# Geology and Soils

This section describes the local geology, soils, groundwater, and seismology in the Sunrise Project area. All of these factors affect the constructability of the project and how it might need to be specifically engineered, including methods to protect other features. Figure 51 and Figure 52 show the main local features of the geology and soils of the project area.

The Geology and Soils Technical Report provides details on the following:

- Methods.
- Regional and local geology, landslides, subsurface soils, surficial soils, groundwater, and seismic settings.
- Environmental consequences: stability of cut slopes and excavation, groundwater, shrink/swell and erodible soils fill embankments, liquefaction, borrow and disposal sites.
- Possible mitigation measures for each environmental consequence.

## Geology

The geology of the Sunrise Project area has base layers of two types of bedrock overlain by a variety of deposits, followed by surface soils. The two types of bedrock units—Boring Lavas and Sandy River Mudstone—have different characteristics that could affect construction of the Sunrise Project. Boring Lavas consist of hard basalt, volcanic sediments, and areas with boulders. Boring Lavas mostly underlie the highland areas immediately north of the alignment and from Mount Talbert to the slopes of Rock Creek. Sandy River Mudstone has a finer, softer texture and is exposed along the slopes of Rock Creek and the Clackamas River (see Figure 51). Bedrock is likely to be encountered in the eastern portion of the project corridor and during construction of deep foundations, particularly in areas where the alignment encroaches on the south-facing slopes flanking most of the corridor.

Both bedrock units are covered by near surface and surface deposits (called geologic units on Figure 51), such as constructed fill, alluvium (soils associated with the Clackamas River and its tributaries), landslide deposits, colluvium (produced by weathering of the Boring Lavas), and terrace deposits. The I-205 Interchange area to Rock Creek Junction contains the Boring Lavas, landslide soils, fills, alluvium, and colluvium. Most of the Sandy River Mudstone is exposed along the toe of the Eastern Landslide and in the slopes along Rock Creek. Construction of the alignment would mostly be in the surface soils but, as noted in the preceding paragraph, could reach into the bedrock as well.

**Alluvium** is soil or sediments deposited by a river or other running water.

**Colluvium** is sediment that has been deposited or built up at the bottom of a low grade slope or against a barrier on that slope, transported by gravity.

**Terrace deposit** is a geological term for a flat platform of land created alongside of a river or sea, where, at some time in the past, the river has cut itself a deeper channel.

## Soils

The near surface soils consist of clay, silt, sand, and gravel mixtures to depths of up to 20 feet, overlying gravel layers. Groundwater levels likely fluctuate in response to precipitation. The slopes north of the Sunrise Project alignment have shallow groundwater and groundwater springs or seeps. The groundwater depth is generally shallower in the I-205 Interchange and Midpoint areas than in the Rock Creek Junction area. Wetland areas have even shallower groundwater (see the previous Wetlands Section).

Soils are shown on Figure 52. Most of the surface soils are described as moderately to severely wet and subject to erosion. In addition, they have a high "plasticity," which means they have a tendency to shrink and swell and can present problems when used to support heavy structures. The area north of Camp Withycombe and east of the Union Pacific Railroad tracks is covered by Cove silty clay loam soils, a soil type susceptible to shrinking and swelling as its moisture content changes. The fluctuation in volume usually occurs unevenly and can be large enough to damage structures and pavements resting on or embedded in the soil.

Two landslides have been mapped in the Midpoint area. One landslide (referred to as the Camp Withycombe Landslide) is in the northeastern portion of Camp Withycombe. The other landslide (referred to as the Eastern Landslide) is located approximately between SE 115th Avenue and SE 119th Avenue. The approximate locations of the two landslides are illustrated on Figure 51.

There is evidence of recent landslide activity near the southeastern corner of the Camp Withycombe Landslide, but no documented evidence of instability at the Eastern Landslide at this time. Construction activities that encroach on the landslide areas could trigger further movement of the landslides.

The general constraints of the underlying geology and soils of the Sunrise Project area apply to the Sunrise Project under all the alternatives. The more construction and excavation needed, the greater the chances of encountering geotechnical issues. Generally, the problems can be engineered to compensate for the constraints (see the Mitigation Measures for the **Preferred Alternative** section), but each engineering solution has different risks and costs associated with it.

Because the road improvements under **Alternative 1–No Build** would involve so little ground disturbance compared to building the Sunrise Project, **Alternative 1** would have little to no impacts. The main difference between **Alternatives 2** and **3** is the degree and location of excavation that would be required for the midpoint interchange. Grading and earthwork present a potential risk of instability where local slopes are composed of soft and weak colluvium soils (mostly in the Midpoint area). The interchange at SE 122nd Avenue under **Alternative 2** would require grading that includes cuts of up to 40 feet high into the Eastern Landslide, and local slopes that could require slope stabilization. Cuts of the magnitude likely to be required by the project would have substantial impacts on the stability of the slopes. Cuts into the toes of the landslides could reactivate them. **Alternative 3** would have less impact on the stability of the slopes compared to **Alternative 2**. In addition, **Alternative 3** may not require temporary shoring and retaining structures to sustain the cut slopes.

Up to 50 feet of fill could be needed for the Sunrise Project at various points. The fill and the embankments at the bridge approaches would cause settlement of several inches in some of the finer-grained soils. Appropriately designed embankment slopes should be relatively stable, but the estimate of the total amount of fill needed could increase as a result of the settlement. In addition, the settling could negatively affect adjacent structures and utilities. Structures and utilities sensitive to settlement near the fill embankments could require site-specific geotechnical investigations to protect them from potential impacts.

Earthwork for construction could encounter cobbles, boulders, and hard intact Boring Lavas basalt. Particularly in the Rock Creek Junction area, construction of the entrance and exit ramps would require excavating to a depth of 40 to 60 feet. That depth of cut could reach to the Boring Lavas, entailing excavation of rock, gravel, cobbles, and boulders. On the other hand, the Boring Lavas could sustain near vertical cuts in the slopes.

Because of the shallow groundwater within the upper 10 to 30 feet in the Rock Creek Junction area, removing water from the soil may be necessary for construction. The dewatering could have several effects, including settling of adjacent structures, drying adjacent wetlands, and lowering groundwater levels in wells.

There appear to be no particular geotechnical advantages to selecting **Design Options A-2, C-2,** or **D-2** over **Alternatives 2** and **3**.

**Design Option B-2** would have impacts similar to **Alternative 3** and less impact than **Alternative 2**. Although cuts into the Eastern Landslide and local slope areas would be required, the cuts would be less deep, thereby reducing potential impacts on the stability of the slopes.

**Design Option C-3** would require deeper cuts into the slopes north of this area than **Design Option C-2** would. East of SE 135th Avenue, **Design Option**

**C-3** would result in a permanent cut slope that extends to the top of the hillside, likely cutting through terrace deposits, colluvium, and Boring Lavas. The basalt can sustain the degree of the slope, but the colluvium could be more unstable during excavation. Groundwater seeps and shallow groundwater are likely to be encountered during construction of the cut slope, which would most likely require groundwater drainage control. While most slopes along this more northerly alignment generally appear to be stable, there is a groundwater spring and seeps are present just west of SE 142nd Avenue.

**Design Option D-3** has a slight advantage related to the westbound exit ramps at Rock Creek Junction. **Design Option D-2** and the design for **Alternatives 2** and **3** place the westbound exit ramp deeper into the basalt knoll, whereas the more southerly alignment of the westbound exit ramp for **Design Option D-3** would probably require less excavation in the knoll.

## Preferred Alternative

Similar to **Alternative 2**, the **Preferred Alternative** impacts include slope instability due to excavation and benching into landslide and slopes; excavation of rock; excavation and handling of boulders; soft and wet soils in wetlands and shallow groundwater areas; springs/seeps on slopes; shrink/swell soils; erodible soils; settlement of foundation soils due to fill embankments; and localized, seismically induced liquefaction. It is estimated that the project would require excavation of about 1.97 million cubic yards and fill of about 3.82 million cubic yards of material.

The Tolbert overcrossing portion of the **Preferred Alternative** will have soils and geology impact issues substantially the same as those described for **Alternative 2** in the I-205 Interchange area. The **Preferred Alternative** in the Midpoint and Rock Creek Junction areas would have fewer impacts through those areas than the other options. Figure PA-47 is the geologic map and Figure PA-48 is the soils map for the **Preferred Alternative**.

Groundwater conditions in the new areas of the **Preferred Alternative** are not likely to vary significantly from those described for the other build alternatives. For example, construction groundwater control (dewatering) may be required because of the potential presence of shallow groundwater within the upper 10 to 30 feet in the Rock Creek Junction area. Construction dewatering has potential adverse impacts, including settlement of adjacent structures and drying of adjacent wetlands. In addition, the use of a dewatering system could reduce the production of existing groundwater wells in the vicinity.

The slope gradient for the cut slopes in this segment would be varied, depending on soil types, depth to bedrock if present, bedrock strengths and jointing, and depth to groundwater.

Several areas of the **Preferred Alternative** were not part of the evaluation of **Alternative 2** and were added as part of the **Preferred Alternative**. In the I-205 Interchange area, the **Preferred Alternative** includes the construction or modification of three bridges including: (1) North Lawnfield Extension, (2) a railroad overcrossing at SE Tolbert Street connecting to the extension of SE Industrial Way, and (3) a lane widening of the existing bridge crossing the railroad at OR 212/224 (east of SE 82nd Avenue). As a result, a feasibility evaluation of those areas was conducted in 2009. Construction of the three bridges is feasible using conventional foundations which may include spread footings, piles, or drilled shafts. Geotechnical investigations and design evaluations during the final design phase will determine the most appropriate foundations for the bridges.

The two areas where impacts from the **Preferred Alternative** will be greatest are within the Midpoint area. Camp Withycombe and the Eastern Landslide, and steep slopes are between the Eastern Landslide and SE 135th Avenue. The other area of concern is where erosion of the north bank has occurred in the Clackamas River near Rock Creek. The results of the feasibility evaluations conducted in 2009 are presented below.

### Camp Withycombe and Eastern Landslides and steep slope between the Eastern Landslide and SE 135th Avenue

The toe of the slope below the two older mapped landslides is adjacent to the shoulder of the westbound lane of the **Preferred Alternative** and associated on- and off-ramps at the intersection with SE 122nd Avenue. Both landslides are potentially active and pose a risk to the corridor segment along the toe of the slopes in that area. The hillside area above the landslides contains private residences and roadways.

The **Preferred Alternative** includes exit and entrance ramps associated with the overpass at the north end of the extension of SE 122nd Avenue. The grading associated with the ramps would result in cuts of up to 50 feet along the toe of the existing steeper slopes and the toe of the Eastern Landslide.

### Erosion of the north bank of the Clackamas River

There is a tight incision meander of the Clackamas River just south of the existing highway and the **Preferred Alternative**, east of SE 142nd Avenue. Erosion of the northern riverbank is occurring along the incision meander. During site reconnaissance in June 2009, the bank was approximately 65 feet high with a near-vertical slope. Soils exposed in the riverbank consist predominantly of lightly cemented gravels with variable amounts of silt, clay, and sand. Although these sediments are capable of supporting a near-vertical exposure, the soils are typically poorly consolidated and subject to failure. Historic riverbank failures have occurred in this area, such as along the eastern side of the manufactured home park, and may encroach on the corridor in the future.

ODOT does not anticipate the need for the Sunrise Project to be set back from the river in that location. Engineering solutions are available to minimize erosion and avoid a setback.

### North Lawnfield Extension bridge

The proposed bridge will be constructed at the northern end of the project to accommodate the extension of SE Lawnfield Road. Final design details for the bridge, such as length, width, number of spans, and type, are not available at this time. In general, the proposed bridge will be located on a westerly-descending slope in an area currently occupied by residential and light commercial development. Subsurface conditions in the area of the bridge would not be investigated until final design of the bridge and its foundations has been completed.

The hillside is likely to be underlain by volcanic rocks and/or sediments of the Boring Lava Formation at depth. The nature and strength of the Boring Lava in the area is highly variable. It varies from deeply weathered volcanic rock that has decomposed to residual soil to hard basalt. Difficult excavation should be anticipated in this unit; local areas of weathered Boring Lava contain hard boulders of volcanic rock that can exceed 10 feet in diameter. The thickness of the flows, based on regional well logs, indicates that individual flows within the Boring Lavas are estimated to range from 100 to 200 feet thick.

No readily apparent indications of slope instability, areas of accelerated erosion, or poor drainage were observed along the slopes in the general vicinity of the proposed bridge location. However, landslides are present on the hillsides east of the bridge site. The largest of these landslides is the aforementioned landslide located east-northeasterly of Camp Withycombe, and it is suspected to be active based on topographic features (e.g., hummock topography and ponded depressions) and tilted trees.

## Earthquakes

Crustal earthquakes (generally within depths of ten miles below the surface) are the most common source of earthquakes in the Portland region. Some of the shallow earthquake faults could be active in the Portland-Vancouver area. Three significant faults within 25 miles of the project area are believed to have undergone movement within the

last 15,000 years. The closest of the three faults is the East Bank Fault (6 miles northwest), followed by the Canby-Molalla Fault (8 miles west). The Mount Angel Fault is approximately 24 miles southwest.

ODOT has seismic design standards for bridges and overpasses.

Liquefaction describes the behavior of loose saturated sands, which go from a solid state to the consistency of a heavy liquid, or reach a liquefied state.

Earthquakes can cause liquefaction of loose, saturated soils that then lose their strength to support structures. Liquefaction would cause footings to lose their capacity to support the overhead structures, embankments to settle and spread laterally, and slopes to lose stability, and it would generally adversely affect any supporting structures in those soils.

A combination of loose sand and low plasticity silt combined with shallow groundwater—susceptible to liquefaction during earthquakes—is present locally throughout the Sunrise Project area (see Figure 53, Fault Location Map). This condition is difficult to associate with specific alternatives or design options; therefore, the risks specific to each alternative and design option including the **Preferred Alternative** are unknown at this time.

## Indirect Effects

The volume of excavation and fill and construction operations would result in a significant increase in truck traffic due to hauling of fill materials to and from the project site. This would likely result in congestion on local streets, pavement damage, noise and air pollution, and aggregate fill extraction (borrow pits).

Construction in areas of shallow groundwater could require drying or dewatering them, which could lower adjacent groundwater levels, thus causing settling of adjacent structures, drying of adjacent wetlands, and increased risk of contamination migrating under the surface.

## Mitigation Measures for the Preferred Alternative

Based on ODOT standard practices, the proposed roadway cuts required for the project would be technically feasible with proposed mitigation measures listed below.

### Stability of Cut Slopes and Excavation

In the vicinity of landslides and slopes, mitigation will consist (if feasible) of avoiding impacting the toe of the existing slopes at the Camp Withycombe and Eastern landslides and local slopes located between Camp Withycombe and SE 135th Avenue. Minimizing the impact to the slopes could include avoiding cuts and adjusting the roadway elevations. However, other geotechnical measures could also be used to support the slopes and accommodate grading. These measures could include placing denser fill along the toe of the slope (buttress fill) and/or use of retaining structures such as soldier pile and tieback and secant pile retaining walls. Multiple retaining walls could be benched into the slope to reduce the height of a single wall.

Additional geotechnical exploration, analysis, and monitoring of both landslide areas should be conducted during final design to evaluate which mitigation measures are appropriate to support the slopes.

Also, if grading along the slopes cannot be avoided, slope drainage (dewatering) and excavation (cut) should be done in short segments, and temporary and permanent retaining structures, or rock buttresses, installed. Dewatering could be required as a temporary measure during construction for deeper excavations to accommodate excavation for structures or utilities. Dewatering may also be permanent where the natural drainage paths are blocked by the addition of embankment fill. The details of any permanent drainage improvements or modifications will occur during final design with input from the civil engineer. Existing groundwater production wells should be taken into account in the design and construction of any dewatering systems that might be needed.

Limits on construction could include restricting the length, height, and duration of open excavations adjacent to steep slopes and mapped landslides, and could require that construction be completed only during dry conditions.

Because of the critical nature of construction in these areas, additional measures to consider could include drainage improvements to prevent the accumulation of water in excavations, limits on construction traffic to reduce unnecessary ground vibration, and full-time observation by a geotechnical engineer or engineering geologist during construction.

In addition, monitoring of both landslides is recommended to be completed before and during construction and on a long-term basis after construction to evaluate potential impacts to the existing slopes and new roads. Slope inclinometers, tiltmeters, and survey points could be used to monitor the landslides.

Because of the height of the exposed near-vertical slope, the risk to the proposed alignment near the incision meander of the north bank of the Clackamas River will require evaluation during final design. This will include slope stability analyses and evaluation of engineering alternatives to reduce the impacts of long-term erosion. Such solutions may include retaining walls and/or soil improvement.

### Embankment Fill and Sediment

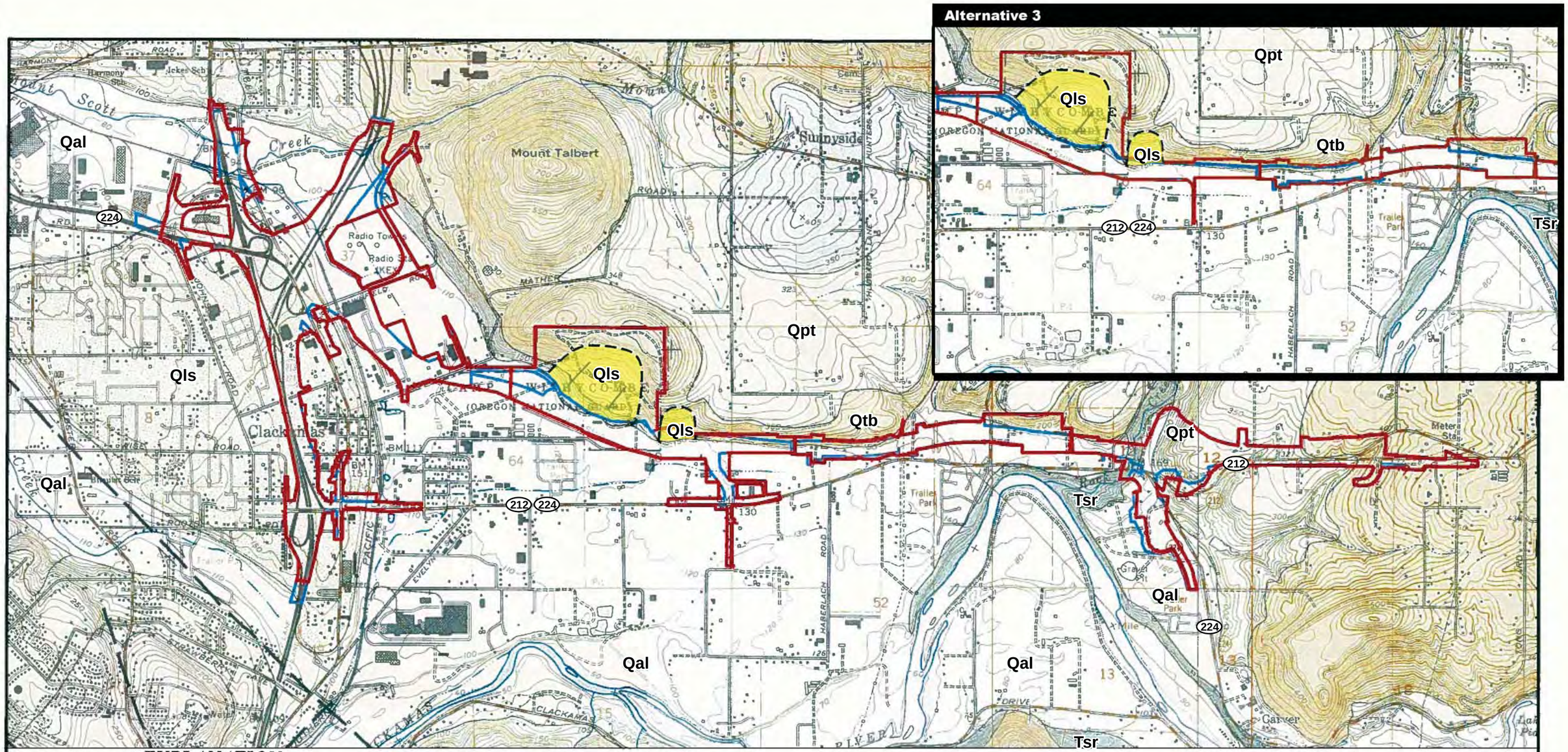
A site-specific geotechnical investigation will be performed to estimate the potential damage and required mitigation resulting from embankment dead loads. Soft, compressible soils should be replaced and ground/soil improvement made with either deep soil mixing or installation of displacement piles or reamed aggregate piers.

### Seismically-Induced Liquefaction

Liquefaction settlement, where present, will be mitigated under embankment fills with ground improvement methods such as installation of rammed stone piers, stone columns, and removal and replacement of soft and potentially liquefiable soils. Bridge foundations will be supported on pile foundations bearing on dense gravels that are present beneath potentially liquefiable deposits, as appropriate.

### Erodible Soils

Erosion will be mitigated during construction by planning earthwork operations to limit the duration and exposure of erodible soils, using erosion and sediment control devices during earthwork construction, and directing surface water off-site through the existing storm system or suitable, erosion-protected discharge following the ODOT's Standard Specifications, Section 280, and Clackamas County erosion protections/control requirements.




## EXPLANATION

### GEOLOGIC UNITS

- Qal / pt — Quaternary Alluvium
- Qls — Quaternary Landslide
- Qpt — Pleistocene Terrace Deposits
- Qpg — Pliocene-Pleistocene Gravels
- Qtb / wx — Boring Lavas
- Tsr — Sandy River Mudstone

### GEOLOGIC SYMBOLS

- Contacts
- Faults
- Normal fault *(ball and bar on downthrown side)*
- Inferred fault
- syncline *(showing plunge of axis)*
- Lineament
- Proposed Right-of-Way Line
- Construction Impact Line

N

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

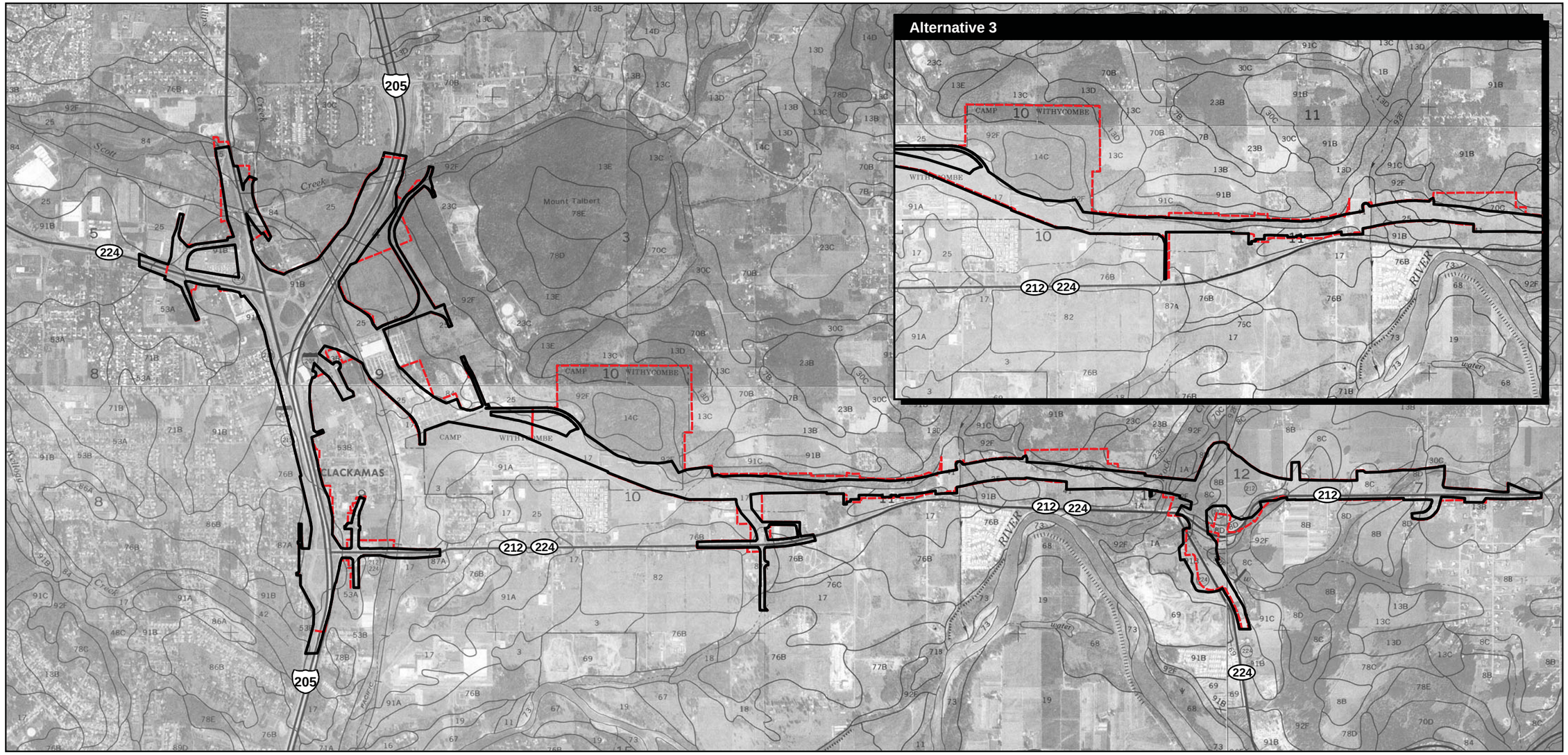
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

Reference (from Schlicker and Finlayson, 1979)

**Figure 51**

*Geologic Map, Alternatives 2 and 3*

Sunrise Project, I-205 to Rock Creek Junction




| | |
|---|---|
| 1A | Aloha silt loam, 0 to 3 percent slopes |
| 8B | Bornstedt silt loam, 0 to 8 percent slopes |
| 8C | Bornstedt silt loam, 8 to 15 percent slopes |
| 8D | Bornstedt silt loam, 15 to 30 percent slopes |
| 13B | Cascade silt loam, 3 to 8 percent slopes |
| 13C | Cascade silt loam, 8 to 15 percent slopes |
| 13D | Cascade silt loam, 15 to 30 percent slopes |
| 14C | Cascade silt loam, stony substratum, 3 to 15 percent slopes |
| 17 | Clackamas silt loam |
| 23C | Cornelius silt loam, 8 to 15 percent slopes |
| 25 | Cove silt clay loam |
| 30C | Delena silt loam, 3 to 12 percent slopes |
| 41 | Huberly silt loam |
| 53A | Latourell loam, 0 to 3 percent slopes |
| 53B | Latourell loam, 3 to 8 percent slopes |
| 70C | Powell silt loam, 8 to 15 percent slopes |
| 71B | Quatama loam, 3 to 8 percent slopes |
| 76B | Salem silt loam, 0 to 7 percent slopes |
| 84 | Wapato silty clay loam |
| 87A | Willamette silt loam, gravelly substratum, 0 to 3 percent slopes |
| 91A | Woodburn silt loam, 0 to 3 percent slopes |
| 91B | Woodburn silt loam, 3 to 8 percent slopes |
| 91C | Woodburn silt loam, 8 to 15 percent slopes |
| 92F | Xerochrepts and Haploxerolls, very steep |

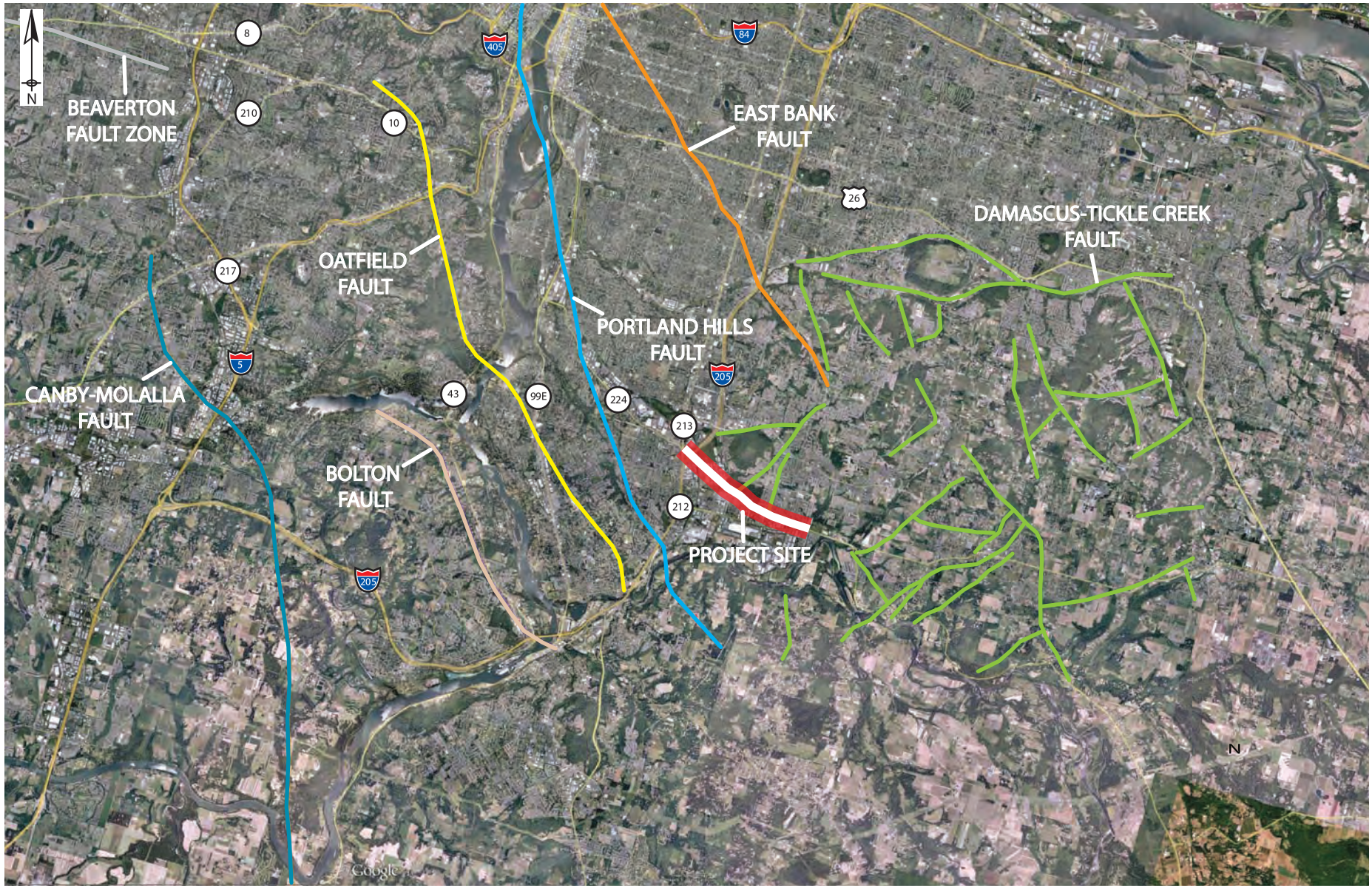
N

0 — 0.86 mi.

**Figure 52**

*Surface Soils Map, Alternatives 2 and 3*

Sunrise Project, I-205 to Rock Creek Junction




**Sources:**
Kleinfelder, 2010
http://earthquake.usgs.gov/hazards/qfaults/or/van.html

* Fault locations are approximate

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No Scale

**Figure 53**

*Fault Location Map*

Sunrise Project, I-205 to Rock Creek Junction

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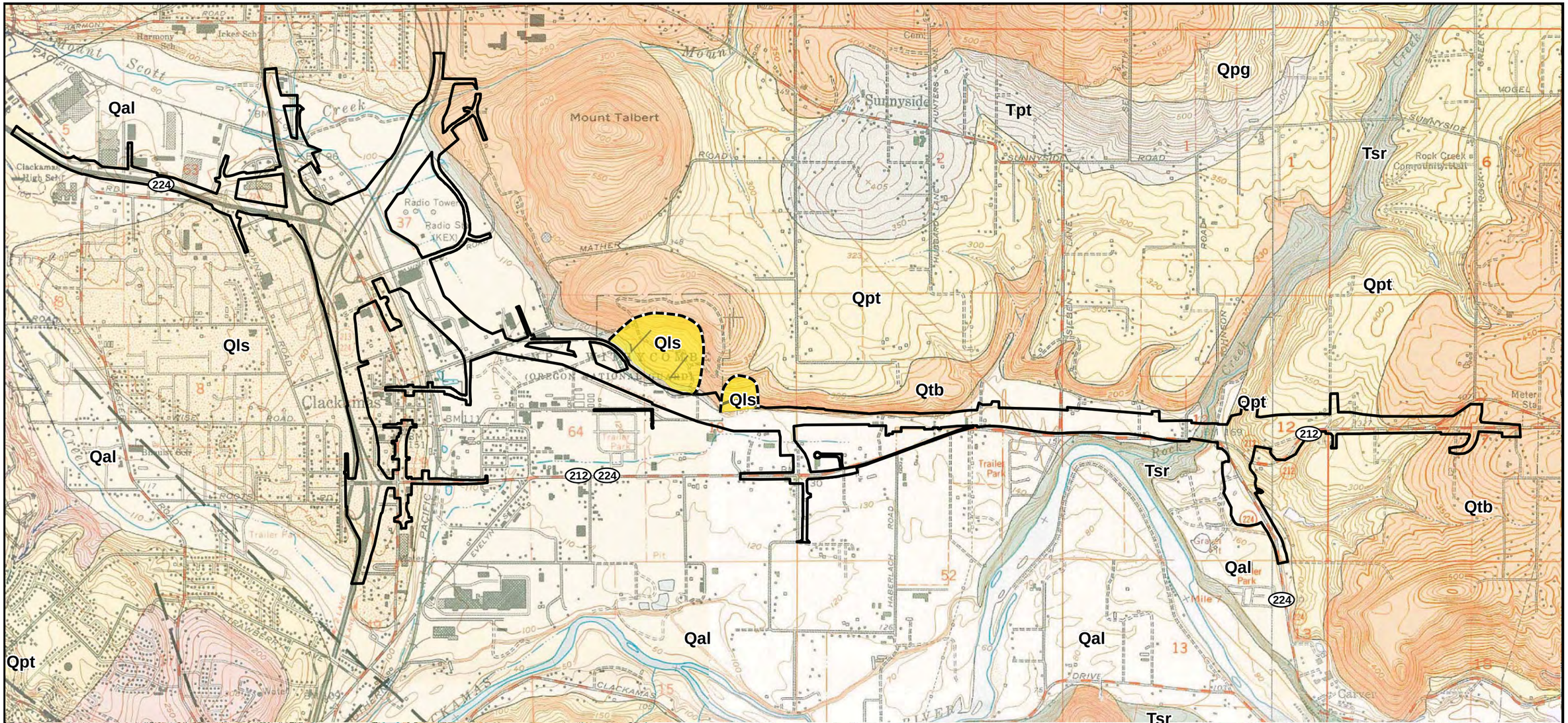


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CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

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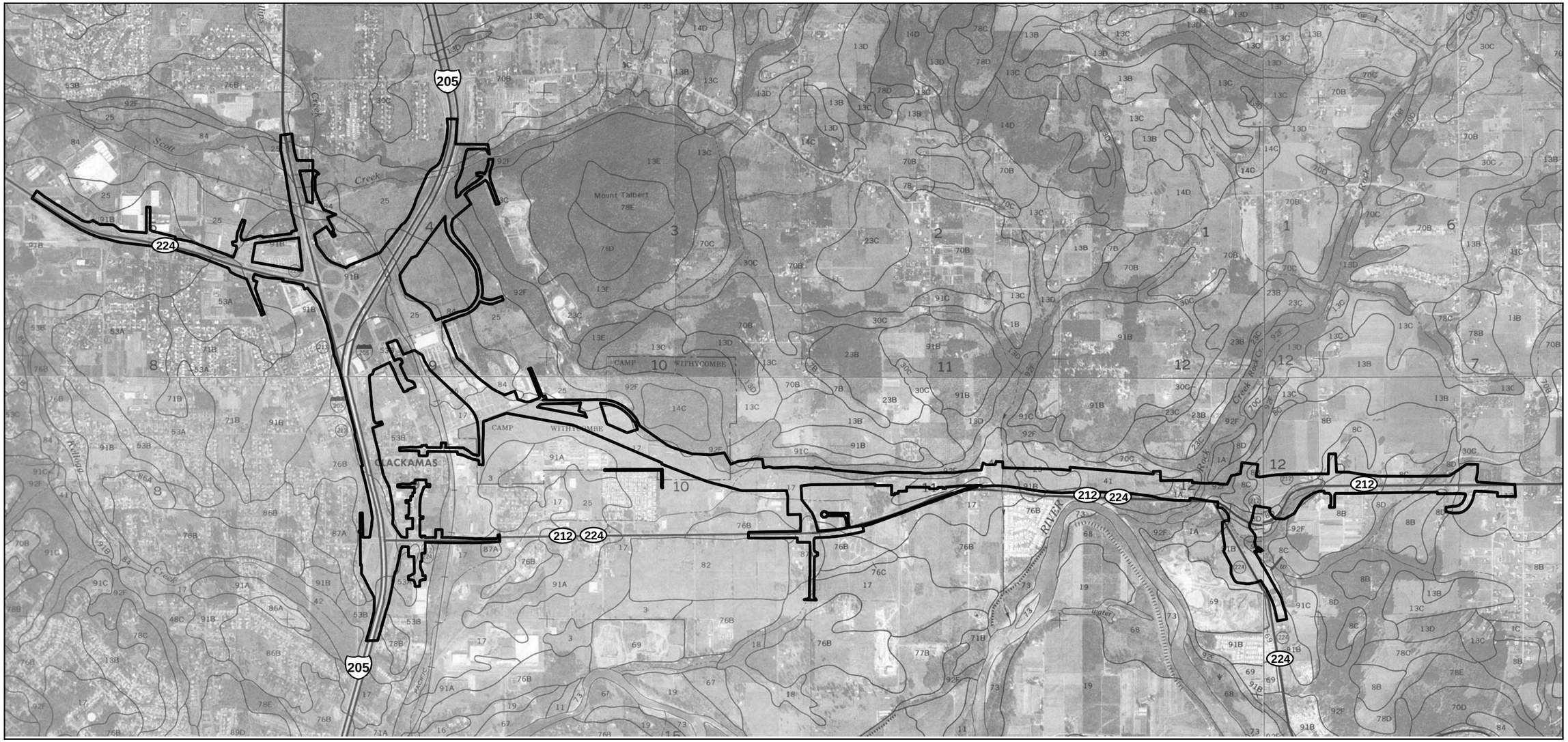
Reference (from Schlicker and Finlayson, 1979)

**Figure PA-47**

*Geologic Map*

Sunrise Project, I-205 to Rock Creek Junction

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N

0 — 0.86 mi.

**Figure PA-48**

*Surface Soils Map*

Sunrise Project, I-205 to Rock Creek Junction