US 20 Pioneer Mountain to Eddyville
Major Elements

- 4,000,000 yds³ of earth movement
  (enough to fill OSU Reiser Stadium about 3 times)
- 10 Bridges, 29 spans, 4140 total ft
  - Little Elk Creek , 1 span, 140 ft long
  - Eddy C Creek, 4 spans, 600 ft long
  - Eddy B Creek, 5 spans, 750 ft long
  - Crystal Creek, 7 spans, 1050 ft long
  - Cougar Creek, 4 spans, 600 ft long
  - Trapp Creek, 2 spans, 310 ft long
  - Yaquina River, 3 spans, 380 ft long
  - Western Pacific RR, 1 span, 150 ft long
  - Elk City at Simpson Creek, 1 span, 80 ft long
  - Hayes Creek, 1 span, 80 ft long
- 8 temporary bridges load rated for heavy haul trucks, spanning approximately 900 feet
- 3 Multiplate Culverts
  - Little Elk Creek Trib. 1, 8-ft diameter, 120-ft long
  - Little Elk Creek Trib. 2, 8-ft diameter, 200-ft long
  - Eddy D Creek Trib., 6-ft diameter, 400-ft long
- 1.5 miles haul roads plus 7 mile of temp road improvement
- 67,000 tons Asphaltic Pavement
- 610,000 yds³ Blasted rock
- 13,000 linear feet new drainage
- 110,000 tons aggregate base
- Labor peak with subs 150 employees
- 90% of labor is local
- 100% of subconsultants have Oregon presence beyond PME

Oregon Department of Transportation

PME Scorecard

- 2006 Wet Season
  - Rainfall = 78.3″
  - Turbidity issues = 238
- 2007 Wet Season
  - Rainfall = 68.8″
  - Turbidity issues = 4

- Wet Season = October 1 to September 30

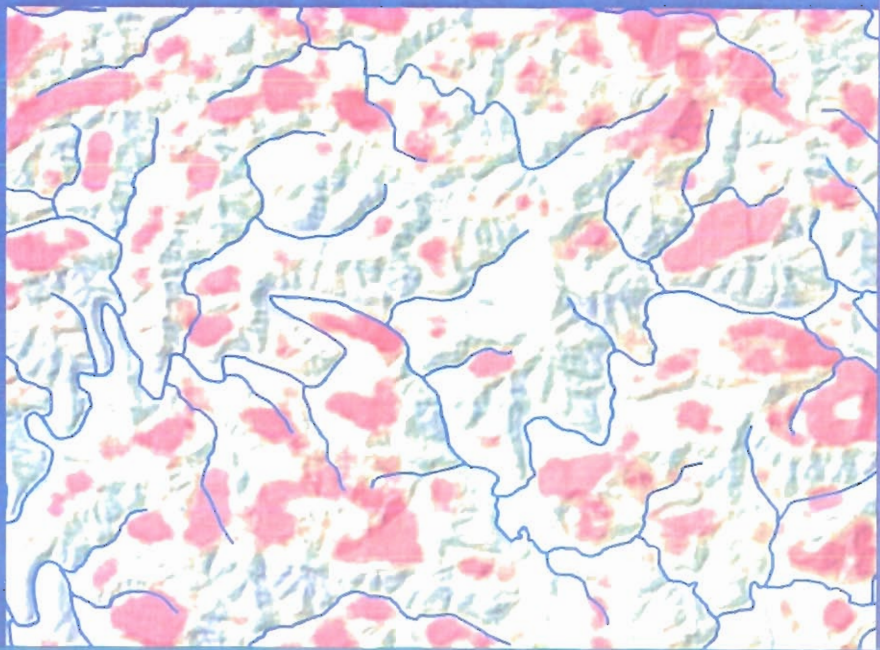
- Meet compliance will all other permit conditions in 2007 Wet Season

- DEQ referenced the PME site to a Lincoln City contractor to demonstrate good winter erosion control techniques

Oregon Department of Transportation

Why this alignment?

1. Balances impact to the natural resources, based on EIS criteria
2. Avoids natural and cultural resources to the extent possible
3. Avoids parallel stream alignments and valley bottoms
4. Avoids mountain tops and their adverse grades by necessity
5. Avoids landslide masses when possible



Oregon Department of Transportation

Seismic Considerations

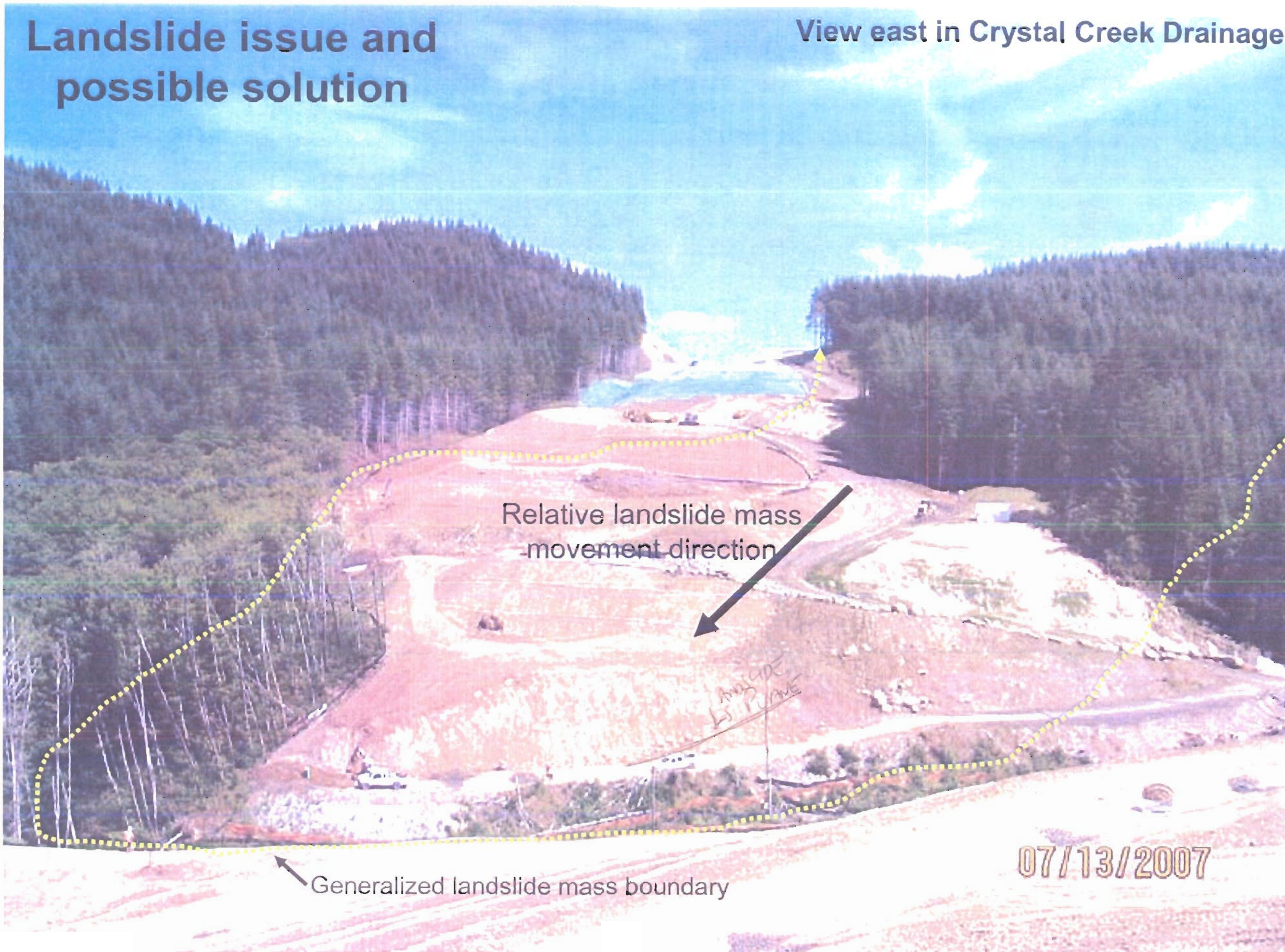
- ✓ Factor of Safety (FS) of 1.0 indicates general stability
- ✓ PME landslide masses are at 1.05 FS prior to construction
- ✓ Proximity to Cascadia Subduction Zone requires protection for a 9.0 Richter scale event
- ✓ Seismic events drive stability factor lower

Without landslide mitigation

- ✓ Large fill FS is less than 0.9
- ✓ Bridge abutment FS is less than 0.75

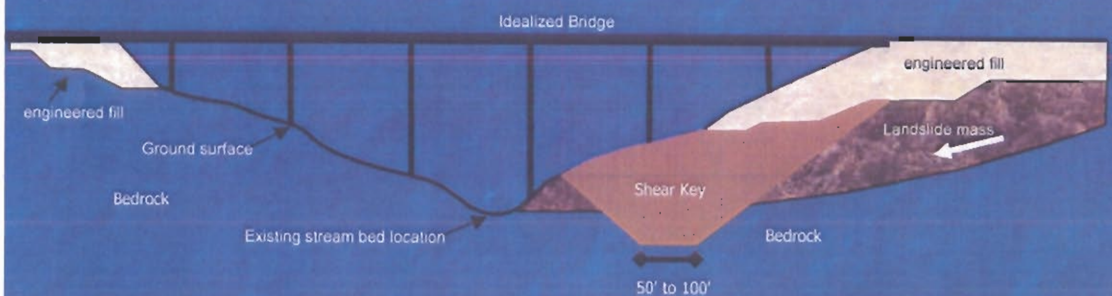
With landslide mitigation

- ✓ Meets ODOT Specification
- ✓ Large fill FS is greater than 1.25
- ✓ Bridge abutment FS is greater than 1.0

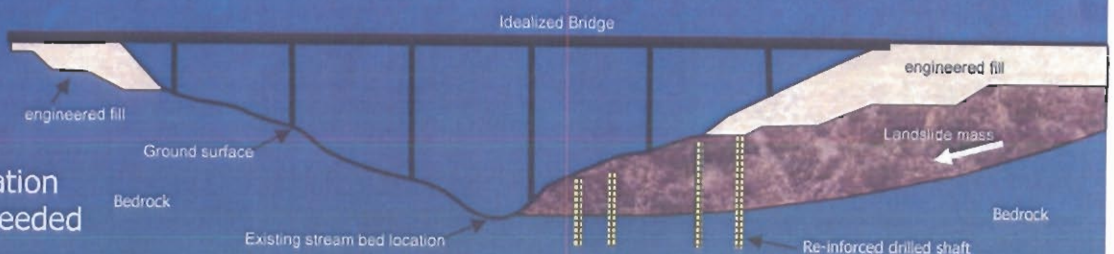

Landslide issue and possible solution
View east in Crystal Creek Drainage
Relative landslide mass movement direction
LANDSLIDE PLANE
07/13/2007
Generalized landslide mass boundary

Mitigation Alternative explored, modeled, and priced

- Deep Shear Keys – not constructable and adds 1M+ cubic yards
- Drilled Shafts (pins) – 4 feet diameter 60 to 120 feet deep
  - ✓ Unique – not well proven for this size of landslide
  - ✓ Infiltration issues with drilling fluids at 450+ locations
- Deep Soil Anchors – similar issues as drilled shafts
- Buttress – proven technology, long successful history world-wide



Deep Shear Key illustration adds +1M yds^3



Drilled shaft illustration approximately 450 needed

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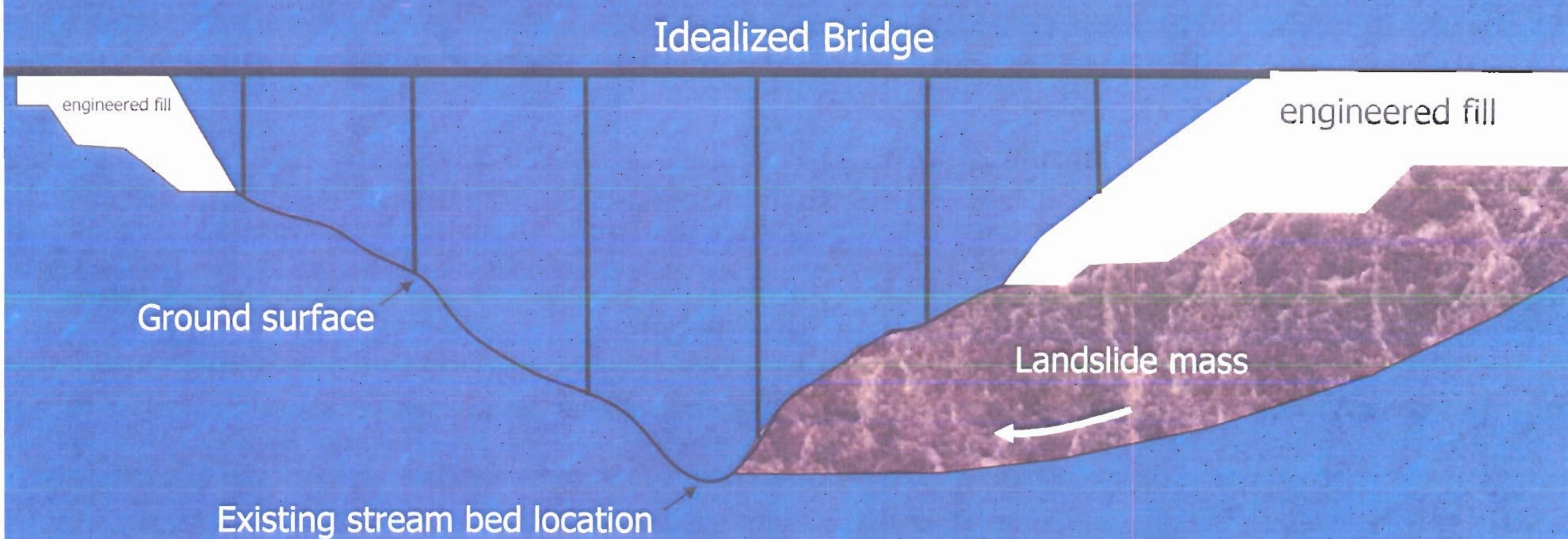


Conceptual landslide mitigation by buttressing

Not to scale

The current geotechnical issue before ODOT and YRC

Oregon Department of Transportation

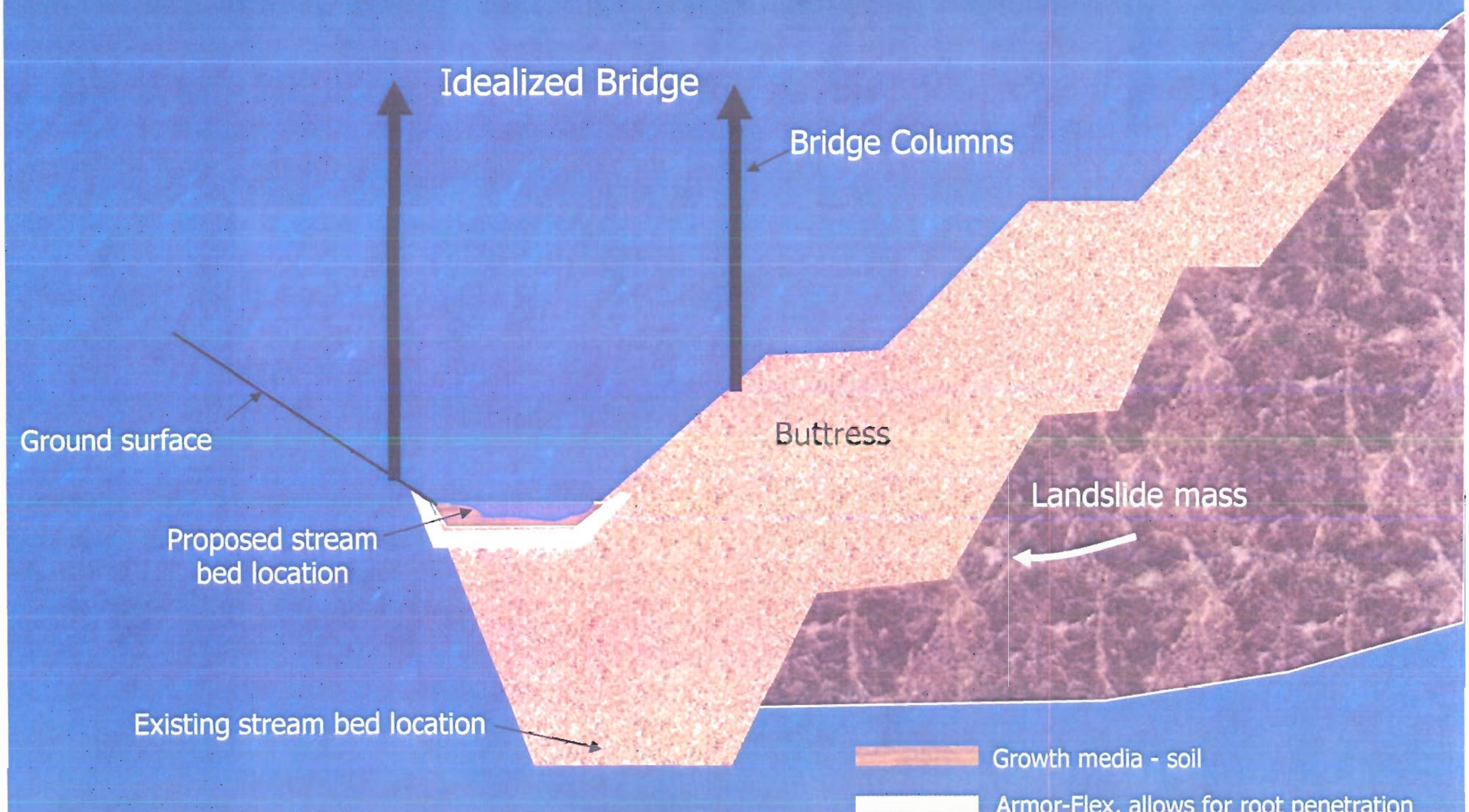
Conceptual landslide mitigation by buttressing

Not to scale

A potential solution

Stand-alone shear keys or drilled shafts eliminated due to constructability and cost

Oregon Department of Transportation

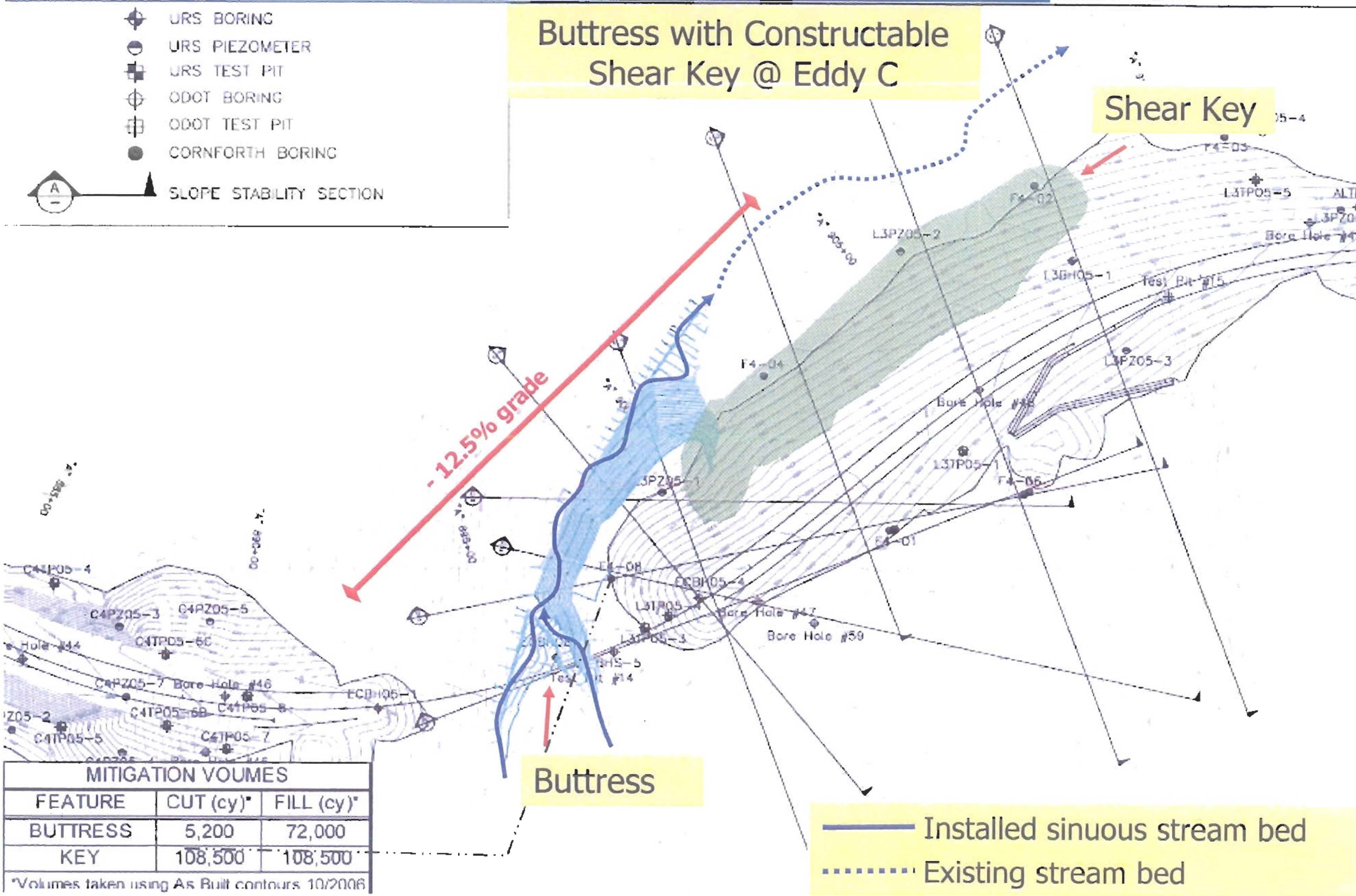


Conceptual landslide mitigation by buttressing

Not to scale

Oregon Department of Transportation

Buttress with Constructable Shear Key @ Eddy C



MITIGATION VOUMES		
FEATURE	CUT (cy)*	FILL (cy)*
BUTTRESS	5,200	72,000
KEY	108,500	108,500

*Volumes taken using As Built contours 10/2006

PB Americas, Inc.
400 SW Sixth Avenue, Suite 802
Portland, Oregon 97204

and

Oregon Department of Transportation
3700 SW Philomath Blvd
Corvallis, Oregon 97333

GEOTECHNICAL DATA REPORT – PHASE 2A
SUPPLEMENTAL GEOTECHNICAL INVESTIGATION

PIONEER MOUNTAIN TO EDDYVILLE SECTION
US ROUTE 20 RELOCATION DESIGN AND CONSTRUCTION

- **FILL 4 (EDDY CREEK TRIBUTARY C EAST)**
- **FILL 8 (CRYSTAL CREEK EAST)**
- **FILL 10 (COUGAR CREEK EAST)**

April 24, 2008

Cornforth Consultants, Inc.
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Portland, Oregon 97223

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1 INTRODUCTION

This report summarizes the supplemental geotechnical investigation completed at three priority landslide areas within the Pioneer Mountain to Eddyville Section of the U.S. 20 realignment project; and includes field reconnaissance, explorations, instrumentation and laboratory testing that were performed to address data gaps and concerns regarding design and construction. Further geologic interpretations are described in a follow-up Geotechnical Interpretation Report.

The project site is near Eddyville, Oregon, flanking the existing US Hwy 20, and extending approximately 7 miles to the west of Eddyville (Figure 1). The three priority areas included in this phase of the investigation are Eddy Creek Tributary C and D (Fill 4), Crystal Creek East (Fill 8), and Cougar Creek East (Fill 10).

1.1 Project Background

The Oregon Department of Transportation (ODOT) retained Yaquina River Constructors, JV (YRC) to provide Design-Build services for the realignment of US Highway 20 between Eddyville and Pioneer Mountain, MP 14.68 and 24.75, near Eddyville, Oregon. The project will replace a 10-mile stretch of existing highway a 7-mile section of highway with improved safety features and added passing lanes. The project includes 8 bridges, approximately 3.5 million cu yards of earthwork, and protection of over 20 waterways.

In May 2007, Cornforth Consultants Inc. (CCI) was retained by Parsons Brinkerhoff (PB) and ODOT to perform a prioritized review of existing geologic information, evaluate data and identify deficiencies, and develop a strategy to supplement the existing information. As part of this evaluation, CCI provided preliminary geologic reconnaissance and interpretation of landslide development. These preliminary studies provided the basis for evaluation of additional subsurface data and instrumentation needs. In July 2007, CCI was authorized by PB and ODOT to perform a supplemental geotechnical investigation. The resulting exploration and instrumentation program was designed to provide data to improve characterization of interpreted landslide areas for use in subsequent analyses and design, and for monitoring of subsurface conditions during and following design and construction.

In general, deep borings and inclinometer borings were needed to extend below potential deep shear zones and at least 30 feet into fresh bedrock. Piezometers were installed to measure groundwater pressure (or head) at and above the shear zone. Vibrating wire piezometers and dataloggers were installed in order to acquire a continuous time history of groundwater level fluctuations, and to measure artesian pressures if they exist. At a range of locations, piezometers were installed at several depths to measure groundwater pressure at multiple potential shear zones. In addition, vibrating wire piezometers and dataloggers were installed in select existing piezometer standpipes that had not been abandoned.

1.2 Scope of Work

This report provides the data developed by the CCI as part of the supplemental investigation into the geology and geotechnical conditions at the east approaches to the three priority bridge sites. The following provides an outline of the work tasks performed. Details are provided in following report chapters.

Task 1: Field Investigation

Reconnaissance: Performed geologic reconnaissance of the priority areas to observe ground morphology and outcrop of soil and bedrock. Interpretation of topography maps and historic aerial photographs was also performed as part of the reconnaissance.

Subsurface Investigation: Accessing and drilling exploratory boreholes, sampling of subsurface materials, and preparation of field boring logs. Additionally, down-hole video logging of select drill holes was performed to assist with interpretation of regional geology and landslide geometry.

Field Rock Strength Measurement: Performed point load tests on rock core specimens to determine index strengths of the varying rock types and weathering stages. Select samples were saved for verification of point load test results, by correlation with unconfined compressive strength testing (as discussed below).

Geotechnical Instrumentation: Monitoring instruments were installed in exploratory drill holes to measure ground movement and groundwater information, which may be used for design as well as monitoring of performance during construction and following. Instruments that were installed include: slope inclinometers, standpipe piezometers, and vibrating-wire pressure (VWP) transducers. The VWP's were installed in both standpipe piezometers and grouted in the annulus of several slope inclinometer boreholes.

Instruments Monitoring: Data from the VWP's have been collected on an approximate monthly basis beginning on November 1, 2007. Initial and secondary readings of the slope inclinometer casings have been measured.

Task 2: Laboratory Testing

Index Properties: Performed index property tests, including natural moisture content on all samples and Atterberg Limits to confirm field classification of soil.

Residual Strength: Performed multi-stage ring shear tests to measure residual friction angle of remolded soil specimens. Samples were chosen from various locations and depths at the three priority sites.

Overburden Soils Strength Testing: ODOT's Materials Laboratory, at the request of CCI, performed consolidated-undrained (CU) triaxial testing, with pore pressure measurements of relatively undisturbed samples of overburden materials. Gradation tests, dry density, and Atterberg limit tests were also performed on all triaxial test samples.

Rock Core Strength Testing: Unconfined compressive strength tests of rock core specimens were performed by both ODOT's Materials Laboratory and by the Colorado School of Mines Materials Testing Laboratory, in order to provide verification for point load strength tests performed in the field.

Task 3: Geotechnical Data Report
Write and submit a Geotechnical Data Report to convey the data results of the drilling and testing program.

Task 4: Presentation of Findings
Findings of the geotechnical investigation have been presented to PB, ODOT and representatives of YRC. Findings have been presented in: i) open workshop format with comments and discussion used to clarify geotechnical findings and to discuss issues relating to design, ii) Interim Memoranda that summarize monitoring results, and iii) submittal of draft summary boring logs and core photographs.

1.3 Project Summary

The additional geotechnical explorations, instrumentation, and geologic characterization have provided both confirmation of previous explorations, and the identification of additional information on geologic and landslide conditions. Explorations used an uncommon technique of coring through overburden materials which allowed for greater sample recovery in colluvium and slide debris. The benefit of this technique was recovery of a greater amount of material and the identification of additional potential shear zones in colluvium and weathered rock residuum. The laboratory testing program has offered additional data that can be incorporated into the existing strength assumptions to further refine analyses. Ring shear testing has provided broader base of potential residual strengths, which are in general agreement with ranges predicted by a few commonly accepted empirical relationships and by back-calculations. Open communication by CCI with ODOT and PB along with YRC and their consultants throughout the exploration and instrumentation program has allowed for a fast-tracked dissemination of data as it has become available and modification of exploration program to provide a further understanding of subsurface conditions.

2 SITE INFORMATION SOURCES

Reviewing available information and site reconnaissance was performed to develop an understanding of the geologic conditions in order to recommend an exploration program that would benefit the analysis and design of cuts, fills and embankments. Data that was included in the review included topography, aerial photographs, and geologic publications and geotechnical reports. The following is a brief description of the available data and a summary of pertinent information.

2.1 Topography and Ground Surface

Topography and ground surface information was used in the interpretation and measurement of geologic features, landforms and subsurface information. Topographic data included published USGS 7.5 minute topographic maps, and maps generated from LIDAR data that was measured for YRC during the construction pre-proposal work. The USGS 7.5 minute maps include the quadrangles Eddyville and Elk City, Oregon, which are published at a scale of 1-inch = 2,000 feet and 40-foot contour intervals. YRC used the LIDAR data to generate drawings of both shaded-relief ground surface and topography. Side hill shaded-relief maps had been generated at a scale of 1-inch = 200 feet, scanned copies of which are included in Appendix A. Topography maps generated from the LIDAR data included maps with contour intervals of 10-foot and 2-foot contour, which were suitable for printing at various scales. The 10-foot contour drawing was used as a base map for a Site Plan Index (Figure 2), and the 2-foot contour drawing was used for the different site plans (Figure 3, Figure 4 and Figure 5).

2.2 Aerial Photographs

Historic stereographic aerial photographs were researched through the Map Library at the University of Oregon in Eugene. The photography was reviewed at the library, and digital scans were made of photographs that were judged to be relevant in the assessment of slope stability along the realignment. Copies of the scan photographs are included in Appendix B, along with a list of all aerial photographs that were reviewed for relevance. Geologic interpretation of the stereographic aerial photographs was performed as part of the assessment and interpretation of slope stability, results of which will be available under separate cover in a Geotechnical Interpretation Report.

2.3 Published Geology

Geologic maps and reports used in the assessment of the geology and its slope stability issues are referenced below. Personal communications were also conducted between Charles M. Hammond, Cornforth Consultants, Inc., and Joshua J. Roering, Associate Professor, Department of Geologic Sciences, University of Oregon.

Heller, P.L., Peterman, Z.E., O'Neil, J.R., and Shafiqullah, M., 1985, Isotopic Provenance of Sandstones from the Eocene Tyee Formation, Oregon Coast Range: Geological Society of America Bulleting, v. 96, p. 770-780.

Lovell, J.P.B., 1969, Tyee Formation: Undeformed Turbidites and their Lateral Equivalents: Mineralogy and Paleography: Geological Society of America Bulletin, V. 80, p. 9-22.

Roering, J.J., Kirchner, J.W., and Dietrich, W.E., 2005, Characterizing Structural and Lithologic Controls on Deep-Seated Landslides: Implication for Topographic Relief and Landscape Evolution in the Oregon Coast Range, USA: Geological Society of America Bulletin, v. 117, no. 5/6, p. 654-668.

Schlicker, H.G., Deacon, R.J., Olcott, G.W., and Beaulieu, J.D., 1973, Environmental Geology of Lincoln County, Oregon: State of Oregon Department of Geology and Mineral Industries, Bulletin 81.

Simpson, R.W., and Cox, A., 1977, Paleomagnetic Evidence of Tectonic Rotation of the Oregon Coat Range: Geology, v. 5, p. 585-589.

Snavely, P.D., Jr., MacLeod, N.A., Wagner, H.C., and Rau, W.W., 1976, Geologic Map of the Yaquina and Toldeo Quadrangles, Lincoln County, Oregon: Department of the Interior, U.S. Geological Survey, Map I-867 (see Appendix C)

Walker, G.W., and Duncan, R.A., 1989, Geologic Map of the Salem 1 by 2 Quadrangle, Western Oregon: Department of the Interior, U.S. Geological Survey, Map I-1893.

Worona, M.A., and Whitlock, C., 1995, Late Quaternary Vegetation and Climate History near Little Lake, Central Coast Range, Oregon: Geological Society of America Bulleting, v. 107, no. 7, p. 867-876.

2.4 Previous Reports with Geotechnical Data

Numerous reports have documented geotechnical conditions along the realignment route, and many of the reports discuss slope stability issues in a relatively cursory manner. The following list includes only the geotechnical reports that contain references to specific slope stability issues that were used in assessment of the potential landslide conditions. The following technical reports include surface mapping, summary drill logs, laboratory testing results, instrument monitoring results, design parameters and other information including geotechnical recommendations.

Parsons Brinckerhoff Quade & Douglas, Inc., Oct. 20, 2004, Geotechnical Data Report, Pioneer Mountain – Eddyville Section, Corvallis-Newport Highway (US-20), Report prepared for Oregon Department of Transportation.

Parsons Brinckerhoff Quade & Douglas, Inc., Jan. 19, 2005, Addendum Geotechnical Data Report, Pioneer Mountain – Eddyville Section, Corvallis-Newport Highway (US-20), Report prepared for Oregon Department of Transportation.

Shannon & Wilson, Inc., 2005, Appendix 1, Supplementary Geotechnical Data: Report prepared for Kiewit Pacific Co.

URS, July 27, 2006, Memorandum to Norm Smit, Landslide Hazards Report Addendum.

URS, Nov. 17, 2006, Memorandum to Scott Nettleton, Preliminary Findings: US20 PME Cougar Creek Landslide

URS, Nov. 20, 2006, Memorandum to Scott Nettleton, Landslide Hazard Report Addendum No. 4, Eddy Creek Tributary "C" East Landslide Evaluation.

URS, Dec. 5, 2006, Memorandum to Scott Nettleton, Landslide Hazard Report Addendum No. 2, East Side Cut 4 Landslide.

URS, Dec. 5, 2006, Memorandum to Scott Nettleton, Landslide Hazard Report Addendum No. 3, Crystal Creek East Landslide Mitigation.

Yaquina River Constructors, Dec. 2005, Preliminary Foundation Report, Eddy Creek Tributary C Bridge, Bridge No. 20236, Pioneer Mountain to Eddyville Section Oregon Highway 0033 (US20), MP 16.96, Lincoln County: Report prepared for Oregon Department of Transportation.

Yaquina River Constructors, June 2006, Foundation Report, Crystal Creek Bridge, Bridge No. 20234, Pioneer Mountain to Eddyville Section Oregon Highway 0033 (US20), MP 15.93, Lincoln County: Report prepared for Oregon Department of Transportation.

Yaquina River Constructors, June 2006, Final Foundation Report, Cougar Creek Bridge, Bridge No. 20232, Pioneer Mountain to Eddyville Section Oregon Highway 0033 (US20), MP 14.24 (on realignment), Lincoln County: Report prepared for Oregon Department of Transportation.

Yaquina River Constructors, February 2006, Roadway Geotechnical Design Report, Pioneer Mountain to Eddyville Section Oregon Highway 0033 (US20), Lincoln County: Report prepared for Oregon Department of Transportation.

Yaquina River Constructors, July 2006, Roadway Geotechnical Design Report, Pioneer Mountain to Eddyville Section Oregon Highway 0033 (US20), Lincoln County: Report prepared for Oregon Department of Transportation.

Yaquina River Constructors, April 2006, Landslide Hazards Report, Pioneer Mountain to Eddyville Section Oregon Highway 0033 (US20), Lincoln County: Report prepared for Oregon Department of Transportation.

3 GEOLOGY

The project area is in the central area of the Coast Range geologic province, and the bedrock geology is primarily comprised of siltstone and sandstone of the Tyee Formation. The elevation of the project is generally between elevations 100 and 200 feet at the east end (Eddy Creek Tributary C East), 400 to 500 feet in the central area (Crystal Creek East) and 200 to 400 feet at the west end (Cougar Creek East). Adjacent to the project, the Coast Range rises up to elevation 1,400 feet on Barber Butte, which is about 4,000 feet to the south of Eddy Creek Tributary C.

In general, geologic materials along the highway realignment consist of alluvium along the creeks, colluvium on the slopes, and Tyee Formation bedrock that underlies the alluvium and colluvium. Tectonic forces that influence the geologic materials include uplift, tilting/folding, and faulting and fracturing. Weathering and erosion have also affected the geologic materials. The hill slopes vary generally from about 15 degrees up to 42 degrees.

3.1 Reconnaissance

Reconnaissance performed by geologists from CCI was completed between May and September 2007, and included ten days of ground reconnaissance. Walking reconnaissance was primarily focused on the three priority sites: the east approaches to the Eddy Creek Tributary C Bridge, Crystal Creek Bridge and Cougar Creek Bridge. Reconnaissance was also performed in areas adjacent to the three priority site areas to collect a broader geologic perspective.

3.2 Regional Geology

Bedrock is the Tyee Formation, Middle Eocene, and is on the order of 45 million years old in the area of the project. A copy of a portion of a regional geology map (Snavely et. al., 1976) is included in Appendix C. Photographs of surface outcrops of the Tyee Formation are shown in Figure 6. The Tyee Formation consists of marine sedimentary rocks that originated as turbidite and pelagic sediments that were deposited in relatively deep water on a ramp distal from the continent. The total thickness of the formation is reported to have been on the order of 5,000 feet. Individual turbidite layers consist of basal sandstone that fines upward into siltstone. Occasionally on the top of the siltstone is deep sea pelagic deposits of shale. Basaltic dike intrusion(s) are also noted to occur in the region: one outcrop of a weathered basalt dike was observed in Cut 6 southeast of the Cougar Creek East area.

The bedrock is slightly tilted and faulted due to tectonic forces during Miocene and into Pliocene. Published mapping of bedding identified the dip and dip direction of the bedrock layering at about 12 degrees to the north-northwest (Snavely et. al., 1976). The tectonic uplift has apparently been relatively constant since Miocene at about 0.05 to 0.2 mm per year (Kelsey et. al., 1996, from Roering et. al., 2004). Regional faults mapped around the project have trends of west-northwest to northwest (Snavely et. al, 1976). No faults had been previously mapped along the realignment; however, fracture zones, likely associated with faulting, have been identified in the new and temporary road cuts.

Erosion of Oregon Coast Range has apparently been relatively constant at about 0.1 mm per year and a little higher (summarized in Roering et. al., 2004). Over 3,000 feet of the Tyee Formation is estimated to have been eroded in the project area (Roering, P.C.).

3.3 Site Geology

Alluvium. Deposits of alluvium occur along creeks and form narrow floodplains. The material consists of silt, sand and gravel and often contains abundant organics. The alluvium is likely a deposit of reworked debris flows that have occurred in the drainages over geologic time.

Colluvium. Colluvium mantles most of the slopes in the area. Photographs of surface outcrops of the colluvium are shown in Figure 7. It typically consists of an intermixed mass of silty sand with gravel-sized fragments of weathered rock, and it may be slightly clayey or cohesive. It also contains a small percentage of carbonaceous material, which often occurs as $^1/_8$- to $^1/_2$-inch pieces of burnt wood. Colluvium is often confused with landslide debris, because both can be a deposit produced by downslope creep. What differentiates the two is the presence of a zone of shear movement that underlies the landslide debris, and if the slide has been dormant for a sufficient period of time, surficial processes can make it difficult to recognize the presence of a slide. The thickness of colluvium is expected to be highly variable, and in areas that do not contain landslides it would be expected to occur in layers of maybe 5 to 10 feet and thicker in local pockets.

Landslide Debris. Landslide debris, in the three priority areas, occurs in two general types, which include an upper unit that is similar to colluvium and a lower unit of variably weathered rock. Detailed geotechnical engineering characteristics of these materials are described in Chapter 5, Subsurface Conditions.

Geologically, the colluvial/slide debris typically consists of an intermixed mass of silt, sand and gravel- to boulder-sized fragments of weathered siltstone and sandstone, and it may be slightly clayey in local areas. Photographs of surface outcrops of the colluvium/slide debris are shown in Figure 7.

The weathered rock slide debris varies from slightly weathered and slightly extended or dilated to highly weathered and extensively dilated. It appears as if landslide movement has sheared the siltstone beds, and pulled apart and crushed the sandstone beds. Individual sheared zones are evident along different siltstone beds; therefore, it contains multiple potential shear zones. Sandstone beds within the weathered rock slide debris are often evident as stringers of sandstone boulders with crushed material between the boulder and sheared material immediately above and below the boulders. Photographs of surface outcrops of the weathered rock slide debris are shown in Figure 8, Figure 9, Figure 10 and Figure 11.

A third slide debris material unit, which does not appear to occur in the immediate areas of the three priority sites, is sequences or zones of intermixed and crushed or extremely fractured rock, including both the siltstone and sandstone. The original bedding in the bedrock is not evident in this unit. Photographs of surface outcrops of the crushed rock slide debris are shown in Figure 12.

Bedrock. In the project area, the Tyee Formation bedrock consists of sandstone and siltstone in roughly equal amounts. Individual sandstone beds range in thickness from 0.1 to 16 feet (typically 1 to 8 feet), and siltstone beds range from 0.1 to 10 feet thick (typically 0.5 to 5 feet). Shale is a relatively minor constituent of the bedrock, and is typically less than 1-foot thick and usually considered part of a siltstone layer.

Sandstone is typically massive with no or limited cross bedding or internal layering, and is typically gray in color. The sandstone appears to consist almost entirely of fine-grained sand, but is also contains oblong pieces of siltstone, ranging from a few inches to a couple feet in length, apparently due to "rip-up" of silt sediment as a turbidite currents scour and deposit.

Siltstone ranges from massive to thinly-laminated and is typically dark gray in color. Laminations are typically parallel, but are often convoluted, which is likely due to soft sediment deformation that occurred early in the consolidation process. The siltstone is formed of fine sand-, silt- and clay-sized sediment particles.

The sedimentary particles that from the rocks do not appear to be cemented; however, a microscopic examination has not been performed to confirm that no cementing material is present. The sediments appear to be consolidated, or lithified, into a soft rock.

Structural discontinuities in the bedrock are separations along bedding separations, and tectonic joints and fracture zones. Based on hand measurement on bedrock outcrops, the bedding dips about 15 degrees in the direction of Azimuth 330 to 340 degrees, and appears relatively consistent across the project area. Tectonic fracture zones/faults were observed at two locations in the temporary haul road cut on the west side of Crystal Creek and at three locations in Cut 1. One of the Crystal Creek and all of the Cut 1 fractures dip 70 to 85 degrees in the direction of Azimuth 230 degrees, and the second Crystal Creek fracture zone dips 75 degrees in the direction of Azimuth 100 degrees. Figure 13 provides photographs of apparent tectonic fractures.

Weathering and Erosion. Processes of weathering and erosion have affected the geologic materials. Weathering is physical disintegration and chemical decomposition of bedrock that breaks it down into sedimentary particles. Erosion carries the sedimentary particles from one location to another, which includes landslide activity. The multiple processes of both weathering and erosion were not considered an integral part of the data needed to evaluate potential landslide conditions along the project; however, the results of the processes are the landforms that are visible in the field and on topography and Lidar imagery. Over geologic time and during the tectonic uplift, erosion is reported to have moved or removed over 3,000 feet of the Tyee Formation in the area of the project.

4 SUBSURFACE INVESTIGATION

4.1 Geotechnical Explorations

The field exploration program was based on review of available information and field reconnaissance. Conceptual models for each of the sites were created and used to determine areas where additional information and sampling were necessary to collect data for the contingency investigation, characterization of potential slope stability issues, and development of remediation alternatives. Drill holes were advanced to collect samples and provide subsurface information to characterize and interpret landslide areas for use in subsequent analyses and design.

In general, due to unknown landslide conditions, deep borings were extended at least 30 feet into fresh bedrock in an attempt to extend below the potential deepest shear zones. Drilling activities were directed by on-site engineers, and were coordinated by a Senior Associate Geologist, all personnel from CCI. Daily contact was maintained between field personnel and office management staff to provide feedback and tracking of exploration progress.

The subsurface exploration program consisted of 31 borings, which included 22 exploratory borings and 9 fast-drilled companion borings. These borings were completed at three priority sites, designated Eddy Creek (Fill 4), Crystal Creek (Fill 8) and Cougar Creek (Fill 10). The locations of the borings are shown on Figure 3, Figure 4 and Figure 5, and a list of the borings with YRC survey data is summarized on Table 1. Due to the relative accuracy of drill sampling, subsurface depths and elevations on the Summary Boring Logs are rounded to the nearest ½-foot.

In addition to the 31 borings, three extra borings were drilled adjacent to F4-01, F4-06 and F8-05 specifically to collect undisturbed thin-walled samples of colluvial materials for laboratory testing. These borings are identified as F4-01B, F4-06B and F8-05B, respectively.

ODOT drill crews performed a series of exploratory borings using a rubber-tire mounted CME 75 drill rig between July 30 and August 9, 2007 and a track-mounted CME 850 drill rig between March 10 and 20, 2008. Boart Longyear, of Tualatin, Oregon, performed the remainder of the exploratory borings between August 20 and February 12, 2008. Boart Longyear utilized both a rubber-tired mounted CME 85 and a track-mounted CME 850 drill rig.

All exploratory borings were continuously sampled with HQ3 coring techniques. Companion standpipe piezometers were quick-drilled using either HQ3 coring techniques or HWT Casing Advancer. A representative from CCI was onsite with each drill rig to coordinate the operation, log and sample the subsurface materials, collect core box photographs, and assist with the installation of instrumentation.

Standard Penetration Tests (SPT) were performed in the exploratory borings at approximately 5-foot intervals through the overburden materials. The SPT sampler consisted of a 2-inch O.D. split-spoon, with a recessed I.D. (without liners), driven by a 140-lb auto-trip hammer. Continuous samples were obtained throughout the exploratory hole with triple barrel coring techniques. The quality of bedrock materials was recorded using Rock Quality Designation (RQD) and core recovery indices.

Relatively undisturbed samples were also collected in companion quick-drill holes, using 3-inch diameter thin-walled Shelby tubes. Drilling methods, sampling depths, total drill hole depths, and descriptions of the soil and rock material encountered are provided on the Summary Boring Logs in Appendix D, Appendix E and Appendix F. Photographs of the core boxes are also included along with the Summary Boring Logs in Appendix D , Appendix E and Appendix F.

4.2 Instrumentation

A summary of the instrument installation depths is provided on Table 2, and the as-built details are included on the Summary Boring Logs (Appendix D, Appendix E and Appendix F). Instrumentation data is referenced to the surveyed ground surface elevation.

Slope inclinometer casings were installed in 16 borings. The inclinometers consist of 10-foot long, 2.75-inch O.D. Slope Indicator casings with quick-connect couplings. The annular space between the inclinometer casing and the boring sidewall was backfilled with cement-bentonite grout. Each inclinometer was capped with an above ground monument embedded in concrete. In general, the HQ borehole diameter was increased by over reaming with HWT casing advancer techniques (5-inch diameter) to allow tremie grouting of annular space.

Standpipe piezometers (SPPs) were installed at 13 locations. The SSP tips consist of 5- and 10-foot long, threaded, 1-inch O.D., 0.010-inch slot PVC tips connected to a 1-inch O.D., solid PVC riser pipe. The annular space between the slotted tip and the boring sidewall was backfilled with No. 10-20 silica sand to approximately 1 to 2 feet above the top of the screen. The remainder of the hole was sealed with bentonite chips to the surface and capped with an above ground monument. Guard posts were installed adjacent to the monuments for additional surface protection.

Geokon model 4500B vibrating wire piezometers (VWPs) were installed in all 13 of the standpipe piezometers and alongside eight of the inclinometer casings. Those installed in SSPs were secured at depths near the tip bottom. Those installed with inclinometers were grouted into the annular space on the outside of the SI casing at specified depths. Geokon model 8002 (LC-2) single channel data loggers were installed on all of the VWP installations. The data loggers were initially configured to record measurements every 4 hours. One of the VWPs, installed in F8-07, solely measures barometric pressure in order to correct the readings for changes in barometric conditions.

4.3 Crux Oriented Borehole Logging

Downhole imagery was collected with Crux Oriented Borehole Logging (COBL) to assist with interpretation of regional geology and landslide geometry. The COBL system logs in-situ conditions on the outside of the drill hole that might not have been recovered or recognizable in the HQ core sampling (degree of rock disturbance, shear zones, possible tectonic faults, bedding orientation and dip, etc.). Crux Subsurface, Inc., from Spokane, Washington provided the specialized video-logging equipment and operator. Downhole logging of five borings was performed. The locations of the videologs are:

- F4-04 at Eddy Creek

- F8-06 and F8-05 at Crystal Creek
- F10-01 and F10-05 at Cougar Creek

COBL logging was performed on prepared drill holes, where the upper overburden zone had been cased off to minimize caving prior to and during video logging. COBL collects video images of the borehole sidewalls using optical and/or acoustic televiewers. The optical system provides a continuous and oriented color image of the borehole wall using a probe equipped with an optical viewer, along with electronic compass and dipmeter. For Boring F4-04, an acoustic televiewer was used due to the presence of murky water in the open borehole. Subsequent interpretation and analysis of the image provides dip and dip direction information for identified planar features (discontinuities) through statistical curve fitting methods. The results of the downhole imaging are included in Appendix G. A representative from CCI was present throughout COBL operations to provide direction and oversight. Office assessment of the COBL data included a preliminary interpretation of the difference between depositional features (bedding, interlayers, soft sediment deformation) and post-depositional or tectonic structures (joints, fractures, faults).

Table 1 Boring Survey Location, Elevation and Depth

Boring No.	Location[a]				Elevation[a] (ft)	Drill Depth (ft)
	Station	Offset	Northing	Easting		
F4-01	902+36.7	109.6 RT	371067.2	7346515	252.7	112.5
F4-02	907+90.2	276.5 LT	371730.2	7346776	154.0	99
F4-03	910+93.8	249.3 LT	371825.8	7347123	149.5	80
F4-04	902+44.4	269.0 LT	371367.0	7346283	189.8	109
F4-05	913+57.5	56.4 RT	371560.1	7347436	259.3	122
F4-06	904+76.6	211.2 RT	371141.4	7346760	277.5	145
F4-07	904+89.1	213.6 RT	371146.7	7346770	277.1	70
F4-08	897+62.6	121.0 LT	370978.5	7346006	221.1	80
F4-09	902+45.4	109.6 RT	371072.4	7346522	252.5	88
F4-10	902+48.6	111.2 RT	371075.0	7346524	252.2	25
F8-01	848+23.1	54.3 RT	373165.9	7342016	470.0	126
F8-02	844+41.8	70.9 RT	373320.2	7341667	392.4	106
F8-03	844+40.8	75.7 RT	373316.4	7341664	392.4	55
F8-04	849+23.9	68.9 RT	373231.5	7342161	483.4	121
F8-05	850+67.1	181.2 RT	372943.9	7342178	503.5	137
F8-06	844+06.6	110.6 LT	373498.5	7341716	359.9	85
F8-07	850+67.3	174.8 RT	372949.5	7342181	503.1	62.5
F8-08	845+79.0	200.1 LT	373502.2	7341910	396.6	116
F8-09	844+02.2	114.9 LT	373504.3	7341714	359.5	45
F8-10	845+80.9	195.9 LT	373497.5	7341910	397.1	87
F8-11	842+95.7	230.8 RT	373241.9	7341465	335.0	51
F8-12	843+75.1	399.4 LT	373771.3	7341816	343.8	73.5
F8-13	842+13.6	331.1 LT	373781.8	7341641	320.7	79.7
F8-14	844+03.2	327.0 LT	373693.9	7341809	348.0	71.7
F10-01	793+46.2	151.4 LT	376426.6	7337833	193.0	100
F10-02	794+52.4	288.1 LT	376411.0	7338011	176.4	78
F10-03	797+78.2	78.1 LT	375940.9	7338077	261.3	100
F10-04	796+52.8	68.8 RT	375961.9	7337885	277.1	77
F10-05	799+53.0	230.5 RT	375705.3	7337864	323.9	100
F10-06	799+42.2	225.6 RT	375717.0	7337862	323.1	34
F10-07	793+43.9	169.0 LT	376437.2	7337847	192.4	45.0

Notes: a) Stationing, Offset, Northing, Easting and Ground Surface Elevation are rounded to the nearest 0.1 feet in feet. Survey data provided by YRC.

Table 2 Boring Instrumentation Data

Boring No.	Elevation[a] (ft)	Drill Depth (ft)	Instrumentation Depth (ft)[b] SI	VWP	SPP
F4-01	252.7	112.5	112.5	-	-
F4-02	154.0	99	99	35.0	-
F4-03	149.5	80	80	43.0	-
F4-04	189.8	109	109	48.0	-
F4-05	259.3	122	122	90.0	-
F4-06	277.5	145	145	-	-
F4-07	277.1	70	-	70.0	71.0
F4-08	221.1	80	80	52.6	-
F4-09	252.5	88	-	88.0	89.5
F4-10	252.2	25	-	26.0	26.5
F8-01	470.0	126	-	84.0	85.0
F8-02	392.4	106	106	-	-
F8-03	392.4	55	-	55.0	55.8
F8-04	483.4	121	-	90.0	102.3
F8-05	503.5	137	137	-	-
F8-06	359.9	85	85	-	-
F8-07	503.1	62.5	-	58.0	60.0
F8-08	396.6	116	116	-	-
F8-09	359.5	45	-	44.2	44.4
F8-10	397.1	87	-	84.0	85.6
F8-11	335.0	51	-	-	-
F8-12	343.8	73.5	73.5	23.2	-
F8-13	320.7	79.7	79.7	31.5	-
F8-14	348.0	71.7	-	-	-
F10-01	193.0	100	100	-	-
F10-02	176.4	78	78	20.0	-
F10-03	261.3	100	-	18.0	18.2
F10-04	277.1	77	-	41.0	42.2
F10-05	323.9	100	100	-	-
F10-06	323.1	34	-	33.5	34.8
F10-07	192.4	45.0	-	45.0	45.4

Notes: a) Ground Surface Elevation are rounded to the nearest 0.1 feet. Survey data provided by YRC.

b) Slope inclinometer casing depths are from the ground surface. Vibrating wire piezometer depths are the tip of the transducer from the top of casing. Standpipe piezometer depths are from the tip of the casing to the top of the casing.

5 SUBSURFACE CONDITIONS

5.1 Subsurface Materials

Exploratory borings encountered materials that are separated into four geotechnical engineering units identified as alluvium, colluvium/slide debris, weathered rock slide debris, and Tyee Formation. In addition, three borings at Crystal Creek East (Fill 8) encountered fill materials overlying the natural subsurface material, Summaries of the material geotechnical descriptions are provided in the following paragraphs, and detailed descriptions of the subsurface materials are included on the Summary Boring Logs (Appendix D , Appendix E and Appendix F). The geology of the subsurface materials was provided in previous sections of this report: 3.2 Regional Geology and 3.3 Site Geology.

Fill

Borings F8-01, F8-04, and F8-05 encountered fill materials to depths of 11 to 30 feet, which generally consisted of medium stiff to stiff, sandy, slightly clayey silt. This fill was likely placed during the 2006 construction. Organic materials were mixed in at the base of the fill and top of the underlying soil. Additionally, a few other borings encountered a thin layer of fill (less than 5 feet) used to create drill access pads.

Alluvium

One boring at Eddy Creek Tributary C (F4-02) encountered a 1-foot layer of sand and rounded gravel with organics buried beneath 32 feet of colluvium/slide debris. It consisted of loose to medium dense, silty sand with occasional rounded gravel and organics.

Colluvium/Slide Debris

Material characterized as colluvium/slide debris is encountered in all borings, with thicknesses that ranged from 10 to 30 feet at Fill 4, 15 to 45 feet at Fill 8, and 5 to 35 feet at Fill 10. This material generally consisted of intermixed medium stiff, clayey silt and loose to medium dense silty sand. Often the material is characterized as having a diced texture with coarse sand- to gravel-sized fragments of siltstone and sandstone in a matrix of silty sand to clayey silt. The "diced texture" and coarse-grained material in a matrix of similar material indicates where it has been crushed and broken into remnants of the siltstone and sandstone bedrock. Occasionally this unit contains sand- to fine gravel-sized pieces of carbonaceous material, likely due to intermixing of organic material during sediment transport and deposition. Wet clayey sheared zones were occasionally observed within the slide debris, indicative of past shearing within the unit.

Weathered Rock Slide Debris

Underlying the colluvium/slide debris at most of the boring sites is a layer of weathered and dilated Tyee Formation. This material generally consists of moderately to highly weathered beds of extremely soft (R0) to very soft (R1) siltstone/shale, and very soft (R1) to soft (R2) sandstone, both of which exhibit progressive degrees of extension or dilation. The rock can be very highly to moderately fractured. It also contains specific zones of stiff, sandy, slightly clayey silt that is often sheared and diced. These shear zones coincide with the top of the siltstone/shale beds, and vary from

4 feet thick down to less than 1-inch thick. The thicker zones often contain sand- to gravel-sized pieces of siltstone/shale.

Tyee Formation

Underlying the slide debris is in-place rock (bedrock) of the Tyee formation, which includes primarily siltstone and sandstone, with some shale. All of the exploratory borings terminated in this unit. In-place siltstone is a fresh dark gray color and a soft rock (R2). It occasionally separates along thin, parallel layering, which is associated or parallel to the bedding within the Tyee Formation. The siltstone is typically slightly fractured, but can also be moderately to highly-fractured. Portions of the siltstone have a tendency to slake into coin-sized chips of soft rock when it dries, which is likely to coincide with siltstone containing a higher percentage of clay particles.

In-place sandstone is a fresh gray color and ranges from a soft to a medium hard rock (R2 to R3). Its fracture characteristic is typically massive, but it occasionally contains isolated zones of highly fractured material. Small pockets of siltstone (rip-up clasts) are occasionally contained within the sandstone.

In-place shale is a fresh dark gray to near-black color, and a very soft to soft rock (R1 to R2). It has a tendency to slake relatively quickly into small coin-sized chips.

Fractures in the bedrock are typically at a low angle (near perpendicular to the access of the core), and are roughly parallel to bedding or layering. Occasionally, fractures are at moderate to high angles and cut across the bedding.

5.2 Groundwater Data

Groundwater data has been recorded in dataloggers that have been configured to record data at four hour intervals. Data from all installations have been uploaded periodically in late 2007 and early 2008 as part of the monitoring program. Charts of groundwater depth below ground surface for each instrument, along with precipitation data provided by PBS Environmental, are included in Appendix H. Calibration sheets for the VWPs are also included in Appendix H. Refer to Summary Boring Logs in Appendix D , Appendix E and Appendix F for instrument as-builts, ground surface elevation and subsurface material descriptions.

5.3 Slope Inclinometer Data

Manual baseline readings of the SIs were collected shortly after instrument installation. Second sets of readings were collected in early December 2007, and subsequent readings were collected in January, February, March and April 2008. Charts of instrument deflection are included in Appendix I. Refer to Summary Boring Logs in Appendix D, Appendix E and Appendix F for instrument as-builts, ground surface elevation and subsurface material descriptions.

6 LABORATORY TESTING

Laboratory testing was performed in general accordance with ASTM Laboratory Testing Procedures. Tests were performed on selected samples collected during field explorations to verify field classifications and to estimate soil and rock characteristics and strength. The tests included:

- Natural moisture contents (included on the Summary Boring Logs),
- Atterberg limits,
- Ring shear strength,
- Compaction tests,
- Consolidated-undrained triaxial test with pore pressure measurements,
- Unconfined compressive strength tests, and
- Point load index.

The laboratory results were performed by Cornforth Consultants, ODOT Materials Laboratory and the Colorado School of Mines (CSM) Earth Mechanics Institute. The laboratory tests are described below and the results are presented in Appendix I.

6.1 Soil and Rock Classification

Soil and rock core samples were visually re-examined to further classify and confirm field observations. CCI's soil classification system is a modified United Soil Classification System (USCS), which uses augmented descriptors appropriate for the particular soil. The objective of the soil classification is to accurately describe the soil behavior. Coarse-grained soils are characterized by their particle size distribution. Fine-grained soil classification is based on field tests and is checked with laboratory index tests. Rock classification system generally follows ODOT's rock classification guidelines. Further details of the descriptors used in classification of soil and a key to terms used is included as in Appendix D. Together with the results of additional laboratory testing, soil descriptions were prepared and are presented on the Summary Borings Logs, included as Appendix D, Appendix E, and Appendix F.

6.2 Atterberg Limits

Liquid and plastic limits (Atterberg limits) were determined for 24 samples in general accordance with ASTM D 4318 laboratory test procedures. Results of all Atterberg limits tests are summarized in Table 3. CCI performed Atterberg limit tests on representative samples of possible shear zone materials at varying depths and locations at the three priority sites. Test results for these Atterberg limits are plotted on Plasticity Charts included in Appendix J. ODOT's Material Laboratory performed Atterberg limits tests on 10 samples of overburden material. Corresponding triaxial tests, natural moisture content and in-situ density tests were performed on these samples. Results of ODOT's laboratory testing program are included in Appendix K.

6.3 Ring Shear Strength

Ring shear strength tests were conducted on 15 samples collected on materials characteristic of possible shear zones (see Table 4 for locations and depths) and at shear zone exposures of local slides at locations STA 798+65 105′ LT and STA 898+00 75′ RT. Atterberg limits tests were performed on all ring shear samples. Ring shear specimens generally consisted of fat clay to clayey silt. Results of ring shear tests were compared to generally-accepted empirical relationships between index properties (Atterberg limits) and residual strengths. Empirical relationships included those proposed by Stark and Eid (1994) and Voight (1973).

Testing procedures were in general compliance with ASTM D-6467. Each specimen was remolded into the ring-shear apparatus. Tests were generally performed at 6.1 and 3.1 tsf confining pressure to simulate the range of in-situ and expected confining stresses along the shear zone. Following consolidation, samples were pre-sheared at a rate of 3 degrees/min, for approximately 15 to 30 minutes, resulting in a displacement of 1.3 to 2.6 inches. Following pre-shear the displacement rate was reduced to 0.024 degrees/min and allowed to run until reaching residual strength (usually a period of at least 12 hours and sometimes as much as 48 hours). Residual shear strength test results indicated an effective residual phi, ϕ'_r, between 8 and 22 degrees. The residual shear strength results, locations and depths are summarized in Table 4 and included in Appendix J.

6.4 Compaction

A compaction test was performed on sample of sandy silt to silty sand (SM-L) retrieved from a fill area in Fill 8 (Crystal Creek area). Compaction testing was performed in accordance with ODOT and ASTM specifications for Standard Proctor (ASTM Test Method D698, Method B). The results of the compaction test are included in Appendix J.

6.5 Consolidated Undrained Triaxial Tests

Consolidated-Undrained triaxial tests were performed on 10 samples. All tests were performed with pore pressure measurements to determine effective stress strength parameters, test each included three loading stages. ODOT's Materials Laboratory performed testing of selected samples overburden materials (representing colluvium and residuum) from various depths and locations at the three priority sites. Results of ODOT's testing as summarized in Table 5 and included in Appendix K.

6.6 Point Load Index Tests

Point load strength index tests were performed on selected rock samples. The results summarized in Table 6 and included in Appendix J, were used to estimate the unconfined compressive strength by subjecting the rock samples to an increasing concentrated point load, applied through a pair of truncated, conical platens, until failure occurred. The tests were performed in accordance with ASTM D 5731-95. One hundred twenty six (126) tests were performed on specimens of fresh sandstone and siltstone and weathered sandstone.

Point load test results require the input of a site-specific calibration factor to determine the

Table 4 Residual Shear Strength

Boring	Core Run	Depth (ft)	Residual Shear Strength, ϕ'_r (°)
STA 898	RT	Surface Sample	14.6
F4-01	R-5	24.0-24.5	12
F4-03	R-9	42.5-43.0	12
F4-04	R-16	77.8-78.8	22
F4-05	R-18	88.0-92.0	16
F4-06	R-20	87.6-88.0	12
F4-08	R-7	31.0-31.6	15
F8-04	R-19	94.2-94.5	14
F8-05	R-12	54.0-54.5	9
F8-06	R-7	28.6-28.8	11
F8-08	R-18	85.0-86.0	8
STA 798+65	105' LT	Surface Sample	17
F10-01	R-7	34.3-34.5	13
F10-04	R-5	24.5-25.0	12
F10-05	R-4	19.0-20.0	16

Table 5 Triaxial Test Shear Strength

Boring	Sample No.	Depth (ft)	Total Stress		Effective Stress	
			ϕ (°)	c (psf)	ϕ' (°)	c' (psf)
F4-01B	S-1	5-7	21	450	35 ½	290
F4-01B	S-3	10-12	16 ½	790	26	630
F4-06B	S-1	10-12	19 ½	470	37	170
F4-06B	S-3	15-17	20 ½	300	38	90
F4-06B	S-5	20-22	19 ½	1440	34 ½	500
F8-05B	S-1	20-22	23	580	36 ½	450
F8-05B	S-3	30-31	26	1080	37 ½	550
F10-07	S-1	15-16 ½	25	900	38 ½	520
F10-07	S-3	20-22	18 ½	1310	33	500
F10-07	S-5	25-27	19	1710	33 ½	550

unconfined compressive strength. The results of point load index strength tests were compared to the unconfined compressive strength tests (see Section 6.7) by ODOT and CSM to determine appropriate correlation factors. The unconfined compressive strength, correlation factors and resulting point load test strengths for the calibration samples are shown in Table 7.

6.7 Unconfined Compressive Strength Tests

Unconfined compressive strength (UCS) tests were performed on five representative samples of siltstone and sandstone to provide calibration and verification of point load strength index tests. UCS tests were performed by the ODOT Materials Laboratory. An additional five tests were performed during subsequent studies by both ODOT and the Colorado School of Mines (CSM) Earth Mechanics Institute. In general, the ODOT and CSM test results are in general agreement. For the softer siltstone material, the ODOT laboratory testing procedures tended to result in slightly lower strength values than the CSM test method. Laboratory test results are summarized in Table 7 and included in Appendix K and Appendix L.

Table 3 Atterberg Limits

Boring	Core Run	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index
STA 898	RT	Surface Sample	61	25	36
F4-01	R-5	24.0-24.5	46	21	25
F4-03	R-9	42.5-43.0	67	21	46
F4-04	R-16	77.8-78.8	66	15	51
F4-05	R-18	88.0-92.0	46	21	25
F4-06	R-20	87.6-88.0	57	25	32
F4-08	R-7	31.0-31.6	58	27	31
F8-01	R-13	59.8-60.2	51	29	22
F8-04	R-14	66.5	56	29	27
F8-04	R-19	94.5	60	24	36
F8-05	R-12	54.0-54.5	62	31	31
F8-05	R-12	54.5-54.7	59	32	27
F8-06	R-7	28.6-28.8	63	36	27
F8-08	R-13	62.5	51	22	29
F8-08	R-18	85.0-86.0	61	26	35
STA 798+65	105' LT	Surface Sample	77	45	32
STA 798+65A	105' LT	Surface Sample	53	36	17
STA 798+65B	105' LT	Surface Sample	73	48	25
F10-01	R-7	34.3-34.5	54	23	31
F10-02	R-2	9.0-9.4	47	21	26
F10-04	R-5	24.5-25.0	52	20	32
F10-04	R-10	51.3-51.7	42	19	23
F10-05	R-4	19.0-20.0	77	32	45
F10-05	R-6	25.0-26.0	57	24	33

Table 6 Point Load Test Summary

Area	Material Type	Axial Test (psi)				Diametral Test (psf)			
		#	Avg	Min	Max	#	Avg	Min	Max
Eddy Ck	Fresh Sandstone	9	3480	2010	6980	8	2890	1720	4530
Trib. C	Wxd. Sandstone	4	1830	780	2520	4	1960	1470	2430
	Fresh Siltstone	8	1370	800	2320	6	1390	860	1720
Crystal	Fresh Sandstone	6	4440	2670	8280	7	4300	3160	6200
Ck	Wxd. Sandstone	1	2250	2250	2250	3	500	470	530
	Fresh Siltstone	8	1920	470	4300	5	1710	1210	2040
Cougar	Fresh Sandstone	4	5650	3680	8220	5	4240	1400	6200
Ck	Wxd. Sandstone	2	1770	1000	2540	1	2200	2200	2200
	Fresh Siltstone	9	1170	400	1760	9	1080	370	1970
All	Fresh Sandstone	19	4240	2010	8280	20	3720	1400	6200
Sites	Wxd. Sandstone	7	1870	780	2540	8	1440	470	2430
	Fresh Siltstone	25	1475	400	4300	20	1330	370	2040

Table 7 Unconfined Compressive Strength Calibration Test Summary

			UCS		Point Load	
Boring	**Depth (ft)**	**Material Type**	**ODOT (psi)**	**CSM (psi)**	**C**	**δ_{uc} (psi)**
F4-02	35.2-36.1	Wxd. Sandstone	1900	-	13	380
F4-04	26.9-28.0	Fresh Siltstone	1280	-	12	1340
F8-05	74.9-76.3	Fresh Sandstone	3130	-	16	3220
F10-01	35.9-37.3	Wxd. Sandstone	2600	-	13	2540
F10-02	26.5-27.9	Fresh Siltstone	3800	-	12	1690
C7-01	94.0-94.8	Fresh Sandstone	4760	4920	16	4370
C7-02	53.8-54.6	Fresh Sandstone	2810	3250	16	3100
C7-04	174.0-174.6	Fresh Siltstone	900	1740	12	1810
C7-05	122.6-123.5	Fresh Siltstone	1310	2320	12	2270
C7-07	58.3-59.0	Fresh Siltstone	1630	2950	12	1840

Limitations in the Use and Interpretation of This Geotechnical Report

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject facility and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive boring and test pit logs, cross-sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory borings, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory borings and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

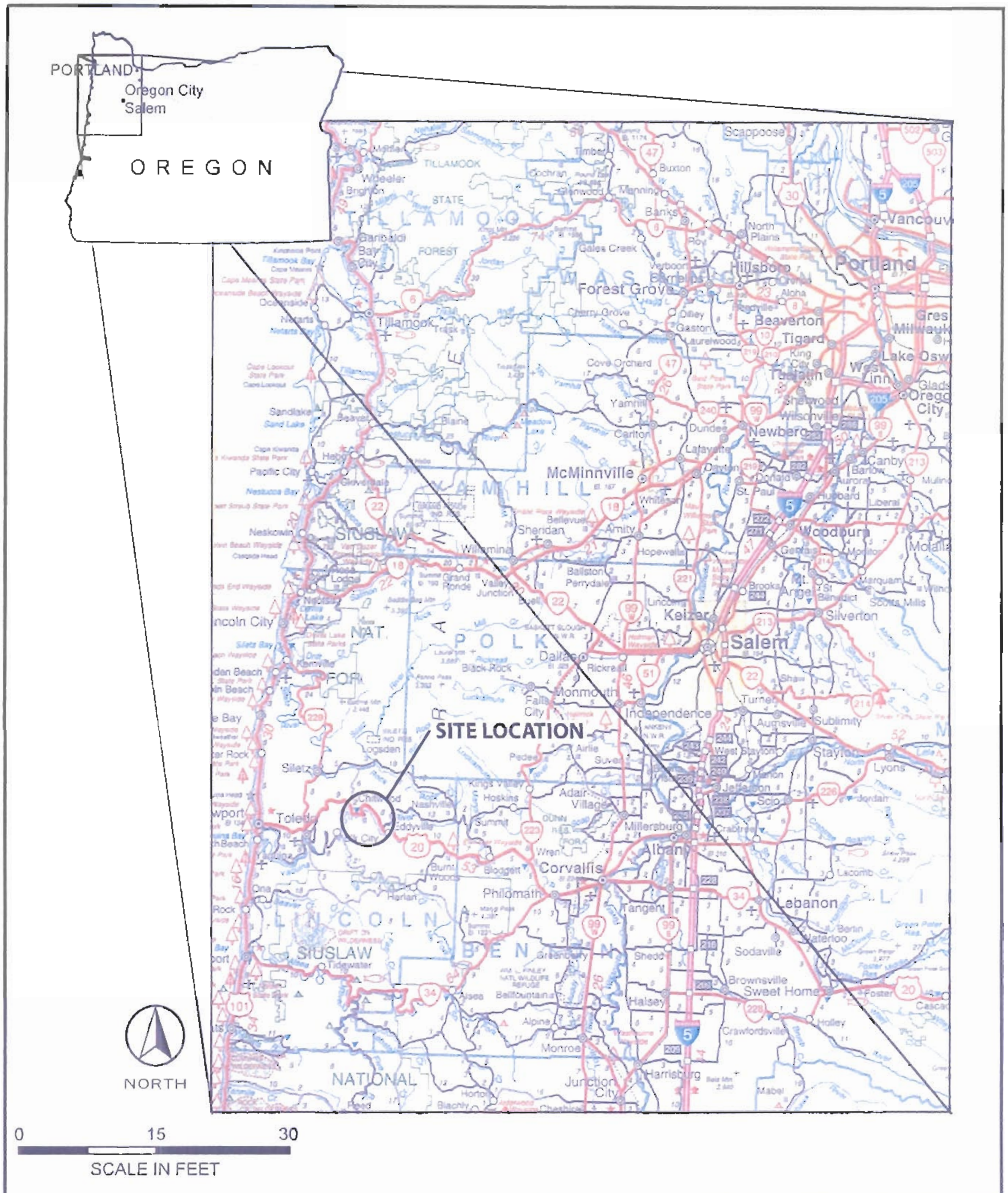
The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The boring logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at these boring locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borings or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.

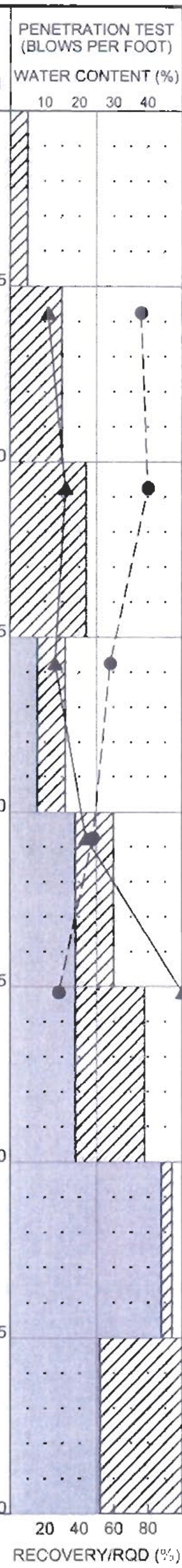


CORNFORTH CONSULTANTS 10250 S.W. Greenburg Road, Suite 111 Portland, Oregon 97223 Main 503-452-1100 Fax 503-452-1528	SITE LOCATION SUPPLEMENTAL DATA REPORT (PHASE 2A) HWY 20, PIONEER MTN - EDDYVILLE, OR	APR 2008 PROJ. 1891 FIG. 1

1891/01.AI NAS

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION SURFACE ELEVATION: 149.5 FT.	RUN NO.	SAMPLE NO.	PEN. DATA
		MEDIUM STIFF, light brown, sandy, slightly clayey SILT; diced texture, scattered gravel and cobble sized fragments of decomposed siltstone and sandstone, scattered mica and iron staining (COLLUVIUM/SLIDE DEBRIS)	R-1		
			R-2	S-1	3 5 8
			R-3	S-2	6 8 8
			R-4	S-3	3 6 7
				S-4	15 13 9
127	22½	VERY SOFT (R1), brown, decomposed to highly weathered beds of SILTSTONE grading to SANDSTONE; very highly to highly fractured, trace clay infilling, black mineralization on high angle fractures, scattered mica (COLLUVIUM/SLIDE DEBRIS)	R-5	S-5	50/4"
122	27½	...base of sandstone at 27.5 feet ...sheared with polished surface, clayey silt matrix, decomposed siltstone with relict rock texture, iron-staining at 27.5 to 27.6 feet	R-6		
		VERY SOFT (R1), gray, moderately to slightly weathered bed of SILTSTONE grading to SANDSTONE; highly fractured (along bedding 10-15° and occasional 30°-45°), (TYEE FORMATION/SLIDE DEBRIS) ...2" zone of highly fractured siltstone with fissile texture at 28 feet ...base of sandstone at 30.1 feet ...2" zone of sheared siltstone (silty clay infilling), with 1/4" light brown (ash?) seam at 33.5 feet	R-7		
112	37½	...highly weathered fracture in siltstone (45°) at 35.5 feet ...sheared siltstone with polished and slickensided surface at 37.4 feet	R-8		

GROUND WATER/ INSTRUMENT INSTALLATION



LEGEND

- 2-INCH O.D SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT / WATER CONTENT / PLASTIC LIMIT
- ▲ STANDARD PENETRATION TEST (BLOWS/FT.)
- ● WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. 2 3/4-INCH SLOPE INCLINOMETER CASING INSTALLED, 0 TO 80 FEET
4. VIBRATING-WIRE PRESSURE TRANSDUCER (S/N 07-13721) INSTALLED IN GROUT BACKFILL ON OUTSIDE OF SI CASING AT 43.0 FEET.

HAMMER ASSEMBLY: AUTO TRIP   SPT SAMPLER: NO LINER - RECESSED ID

DRILL ROD USED: NWJ   BOREHOLE DIAM.: 4"

DRILLER: BOART LONGYEAR

DATE START: 8/28/2007 FINISH: 8/29/2007

DRILLING TECHNIQUE: HQ3 CORING

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Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

SUMMARY BORING LOG
F4-03 (1 of 3)

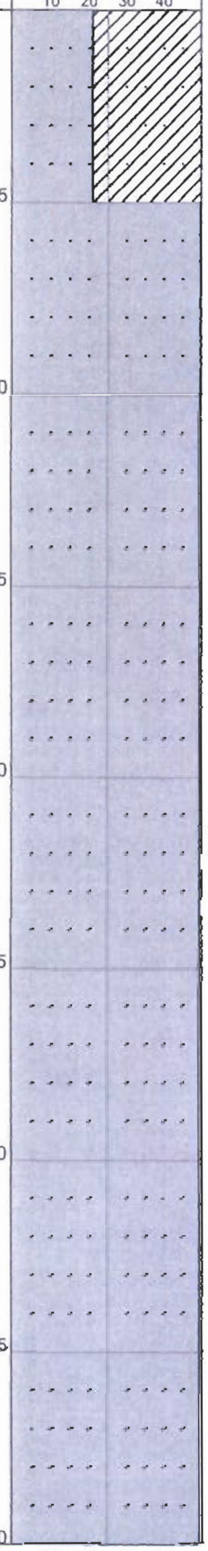
SUPPLEMENTAL DATA (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE

APR 2008

PROJ 1891

FIG. D-5

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION SURFACE ELEVATION: 149.5 FT.	RUN NO.	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION	PENETRATION TEST (BLOWS PER FOOT) WATER CONTENT (%) 10 20 30 40
		EXTREMELY SOFT (R0), brown, decomposed to highly weathered bed of SILTSTONE grading to SANDSTONE; highly fractured (along bedding 10-15°)					
106½	43	becomes... STIFF, orange-brown, sandy, slightly clayey SILT; sheared/diced texture, scattered iron staining and organics (TYEE FORMATION/SLIDE DEBRIS) ...siltstone with slickensides and striations, rake of 65° at 42.9 feet	R-9				45
		Beds of SOFT (R2), dark gray, fresh SILTSTONE (varies 0.5-3' thick), grading to MEDIUM HARD (R3), gray, fresh SANDSTONE (varies 2.5-8' thick); slightly fractured to massive (10-15°, occasional 70°), occasional ripup clasts within sandstone, scattered mica, occasional carbonized organics (TYEE FORMATION)	R-10				50
		...base of sandstone at 53.5 feet	R-11				55
		...base of sandstone at 57 feet	R-12				60
		...base of sandstone at 64 feet	R-13				65
			R-14				70
		...fracture (70°) in sandstone at 70.3 feet ...base of sandstone at 70.5 feet ...base of sandstone at 73.3 feet	R-15				75
		...base of sandstone at 78.5 feet	R-16				80
		Bottom of Boring: 80 FT					



HAMMER ASSEMBLY: AUTO TRIP

SPT SAMPLER: NO LINER - RECESSED ID

DRILL ROD USED: NWJ

BOREHOLE DIAM.: 4"

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT / WATER CONTENT / PLASTIC LIMIT
- ▲ STANDARD PENETRATION TEST (BLOWS/FT.)
- ● WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

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2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. 2 3/4-INCH SLOPE INCLINOMETER CASING INSTALLED, 0 TO 80 FEET.
4. VIBRATING-WIRE PRESSURE TRANSDUCER (S/N 07-13721) INSTALLED IN GROUT BACKFILL ON OUTSIDE OF SI CASING AT 43.0 FEET.

DRILLER: BOART LONGYEAR

DATE START: 8/28/2007 FINISH: 8/29/2007

DRILLING TECHNIQUE: HQ3 CORING

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SUMMARY BORING LOG
F4-03 (2 of 3)

SUPPLEMENTAL DATA (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE

APR 2008

PROJ 1891

FIG. D-5

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION SURFACE ELEVATION: 149.5 FT.	RUN NO.	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION	PENETRATION TEST (BLOWS PER FOOT) WATER CONTENT (%) 10 20 30 40
69½	80						
	85						
	90						
	95						
	100						
	105						
	110						
	115						
	120						20 40 60 80 RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT, WATER CONTENT, PLASTIC LIMIT
- ▲ STANDARD PENETRATION TEST (BLOWS/FT.)
- ● WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. WATER LEVEL IS FOR DATE SHOWN AND MAY VARY WITH TIME OF YEAR.
3. 2 3/4-INCH SLOPE INCLINOMETER CASING INSTALLED, 0 TO 80 FEET
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HAMMER ASSEMBLY: AUTO TRIP SPT SAMPLER: NO LINER - RECESSED ID
DRILL ROD USED: NWJ BOREHOLE DIAM.: 4"

DRILLER: BOART LONGYEAR
DATE START: 8/28/2007 FINISH: 8/29/2007
DRILLING TECHNIQUE: HQ3 CORING

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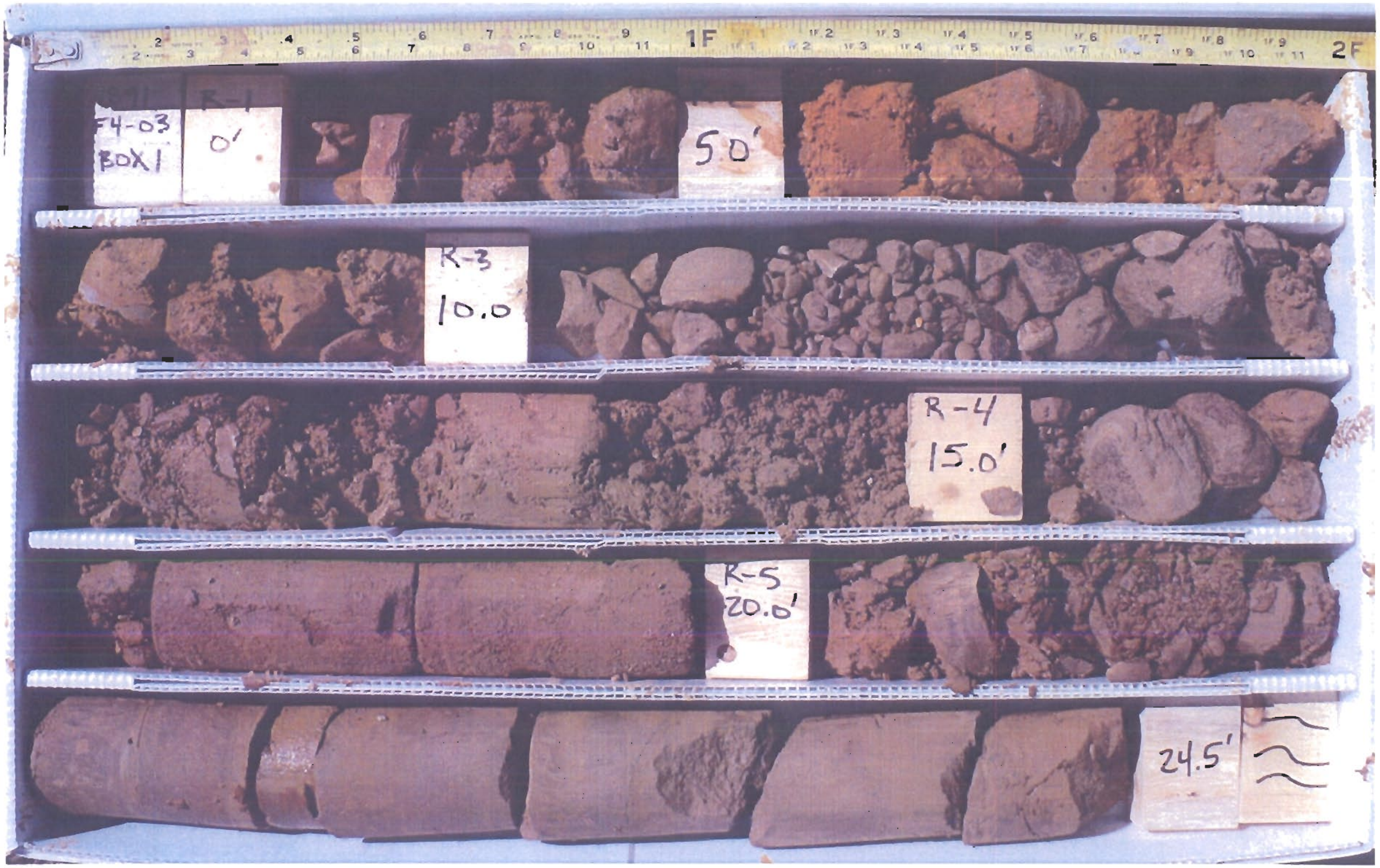
SUMMARY BORING LOG
F4-03 (3 of 3)

SUPPLEMENTAL DATA (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE

APR 2008
PROJ 1891
FIG. D-5



BOX 1
DEPTH 0 TO 24.5 FEET

1891\F402.AI LJO

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BORING F4-03
CORE BOX 1 of 8

SUPPLEMENTAL DATA REPORT (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE, OR

APR 2008

PROJ. 1891

FIG. D-6

BOX 2
DEPTH 24.5 TO 35 FEET

1891\F402.AI LJO

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CORE BOX 2 of 8

SUPPLEMENTAL DATA REPORT (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE, OR

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FIG. D-6

BOX 3
DEPTH 35 TO 43.8 FEET

1891\F402.AI LJO

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CORE BOX 3 of 8

SUPPLEMENTAL DATA REPORT (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE, OR

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FIG. D-6

BOX 4
DEPTH 43.8 TO 52.2 FEET

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HWY 20, PIONEER MTN - EDDYVILLE, OR

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FIG. D-6

BOX 5
DEPTH 52.2 TO 61.4 FEET

1891\F402.AI LJO

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CORE BOX 5 of 8

SUPPLEMENTAL DATA REPORT (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE, OR

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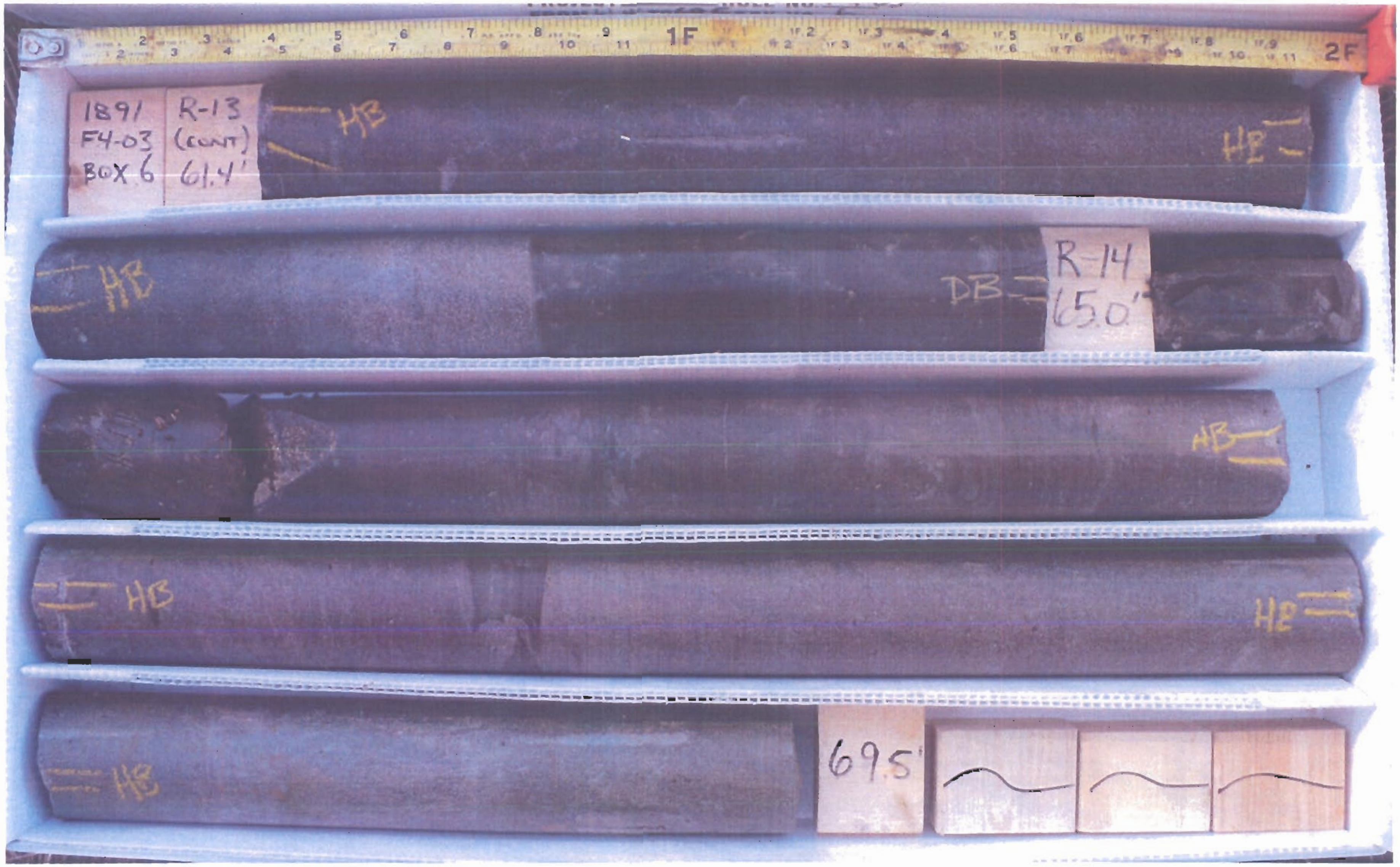
PROJ. 1891

FIG. D-6



BOX 6
DEPTH 61.4 TO 69.5 FEET

1891\F402.AI LJO

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BORING F4-03
CORE BOX 6 of 8

SUPPLEMENTAL DATA REPORT (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE, OR

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FIG. D-6

BOX 7
DEPTH 69.5 TO 78.4 FEET

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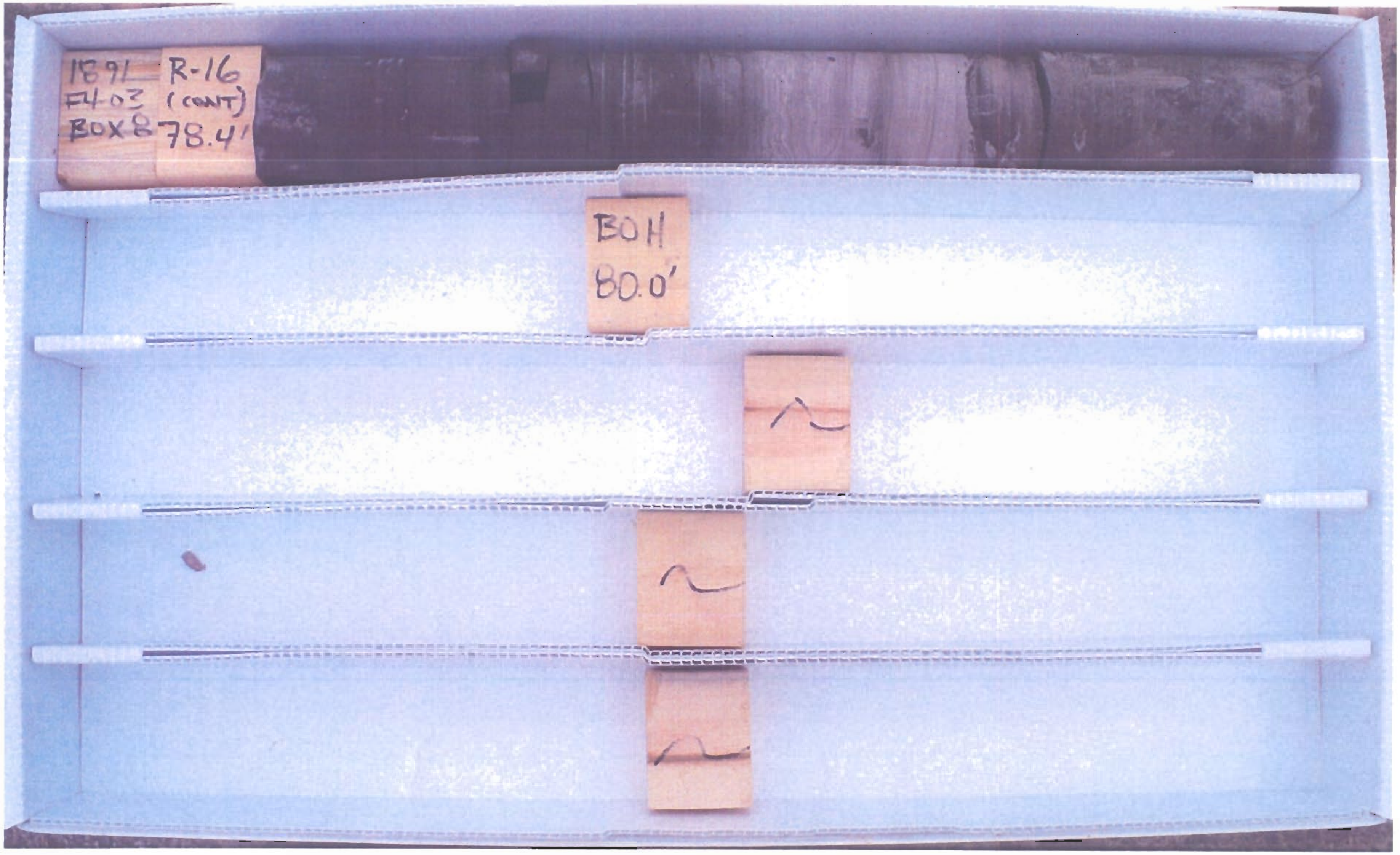
BORING F4-03
CORE BOX 7 of 8

SUPPLEMENTAL DATA REPORT (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE, OR

APR 2008

PROJ. 1891

FIG. D-6



BOX 8
DEPTH 78.4 TO 80 FEET

1891\F402.AI LJO

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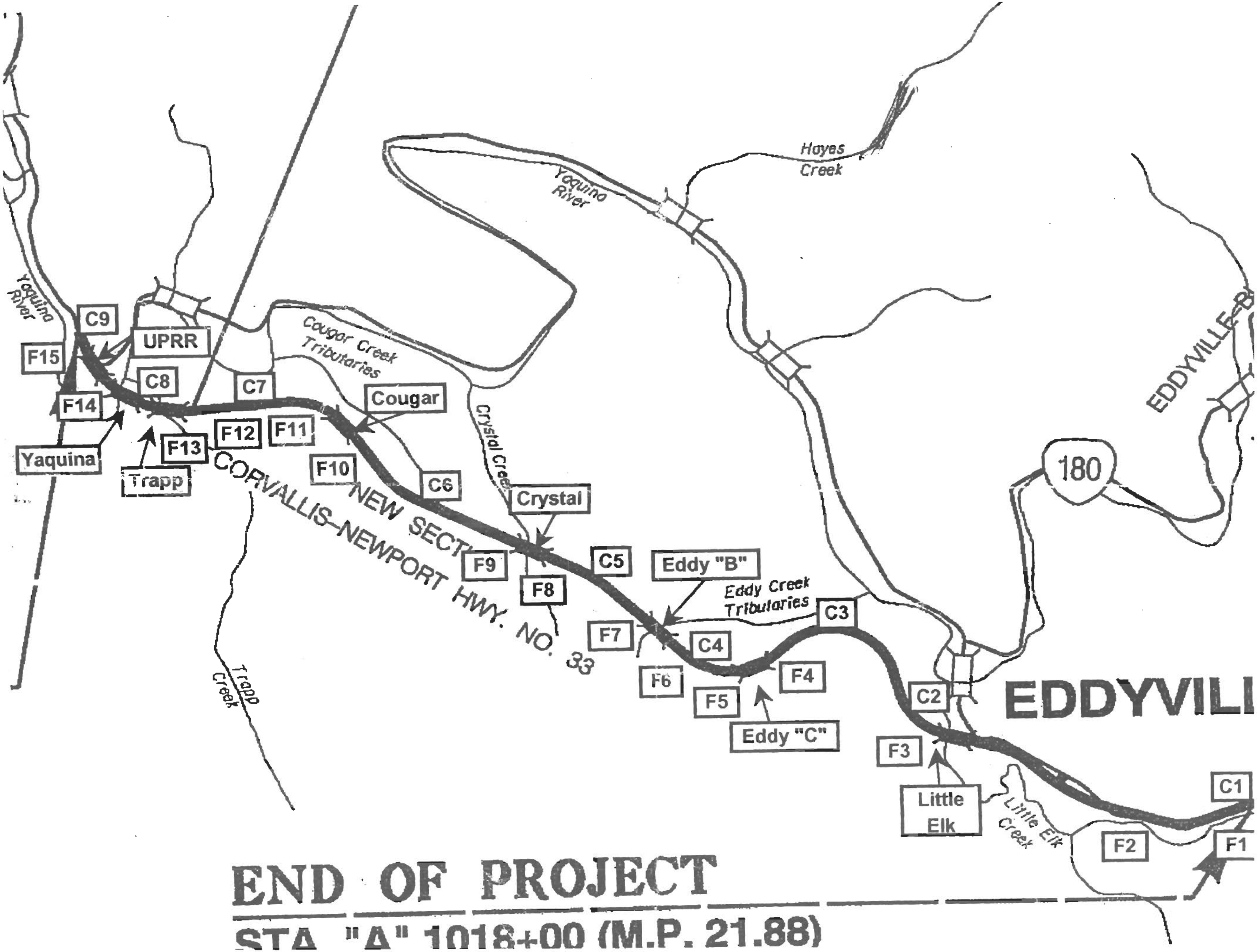
BORING F4-03
CORE BOX 8 of 8

SUPPLEMENTAL DATA REPORT (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE, OR

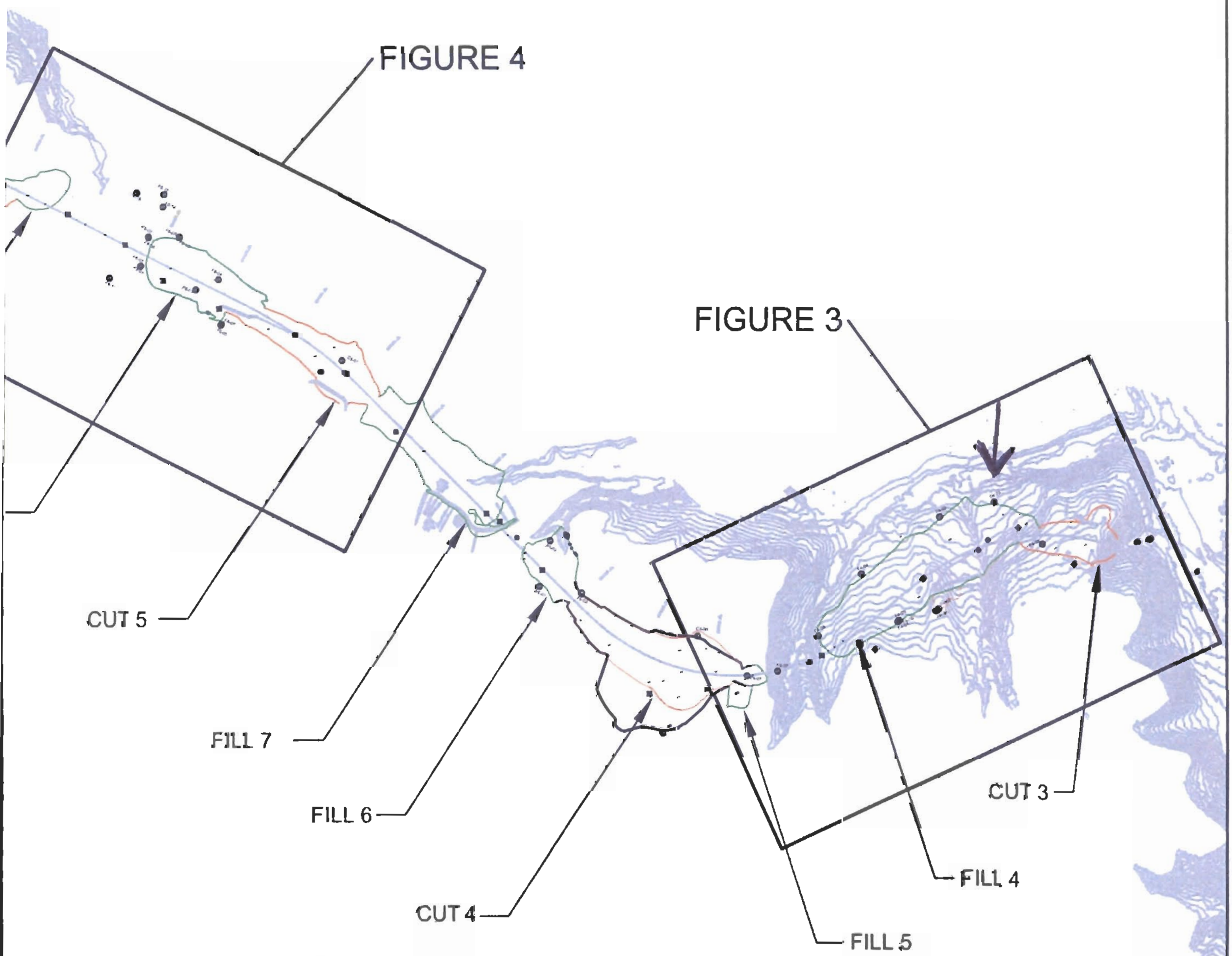
APR 2008

PROJ. 1891

FIG. D-6



Yaquina River
C9
F15
UPRR
C8
F14
Yaquina
Trapp
F13
F12
F11
C7
Cougar Creek Tributaries
Cougar
F10
C6
Crystal Creek
Crystal
NEW SECTI
CORVALLIS–NEWPORT HWY. NO. 33
F9
F8
C5
Trapp Creek
Yaquina River
Hayes Creek
Eddy "B"
Eddy Creek Tributaries
F7
C4
F6
F5
F4
Eddy "C"
C3
C2
F3
Little Elk
Little Elk Creek
EDDYVILLE-B
180
EDDYVILL
C1
F2
F1
END OF PROJECT
STA "A" 1018+00 (M.P. 21.88)



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SITE PLAN INDEX

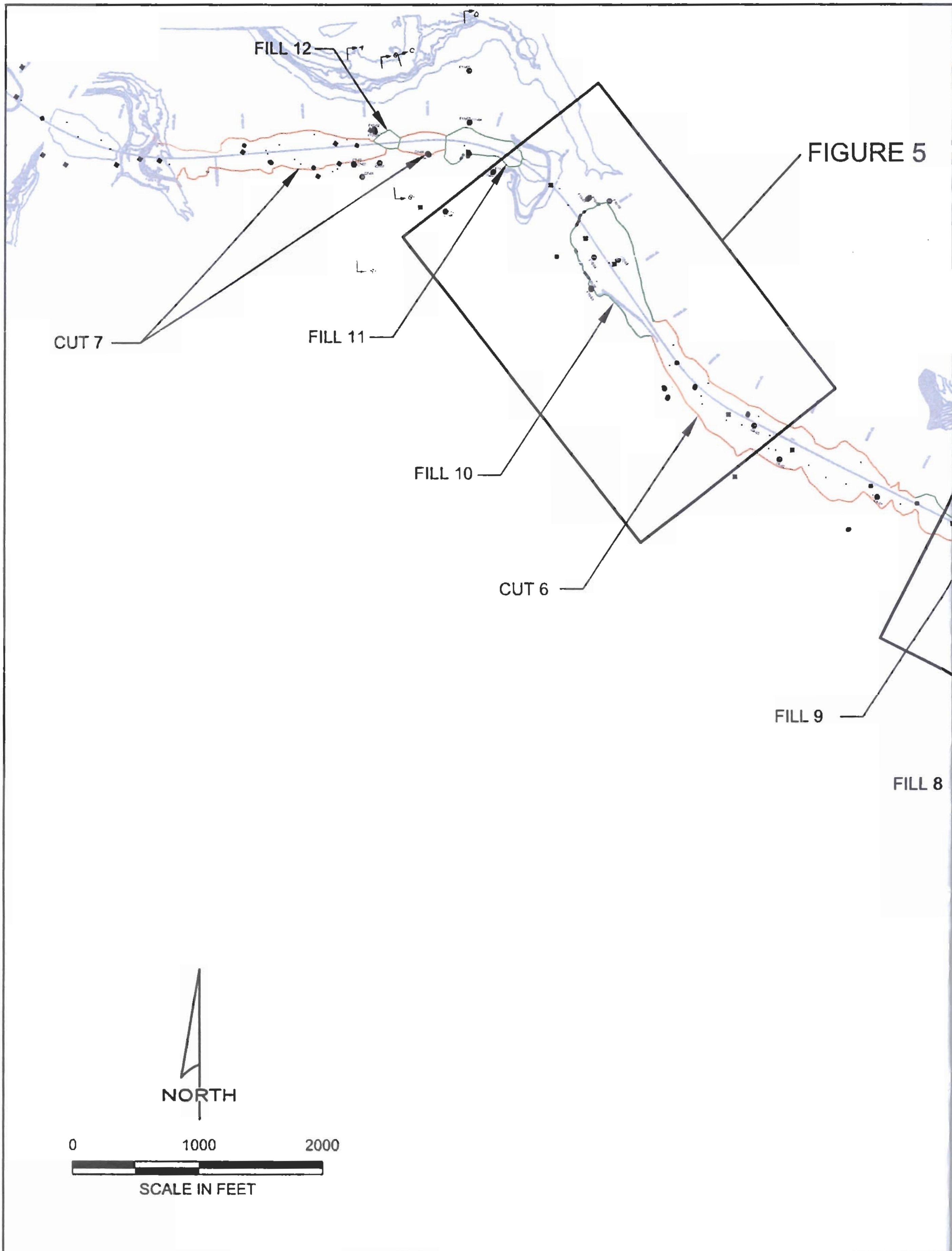
SUPPLEMENTAL DATA REPORT (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE, OR

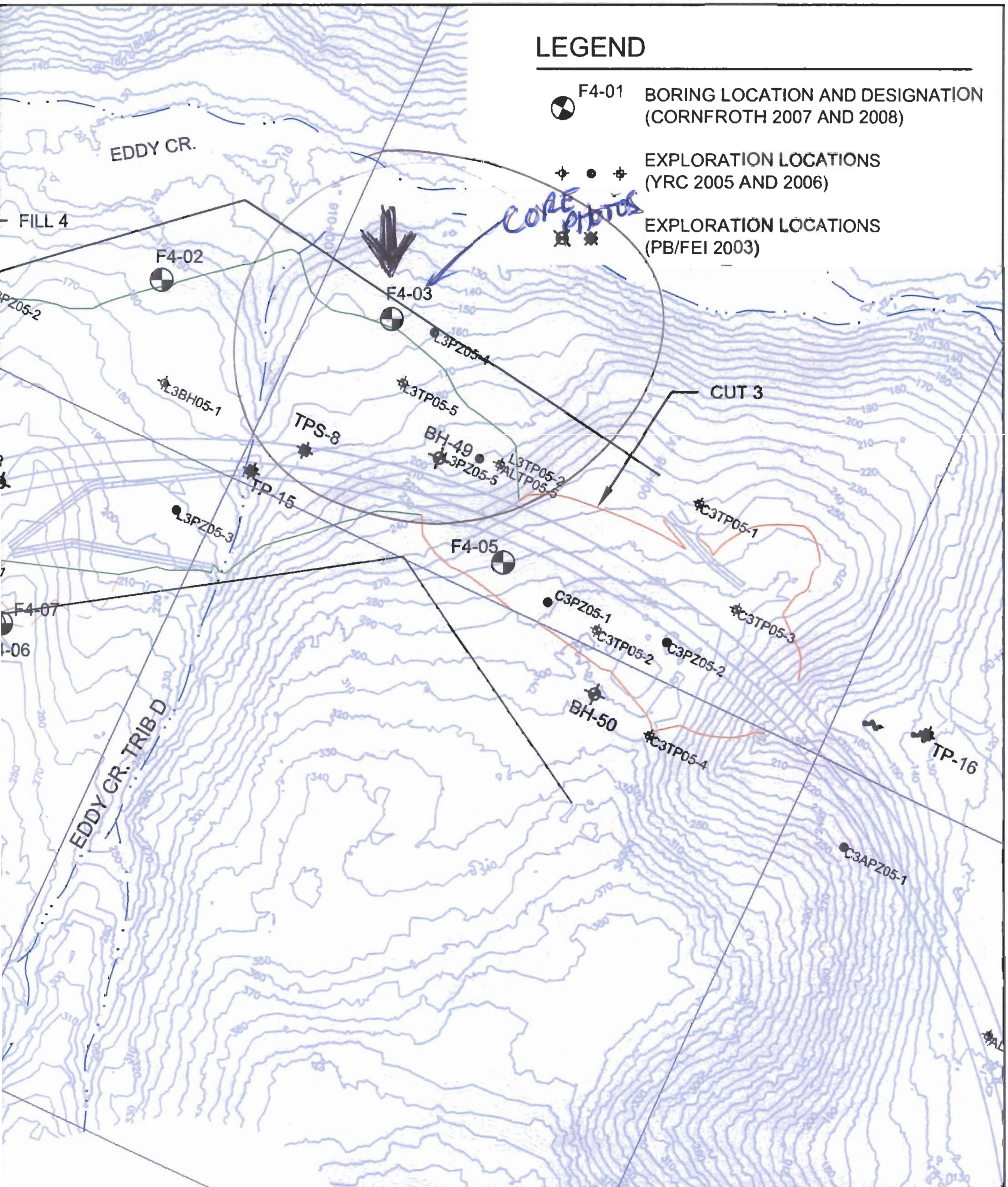
APR 2008

PROJ. 1891

FIG. 2

1874\1891 FIGURES_DWG NAS


FILL 12
FIGURE 5
CUT 7
FILL 11
FILL 10
CUT 6
FILL 9
FILL 8
NORTH
0
1000
2000
SCALE IN FEET



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1874\1891 FIGURES_DWG NAS

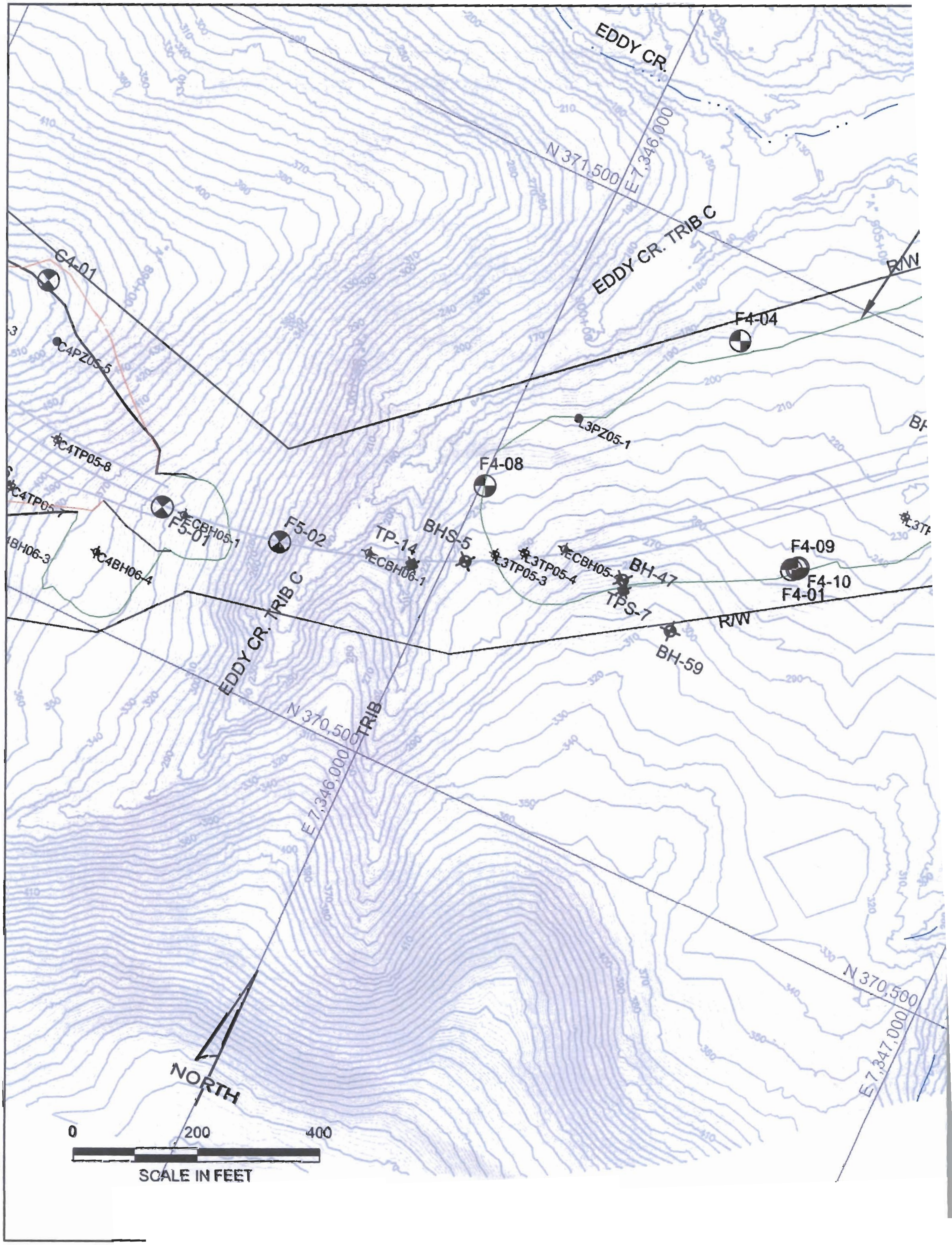
FILL 4 & CUT 3 SITE PLAN (EDDY CREEK TRIB C & D)

SUPPLEMENTAL DATA REPORT (PHASE 2A)
HWY 20, PIONEER MTN - EDDYVILLE, OR

APR 2008

PROJ. 1891

FIG. 3


EDDY CR.
N 371,500
E 7,346,000
EDDY CR. TRIB C
R/W
C4-01
C4PZ05-5
F4-04
L3PZ05-1
C4TP05-8
F4-08
F5-01
ECBH05-1
F5-02
TP-14
BHS-5
C4BH06-4
ECBH06-1
L3TP05-3
L3TP05-4
ECBH05-4
BH-47
F4-09
F4-10
F4-01
TPS-7
R/W
BH-59
EDDY CR. TRIB C
N 370,500
TRIB
E 7,346,000
N 370,500
E 7,347,000
NORTH
0
200
400
SCALE IN FEET