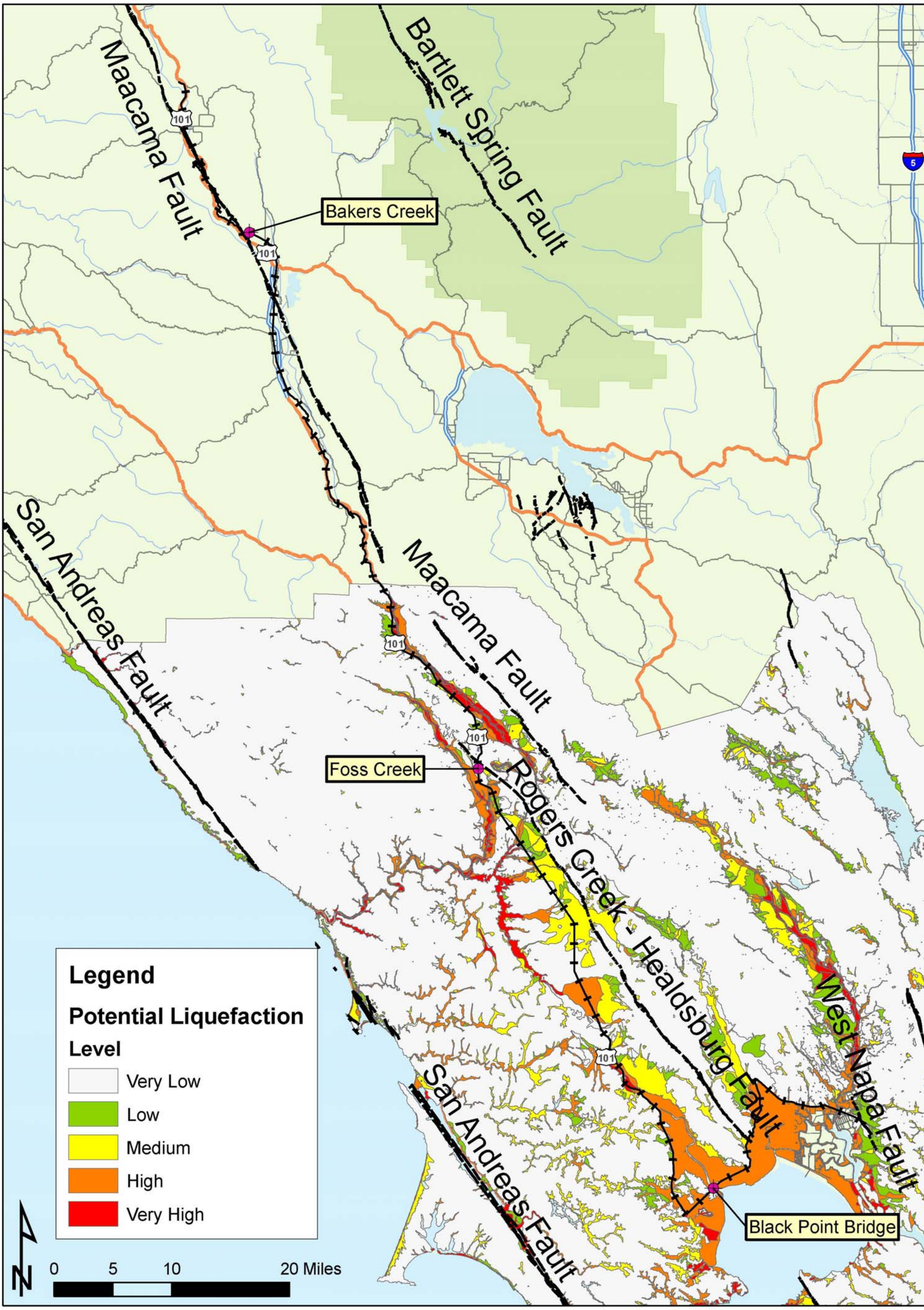
| FILE NAME: | Figure 3.4-1 |

**GEOLOGY OF THE PROPOSED PROJECT AREA**

NORTH COAST RAILROAD AUTHORITY
RUSSIAN RIVER DIVISON
FREIGHT RAIL PROJECT

**FIGURE**

**3.4-1**

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| PROJECT NO. 78207 | ACTIVE FAULTS AND POTENTIAL LIQUEFCATION | | FIGURE |
| DRAWN: 5/10/08 | | | 3.4-2 |
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| CHECKED BY: BE | NORTH COAST RAILROAD AUTHORITY RUSSIAN RIVER DIVISON FREIGHT RAIL PROJECT | | |
| FILE NAME: Figure 3.4-2 | | | |


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| KLEINFELDER Bright People. Right Solutions. www.kleinfelder.com | PROJECT NO. 78207 | LARGE HISTORIC EARTHQUAKES | FIGURE |
| | DRAWN: 5/10/08 | | 3.4-3 |
| | DRAWN BY: IPM | | |
| | CHECKED BY: BE | NORTH COAST RAILROAD AUTHORITY<br>RUSSIAN RIVER DIVISON<br>FREIGHT RAIL PROJECT | |
| | FILE NAME: Figure 3.4-3 | | |