GEOLOGY TECHNICAL REPORT

I-5: Fern Valley Interchange

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LIST OF ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
FHWA	Federal Highway Administration
IBC	International Building Code
NRCS	National Resource Conservation Survey
ODOT	Oregon Department of Transportation
OSSC	Oregon Structural Specialty Code
USGS	United States Geological Survey
WRD	Water Resources Department

EXECUTIVE SUMMARY

The following provides a summary of the key elements of the Geology Technical Report for the Fern Valley Interchange project.

METHODOLOGY

The purpose of this report is to present the findings of the literature review of the local and regional soil survey, well logs, geologic maps, existing Oregon Department of Transportation (ODOT) subsurface information, and site reconnaissance in the vicinity of the proposed interchange alternatives. The information collected in the literature review and site reconnaissance has been used to develop the analysis and recommendations contained in this report.

EXISTING CONDITIONS

The project site is relatively flat, with slopes to the east. A relatively small amount of the natural landscape exists in the vicinity of the site. The existing roadway embankment fill at the site consists mainly of sandy gravel to gravelly sand. Alluvial soils east of I-5 consist mainly of gravelly to clayey sand with some silt. West of I-5, alluvial soils consist of mainly sand, sandy silt, and silty sand with some gravel.

The existing Bear Creek Bridge and the Fern Valley Interchange overpass structure do not meet the current seismic code.

Slope stability hazards common to the Pacific Northwest include rock fall, rotational-translational slides, earthflows, debris slides, and debris flows. Topographic relief in the project area is relatively flat with the exception of the banks of Bear Creek and the northern portion of the proposed N. Phoenix Road realignment (the same for both alternatives). The banks of Bear Creek, cut slopes along the northern N. Phoenix Road realignment, and fill slopes associated with roadway construction are the only areas of the project with enough topographic relief for slope instability to be a consideration.

SUMMARY OF IMPACTS

The Fern Valley Thru Alternative would require approximately 20 acres of land that is not currently developed. In comparison, the N. Phoenix Thru Alternative would require about 17 acres of undeveloped land. Some portions of the proposed construction would traverse areas that could potentially be used as sources of aggregate or for agricultural uses, or may contain paleontological resources (fossil locations). Construction of the project may reduce the potential for these other uses.

With either build alternative, the Bear Creek Bridge and the I-5 interchange structure would be constructed to current seismic standards.

Anticipated soil and rock conditions in the project area are not considered highly susceptible to slope instability at the temporary or finished slope configurations that would result from construction of the project. To assure adequate stability of the project elements on or near slopes, stability analyses of cut slopes, bridge embankment fills, and natural slopes would be performed during final design of the project.

The proposed cuts and fills required for the build alternatives could potentially create temporary slope instability during construction of road cuts and retaining walls. Additionally, permanent cut and fill slopes may be susceptible to erosion. Temporary and permanent slopes would be designed to minimize the likelihood of instability or susceptibility to erosive forces. Stability analyses would be conducted for all cut slopes, embankment fills, and walls during final design. Based on existing subsurface information and site reconnaissance performed in support of this report, the project can be designed and constructed without detrimental effects on slope stability along the proposed alignments.

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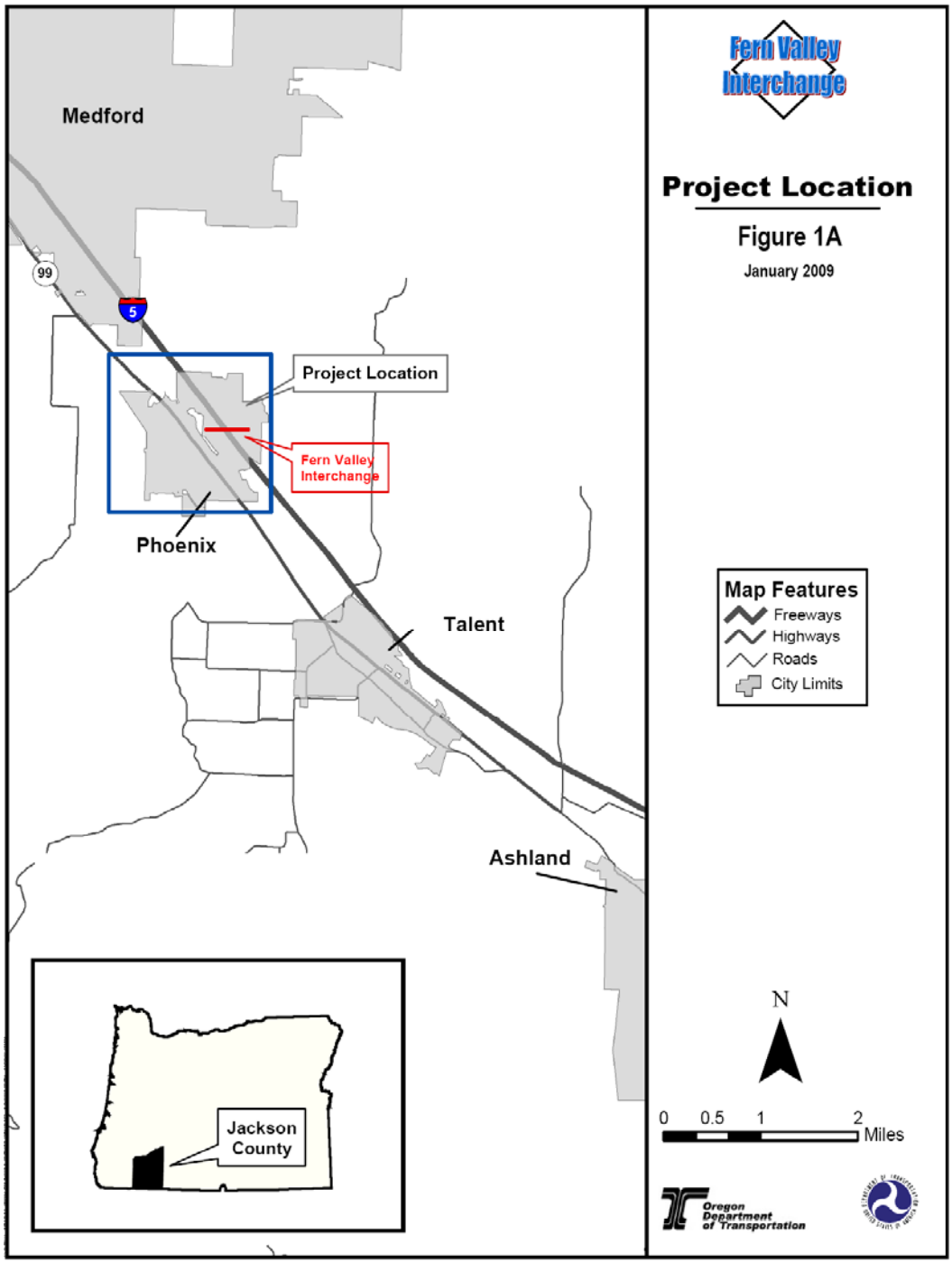
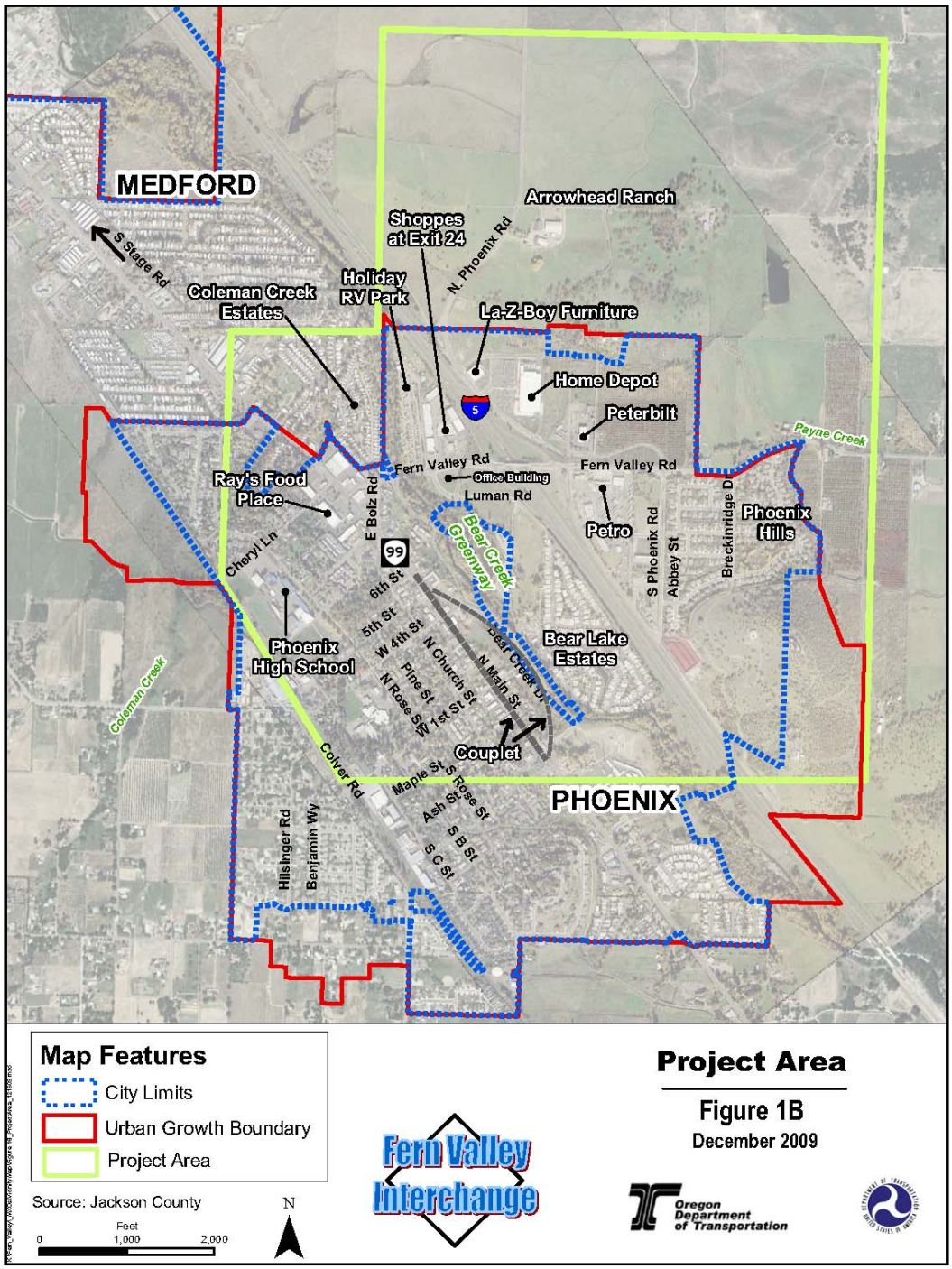
1. INTRODUCTION

The Geology Technical Report has been prepared to support the Environmental Assessment (EA) for the proposed Fern Valley Interchange project, located along I-5 in southwest Oregon (shown in Figures 1A and 1B).





Most of the project is located within the Phoenix city limits and urban growth boundary (UGB), and extends from OR 99[1] (in Phoenix) west of the interchange to the Phoenix UGB and to Arrowhead Ranch (north of the UGB) east of the interchange. The project area west of the interchange is primarily a developed urban area, except for the Bear

[1] OR 99 is also known as Highway 99, and also as Main Street (including the southbound portion of the couplet) through the City of Phoenix.

Creek Greenway (a narrow corridor of publicly-owned land along Bear Creek) and partially developed land in the southwest interchange quadrant. The project area northeast of the interchange is primarily located in an area that has been experiencing increased commercial development. The southeast interchange quadrant contains commercial development and the Phoenix Hills neighborhood.

The purpose of this technical report is to provide an assessment of the potential geological impacts associated with this project. This impact analysis has been conducted pursuant to the requirements of the National Environmental Policy Act; the Council of Environmental Quality; and the Federal Highway Administration (FHWA).

1.1 PURPOSE OF AND NEED FOR THE PROPOSED ACTION

The following provides an overview of the purpose and need for the Fern Valley Interchange project. A detailed description of the purpose and need is provided in the EA published for this project.

The purpose of the proposed action is to reduce congestion and improve operational conditions at the Interstate 5 (I-5) interchange with Fern Valley Road, on Fern Valley Road within the City of Phoenix UGB, and on OR 99 near its intersection with Fern Valley Road. The need for the proposed action includes the following:

- The Fern Valley Interchange is experiencing increasing congestion, which has caused vehicles to queue on the off-ramps during commute times. By 2030, these queues will spill back onto I-5, increasing the risk of high-speed, rear end collisions. The capacity of the interchange is degrading rapidly, and traffic safety remains an ongoing concern. Future traffic problems will worsen these conditions.
- The Fern Valley Interchange does not meet current interchange design standards—the approaches to the overcrossing are steep and limit traffic visibility; and the length of the I-5 ramps and acceleration lanes are substandard, which results in short stopping and acceleration distances.
- Fern Valley Road and OR 99 have substandard shoulders, do not have dedicated bicycle lanes, and sidewalks are discontinuous; these conditions create safety concerns for bicyclists and pedestrians.
- Fern Valley Road crosses Bear Creek between I-5 and OR 99. This narrow bridge creates a bottleneck on Fern Valley Road. In addition, the bridge is in poor condition;[2] the bridge is now limited to loads less than 80,000 pounds.
- The OR 99/Fern Valley Road intersection is substandard--the western leg of the intersection is a retail business parking lot rather than another roadway. There are numerous driveways close to the intersection creating safety issues.

[2] Bridge inspection (in July 2007) resulted in a bridge sufficiency rating of 6 out of 100, with 100 being the best rating possible.

2. DESCRIPTION OF THE ALTERNATIVES

Three alternatives are evaluated in this technical report: a No-Build Alternative and two build alternatives. The proposed build alternative descriptions are based on preliminary design only. Projects normally have design changes during the final design phase—after the environmental process is complete but prior to construction. A full description of the project alternatives and more detailed graphics are provided in the EA.

Addendum: Subsequent to completion of this technical report, the Fern Valley Thru Alternative was dismissed from consideration based on land use goal exception requirements. The N. Phoenix Thru Alternative was advanced as the Build Alternative into the EA.

Additionally, further design of the Bear Creek Bridge was completed subsequent to the completion of this technical report, but prior to the publication of the Environmental Assessment. The design information discussed in the EA does not change the conclusions reached in this technical report.

2.1 NO-BUILD ALTERNATIVE

The No-Build Alternative is evaluated and documented to provide a basis for comparison with the build alternatives. The No-Build Alternative means the proposed project would not be built. Routine maintenance would continue and short-term minor safety improvement activities would occur. If the No-Build Alternative is selected, the following planned projects and developments in the project area are still likely to occur in the next 20 years:

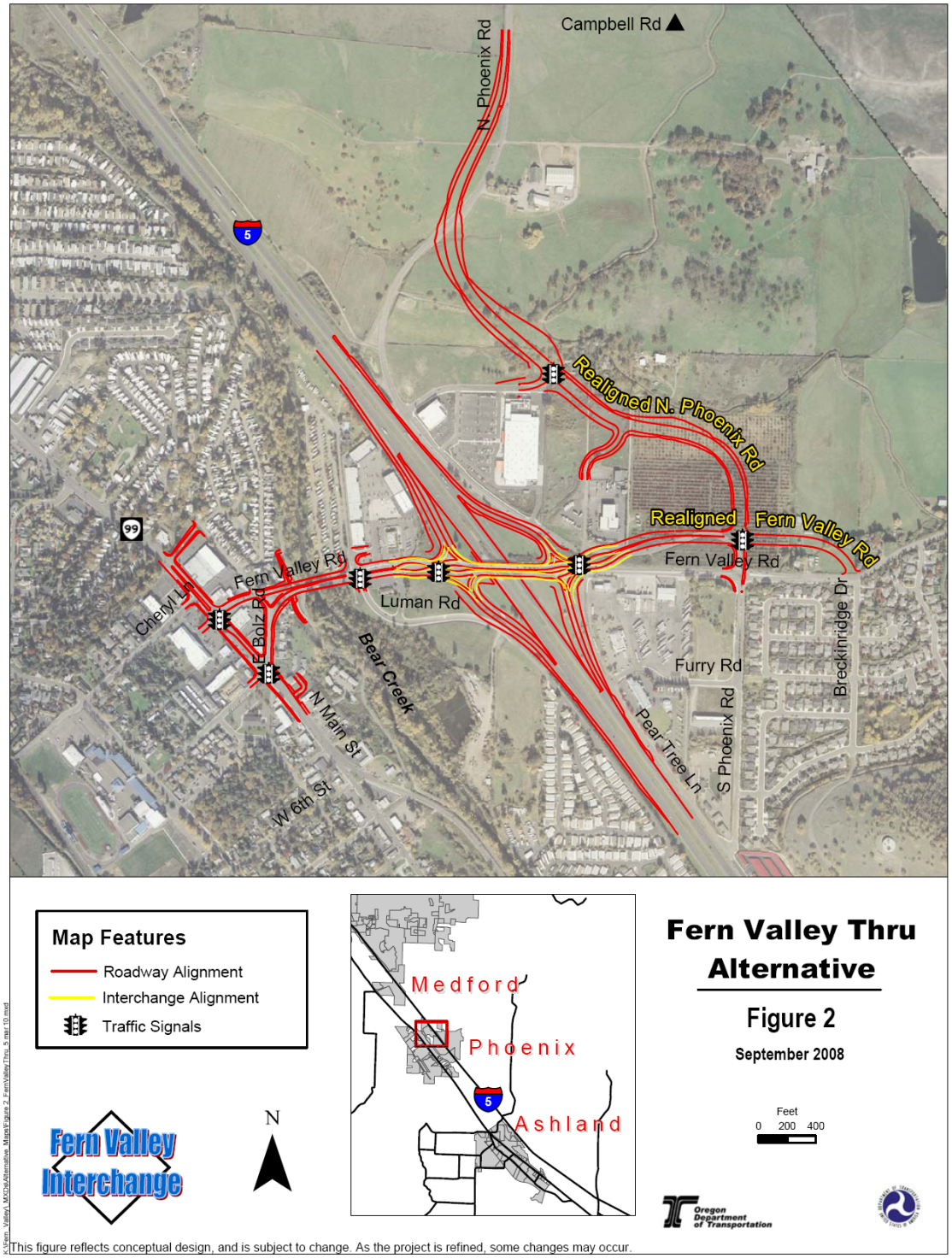
- Providing bike lanes and sidewalks on 1st Street (Rose Street to OR 99 southbound), on 4th Street (Rose Street to Colver Road), on Bolz Road (OR 99 to Fern Valley Road), and on Colver Road (1st Street to the Phoenix southern UGB);
- Providing bike lanes on 4th Street (OR 99 southbound to OR 99 northbound), and on Rose Street (1st Street to 5th Street); and
- Constructing new streets with bike lanes and sidewalks on 3rd Street (existing terminus to OR 99 northbound) and Parking Street (OR 99 northbound to 3rd Street).

2.2 BUILD ALTERNATIVES

Two build alternatives are evaluated in this report: the Fern Valley Thru Alternative and the N. Phoenix Thru Alternative. Both build alternative alignments are almost the same west of I-5, but are very different east of I-5. The following summarizes the build alternatives.

2.2.1 Fern Valley Thru Alternative

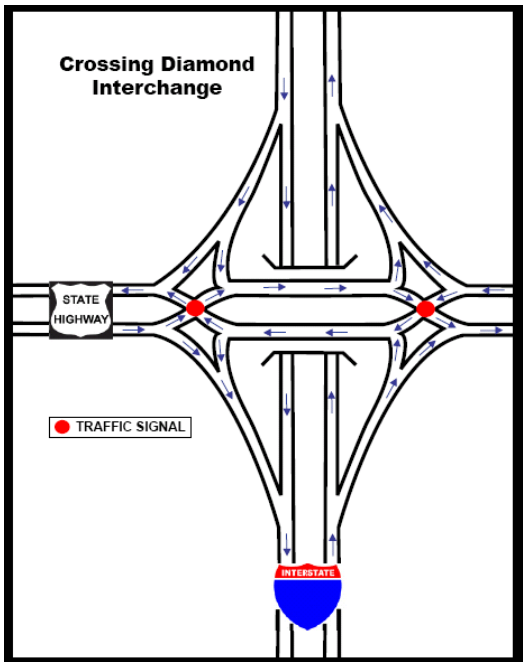
The Fern Valley Thru Alternative, shown in Figure 2, generally follows the existing alignment of Fern Valley Road and includes the following:



West of I-5, the following elements are included:

- From MP 11.07 to MP 11.34, OR 99 would be two lanes in each direction (except at intersections). Fern Valley Road would be two lanes in each direction, but would turn into a one-way road just west of Bear Creek—westbound traffic would follow Fern Valley Road and eastbound traffic would use E. Bolz Road.
- Travel lane widths on OR 99 in the project area would be reduced to 11 feet.
- Bikes on Fern Valley Road and E. Bolz Road would use 6-foot-wide shoulders that would be designated by pavement markings for bike travel. OR 99 and in transition areas (e.g., when a 4-lane roadway transitions to a 2-lane roadway) would have 5-foot shoulders.
- OR 99, Fern Valley Road, and E. Bolz Road would have 6-foot sidewalks on both sides of the roadway.
- The 2-lane Bear Creek Bridge (36 feet wide) would be replaced with a 4-lane bridge (100 feet wide).
- A median would be installed on OR 99 from north of Cheryl Lane to E. Bolz Road.
- If this alternative is selected, final design could indicate that some existing pavement may no longer be needed, and would therefore be removed upon completion of the project. Minimal pavement removal is anticipated west of I-5.
- Retaining walls may be constructed east of OR 99 from Cheryl Lane to E. Bolz Road, east of the Bear Creek Greenway multi-use path and adjacent to the Bear Creek Bridge, and north and south of Fern Valley Road near the Fern Valley Road/Luman Road intersection.

The interchange would be a new interchange design concept, the Crossing Diamond Interchange (CDI) (also known as the Diverging Diamond Interchange). With this type of interchange, drivers are directed to the opposite side of the bridge to cross the interstate (see inset). This allows drivers to make "free" left turns onto the interchange ramps. This design concept results is very efficient traffic operations, and has the advantage of a narrower width than the conventional diamond interchange design concept.



The new interchange would generally follow the existing alignment of Fern Valley Road, except at the east end, which would be shifted slightly to the north. Signals would be located at both the west and east interchange ramp terminals. There would be two lanes in each direction for the CDI. Bikes would be accommodated on the CDI by 6-foot shoulders at most locations; the shoulders would be designated by pavement markings for bike travel. Pedestrian movement would be through the center of the CDI.

East of I-5, the following elements are included:

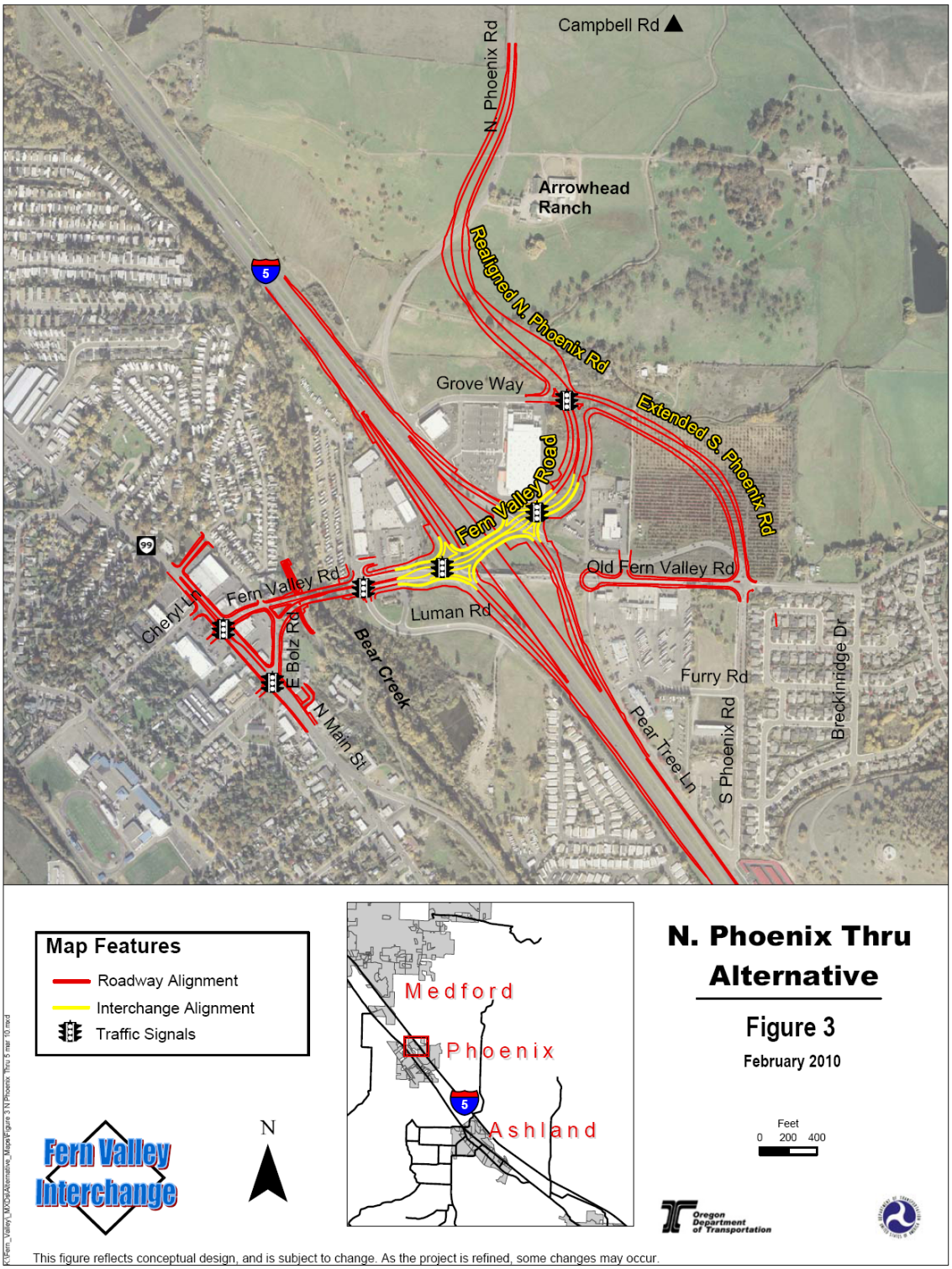
- Realigned Fern Valley Road would be two lanes in each direction (except at intersections), would be located just north of and parallel to existing Fern Valley Road, and would reconnect to existing Fern Valley Road at Breckinridge Drive.
- Realigned N. Phoenix Road would be located further east than existing N. Phoenix Road, would be two lanes in each direction (except at intersections), and would reconnect to existing N. Phoenix Road near Campbell Road.
- Bikes on Realigned Fern Valley Road, Realigned N. Phoenix Road, S. Phoenix Road, and existing Fern Valley Road would have 6-foot shoulders that would be designated by pavement markings for bike travel. (Some locations in transition areas may be 5- to 8-foot shoulders.)
- Both Realigned Fern Valley Road and Realigned N. Phoenix Road would have 6-foot sidewalks on both sides of the roadways.
- The east leg of the existing Fern Valley Road/S. Phoenix Road intersection would be blocked; no through movement for vehicles would be allowed. Bike and pedestrian circulation through the east leg of the intersection would remain.
- Retaining walls may be constructed at the east end of the I-5 structure and adjacent to the Home Depot parking lot.
- If this alternative is selected, final design could indicate that some existing pavement may no longer be needed, and would therefore be removed upon completion of the project.

2.2.2 N. Phoenix Thru Alternative

The N. Phoenix Thru Alternative, shown in Figure 3, generally follows a more north-south orientation than the Fern Valley Thru Alternative. West of I-5, the alternatives would be the same, except the N. Phoenix Thru Alternative would slightly shift the alignment to the north just west of I-5. The design concept of the CDI would be the same as the Fern Valley Thru Alternative, except the alignment would have a slightly more north/south alignment with the N. Phoenix Thru Alternative.

East of I-5, the following elements are included:

- The N. Phoenix Thru Alternative would turn north and reconnect with existing N. Phoenix Road near Campbell Road.
- S. Phoenix Road would be extended directly north, and turn west to connect with Realigned N. Phoenix Road directly across from Grove Way.
- Realigned N. Phoenix Road would be two lanes in each direction until it tapers to reconnect to existing N. Phoenix Road near Campbell Road. Existing Fern Valley Road would be one lane in each direction. Extended S. Phoenix Road would be one lane in each direction with a center turn lane. Grove Way would be one lane in each direction with a center turn lane at the intersection with Realigned N. Phoenix Road.


Campbell Rd
N. Phoenix Rd
Arrowhead Ranch
Realigned N. Phoenix Rd
Grove Way
Extended S. Phoenix Rd
Fern Valley Road
Old Fern Valley Rd
Fern Valley Rd
Luman Rd
Cheryl Ln
E Bolz Rd
Bear Creek
N Main St
Furry Rd
Pear Tree Ln
S Phoenix Rd
Breckinridge Dr
5
99
Map Features
Roadway Alignment
Interchange Alignment
Traffic Signals
Medford
Phoenix
Ashland
N
Fern Valley Interchange
N. Phoenix Thru Alternative
Figure 3
February 2010
Feet
0 200 400
Oregon Department of Transportation
This figure reflects conceptual design, and is subject to change. As the project is refined, some changes may occur.

- Bikes on Realigned N. Phoenix Road, Extended S. Phoenix Road, and existing Fern Valley Road would be accommodated on 6-foot shoulders that would be designated by pavement markings for bike travel. (Some locations in transition areas may include 5 to 8-foot shoulders.)
- All roads affected by the project east of the interchange would have 6-foot sidewalks on both sides of the roads.
- Full traffic movements would be provided at the existing Fern Valley Road/S. Phoenix Road intersection (compared to restricted traffic movements with the Fern Valley Thru Alternative—where no traffic movement would be allowed at the east leg of the intersection).
- A median would be installed from the northbound ramps to the Realigned Phoenix Road/Grove Way intersection.
- Retaining walls may be constructed at the east end of the I-5 structure and adjacent to Home Depot.
- Short sections of pavement may be removed from existing N. Phoenix Road north of the urban growth boundary (UGB), where they are not needed for approach roads.

2.2.3 Interchange Area Management Plan

High traffic volumes can overload an interchange—using up available traffic capacity so the interchange no longer functions effectively. In order to ensure the interchange functions as long as possible, an Interchange Area Management Plan (IAMP) is being been developed. The Fern Valley Interchange IAMP is being developed to:

- Preserve the capacity of the proposed interchange for at least the first 20 years of its design life, and the capacity of Fern Valley Road, OR 99 and N. Phoenix Road in the vicinity of the interchange.
- Ensure the safe and efficient operation of the interchange and connecting roadways, and protect the function of the interchange in the transportation system.

Measures included in the IAMP are intended to:

- Limit the extent of land uses that generate high rates of motor vehicle trips in the interchange area (e.g., fast-food restaurants, discount club stores, and discount "superstores").
- Apply specific transportation system management (TSM) actions and transportation demand management (TDM) actions. TSM addresses the operation of the roadway system, transit system, and facilities for bicycles and pedestrians. TDM seeks to reduce peak-hour motor vehicle trips by encouraging people to make trips using alternatives to single-occupant motor vehicles or during off-peak times.
- Limit trip generation outside the interchange area if necessary to meet mobility performance standards and preserve interchange capacity.

The IAMP includes the measures listed below; these are described in the EA in Section 2.2.1, Land Use Measures; Section 2.2.2, Transportation System Management Measures; and Section 2.2.3, Transportation Demand Management Measures.

Land use measures

- Trip budget overlay zone
- Capacity expansion and retention
- ODOT adoption of plan and code components
- South Valley Transportation Strategy
- Alternative mobility standard at I-5 ramp terminal intersections
- Building setback requirements on OR 99

TSM measures

- Future bus transfer sites and bus stop locations
- Shared park-and-ride lots

TDM measures

- Motor vehicle trip reduction requirements and programs

3. METHODOLOGY

3.1 INFORMATION SOURCES

The following sources of information were used during development of this report:

- Geologic, soil survey, and seismic maps (see reference)
- Water well logs from the Oregon Water Resources Department website
- Google Earth aerial photographs
- Site map of property boundaries
- Engineering Geology Report: Fern Valley Interchange Pacific Highway No. 1, MP 24.40, Jackson County, Oregon, Key #10841, by ODOT Region 3 Geo/Hydro Unit (dated December 12, 2001)
- ODOT Bridge Drawings and Plan and Elevation sheet for the Bear Creek Bridge (1951)
- ODOT Fern Valley Road Interchange Drawings and Plan and Elevation sheet for the Fern Valley Road Interchange (1961)
- Site reconnaissance

The site reconnaissance consisted of a review of the existing Bear Creek structure, notations of surface topography, notations of vegetation, trees and observed surface features. The information collected in the literature review and site reconnaissance has been used to develop the analysis and recommendations contained in the report.

3.2 METHODS FOR DATA ANALYSIS

An analysis of the local seismicity (the relative frequency and distribution of earthquakes) was conducted for this report. The geologic and surficial soils maps were used to assess potential impacts based on engineering judgment. The borehole logs were reviewed for proposed foundation designs at the site. Potential mitigation measures discussed are based on experience with field exploration and anticipated foundation, embankment and pavement construction. Actual mitigation measures will have to be established after subsurface conditions and foundation types and locations are known. Specific bridge features are not currently available so URS has developed this report without this information, but has based the following sections on the information provided in Sections 1 and 2 of this report. Once the bridge features, including specific abutment and bridge approach designs have been developed, the general recommendations presented herein should be evaluated in light of the proposed design.

4. AGENCY COORDINATION AND INVOLVEMENT

4.1 FEDERAL

Geotechnical design of the build alternatives would be conducted in accordance with the design guidance set forth in the American Association of State Highway and Transportation Officials (AASHTO) 2007 4th Edition with 2008 interims for bridge design as the appropriate Federal Highway Administration (FHWA) design guidelines.

4.2 STATE

ODOT maintains records of subsurface information that was previously obtained for the design of the existing interchange. Information includes a geotechnical report for improvements in the area, as well as drawings and details for the existing Fern Valley Interchange structure and the Bear Creek Bridge. Soil and rock descriptions contained on the ODOT borehole and test pit logs have been incorporated into this report. Additional subsurface information was collected using the Oregon Water Resources Department (WRD) Well Log Query (WRD 2007). As a part of final design, future subsurface explorations will be conducted.

Materials and construction practices used for the proposed interchange project would be in accordance with the Oregon Department of Transportation (ODOT) Standard Specifications for Construction (ODOT, 2008). Geotechnical design for the proposed project must meet the design guidance required by the ODOT (2008a) Geotechnical Design Manual. In addition to this manual, the ODOT Retaining Structures Manual

would be utilized for design. These manuals, along with the most current updates and related reference manuals, can be found on ODOT's website.[3].

4.3 LOCAL

Jackson County was contacted for subsurface information in the vicinity of the Bear Creek Bridge. ODOT will coordinate with Jackson County prior to advancing required geotechnical exploration.

4.4 PROPERTY OWNERS

Prior to any additional geotechnical investigations, property owners would be contacted and right of entry forms would be obtained for each property entered.

5. AFFECTED ENVIRONMENT

The affected environment is focused on the footprint of the boring locations, bridge foundations, embankment fills, retaining walls, relocated roadways and any required access/construction roads. These items are discussed in the following sections.

5.1 REGIONAL GEOLOGY

The project site is located within the Oregon Klamath Mountains physiographic province, which contains seven various geologic/tectonic terranes. The Mesozoic to Cenozoic terranes have been identified in the project area, and represent fault-bounded, geologically-diverse blocks that were accreted to the active continental margin between the Jurassic and late Eocene (±170 to 55 million years) (Wells et al., 2000; Orr and Orr, 1999). The terranes are like dominoes indicating a northwestward thrust with older terranes found to the east (Wells et al., 2000; Orr and Orr, 1999).

During the end of the Jurassic period (±144 million years ago), extensive folding and faulting occurred along with the emplacement of several granitic intrusions found primarily along four major northeast-trending belts (Orr and Orr, 1999). These intrusions were then covered by sand, silt and gravel deposited in the Cretaceous transgressive sea. By the end of the Cretaceous (±65 million years), the sea rapidly retreated, resulting in a northwest-trending shoreline crossing into western Idaho and eastern Washington. A new volcanic island arc (Coast Range) formed west of the shoreline and was eventually accreted onto the North American plate. The volcanic island chain began to subside during the Eocene to Miocene (±55 to 5 million years ago), allowing for deposition of marine sediments originating partially from the eroding Klamath Mountains. Eocene

[3] http://egov.oregon.gov/ODOT/HWY/GEOENVIRONMENTAL/geology_geotechnical.shtml

volcanics of the newly-formed Western Cascades unconformably overlie the marine sediments. During the Miocene, the Coast Range block was uplifted causing the sea to retreat westward. Continued uplift and tilting in combination with sea level changes during the Pleistocene (±2 million years ago) also created terraces along the coastal mountains and within selected areas in the upper Klamath Mountains (Wells et al., 2000; Orr and Orr, 1999).

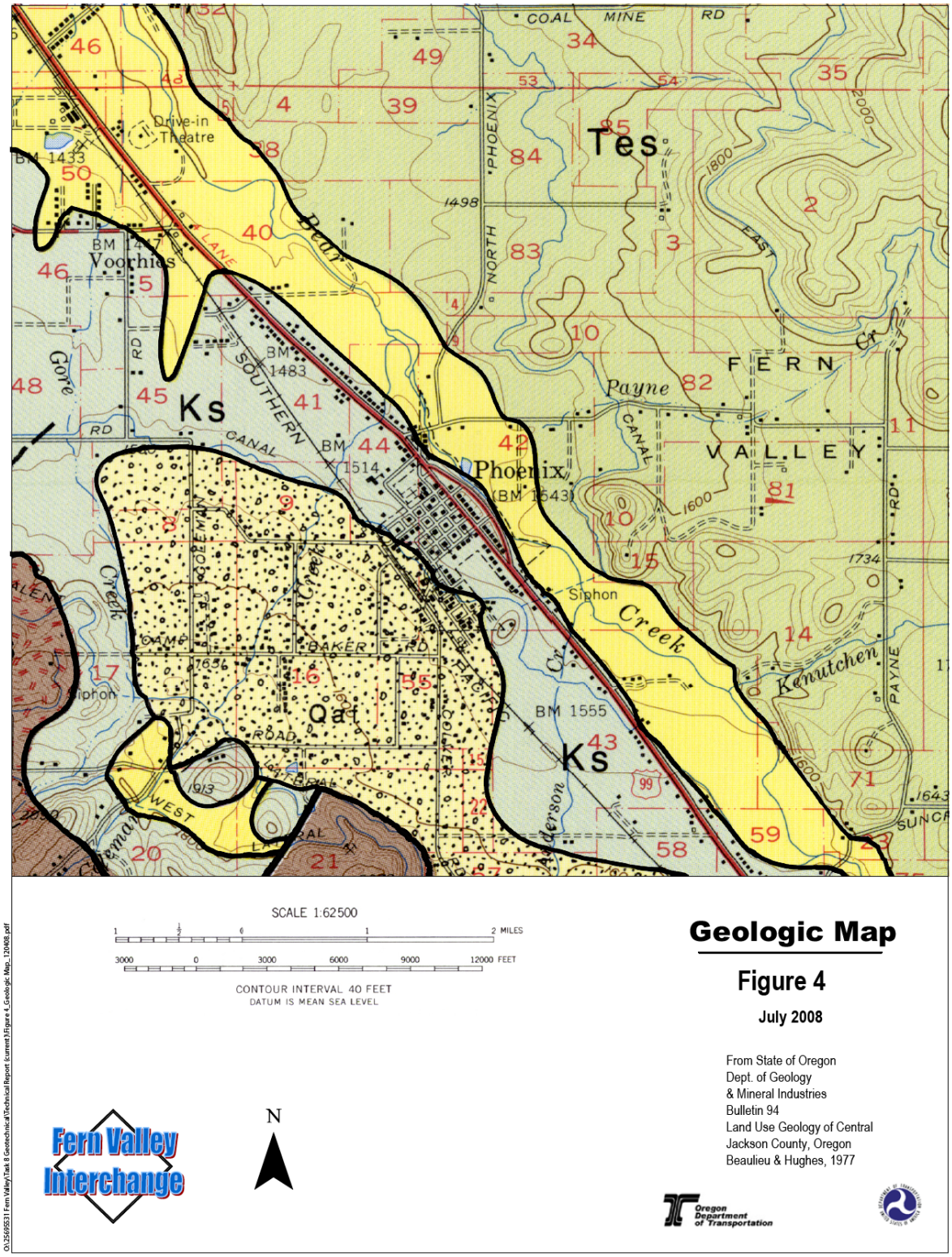
5.2 LOCAL GEOLOGY

The project site is located in Phoenix, Oregon. The proposed interchange would be located in the general vicinity of the existing interchange. On the surface, the site is relatively flat, with slopes to the east. A relatively small amount of the natural landscape exists in the vicinity of the site. Commercial and residential developments are present to the east and west of the proposed interchange. In addition, a small orchard is located to the north of the intersection of Fern Valley Road/S. Phoenix Road.

The general geology of the project site consists of Quaternary alluvium overlying the Eocene Aged Umpqua and Payne Cliffs formations; and Upper Cretaceous Hornbrook formation. Figure 4 is excerpted from Beaulieu (1977)_and shows the general geology present in the project area.

The alluvial deposits consist of unconsolidated gravel, sand, silt and clay. The Eocene sedimentary rocks, which crop out on the east side of the valley, consist of buff sandstone, mudstone and conglomerate. The Payne Cliff Formation consists of conglomerate, sandstone, siltstone, mudstone and coal in nonmarine, fluvial deposits, provenance variation suggests local derivation in part. The Hornbrook formation, which crops out on the west side of the valley, consists of greenish to buff arkosic sandstone with layers of conglomerate consisting of pebbles of quartz, diorite, gneiss, and greenstone. Geologic literature indicates that Cretaceous mollusks have been identified within the Hornbrook Formation, which is present at the site (Squires, 2002). The Cretaceous fossils could represent an affected paleontological resource if fossiliferous members of the Hornbrook Formation are exposed or buried during construction of proposed cut slopes and embankments.

Local water well logs (WRD (2007)), Soils Maps (NRCS 2007) and ODOT's exploration logs developed for their Engineering Geology Report (ODOT 2001) were reviewed. ODOT's explorations consisted of four test pits along N. Phoenix Road east of the interchange, four test pits along Luman Road east of the interchange, and a total of 6 drill holes (3 east and 3 west of the interchange) directly along Fern Valley Road. In addition, a borehole was advanced in both the southwest and southeast quadrants of the interchange for exploration at either end of the Payne Creek box culvert.



Numerous additional logs (Geotechnical, water well and environmental Logs) were also reviewed. Several were for the Unocal Station to the east of the interchange, Home Depot to the southeast of the interchange, and the Pacific Surfside Corporation. The

geology report on these explorations revealed that the site is underlain by alluvial soils east of I-5 that consist mainly of loose to medium dense gravelly to clayey sand with some stiff silt and clay. West of I-5, alluvial soils consist of mainly loose to medium dense sand, stiff sandy silt, and loose to medium dense silty sand with some gravel. The existing roadway embankment fill at the site consists mainly of sandy gravel to gravelly sand. The alluvial soils are underlain by the Hornbrook Formation at a depth of about 15 to 20 feet below the ground surface. A site-specific geotechnical report will be required prior to final design to fully capture the underlying conditions at the subject site.

5.3 SEISMIC SETTING

Phoenix lies ±140 miles inland from the surface expression of the Cascadia Subduction Zone (CSZ), a converging, oblique plate boundary where the Juan de Fuca plate is subducted beneath the western edge of the North American continent (Geomatrix Consultants 1995). The CSZ extends from central Vancouver Island in British Columbia, Canada, through Washington and Oregon to Northern California. Available information indicates the CSZ is capable of generating earthquakes within the descending Juan de Fuca plate (intraplate), along the inclined interface between the two plates (interface or subduction zone), or within the overriding North American Plate (crustal) (Weaver and Shedlock 1996). Therefore, western Oregon is located in an area of potentially high seismic activity.

Due to the relative proximity of the CSZ, three earthquake scenarios are addressed herein. No significant interface (subduction zone) earthquakes have occurred in historic times; however, several large-magnitude subduction zone earthquakes are believed to have occurred in the past few thousand years. This is evidenced by recently discovered tsunami inundation deposits, combined with evidence for co-seismic subsidence along the Oregon and Washington coasts (Atwater et al., 1995; Peterson et al., 1993). According to the Oregon Department of Geology and Mineral Industries (DOGAMI), the maximum estimated magnitude of a subduction zone earthquake ranges from M 8.5 to M 9.0 (Wang et al., 2001; Wang et al., 1998; Wang and Leonard, 1996), and the rupture may potentially occur along the entire length of the CSZ (Weaver and Shedlock, 1996). Interface earthquakes are believed to have an average return period of 400 to 700 years (Nelson and Personius, 1996), with the last event occurring ±300 years ago (Nelson et al., 1995).

Intraplate earthquakes occur within the descending Juan de Fuca Plate at depths of ±28 to 37 miles (Weaver and Shedlock, 1996). The maximum estimated magnitude of an intraplate earthquake is about M 7.5 (Wang et al., 2001). No intraplate earthquakes have been recorded in Oregon in modern times. However, the Puget Sound region has experienced three intraplate earthquakes in the last ±59 years, including a Ms 7.1 event (Ms = surface wave magnitude) in 1949 (Olympia), a Ms 6.5 event in 1965 (Seattle/Tacoma) (Wong and Silva, 1998), and a Mw 6.8 event (Mw = moment magnitude) in 2001 (Nisqually) (USGS, 2001).

Crustal earthquakes dominate Oregon's seismic history. Crustal earthquakes occur within the North American Plate, typically at depths of ±6 to 12 miles. The estimated maximum

magnitude of a crustal earthquake is about M 6.5 (Wang et al., 2001; Wang et al., 1998; Wang and Leonard, 1996). Only three major crustal events recorded in Oregon have reached Richter local magnitude (ML) 6, with the majority in the ML 4 to 5 range (Wong and Bott, 1995). It should be noted that seismic events in Oregon were not comprehensively documented until the 1840's and was highly dependent upon settlement and population (Wong and Bott, 1995). According to Wong and Bott (1995), seismograph stations sensitive to smaller earthquakes (ML ≤4 to 5) were not implemented in northwestern Oregon until 1979 when the University of Washington expanded their seismograph network to Oregon.

The local Richter magnitude (ML) of events occurring prior to the establishment of seismograph stations have been estimated based on correlations between magnitude and Modified Mercalli (MM) intensities. However, some discrepancy exists in the correlations. Distant strong earthquakes felt in the project area include the following (MM intensities in parentheses): the 1993 Klamath Falls Earthquakes (IV), 1993 Scotts Mills Earthquake (III), and the 1873 Crescent City Earthquake (VI) (Black, 1996; Wong and Bott, 1995; Madin et al., 1993; Wiley et al., 1993). None of these events caused significant damage in the area.

Several faults are located within ±10 miles of the project site. However, none of these faults are considered potentially active (ie. evidence of rupture within the last +/- 1.8 million years) (USGS (2008), Beaulieu, et al. (1977) and Geomatrix Consultants (1995)). No faults are mapped beneath the site.

The Sky Lakes Fault Zone lies approximately 30 miles east of the site (USGS 2008). These north- and northwest-striking, mostly down-to-the-east normal faults offset late Miocene and Pliocene to Pleistocene volcanic rocks, and probably are older structures related to the western margin of the Klamath graben. These faults form prominent escarpments on late Tertiary and Quaternary volcanic rocks. Scarps range in height from less than 10 m to as much as 300 m; most are less than 30 m high and have slope angles of less than 25°. Scarps are formed in bedrock, and in most places are covered by late Pleistocene (approximately 10-30 ka) glacial deposits and Holocene colluvium. Although most faults in the zone have been active in the middle and late Quaternary, at least one fault strand near the northern end of the zone has apparently been active in the latest Quaternary.

The Klamath graben fault system is also located about 30-40 miles east of the site and consists of a group of north and northwest-trending normal faults that form a complex graben system that confines the Klamath Lake basin at the intersection of the northwestern Basin and Range and Cascade Mountains in southern Oregon (USGS 2008). These faults offset upper Miocene to Holocene volcanic rocks and Pleistocene and Holocene valley-fill sediments. The Klamath graben fault system is divided into three sections--the West Klamath Lake section, the East Klamath Lake section, and the South Klamath Lake section. The West Klamath Lake and South Klamath Lake sections, in part, show evidence of latest Quaternary displacement; youngest displacement on the East Klamath Lake section occurred in the Quaternary.

5.4 GROUNDWATER

Groundwater levels were recorded during the subsurface investigation conducted by ODOT in late summer and early fall of 2001. Depth to groundwater ranged from approximately 6 feet to 12 feet and generally matched the flow elevations of the adjacent water ways (Payne Creek and Bear Creek). Higher groundwater levels and soil moistures can be anticipated during winter and spring months.

5.5 GEOLOGIC HAZARDS

Geologic hazards include seismic hazards, slope stability (landslide) hazards, and soil erosion hazards. The proposed build alternatives would be exposed to minimal potential geologic hazards. The hazards are discussed individually below.

5.5.1 Seismic Hazards

Seismic hazards can include the primary effects of an earthquake (such as surface rupture or ground shaking), as well as secondary responses (such as liquefaction or seismically induced landslides).

Probabilistic analyses conducted by the USGS in support of the 1996 National Seismic Hazard Maps indicate that the ground motions from the Cascadia Subduction Zone dominate the seismic hazards at all spectral accelerations (i.e., the Cascadia Earthquakes produce larger spectral accelerations at all period contents relative to the local fault scenarios). There have been no historical damaging earthquakes recorded in the project vicinity. Ground shaking from distal earthquake sources may have been felt in the past, but the seismic record for the region does not indicate any damage caused by historic earthquakes.

To evaluate the potential for Seismic Hazards, one of the considerations is the potential for the Ground Motion Amplification as an input to the hazard. Ground motion amplification is the influence of a soil deposit on the earthquake motion. As seismic energy propogates up through the soil strata, the energy is typically increased (amplified) or decreased (attenuated) to some extent. Since the site is underlain by relatively shallow Hornbrook formation, the amplification hazard is considered to be low.

URS considered the potential for the primary effect of Site Faulting and Ground Rupture. No faults have been mapped at the project site. However, several faults have been mapped within +/- 10 miles of the site. The displacement of these faults is believed to have possibly occurred prior to +/- 1.8 million years ago (Pliocene or older) and the faults are considered inactive.

A lower potential for ground rupture is assumed since there is no indication of active faulting beneath the site. However, hidden and/or deep-seated active faults could remain undetected. In addition, recent crustal activity cannot always be tied to observable faults.

In the event of a catastrophic earthquake with a large seismic moment, inactive faults could potentially be reactivated.

URS also considered the secondary seismic hazard effects of Liquefaction and Seismically-Induced Settlement. The foundation soils are expected to consist of alluvial silts, sands and clays (above the Hornbrook Formation). There has not been any laboratory testing for the fine fraction of the alluvial formation, and the alluvial sands are noted to be loose and may be subject to liquefaction effects. The limited thickness of these beds and relatively shallow Hornbrook Formation may reveal that liquefaction is not a site hazard; however, additional geotechnical exploration is required for a full assessment.

Additional secondary seismic hazards URS evaluated were the potential for Tsunami and Seiche. Tsunami inundation is not applicable since the site is not on the Oregon Coast. Seiche is the back and forth oscillations of an enclosed or semi-enclosed body of water during a seismic event. Since there is no large body of enclosed water at the project site, seiche is also not considered a hazard.

The existing Bear Creek Bridge was constructed in 1951, and does not meet the current seismic code. The bridge is currently considered to be structurally deficient and is designated as a Highway Bridge Replacement and Rehabilitation Program eligible bridge. The existing Fern Valley Interchange overpass was constructed in 1961, and is also not designed to the current seismic code.

5.5.2 Slope Stability Hazards

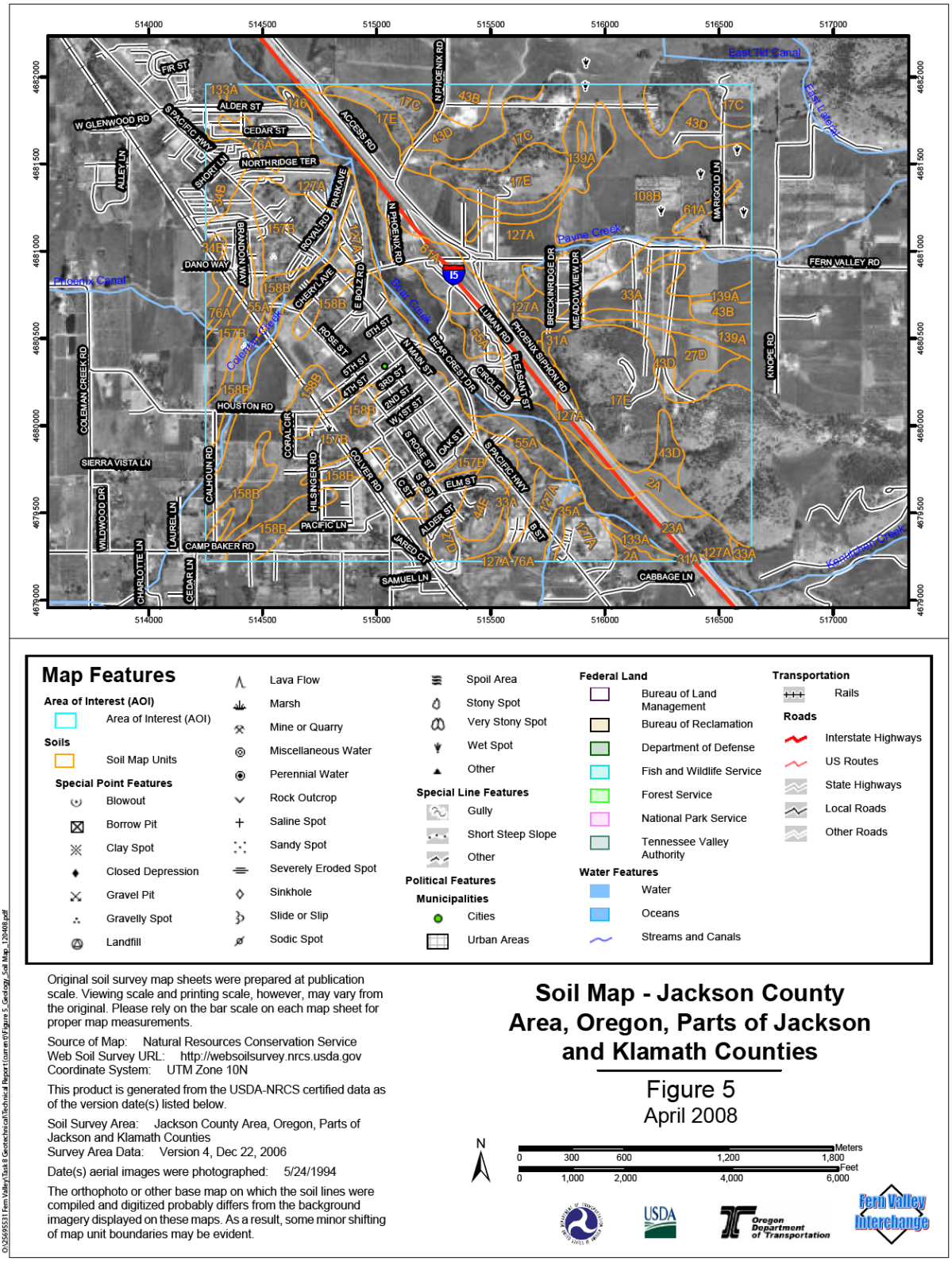
Slope stability hazards common to the Pacific Northwest include rock fall, rotational-translational slides, earthflows, debris slides, and debris flows. Topographic relief in the project area is relatively flat with the exception of the banks of Bear Creek and the northern portion of the proposed N. Phoenix Road realignment (the same for both alternatives). The banks of Bear Creek, cut slopes along the northern N. Phoenix Road realignment, and fill slopes associated with roadway construction are the only areas of the project with enough topographic relief for slope instability to be a consideration.

Anticipated soil and rock conditions at the project are not considered highly susceptible to slope instability at the temporary or finished slope configurations that would result from construction of the project. To assure adequate stability of the project elements on or near slopes, stability analyses of cut slopes, bridge embankment fills, and natural slopes would be performed during final design of the project.

5.5.3 Soil Erosion Hazards

Soil erosion can occur during intense and/or prolonged rain or rain-on-snow events and during elevated flow events along creeks and rivers. Based on limited subsurface information and the National Resource Conservation Survey (NRCS) Soil Survey of

Jackson County Area, Oregon (Figure 5), the soils in the project area have low to moderate susceptibility to soil erosion.



6. ENVIRONMENTAL CONSEQUENCES

Potential geologic impacts associated with this project include cuts into, and fills over the existing geology, changes in existing slope geometry, and construction of structures based on current seismic requirements.

6.1 GEOLOGY/GEOTECHNICAL AND SOILS

6.1.1 Direct Impacts

No-Build Alternative

There would be no direct geologic or soil impacts associated with the No-Build Alternative.

Fern Valley Thru Alternative

The proposed construction includes approximately 20 acres of land that is not currently developed. Some portions of the proposed construction would traverse areas that could potentially be used as sources of aggregate or for agricultural uses, or may contain paleontological resources (fossil locations). Construction of the project may reduce the potential for these other uses.

As indicated above, geologic literature indicates that Cretaceous mollusks have been identified within the Hornbrook Formation, which has been mapped in the area of the proposed construction (Squires, 2002). The Hornbrook Formation may be exposed in proposed road cuts or buried under proposed embankment fills. Construction of the Fern Valley Thru Alternative may result in the loss of access to potential paleontological resources.

N. Phoenix Thru Alternative

The direct impacts for the N. Phoenix Thru Alternative would essentially be the same as the impacts listed for Fern Valley Thru Alternative, with the following exception: The proposed construction of the N. Phoenix Thru Alternative includes approximately 17 acres of land that is not currently developed. As with the Fern Valley Thru Alternative, some portions of the proposed construction would traverse areas that could potentially be used as sources of aggregate, agricultural land, or contain paleontological resources.

6.1.2 Indirect Impacts

Indirect effects are caused by the proposed action, but are impacts that would later in time, and yet can be reasonably expected to occur (50 CFR 402.02).

Potential indirect impacts associated with this project would be virtually the same for both of the build alternatives. Permanent cut and fill slopes may be susceptible to erosion over time. Temporary and permanent slopes would be designed to minimize the likelihood of instability or susceptibility to erosive forces.

6.1.3 Cumulative Impacts

Cumulative impacts are defined as the environmental impacts which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes the other actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time. (40 CFR 1508.7)

No cumulative geologic impacts are anticipated with either build alternative.

6.1.4 Construction Impacts

The proposed cuts and fills required for the Fern Valley Thru Alternative could potentially create temporary slope instability during the construction of road cuts and retaining walls. Retaining walls, fill slopes, and temporary and permanent cut slopes would be designed to minimize the potential for erosion and slope instability.

Approximately 202,000 cubic yards of fill material would be imported to the site with the Fern Valley Thru Alternative. Approximately 251,000 cubic yards would be imported with the N. Phoenix Thru Alternative. Transport of this material would require from 10,000 to 50,000 dump truck loads (depending on truck capacity).

6.2 GEOLOGIC HAZARDS

6.2.1 Direct Impacts

No-Build Alternative

The Bear Creek Bridge and the existing Fern Valley Road overpass of I-5 are not constructed to current seismic standards. The No-Build Alternative would allow these substandard bridges to remain in place and deteriorate over time. The existing bridge structures expose the public to an elevated risk from failure during a seismic event.

Build Alternatives

Seismic Hazards. The November 2008, ODOT Geotechnical Design Manual references seismic design maps that are based on the 2002 USGS National Seismic Hazard Maps. ODOT recommends that all bridges be designed using a "no collapse" criterion for an earthquake with a 1,000 year return period and a "serviceable" criterion for an earthquake with a 500-year return period. The seismic design maps indicate peak ground accelerations (PGA) of 0.106 g and 0.154 g, respectively, on rock at the project site for the 500-year and 1,000-year events. Based on the anticipated depth to bedrock, an AASHTO Soil Profile Type I and a Site Coefficient (S) of 1.0 are recommended for preliminary design.

Nominal ground amplification would occur at the site. Based on the preliminary site study performed for this report, the project can be designed and constructed without detrimental effects due to seismic hazards along the proposed alignments.

Slope Stability. The proposed cuts and fills required for the build alternatives could potentially create temporary slope instability during construction of road cuts, bridges and retaining walls. Additionally, permanent cut and fill slopes may be susceptible to erosion. Temporary and permanent slopes would be designed to minimize the likelihood of instability or susceptibility to erosive forces.

The proposed project construction would include re-grading areas surrounding the proposed roadways, and would involve cuts, fills, and retaining walls. Per the ODOT (2008a) Geotechnical Design Manual, For slopes adjacent to but not directly supporting structures, a maximum resistance factor of 0.65 (factor of safety of 1.3) should be used. For foundations on slopes that support structures such as bridges and retaining walls, a maximum resistance factor of 0.75 (factor of safety of 1.5) should be used. Exceptions to this could include minor walls that have a minimal impact on the stability of the existing slope, in which the 0.75 (factor of safety of 1.5) resistance factor may be used. When considering seismic loads or temporary slopes, a maximum resistance factor of 0.9 should be used for slopes involving or adjacent to walls and structure foundations. This is equivalent to a safety factor of 1.1. For other slopes (cuts, fills, and landslide repairs), a minimum seismic safety factor of 1.05 should be used.[4]. Approved embankment fills and slopes shallower or equal to 2H:1V are anticipated to meet these criteria.

Mechanically Stabilized Earth (MSE) wall systems are proposed for both alignment options at the abutments of the Bear Creek Bridge, the new interchange structure, and Fern Valley Road at Luman Road. An additional MSE wall is proposed along the northbound I-5 onramp for the N. Phoenix Thru Alternative. At the time of this report, the lengths and heights of these walls were not known, but they should be systems approved by ODOT and be designed to meet the stability (bearing, sliding, overturning and internal stability) as set forth in the ODOT (2008a) Geotechnical Design Manual.

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[4] Factor of Safety (FoS), with respect to slope stability, represents a ratio of the sum of forces acting to resist downslope movement (mass at the slope toe, retaining walls, internal soil strength) to the sum of forces acting to cause downslope movement (weight of soil, groundwater, structures at top of slope, etc.).

Stability analyses would be conducted for all cut slopes, embankment fills, and walls during final design. Based on existing subsurface information and site reconnaissance performed in support of this report, the project can be designed and constructed without detrimental effects on slope stability along the proposed alignments. Slope stability hazards are the same for each of the build alternatives.

Bridge Foundations. Replacement of the Fern Valley Road Interchange Structure Bridge would likely consist of a two or three span bridge that would have end bents supported on steel piles driven through the embankment fills and founded in the underlying Hornbrook Formation. The interior bent(s) would be supported by drilled shafts in the Hornbrook Formation or by shallow spread foundations supported on the dense alluvial sand and gravel deposits, or possibly the deeper Hornbrook Formation. The impacts from these foundation systems would be loss of surface vegetation (primarily grasses).

The Bear Creek Structure is anticipated to be a simple span structure with each abutment supported by either drilled shafts or driven piles. Impacts may include disturbance of the streambank vegetation and possible rutting of the ground surface. If work is planned in the riverbank, this work should be done during dry weather and in consideration of environmental and natural resource impacts.

Soil Erosion. All proposed embankment fills, cut slopes, and bridge abutments would be designed and constructed with appropriate temporary and permanent erosion and/or scour control measures in accordance with ODOT, American Association of State Highway and Transportation Officials (AASHTO), and FHWA guidelines. This would include erosion and scour protection of bridge abutments and wall systems at the proposed Bear Creek Bridge. Soil erosion hazards are the same for each of the build alternatives.

Proposed road cuts along the northern portion of the N. Phoenix Road realignment would create slopes that are steeper than the existing topography. The steeper slopes would be more susceptible to erosion, especially during the early life of the project, prior to the reestablishment of vegetation.

Groundwater. As indicated above, groundwater levels were recorded during the subsurface investigation conducted by ODOT in late summer and early fall of 2001. Depth to groundwater ranged from approximately 6 feet to 12 feet and generally matched the flow elevations of the adjacent water ways (Payne Creek and Bear Creek). Higher groundwater levels and soil moistures can be anticipated during winter and spring months. Elevated groundwater levels could impact construction of any of the build alternative elements that require subgrade excavation, such as bridge and/or wall foundations. To minimize impacts of elevated groundwater and soil moistures, it is recommended that construction of such project elements occur during the dryer summer and early fall months.

6.2.2 Indirect Impacts

No-Build Alternative

The Bear Creek Bridge and the existing overpass are not constructed to current seismic standards. The No-Build Alternative would allow these substandard bridges to remain in place and present a hazard to the public in the event of an earthquake.

Build Alternatives

No indirect geologic hazard impacts are anticipated.

6.2.3 Cumulative Impacts

No cumulative geologic hazard impacts are anticipated in association with this project with either of the build alternatives.

6.2.4 Construction Impacts

The proposed construction of either build alternative may create potential slope instability of temporary cuts and excavations. Additionally, temporary cuts may be susceptible to erosion. As indicated above, measures would be taken to minimize these potential impacts.

7. SUMMARY OF GEOLOGICAL MITIGATION AND CONSERVATION MEASURES

- Geotechnical design would be conducted in accordance with the AASHTO Standard Specifications for Highway Bridges, as well as appropriate FHWA and ODOT design guidelines. A formal geotechnical report, including additional subsurface investigations would be required for final design. The following geotechnical requirements would be included with either build alternative, and would comply with the ODOT (2008) Geotechnical Design Manual:
    - Determine the Peak Bedrock Acceleration (PGA), 0.2 and 1.0 second spectral accelerations for the bridge site from the 2002 USGS National Seismic Hazard Maps for the 500 and 1000-year event;
    - Determine the Site Class and Site Coefficients based on the properties of the soil profile;
    - Develop the Design Response Spectrum for the site or conduct ground response analysis if necessary; and
    - Determine liquefaction potential of foundation soils,

- ODOT's Standard Specifications for Construction would be utilized for construction, and applicable measures would be incorporated into the project's construction design plans and special provisions to address the following issues:
    - Retaining Wall Construction
    - Bridge Abutment and Embankment Construction
    - Subgrade Compaction
    - Erosion Protection

- ODOT would design the new bridge structures to withstand an earthquake of a magnitude that, based on probability studies, is predicted to occur about once every 1000 years. The magnitude of ground shaking that this represents is approximately a magnitude 8 or 9 earthquake in the Cascadia Subduction Zone. (ODOT recommends that all bridges be designed using a "no collapse" criterion for an earthquake with a 1,000-year return period (annual probability = 0.001) and a "serviceable" criterion for an earthquake with a 500-year return period (annual probability = 0.002). The seismic design maps indicate peak ground accelerations (PGA) of 0.106g and 0.154g, respectively, on rock at the bridge site for the 500-year and 1,000-year events. Based on the anticipated depth to bedrock, an AASHTO Soil Profile Type I and a Site Coefficient (S) of 1.0 are recommended for preliminary design.)

- A design-level geotechnical investigation would be used to design the roadway and retaining walls for minimum risk for inducing slope instability. This would include at a minimum: a more complete mapping of surface soils and bedrock conditions along the selected alternative; soil borings and rock coring, as needed along the alignment (with closer spacing where walls and/or bridges are proposed); and installation of piezometers to monitor groundwater elevations and quality along the proposed walls. The geotechnical investigation would be performed following ODOT Best Management Practices.

- Drainage from the highway would likely be directed into an enclosed stormwater drainage system. To reduce runoff and erosion, unused pavement area would be removed and replaced with a vegetative surface. This would allow more controlled infiltration of stormwater. Also, regraded slopes could be replanted to minimize erosion and allow natural infiltration of stormwater.

- Cut and fill slopes could be optimized to minimize the area impacted. Steeper slopes and smaller footprints may be attainable where shallow bedrock is encountered. The results of subsurface investigation could be used to minimize the earthwork footprint.

8. LIST OF PREPARERS

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