OREGON DEPARTMENT OF FISH AND WILDLIFE

Fish Passage WAIVER Application

• Use this form if providing fish passage at the artificial obstruction for which a Waiver is being requested would benefit native migratory fish.
• Use the "Fish Passage EXEMPTION Application" if a waiver has already been granted for the artificial obstruction, fish passage mitigation has already been provided for the artificial obstruction , or if there would be no appreciable benefit for native migratory fish if passage were provided at the artificial obstruction.
• If you unlock and re-lock this Form, information already entered may be lost in certain versions of MS Word.

APPLICANT INFORMATION

The Applicant must be the owner or operator of the artificial obstruction for which a Waiver is sought.

ORGANIZATION/APPLICANT: Oregon Department of Transportation
CONTACT: Nicholas Testa **TITLE:** Region Biologist
ADDRESS: 3700 SW Philomath Blvd.
CITY: Corvallis **STATE:** OR **ZIP:** 97333
PHONE: 541-757-4155
FAX: 541-757-4220
E-MAIL ADDRESS: nicholas.r.testa@odot.state.or.us

SIGNATURE: [signature] **DATE:** 12-17-15

OWNER (*if different than Applicant*):
CONTACT: **TITLE:**
ADDRESS:
CITY: **STATE:** **ZIP:**
PHONE:
FAX:
E-MAIL ADDRESS:

SIGNATURE: ______________________ **DATE:** __________
Signature indicates that you understand and do not dispute this request.

APPLICATION COMPLETED BY (*if different than Applicant*): Stuart Myers
TITLE: Environmental Scientist
ORGANIZATION: Mason, Bruce & Girard, Inc. (MB&G)
ADDRESS: 707 SW Washington St. Suite 1300
CITY: Portland **STATE:** OR **ZIP:** 97205
PHONE: 503-224-3445
FAX: 503-224-6524
E-MAIL ADDRESS: smyers@masonbruce.com

SIGNATURE: [signature] **DATE:** 12/17/15

To Be Completed by ODFW Fish Passage Coordinator

APPLICATION #: **DATE RECEIVED:**

FILE NAME:

APPROVED ☐ **SIGNATURE:** ______________________ **DATE:** __________
DENIED ☐ **TITLE:**

ARTIFICIAL OBSTRUCTION (*for which a Waiver is being requested*)

1. TYPE OF ARTIFICIAL OBSTRUCTION:

- ☐ Dam
- ☒ Culvert/Bridge
- ☐ Tidegate
- ☒ Other (describe): Rock Buttresses

New ☒ Existing ☐

2. PLEASE PROVIDE A BACKGROUND AND DESCRIPTION OF THE PROPOSED ACTION TRIGGERING THE NEED TO ADDRESS FISH PASSAGE:

The Oregon Department of Transportation (ODOT) proposes impacts to existing fish habitat and passage conditions in two fish-bearing streams located in the Yaquina River basin as part of the Pioneer Mt. to Eddyville (now known as FFO- US20 PME: UPRR – Eddyville Phase II) highway project (PME project).

The PME project has experienced extensive challenges due to Oregon Coast Range geology and climate. As such, in the current waiver project ODOT proposes to install rock buttresses and culverts within two fish-bearing streams in order to stabilize the movement of valley fill supporting the newly-aligned state highway. Specifically, the PME project will involve permanent impacts to Eddy Creek Tributary C (Eddy Creek C) and Cougar Creek, both of which support native migratory fish (NMF), resulting in the permanent loss of 1,936 feet of NMF habitat. Existing landslides and potential future landslide risks prevent bridge construction at Eddy Creek C and Cougar Creek. Artificial obstructions (rock buttresses and culverts) are proposed to enhance existing rock buttresses and drainage features located in these drainages to stabilize the landslide-prone areas.

The current waiver is part of the larger PME project. There have been several fish passage plan approvals and previous fish passage waivers associated with the larger project. These waivers and other permitted impacts have been mitigated as part of previous project approvals.

The PME project involves constructing a new 5.37-mile alignment of Highway 20 (US 20) through the Oregon Coast Range near the town of Eddyville in Lincoln County, Oregon. US 20 is a critical east-west travel route for west central Oregon, is a major freight route between the Interstate 5 and the coast, and is currently length restricted for freeway-size loads. The purpose of the project is to improve this section of US 20 from Corvallis to Newport so that it will:

- Facilitate safe and efficient movement of existing and future traffic volumes within this segment of US 20
- Reduce existing US 20 vehicular crash rates
- Allow the passage of interstate truck traffic
- Provide an improved link to coastal communities for interregional commercial and tourist traffic.

In 2013, the Average Daily Traffic (ADT) figure for this roadway was estimated to be 5,200 vehicles. The ADT is projected to increase to 6,500 vehicles by the year 2025 based on ODOT traffic data for the corridor.

3. PASSAGE WILL NOT BE PROVIDED FOR THE FOLLOWING REASON(S):

During the summer of 2006, landslide areas were discovered within the PME project site during excavation of the temporary haul road located east of Eddy Creek C. Since that time, many historic and active landslide areas have been identified within the project area. ODOT's geotechnical engineers and their engineering consultants have thoroughly evaluated the project area and have determined there are major landslide masses in all four of the major creek sub-basins affected by the PME project. These include Cougar Creek, Crystal Creek, Eddy Creek Tributary B (Eddy Creek B), Eddy Creek C, and their tributaries. Consequently, before the project can be completed, these landslide areas must be stabilized to ensure stability and safety along the proposed highway alignment.

Using a combination of field data and geotechnical models, several alternatives for stabilizing the landslides have been considered and analyzed since the landslides were detected in 2006 along the PME project corridor. The use of computer models allowed ODOT engineers to design a range of landslide stabilization measures and to develop suitable factors of safety and relative stability. Based on these models, three primary geotechnical solutions to landslide movement at PME are being utilized to complete construction and open the highway in 2016. These solutions include rock buttresses, ground anchors, and horizontal drains. The horizontal drain network is needed to drain subsurface flows in landslide-prone areas to reduce water table elevations and reduce landslide risks along PME project corridor. In combination with the large culverts and network of subsurface and surface drainage features in the project area, these measures will provide the desired level of protection against landslide movement.

Simultaneous with the preliminary geotechnical modeling, ODOT initiated additional geotechnical field investigations that have been integrated into the landslide stabilization models. The fieldwork also included installation of instrumentation for long-term monitoring of slope movement and groundwater elevations that continuously feed the geotechnical engineers real-time data on landslide movement and performance of landslide mitigation techniques being applied. Through multiple modeling iterations, the project geotechnical engineers have developed working models that allow for landslide stabilization meeting factors of safety and conveyance of stream water through the rock buttresses via large culverts.

More information regarding the geologic setting the PME project area, landslide risks, buttress details, and highway construction implications are included in the Geotechnical Data Report located in Attachment D. A map of the PME project corridor and proposed fish passage impact locations is located in Attachment A.

4. DATE THE TRIGGER ACTION IS SCHEDULED TO BEGIN *(a minimum of two months should be planned for the waiver process after ODFW receives your application; requests that must go before the Commission will take longer)***:**

The rock buttresses and culverts at Eddy Creek C and Cougar Creek are proposed to be constructed in spring 2016, with completion by fall 2016. In-water work associated with the proposed actions at both creeks (i.e., culvert construction) will occur during the ODFW-preferred in-water water work window (IWWW) (July 1st to September 15th).

5. LOCATION

COUNTY:	Lincoln
ROAD CROSSING (if applicable)**:**	Pioneer Mt. to Eddyville New Alignment of Highway 20
RIVER/STREAM:	Eddy Creek C and Cougar Creek
TRIBUTARY OF:	Eddy Creek C is a tributary of Eddy Creek Cougar Creek is a tributary of the Yaquina River
BASIN:	Yaquina
COORDINATES[a]**:**	Eddy Creek C Longitude: 123.7911 °W Latitude: 44.6379°N Cougar Creek Longitude: 123.8244°W Latitude: 44.6514°N

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

6. STREAM DESCRIPTION

6A. BARRIER TABLE (*please provide the following information for barriers, which will help determine the benefit of providing passage at the Artificial Obstruction; indicate measurement units if applicable*):

EDDY CREEK C

	DOWNSTREAM					UPSTREAM			
Locations	3	C/N	2	1	AO	1	2	E	*example*
Type					Culvert/Buttress	C			C
Length					216 ft	1,282 ft			80 ft
Distance		200 ft				0 ft		1,282 ft*	1,200 ft
Level					5	5			5

Type= C (culvert/bridge), D (dam), T (tide gate), N (natural; *describe below*), O (other; *describe below*)
Length= length of the barrier in the stream (e.g., culvert's length, dam's width/footprint)
Distance= distance from the Artificial Obstruction (to closest point of other barriers)
Level= amount of passage at the barrier using the following codes:
5 - barrier to all native migratory fish
4 - barrier to some native migratory fish adults and/or species
3 - barrier to some native migratory fish adults and/or species for only part of migration period
2 - barrier to all native migratory fish juveniles
1 - barrier to some native migratory fish juveniles and/or for only part of migration period
LOCATIONS:
AO= the existing or proposed Artificial Obstruction
1,2= other barriers in the same stream as the Artificial Obstruction
3= downstream barrier outside the immediate stream in which the Artificial Obstruction is located (*only needed if C/N is a confluence rather than a complete natural barrier*)
E= end of historic native migratory fish use, including all tributaries (i.e., potential range without any artificial barriers in place)
C/N= first downstream confluence or complete natural barrier, whichever comes first

NOTE: The *example* indicates that there is culvert which is 80 feet long, is located 1,200 feet from the Artificial Obstruction in question, and is a complete fish passage barrier.
**Historic NMF habitat upstream of the AO was impacted and mitigated during an earlier phase of the PME project.*

COUGAR CREEK

	DOWNSTREAM					UPSTREAM			
Locations	3	C/N	2	1	AO	1	2	E	*example*
Type					Culvert/Buttress				C
Length					710 ft				80 ft
Distance		1,863 ft						1,010 ft	1,200 ft
Level					5				5

PLEASE PROVIDE ADDITIONAL DESCRIPTIONS FOR THOSE BARRIERS INCLUDED IN THE BARRIER TABLE OR FOR OTHER BARRIERS AFFECTING NATIVE MIGRATORY FISH MOVEMENT TO OR FROM THE ARTIFICIAL OBSTRUCTION:

Eddy Creek C

ODOT proposes a downstream extension of the existing rock buttress and culvert that was permitted in 2012 and constructed for the PME project in Eddy Creek C in 2013. The rock buttress and culvert extension will permanently eliminate a total of 216 feet of additional fish-bearing aquatic habitat in Eddy Creek C. The proposed rock buttress at Eddy Creek C will encompass approximately 0.676 acre of aquatic, riparian, and upland habitat. The slope of the affected portion of Eddy Creek is between 2-

4%.This proposed artificial obstruction culvert/fill will convey water from upstream of the project area to receiving waters below it (i.e., Eddy Creek main stem and Yaquina River). A large, 6.5-foot diameter metal culvert will be constructed to convey flows in Eddy Creek C. As noted, this culvert will not pass fish due to length and grades, and upstream habitat has been eliminated by the rock buttress constructed in 2013. However, the culvert is sized to pass natural debris and sediment load. Energy dissipation splash pads constructed with rock will be installed at the downstream end of the culvert to prevent downstream scour and channel head-cutting resulting from the altered local flow regime imposed on the creek from the culvert. The splash pads are included in the fish passage impact calculations. The culvert will not have stream substrate material placed in it to aid upstream bedload material transport through the culvert to downstream reaches and given the culvert will not be passable to NMF. The design life of the culvert is 75 years and ODOT expects to be able to slip line the culvert twice after the culvert has reached the end of its initial design life, while also passing stream materials.

Initially ODOT planned to construct a multi-span bridge to span and avoid the aquatic habitat in Eddy Creek C. However, hillslope instability and the potential for large landslides caused a need to develop the proposed valley fill approach with creek drainage placed in a culvert. The existing rock buttress and culvert upstream of the proposed rock buttress and culvert extension is 1,282 feet long and is a permanent barrier to fish passage. The upstream rock buttress and culvert were permitted in 2012 with fish passage mitigation for this impact occurring in Poole Slough within the Yaquina Estuary. Approximately 200 feet of Eddy Creek C will be avoided during proposed rock buttress and culvert construction. This reach spans from the downstream extent of the proposed rock buttress/culvert installation to the creek's confluence with Eddy Creek.

Cougar Creek

ODOT proposes an artificial obstruction at Cougar Creek that would block passage to upstream NMF habitat. Geotechnical monitoring and analysis in the Cougar Creek subbasin has documented the need to extend the existing fill slope that was constructed for the PME project parallel to the mainstem of Cougar Creek. The increased volume of landslide stabilization material (rock buttress fill) and culvert will permanently block 1,720 feet of Cougar Creek to fish passage. A large 5.5-foot diameter metal culvert will be constructed to convey flows in Cougar Creek to areas downstream of the proposed rock buttress (i.e., Cougar Creek and Yaquina River). The proposed buttress will impact 710 feet of stream habitat in Cougar Creek. Cougar Creek will flow a distance of 425-foot in a new channel construction on top of the buttress at the upstream end of the structure and then flow through the proposed 285-foot long, 5.5-foot diameter culvert through the buttress prior to discharge to unaffected downstream areas. As noted, this culvert will not pass NMF due to length and grade; however, the culvert is sized to pass natural debris and sediment load. Energy dissipation splash pads constructed with rock will be installed at the downstream end of the culvert to prevent downstream scour and channel head-cutting resulting from the altered local flow regime imposed on the creek from the culvert. The culvert will not have stream substrate material placed in it to aid upstream bedload material transport through the culvert to downstream reaches and given the culvert will not be passable to NMF. The design life of the culvert is 75 years and ODOT expects to be able to slip line the culvert twice after the culvert has reached the end of its initial design life, while also passing stream materials.

The proposed rock buttress at Cougar Creek will encompass approximately 2.42 acres of aquatic, riparian, and upland habitat. The 1,720 feet of fish passage impact proposed at Cougar Creek will occur as a result of the 5.5-foot diameter, 285-foot long culvert placed in the creek, and a rock buttress over top of and upstream of the culvert for 425 feet, which will block access to 1,010 feet of upstream cutthroat trout habitat in the Cougar Creek headwaters. The slope of the creek bed in the affected section of Cougar Creek is between 4.5-8.3%.

6B. SUMMARY TABLE (*please provide the following information relative to the Artificial Obstruction, which will help determine the benefit of providing passage at it*)**:**

Eddy Creek C	**DOWNSTREAM**	**UPSTREAM**
NMF Species Present Currently	Coho salmon (adults/juveniles), cutthroat trout (all life stages), Pacific and western brook lamprey	None
NMF Species Present Historically	Coho salmon (adults/juveniles), cutthroat trout (all life stages), Pacific and western brook lamprey	Coho salmon (adults/juveniles), cutthroat trout (all life stages), Pacific and western brook lamprey
Habitat Quality	Category 4 (Important Habitat) per ODFW Habitat Categories	Category 6 (Poor) per ODFW Habitat Categories due to the presence of existing rock buttress and culvert
Flows	Perennial with seasonal variation	Perennial with seasonal variation
Water Quality	Good	Good
Water Right Availability	N/A	N/A
Land Use/Zoning	Forestry/Timber Conservation	Forestry/Timber Conservation
NMF = native migratory fish		

Cougar Creek	**DOWNSTREAM**	**UPSTREAM**
NMF Species Present Currently	Coho salmon (adults/juveniles), cutthroat trout (all life stages), Pacific and western brook lamprey	Coho salmon (adults/juveniles), cutthroat trout (all life stages), Pacific and western brook lamprey
NMF Species Present Historically	Coho salmon (adults/juveniles), cutthroat trout (all life stages), Pacific and western brook lamprey	Coho salmon (juveniles), cutthroat trout (all life stages), Pacific and western brook lamprey
Habitat Quality	Category 4 (Important Habitat) per ODFW Habitat Categories	Category 4 (Important Habitat) per ODFW Habitat Categories
Flows	Perennial with seasonal variation	Perennial with seasonal variation
Water Quality	Good	Good
Water Right Availability	N/A	N/A
Land Use/Zoning	Forestry/Timber Conservation	Forestry/Timber Conservation
NMF = native migratory fish		

PLEASE PROVIDE ADDITIONAL DETAILS REGARDING THE INFORMATION PROVIDED IN THE SUMMARY TABLE (*such as species listed under the state or federal ESA and descriptions of the stream channel and riparian habitat*)**:**

Eddy Creek C

Eddy Creek C is a small, steep headwater creek that is approximately 2,700 feet long and drains an area of approximately 70 acres. The creek contains one small ephemeral tributary that is approximately 130 feet long. The subbasin's historic and current land use is private timber production in addition to recent highway construction. The creek has natural slopes ranging from 6% to 17%. Cutthroat trout and resident taxa were sampled in the area that was impacted by the rock buttress and culvert constructed in 2013 by ODFW and ODOT staff during PME project field studies in 2007 and 2009. Natural barriers other than slope and variable flows do not appear to restrict pre-construction movements of NMF up to existing and proposed project-related culvert and rock buttress fill locations. Results of the stream habitat survey indicate that Eddy Creek mainstem and Eddy Creek C met most of the ODFW habitat benchmarks for forested streams. Both streams met the benchmark for shade, pool area, pool frequency, complex pools, width-to depth ratio, gravel in riffles, large woody debris (LWD) pieces, and LWD volume. Benchmarks not met by both streams included residual pool depth, silt-sand-organics, key pieces of LWD, and number of large conifers in riparian areas.

ODOT fish sampling efforts within the portion of Eddy Creek C affected by the 2013 rock buttress/culvert fills immediately upstream of the currently proposed impacts revealed juvenile coho salmon (23) and cutthroat trout (167). ODOT and ODFW estimate that coho densities in Eddy Creek C are likely to average 0.483 coho/m^2 or greater. As noted above, cutthroat trout and Pacific and western brook lamprey are also known to occur in the Eddy Creek system including Eddy Creek C. While the periodic presence of Chinook salmon and steelhead occurs at times in the lower reaches of Eddy Creek, the Eddy Creek subbasin is not expected to consistently be used by these NMF species to carry out their life histories (John Spangler ODFW, pers. comm., November 3, 2015). These species ae not known to occur in Eddy Creek C.

Cougar Creek

Cougar Creek is a small, approximately 5,000-foot long headwater tributary that discharges directly into the Yaquina River. The subbasin drains approximately 170 acres and its land use is private timber production. Coho salmon have been documented (at very low densities as discussed below) in the lower section of the proposed rock buttress footprint and coho salmon and cutthroat trout occupancy have been assumed up to a natural slope break from 5-9% to over 20%. Construction of the proposed rock buttress and culvert will permanently block fish passage to 1,720 feet of high quality cutthroat trout habitat and lower quality coho habitat (710 feet of culvert and buttress + 1,010 feet of open channel upstream of the rock buttress to assumed cutthroat trout and coho salmon limits). Cougar Creek supports very low densities of coho salmon and a larger population of cutthroat trout within the project limits. The slope of the creek bed in the reach of Cougar Creek where impacts are proposed is between 5-9%.

Like the Eddy Creek basin, land use in the Cougar Creek subbasin is private timber practices where ODOT has not acquired right-of-way to construct the PME project. As such, the subbasin has and continues to experience timber harvest on a western Oregon industrial timberland harvest rotation of about every 40-50 years. This has resulted in a homogenized forest structure in terms of forest age, tree species diversity, and tree densities, which in turn has limited the subbasin's ability to develop late successional forest characteristics. Timber harvest removes large wood from the landscape that could eventually enter stream channels and provide important habitat for NMF. In addition, the removal of timber at an industrial scale can affect precipitation infiltration and overland flow rates, and can promote erosion and downslope sediment delivery to stream channels. These effects can affect NMF in adverse ways, though it is unknown the extent to which historic timber harvest has affected NMF populations in Cougar Creek and Eddy Creek C over the long-term. However, it is important to consider this land use pattern for both basins when also considering the long-term effect of the PME project on the affected subbasins to understand the long-term trajectory of NMF habitat and assemblages in the subbasins if the PME project was not proposed.

Fish sampling conducted in Cougar Creek by ODFW and ODOT in 2007 and 2012 has resulting in average coho salmon densities of 0.031 coho/m^2, which is 15 times lower than the Yaquina basin average for headwater tributaries. The longitudinal profile of the affected reach of Cougar Creek has a high average gradient (4.5-8.3% slope) and the gradient upstream of the affected reach that will be blocked to fish passage quickly increases to 12.1-19.7% and greater. One juvenile coho salmon was sampled within the 4.5-8.3% gradient/ PME project impact reach of Cougar Creek during sampling, which is upstream of ODFW's coho salmon distribution for the creek and in a reach that has a high gradient relative to coho salmon preferred stream gradients. As such, ODOT has assumed coho salmon presence within the entire buttress impact area/4.5-8.3% slope reach upstream to the 12.1-19.7% slope break. This represents a very conservative estimate of distribution of coho salmon within Cougar Creek based on ODFW data and coho salmon habitat preferences. Coho salmon prefer low gradient, complex stream channels with accessible off-channel habitat. This type of habitat is largely absent from Cougar Creek. Cutthroat trout have been sampled throughout the mainstem of Cougar Creek and in two tributaries that were affected by earlier phases of the PME project. Current and historic cutthroat trout distribution in Cougar Creek is assumed to occur from the confluence with the Yaquina River upstream to the 12.1-19.7% slope break. This marks the upstream extent of all NMF in Cougar Creek.

Stream Function Impacts

Construction of the proposed rock buttresses and culverts is expected to result in localized permanent impacts to several stream functions within Eddy Creek C and Cougar Creek. This section provides information on the stream functions in Eddy Creek C and Cougar Creek that are important to NMF that will likely be affected to varying degrees from the proposed project. Fish passage and habitat mitigation actions discussed later in this application are intended to replace lost stream functions to provide and overall net benefit for NMF.

Headwater stream habitat is important to NMF because of the unique role these areas provide in contributing to downstream environments where most NMF carry out their life histories. Although NMF may be absent or in limited numbers in headwater stream habitat due to low or intermittent flows, high slopes, and minimal aquatic habitat area, forested headwaters are important in their support of fluvial transport of sediments, nutrient cycling, temperature regulation, and input of organic matter to NMF-bearing waters and food webs downstream. Riparian vegetation communities, and their associated forested upland areas, increase the productivity of headwater streams and the subsequent delivery of invertebrates and organic matter to areas lower in the drainage.

Surface Hydrology

The parameters most commonly studied in forest hydrology include water yield, timing of peak flows, and changes in low flows or alterations in water quality. The spatial and temporal scales at which these parameters are reviewed influence their outcomes.

The rock buttresses and culverts to be installed in Eddy Creek C and Cougar Creek will not change the ultimate amount of water going to the streams primarily because the fill area will be a small fraction of the subbasins' collective drainage area. Further, the runoff coefficient (C) of the fills ($C = 0.3$) is not significantly different from the native soils ($C = 0.2$), both of which have similar slopes and will be saturated or near saturated during the winter (rainy) season. As shown by the runoff coefficients above, there could be slight differences in permeability due to the buttresses having less vegetation (at least initially) and more compaction than the native ground. Native ground may also provide more interception and evapotranspiration; however, since significant precipitation events in the project area are in winter months, the potential for interception and evapotranspiration is lower than in the summer months and therefore this difference is expected to be small. If it is assumed the buttresses will have a small affect to surface water infiltration locally versus the native soils, (i.e., the native soils show a higher permeability than the buttress fills), the cumulative footprint of the two buttress fills (3.1 acres) is still a very small portion (1.3%) of the combined Eddy C Creek and Cougar Creek drainage area (240 acres). Consequently, ODOT believes the effect of the buttress fills on surface hydrology will be negligible and likely not be measureable down-slope/stream of the project site. During the rainy season when the groundwater level is likely near its highest elevation, the native soils will tend to accommodate less infiltration and exhibit more surface runoff, (i.e. runoff coefficients between native ground and fills showing more convergence, and thus, both features will tend to shed water primarily by surface flow). Similarly, the embankment drainage infrastructure being installed at both sites, (i.e., horizontal drains, trench drains, etc.), have a large capacity to drain subsurface water, and thus, allow the soils to absorb more water. According to geotechnical studies at both sites, seasonal variations in groundwater levels generally range from 1 to 20 feet; however, one instrument measured a 35-foot seasonal variation. Spikes in groundwater due to storms generally vary from 1 to 15 feet.

Peak flow and flow curves in downstream reaches of Eddy C Creek and Cougar Creek, and especially in the Yaquina River will not change significantly because the buttress fill areas are a small portion of the subbasins' cumulative contributing drainage area (1.3%) and the drainage network installed at PME is constantly active, draining water from the buttresses and surrounding hillsides. During the rainy season the total surface runoff from the buttresses will likely be little different from the native soils. Once the slopes are vegetated, the time of concentration is not expected to be shorter because the slopes of the fills will essentially be the same as the natural conditions. Streamflow downstream of the buttresses has the potential to be affected by the channelization of flow and relative lack of roughness in the culverts compared to un-culverted headwater streams. However, energy dissipation splash pads constructed of rock will be installed immediately downstream of the culvert outlets to attenuate flows and avoid downstream channel scour and headcutting. The impacts from these structures have been included in the total fish passage impact calculations.

In summary, the buttresses at Eddy Creek C and Cougar Creek are a relatively small portion of the two subbasins' total drainage area and the flow volume and duration change, whether on the surface or in the ground, as a result of the buttresses and culverts at any point along the natural flow path of a stream is expected to be minor if not negligible during winter months. During summer months, discharge from the horizontal drainage networks in the buttresses will likely supplement headwater streams base-flow with cool, clear groundwater.

Subsurface Hydrology
In forested headwater areas water originating from precipitation and snowmelt seeps into the ground and moves in a general downward direction until it reaches the water table. Then it moves along a nearly horizontal hydraulic gradient (flow path) to discharge naturally downstream where the water table intersects surface water features, creeks, seeps, and rivers. If groundwater recharge is reduced, it will tend to result in a decrease of the natural discharge (i.e., less flow entering surface waters). This natural discharge supports riparian, wetland, and other groundwater-dependent ecosystems, and the base (summertime) flow of streams and rivers. Both the vertical and the lateral stream and streamside characteristics of given stream are important to evaluate when considering PME project impacts the subsurface hydrology.

A stream is described as gaining, losing, or static depending on whether the groundwater flows toward the stream, drains away from the stream, or remains the same. This can occur over short distances and/or seasonally. Although many instruments are installed at the PME project to evaluate ground water levels and soil pore-pressures, specific groundwater studies have not been conducted along the impacted stream reaches. However, based on field observations and the data derived for project-related horizontal drain networks Eddy Creek C and Cougar Creek appear to be gaining reaches with increasing surface flow and subsurface seepage occurring along a longitudinal (downhill) gradient given the subbasins' steep hill sides, extensive precipitation budgets, and relatively porous soils. As discussed in the previous section, precipitation falling on the buttresses is expected to travel to the streams via surface runoff, although ground water levels will also rise and fall with storm events. Similarly, when the adjacent native ground is near saturation (as in the rainy season) much of the precipitation that falls on the buttresses will be expressed as surface runoff to the streams. However, culvert construction will affect creek length in headwaters and thus surface runoff will run over vegetated slopes longer before it enters the streams.

Longitudinal (downhill) water velocities are influenced by the geomorphology of the stream channels. In addition, the complexity of subsurface flows may be more pronounced in headwater streams where landslide-prone terrain and remnant debris flow deposits are encountered. This is primarily due to the formation of subsurface, locally confined or unconfined aquifers within slide debris and bedrock. Because hyporheic exchange affects aquatic nutrient cycling and aquatic habitat, the relative proportion of up-welling (flux of hyporheic water into the stream) and down-welling (flux of stream water into the hyporheic zone) zones likely determines aquatic habitat patterns observable in the creek channels. Similarly, hyporheic return flows to streams may have different physical characteristics depending on whether the water has moved along a long or short, shallow or deep, hyporheic flow path. These differences may be in the form of dissolved chemicals and/or biologically-active nutrients.

The delineation of hyporheic zones within the two streams is not something easily accomplished. Without the hyporheic zone delineated and its dynamics well defined, accurate estimates of the project's impacts to it cannot be conclusively made. However, the buttresses and culverts will have some degree of impact on the hyporheic zone that currently exists in the portions of the streams to be covered by buttresses and put into culverts.

The proposed culverts at Eddy Creek C and Cougar Creek will be placed at a higher elevation than the existing creek beds due the need to provide a stable substrate medium for installing the culverts. The culverts will be placed on stabilized fill materials that cover the existing creek bed for the length of the culverts. Because the fill material will be compacted and the culverts are composed of corrugated metal, the flux of hyporheic water into the stream bed and stream water into the hyporheic zone is likely to be changed within culverted creek lengths. Because hyporheic flows are generally correlated with geomorphic surfaces, which in turn dictate the spacing of the longitudinal slope breaks that in turn drive hyporheic exchange, it cannot be conclusively determined whether the implication of these alterations are of ecological significance. However, field observations indicate that the pool-riffle ratio generally found in the two creek channels is spaced closer together than the average proposed lengths of the culverts. Consequently, the likely localized influence the buttresses and culverts will have on the creeks' hyporheic zone is that the frequency of hyporheic up-wellings and down-wellings may be affected. On a larger subbasin scale, the hyporheic zone should not be significantly changed from its current equilibrium upstream and downstream of the buttress and culvert areas. Any impact to chemical or biological nutrient cycling is likely to be negligible due to the relative small size of the fills when compared to the entire subbasin drainage areas and the circulation times involved. The buttresses will be constructed predominately of native materials. Water temperature in the creeks may drop due to culvert shading during summer months.

Because base flows that support summertime creek flows are measured as a long-term flow rate, which represents the regional (drainage-wide) flow at any given point along the stream course, the placement of the proposed fills and culverts should not make any measurable negative change (loss of flow) to summertime flows in waterways downstream of the project site, especially with the significant network of horizontal drains installed at the PME project which are intended to stabilize the buttresses and help deliver subsurface water to creek channels.

Sediment/Bed Material Transport

Sediment and bed material transport in creek systems plays an important role in the development and evolution of NMF habitat by affecting channel dynamics, maintenance of in-stream complexity, and the formation of biological assemblages. Historically, Eddy Creek C and Cougar Creek received debris input from large-scale landslides and debris flows. This material consisted of surface and subsurface soil materials, large wood, and in some instances bedrock in volumes capable of changing channel form. Currently, with the extensive network of stabilized logging roads and young forests upslope of the stream channels, most of the debris entering the channels is from small, localized soil failures that slough off small trees and soil into a creek during rain storms. This constitutes the existing, pre-construction baseline for sediment and material transport to the creeks.

The buttress and culverts placed in Eddy Creek C and Cougar Creek will permanently remove riparian and upland habitat adjacent to the channels. Approximately 216 linear feet of riparian and upland habitat will be removed from Eddy Creek C and approximately 710 linear feet of riparian and upland habitat will be removed at Cougar Creek. As such, creek-side habitats containing trees, sediment, organic debris, and nutrients that over time would have entered the creek system will be permanently lost.
The exact long-term effects of this lost contribution of sediment and material transport to downstream reaches of Eddy Creek C and Cougar Creek on NMF is impossible to assess completely. However, these effects on downstream habitat are expected to be confined to the immediate area downstream of the culverts given the ability for sediment and material to enter the channel from unaffected areas downstream of the impacted areas.

The culverts proposed to be installed in Eddy Creek C and Cougar Creek are sized to accommodate bed material and sediment that washes down the system from higher in the subbasins. Local lateral migration of sediment/debris into affected channel segments from riparian/upland areas will be reduced over the long-term due to the buttresses. However, because of the large diameter of the culverts and their gradient, movement of stream debris downstream through the culverts will occur, but most likely at reduced rates compared to unaffected channels. The proposed fish passage and habitat mitigation discussed later in this application is expected to functionally replace lost riparian, floodplain, and upland functions lost in the Eddy Creek C and Cougar Creek subbassins.

Prey Availability

Local invertebrate densities in reaches of Eddy Creek C and Cougar Creek to be culverted are likely to decline from pre-construction conditions; however, the extent of decline is not currently known. The culverted creek reaches are expected to have lower summertime water temperatures than unaffected creek reaches due to culvert shading. This may attract invertebrates into the culvert sections where cool, clean water, moist air, and adequate space are available for colonization. This re-colonization by invertebrate species has already been observed in the culverts that were installed in 2013 for the PME project, especially near the culvert inlets and outlets. This process may take several years, but will eventually occur, especially after winter rains wash debris and sediment into the culverts.

Because sunlight will be unavailable within the culverts, it is anticipated that densities of "grazing" invertebrate species may decline or longitudinally shift to other sections of the creek, while other taxa may increase (detritus feeders, gathers and shredders) to colonize new and available habitat within the culverts. Once installed, terrestrial and aquatic invertebrates (*Nematoda, Annelida, Mullusca,* and *Arthropoda*) are all expected to colonize inside the culverts; however, overall population densities of these groups cannot be forecasted. As in all systems, higher flows may periodically move species (or groups of species) temporarily to downstream locations, thus providing seeding of downstream reaches with invertebrates originating from unaffected upstream reaches. As such, it is not expected that the proposed buttresses and culverts will significantly affect existing prey availability for salmonid NMF downstream of the culverts and buttresses. The proposed culverts are not expected to result in a change in prey availability for Pacific lamprey ammoecetes given this life form filter feeds in stream substrates prior to emergence and downstream out-migration.

Riparian Dynamics

As discussed in the above sections, riparian habitat in portions of Eddy Creek C and Cougar Creek will be permanently lost due to buttress construction. Project-related impacts will affect local riparian habitats that contribute debris, nutrients, shade, and organic input to the creek systems. These inputs in turn provide habitat and the basis for NMF food webs. As discussed above, surface and subsurface water are not expected to change significantly as a result of culvert/buttress placement. It is impossible to completely assess how the loss of riparian habitat in these creeks will locally affect NMF in the same subbasins downstream of the impacts. However, it can be assumed that these effects will be negligible on a broader watershed scale for NMF given the amount of riparian habitat to be removed (926 linear feet cumulatively) compared to the size of the Big Elk Creek and Yaquina River watersheds and their associated network of tributaries, and in the context of the proposed riparian and upland mitigation discussed later in this application. Proposed off-channel fish habitat mitigation focuses on replacing the lost functions from the riparian impacts at the buttress/culvert sites and providing a long-term net benefit for NMF relative to riparian habitat functions lost.

Temperature and Dissolved Oxygen

ODOT does not anticipate an adverse effect (an increase) in stream temperature because of culvert and buttress installation due to the thermal refuge provided by the creeks flowing through the culverts. This localized temperature moderation can be especially important for the streams during summertime periods of higher air temperatures, solar radiation, and subsequent higher stream temperatures. The oxygen content of stream water can vary with temperature, oxygen exchange with the atmosphere, groundwater exchange, respiration, photosynthesis, decomposition of organic matter, salinity, and mineralization. Oxygen is constantly being removed and produced (via photosynthesis) and maintains relative equilibrium based on the magnitude of the abovementioned variables. Water flowing down the proposed corrugated, galvanized metal culvert also acts to maintain dissolved oxygen equilibrium. However, rates of photosynthesis and decomposition will be changed inside culverted stream reaches, while other variables such as temperature are expected to decrease while aeration may actually increase within the culverted section via water flowing constantly over the corrugations of the culverts, which increases oxygen exchange. ODOT believes the moderating thermal influence of the culverts, and nominal decomposition (oxygen consumption) within the culverts may increase dissolved oxygen levels downstream of the culverts.

Summary

The proposed buttresses and culverts to be constructed at Eddy Creek C and Cougar Creek will result in localized effects to several NMF habitat parameters in the impact footprints and downstream of construction footprints. However, potential downstream impacts are not expected to extend to the creeks' receiving waters; Eddy Creek and the Yaquina River respectively. Negligible impacts are expected to occur on surface and subsurface hydrology, prey availability, and temperature and dissolved oxygen parameters in downstream reaches where NMF will not be displaced from habitat. Primary downstream impacts of NMF habitat resulting from the culverts and buttresses are expected to occur on sediment/bed material transport and riparian dynamics habitat parameters. The proposed fish passage and habitat mitigation actions are focused on mitigating impacts to all of the NMF habitat parameters affected by the PME project.

6C. PROVIDE THE SOURCE FOR INFORMATION CONTAINED IN THE BARRIER AND SUMMARY TABLES: (Note: information from these sources is included in other sections of this waiver application)

- Coordination with ODOT, ODFW, and other agency staff
- Site visits
- Map review
- GIS data review (i.e., ODFW, BLM, and USGS National Hydrogaphy Dataset data)
- 1991 ODFW Yaquina Basin Fish Management Plan
- ODFW/ODOT field surveys of the PME project in 2007, 2009, and 2012
- 2005 ODFW Coastal Multi-Species Conservation and Management Plan
- 2009 PME project fish salvage reports
- 2012 PME Project Fish Passage Waiver Application
- 2015 FFO US20 PME: UPRR-Eddyville (KN18323) Biological Assessment
- 2015 FFO US20 PME: UPRR-Eddyville (KN18323) Joint Permit Application

MITIGATION (*attach additional copies of this section if multiple mitigation sites are proposed*)

1. DESCRIBE THE MITIGATION TO BE PROVIDED:

ODOT proposes several actions within the Siletz-Yaquina 4th-field hydrologic unit code basin to mitigate the proposed fish passage barriers to be constructed for the PME project rock buttresses. The proposed fish passage improvements will occur in the Big Elk Creek subbasin at Bull Creek and Big Elk Creek. The proposed improvements focus on mitigating the loss of passage at the PME rock buttresses, as well as the loss of critical aquatic, riparian, and upland processes that contribute to properly functioning NMF habitat. The improvements include the removal of an existing state-priority, fish passage barrier (i.e., culvert) and restoration of Bull Creek on private property, preservation of riparian buffers along a portion of Bull Creek and Big Elk Creek, the transition of 52 acres of private industrial timberland to the US Forest Service for late successional reserve management, the abandonment of a logging road that currently crosses Bull Creek and accesses the 52-acre private timberland parcel, and restoration of 9.5 acres of the Big Elk Creek floodplain and riparian corridor. These mitigation actions are intended to result in a net benefit to NMF in relation to the fish passage and habitat impacts associated with the PME project.

Attachment A includes maps of the proposed mitigation areas. Attachment B includes photographs of the proposed mitigation areas and associated habitat conditions. Attachment C includes preliminary design plans for the mitigation sites.

Bull Creek Culvert Removal

ODOT proposes to remove the existing undersized, perched 5-foot diameter corrugated metal culvert that conveys Bull Creek under a private logging road and restore the Bull Creek stream channel and riparian zone in the vicinity of the existing crossing. Removal of the culvert will eliminate a barrier that is a seasonal/partial upstream barrier for adult coho salmon and a complete upstream barrier for juvenile coho salmon, cutthroat trout, and lamprey species (see Table 6B for a description of NMF in Bull Creek). The lack of passage at the culvert for juvenile coho salmon is especially problematic for the species given that it can limit juvenile coho salmon access to critical overwinter rearing habitat and summer thermal refuge upstream and downstream of the culvert during periods when juvenile fish are seeking these habitat types. The culvert outlet is perched 2-3 feet above the downstream scour pool during most flow conditions, photographs of the perched culvert outlet are included in Attachment B. When flows and water levels increase, the downstream scour pool elevation rises to the culvert outlet elevation and provides brief periods when adult coho salmon are able to migrate through the culvert. The creek's average active channel width (ACW) is approximately 20 feet in the vicinity of the culvert. Therefore, the culvert is expected to also present a potential velocity barrier to NMF with poorer swimming abilities than adult coho salmon (i.e., cutthroat trout) when water surface elevations in the culvert and scour pool are equal given the size of the culvert (5-foot diameter) relative to the 20-foot average ACW.

Bull Creek is a tributary of Big Elk Creek, which is a tributary of the Yaquina River. Bull Creek empties into Big Elk Creek at approximately river mile 10.5. The culvert proposed for removal occurs approximately 0.55 mile upstream of the Bull Creek/Big Elk Creek confluence. The culvert removal will result in the abandonment of the existing road segment upstream of the crossing and facilitate a land donation to the Siuslaw National Forest that is also a part of the proposed mitigation package discussed later in this section. The culvert is listed on the 2013 ODFW Statewide Priority Fish Passage List as a Group 11 barrier and is noted as a priority barrier in the Siletz-Yaquina Basin. Culvert removal and restoration of the stream channel will provide full volitional access to approximately 10,900 feet of upstream coho salmon spawning and rearing habitat and approximately 23,593 feet of upstream coastal cutthroat trout habitat.

Given that the culvert is partial upstream barrier to adult coho salmon and a complete barrier to adult and juvenile cutthroat trout and juvenile coho salmon, analysis was completed to determine the culvert's likely overall passability to weight upstream habitat available for salmonid NMF. Application of the Washington Department of Fish and Wildlife's *Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual* (Manual) was conducted to determine the likely extent of salmonid passage provided by the existing Bull Creek culvert in terms of the exiting culvert geometry relative to local stream conditions. The Manual provides a process for rating a culvert's passability to determine its effect on fish passage and assist in the prioritization of addressing several fish passage barriers within a single management area. The Manual's percent passability estimates are intended to represent general categories of passability, not actual estimates of the number of fish that may pass a potential barrier. Application of the Manual indicates that the Bull Creek culvert is currently 33% passable based on the size of the culvert and its perched outlet. Thus, adult salmonids (i.e., adult coho salmon) would be expected to have on average 33% of a chance to pass upstream through the culvert at any given time. This passability rating is consistent with ODFW's Bull Creek culvert passage rating range of 20%-40%.

The 33% passage probability is related to high flow periods in winter when the elevation of the downstream scour pool raises above the bottom height of the culvert outlet after storm events and provides a consistent water surface elevation through the road crossing. It is not fully understood how long the water surface elevations at the culvert and flows through the culvert are sufficient to provide upstream passage. However, given the flashy nature of the creek's coastal runoff regime, it is expected that the water rises to passable levels for discrete, brief periods (i.e., 1-2 days) numerous times annually during the winter high flow periods and then drops back to unpassable levels relatively quickly after storm event flows peak. Coho salmon enter freshwater systems in late summer and fall to spawn at the onset of fall rain events that raise creek levels from low summer baseline levels. Given the lack of downstream fish passage barriers in Bull Creek, Big Elk Creek, and the Yaquina River, it is expected that adult coho salmon arrive at the culvert location in fall at the onset of their spawning run. As such, it is also likely that adult coho salmon arrive at the culvert scour pool during periods when flows are not high enough for fish to immediately pass upstream through the structure. This can result in impacts or delays to spawning timing and ultimate spawning success, and fish crowding downstream of the culvert can promote disease transmission among fish that stay in the scour pool waiting for flows to rise to pass through the culvert.

The passability metric derived for the culvert based on application of the Manual's passability model (33%) was used to weight the existing upstream habitat available to NMF. This was done to account for the culvert's partial passage capability to develop an estimate of how much NMF habitat is inaccessible upstream of the barrier. Application of the passability metric (i.e., 67% of upstream habitat is inaccessible) to available upstream cutthroat trout (23,593 feet) and coho salmon (10,900 feet) habitat indicates that approximately 15,807 feet of weighted available cutthroat trout habitat and approximately 7,303 feet of weighted available coho salmon habitat is inaccessible due to the culvert.

As noted above, the Bull Creek culvert is considered a complete barrier to lamprey species. Pacific lamprey and western brook lamprey are known to occur in Bull Creek as well as in Eddy Creek C and Cougar Creek. Western brook lamprey is not a NMF; therefore, passage analysis for lamprey species in this application is based solely on Pacific lamprey. Adult Pacific lamprey migrate from marine to natal freshwater environments between February and June to spawn and most upstream migration occurs at night. Pacific lamprey spend approximately one year in freshwater streams prior to spawning. As such, Pacific lamprey can be affected by the Bull Creek culvert during the full range of annual flows passing through the culvert as they move through the system to favorable habitats during their adult freshwater life cycle prior to spawning. Spawning typically occurs between March and July. Passage barriers are considered the primary threat to the viability of Pacific lamprey populations. The excessive use of swimming energy required by adult Pacific lampreys to pass culverts combined with sharp angles and high water velocities, effectively block passage. Pacific lamprey cannot jump and therefore are not able to pass into the Bull Creek culvert even when the culvert is only perched a couple of inches above the scour pool water surface. As such, given the periodic perched nature of the culvert and high flows expected to occur in the culvert when it is not perched, the Bull Creek culvert is considered a complete barrier to Pacific lamprey passage.

The watershed segment upstream of the culvert includes high-quality stream, riparian, and upland habitat located on land managed as late successional reserve by the Siuslaw National Forest. There are no known fish passage barriers or roads upstream of the culvert. The reach of Bull Creek downstream of the culvert and road crossing includes high-quality, low-gradient, sandstone-based in-stream habitat with a well-established riparian corridor. Upstream and downstream reaches contain critical overwinter rearing habitat for coho salmon, which has been documented as being a critical stream habitat element for sustaining viable coho salmon populations. As noted earlier, the average ACW of Bull Creek within the vicinity of the Bull Creek culvert is approximately 20 feet. The channel gradient in the vicinity of the culvert is approximately 1.9 percent. Approximately 20 large wood structures have been installed in the downstream reach between the Bull Creek/Big Elk Creek confluence and culvert by ODFW to further enhance the in-stream habitat and channel complexity. Approximately six large wood structures occur upstream of the Bull Creek culvert. These structures have helped encourage additional sediment deposition, the creation of point bars and small islands, and a complex glide-riffle dominated wetted channel type. However, at the culvert outlet, a large scour pool has formed due to the hydraulic impacts of the undersized culvert. The scour pool has led to the deformation of the adjacent streambanks, as seen in the northeast quadrant of the road crossing where there is an approximately 10-foot vertical, eroding bank.

The culvert removal and in-stream restoration is proposed to occur during the 2017 ODFW-preferred IWWW of July 1 – September 15. Construction and site restoration are expected to require up to six weeks to complete. Restoration of the road crossing will involve removing the existing corrugated metal pipe and fill supporting the road. This will be facilitated by isolating the in-water construction area at the upstream and downstream extents with sandbags and visqueen and pumping stream flow around the in-water work area. In addition, the banks in the vicinity of the crossing will be graded to match existing contours upstream and downstream of the culvert that are outside of its geomorphic influence. The restored banks will have geotextile fabric and native riparian plantings installed to stabilize the bank and return it to functioning riparian habitat. The large wood placed immediately downstream of the culvert will be salvaged and repositioned in the channel after culvert and road fill removal and streambank rehabilitation. The limited large wood removed to facilitate the construction process will also be placed in the stream to further bolster in-stream habitat, with an emphasis on enhancing juvenile salmon winter rearing habitat. In total, approximately 400 feet of stream restoration will occur, which will help to improve overwinter habitat conditions and accessibility for juvenile coho salmon and other NMF. The portion of the road along Bull Creek downstream of the culvert to the spur road that heads to Harlan Road will serve as the primary construction access and staging area. The segment of road downstream of the culvert within the construction footprint will be graded to be more consistent with the adjacent hillside and stream contours and planted with native vegetation after completion of the channel and streambank work. The road upstream of the culvert within the construction footprint will be graded and seeded; areas of the decommissioned road outside of the construction footprint upslope of the culvert construction area will be restored by removing three culvert cross drains, installing drainage bars to control surface drainage and erosion, and the road surface will be de-compacted with a excavator bucket.

Bull Creek Riparian Buffers

Riparian conservation buffers are proposed along both sides of Bull Creek downstream of the culvert proposed for removal within private industrial timberland. Riparian buffers are proposed to offset the loss of riparian, floodplain, and upland habitat and functions that will be permanently impacted by the PME buttresses. Property deed restrictions will be established in perpetuity to ensure that no timber removal or new road building will be allowed to occur within the buffers. The existing landowner will maintain ownership of the property encompassed by the riparian buffers. The Wetland Conservancy, or a similar land trust, will provide long-term stewardship of the buffers.

Given proximity of the buffers to actively managed forestland, the property owner will reserve the right to cable yard timber felled outside of the buffer boundaries over or through the buffer to a landing area located outside of the buffers. Cable yarding is a method of removing logs from a harvest area that uses cables to transport logs to a yarder landing. While there are multiple configurations that cable yarding can take on, all have a yarder located at the top of the landing that pulls the cables, which are aerially strung in corridors throughout the stand. Cable stringing initially involves a worker unspooling a 1/4-inch cable haywire in 200-foot sections, which are light enough to be carried, in the footprint of the cable corridor. The cable haywire is attached to the thicker skyline cable, which the carriage pulls taught. This stringing process can snap some limbs as the cable is pulled taught, and approximately 5% of corridors require a tree to be felled or broken to allow the cable to straighten. If a tree would need to be felled within the buffer, it would remain in place as large woody debris. Cable yarding corridors are approximately 15 feet wide and are spaced approximately 200 feet apart. If cable yarding over or through the buffers is required, it would occur at the frequency of standard western Oregon timber harvest rotations (i.e., approximately once every 40-50 years). In addition, routine maintenance of the existing road segment that occurs in the buffer, felling of danger trees, and placement of fire hoses will be allowed. The Wetland Conservancy, or similar land trust, will be notified by the land owner regarding the need of any of these actions to review the activities and conduct any localized restoration as needed.

The riparian buffers will extend approximately 0.55 mile downstream of the existing culvert crossing along Bull Creek and a major tributary that joins Bull Creek downstream of the crossing from the southwest to the Bull Creek confluence with Big Elk Creek. The buffer will lie adjacent (downstream) of the 52-acre parcel that will be donated to the U.S. Forest Service (USFS) for late successional reserve management, providing a contiguous preservation corridor from the Bull Creek headwaters to the confluence with Big Elk Creek. The buffers will average approximately 275 feet in total width (horizontal distance) excluding the stream area between the ordinary high water marks (OHWM) on both banks, and include a variety of tree species and age classes including both deciduous and coniferous species. Current Oregon Department of Forestry riparian buffers along the project reach of Bull Creek are 70 feet on both sides of the creek. The buffers will be tapered along their northern extent to the existing private road toe. The buffer will be established along approximately 2,900 feet of stream and will encompass a total of approximately 17 acres. A map of the proposed Bull Creek riparian buffers is included in Attachment A.

By permanently limiting timber harvest, road building, and other potential impacts from occurring within the buffers, the buffers will provide important riparian and upland services to Bull Creek such as temperature moderation, large wood recruitment, and bedload stability that are critical for functioning NMF habitat. As noted earlier, riparian habitats contribute debris, nutrients, shade, and organic input to the creek systems that help maintain properly functioning NMF habitat and help sustain primary productivity for NMF food webs. The buffers are proposed to offset the permanent loss of some of these functions at the PME buttress sites. It is important to note again that the PME buttress locations occur on private industrial timberland, harvested on industrial timberland rotations. Therefore, even if the PME buttresses were not constructed, it is likely that deleterious effects from these ongoing timber practices would degrade the upland, riparian, and aquatic habitat at Eddy Creek C and Cougar Creek and subsequently marginalize NMF habitat. Approximately 926 linear feet of riparian habitat will be lost at

Eddy Creek C and Cougar Creek from buttress construction. ODOT proposes approximately 7,167 feet of riparian habitat conservation and restoration cumulatively from the proposed mitigation package (see Table 1). Therefore, it is expected that the proposed conservation buffers along Bull Creek in conjunction with the 52-acre land conservation and the Big Elk Creek floodplain restoration mitigation elements discussed below will provide a net benefit to NMF in terms of compensating for upland and riparian habitat lost at the two PME buttress site.

52-Acre Land Conservation

As noted earlier in this section, ODOT proposes to purchase a 52-acre parcel of private industrial timberland from Nestucca Forests LLC (managed by Hancock Forest Management) and donate the parcel to the Siuslaw National Forest to transition the land’s use from industrial timber production to late successional reserve management. This parcel is bounded by USFS land to the east, south, and west that is managed for late successional/riparian reserve. This aspect of the mitigation approach is intended to offset the permanent stream function and process impacts that will occur from construction of the PME buttresses, and is intended to provide a net benefit to NMF.

The culvert proposed for removal occurs in the 52-acre parcel as well as approximately 12.5 acres of riparian habitat and 39.5 acres of forested upland habitat. Approximately 2,067 linear feet of stream habitat is included in the 52-acre parcel. The parcel is composed primarily of Douglas fir and secondarily western hemlock second growth and was last harvested in 2000. As such, the parcel contains approximately 15 year-old timber. The road that crosses Bull Creek traverses the parcel to a high point where timber harvest yarding historically occurred. ODOT also proposes to conduct restoration of the forest stands on the 52-acre parcel by thinning the existing densely-planted stands to decrease competition and foster more natural forest structure and dynamics to set the parcel on a late successional forest trajectory as the forest matures. This is expected to help shift the parcel from a tree farm to a healthy mature forest in the future.

As noted earlier, it is expected that restoration and preservation of the 52-acre parcel, as well as the conservation riparian buffers downstream of the parcel, will offset the ecological functions permanently lost from the riparian and upland impacts associated with the PME buttresses, resulting in a net benefit for NMF. Preserving the riparian and upland areas on the 52-acre parcel from industrial timber practices (e.g., logging and road construction) will promote favorable stream channel stability and water quality in Bull Creek by limiting the potential for erosion and sedimentation that can occur in streams from upslope industrial timber practices. In addition, restoration and protection of these areas will better promote large wood and gravel recruitment and retention in Bull Creek compared to subbasins with intensive timber practices that typically have limited large wood and gravel recruitment. Forest restoration and preservation will promote normative surface and subsurface water cycling by maintaining healthy forests that over time, as they mature, promote beneficial levels of evapotranspiration, slope stability, normative precipitation infiltration, and cross-gradient delivery of surface and subsurface flows to the creek as soils saturate. Maintaining an intact and contiguous riparian corridor along the entire course of the Bull Creek mainstem will also moderate stream temperature from shading, and promote organic material input to the creek channel, which in turn maintains properly functioning NMF habitat and sustains primary productivity for NMF food webs.

The effects of industrial timberland management on watershed-based ecological systems is well documented; these effects will be avoided by the proposed riparian and upland mitigation at Bull Creek in areas currently managed for industrial timber practices. These effects would continue to occur at the Eddy Creek C and Cougar Creek buttress locations if the PME project was not constructed given existing land use designation (private timberland) in these subbasins.

Big Elk Creek Site

A second fish habitat mitigation site is proposed in the Big Elk Creek subbasin that occurs along Harlan Road approximately 1 mile upstream of the confluence between Big Elk Creek and the Yaquina River. The 10-acre site is a narrow riparian/floodplain parcel bounded by Harlan Road to the east and Big Elk Creek to the west. ODOT proposes to restore an existing freshwater wetland and create a new stream channel-influenced freshwater wetland, remove invasive vegetation species, and improve floodplain/channel connectivity at this site to improve channel/floodplain connectivity and create high quality off-channel habitat for NMF. Restoration of the site is intended to mitigate the wetland, riparian, and floodplain habitat impacts associated with the PME project rock buttresses. The Big Elk Creek mitigation site will result in approximately 2,200 linear feet of riparian and floodplain habitat restoration.

Mitigation at this site will involve grading to provide the needed wetland hydrology to support two emergent and scrub-shrub freshwater wetlands (upper wetland and lower wetland) and to improve floodplain connectivity during high flow events in Big Elk Creek. The upper wetland will be approximately 1.2 acres in size and will have an undulating bed elevation to increase habitat diversity. Large wood assemblages will be installed in the wetland and in select floodplain locations to enhance habitat conditions and increase floodplain complexity. The wetland will be connected to three overflow channels; one northwest of the wetland, one west of the wetland, and one southwest of the wetland to provide habitat connectivity, maintain floodplain hydrology and provide conduits for flows and fish to egress the wetland and general floodplain area during high flow events that overtop the creek bank and inundate the floodplain.

Grading in the southern end of the property will involve the creation of an additional approximately 0.3-acre wetland (lower wetland) at the currently near-vertical streambank. This area will serve as a wetland mitigation feature and also as an egress for flows that overtop the Big Elk Creek streambank during high flow events (i.e., greater than two-year flood event) that inundate the entire floodplain. The entire lower wetland will be positively graded toward Big Elk Creek to avoid fish entrapment. A small low-flow channel will be graded at the northern extent of the lower wetland to provide a flow path for tidal fluctuations. Two grade controls will be constructed below the low-flow channel (subsurface) of the lower wetland to prevent incision and headcutting. The main wetland bench will be graded at an elevation of 8 to 9 feet NAVD88 to intercept groundwater levels. Preliminary surface water elevation data for Big Elk Creek indicate summer flows fluctuating between 1 to 8 feet NAVD88 on a daily basis, with some high tides reaching 10 feet NAVD88; tidal interactions are anticipated within all or portions of the lower wetland multiple days per month. The lower wetland will allow flows greater than the two-year event (>17 feet NAVD88) to interact with the floodplain and will provide additional egress for fish that are entrapped at the site during high flow events. The proposed grading plan for the site allows these high flow events that inundate the floodplain to exit the site in a manner that releases flow from the three proposed floodplain channels and decreases the potential for fish entrainment on the site as flood waters recede. It is expected that this will reduce the existing fish entrainment potential of the site. The existing topography with depressions lacks floodplain channels to allow egress for fish to return to Big Elk Creek that enter the depressions during flood events. All three floodplain overflow channels will slope slightly towards Big Elk Creek. The Big Elk Creek site is infested with Himalayan blackberry which will be removed; native riparian vegetation will be planted and maintained throughout the site. Preliminary design drawings, grading plans, and planting plans for the Big Elk Creek mitigation site are located in Attachment C.

It is expected that the combination of wetland creation, invasive species removal, native vegetation planting, improved floodplain connectivity, and establishment of off-channel fish rearing areas will locally improve in-stream, riparian, and floodplain conditions and result in a benefit for NMF when viewed in the context and scale of riparian, floodplain, and off-channel habitat impacts at the two PME buttress sites, and in the context of mitigation proposed in the Bull Creek subbasin. Cumulative linear riparian and floodplain impacts at Eddy Creek C (216 feet) and Cougar Creek (710 feet) will total 926 feet. Cumulative riparian, floodplain, and off-channel restoration and preservation associated with the Big Elk Creek site (2,200 feet), Bull Creek riparian buffers (2,900 feet), and 52-acre land conservation (2,067 feet) will total 7,167 linear feet. Riparian and floodplain habitat functionally replaced at the Big Elk Creek site to mitigate riparian and floodplain impacts from the PME project will provide riparian connection to the creek, debris input (organics/wood), and provide critical high flow, off-channel fish habitat over the long-term lower in the Yaquina River watershed where fish populations are more diverse than in Eddy Creek C and Cougar Creek. This is essential habitat given the documented need for accessible overwinter rearing habitat for juvenile coho salmon to sustain viable coho salmon populations in Oregon Coast Range streams. Further, Big Elk Creek has limited functioning off-channel habitat along its course due to the presence of rural residential development and agriculture (primarily cattle grazing) along the vast majority of its floodplain. These land uses, as well as the presence of Harlan Road that closely parallels most the creek's course, has degraded existing floodplain conditions by filling and/or draining wetlands, removing native vegetation, and promoting the unnatural delivery of sediment to the creek channel. Table 1 includes a numeric summary of proposed fish passage and habitat impacts and mitigation and conservation measures intended to offset the impacts and provide a net benefit to NMF.

Table 1. Summary of Proposed Impacts and Mitigation and Conservation Measures

Impact and Mitigation Sites	**NMF Stream Habitat Lost**	**Aquatic, Riparian, and Upland Habitat Lost**	**NMF Stream Habitat Access Provided**	**Weighted NMF Stream Habitat Access Provided**	**Riparian Buffer Area Conserved***	**Upland Habitat Conserved**	**Stream Length Conserved****
Eddy Creek C	216 ft.	0.676 ac.	0	0	0	0	0
Cougar Creek	1,720 ft.	2.42 ac.	0	0	0	0	0
Bull Creek	0	0	10,900 ft. (CS) 23,593 ft. (CT)	7,303 ft. (CS) 15,807 ft. (CT)	17 ac.	0	2,900 ft.
52-Acre Parcel	0	0	0	0	13.4 ac.	38.6 ac.	2,067 ft.
Big Elk Creek	0	0	0	0	9.5 ac.	0	2,200 ft.
Total	**1,936 ft.**	**3.096 ac.**	**10,900 ft. (CS) 23,593 ft. (CT)**	**7,303 ft. (CS) 15,807 ft. (CT)**	**39.9 ac.**	**38.6 ac.**	**7,167 ft.**

*****Riparian buffers areas also include upland habitats.
******Stream length conserved includes stream reaches that will have riparian buffers established, in-stream or riparian habitat improved, and/or land use changed from industrial timberland to late successional reserve management.
CS - Coho Salmon
CT – Cutthroat Trout

2. DISTANCE BETWEEN MITIGATION SITE(S) AND ARTIFICIAL OBSTRUCTION:

The Big Elk Creek mitigation site is approximately 2.5 miles southwest of the PME project. The Bull Creek mitigation site is approximately 6.5 miles south of the PME project. By road, the Big Elk Creek mitigation site is approximately 10 miles from the PME project and the Bull Creek mitigation sites is approximately 12.5 miles from the PME project.

3. OWNER (*if different than Applicant*)**:** Nestucca Forests LLC

CONTACT: Jerry Anderson (Hancock Forest Management) **TITLE:** NW Division Region Manager
ADDRESS: 955 N. Main St.
CITY: Independence **STATE:** OR **ZIP:** 97351
PHONE: 503-838-6931
FAX:
E-MAIL ADDRESS: JAnderson@hnrg.com

4. DATE THE MITIGATION IS SCHEDULED TO BE COMPLETED:

Construction at the Bull Creek mitigation site is currently planned to occur in the summer of 2017 after the 52-acre parcel land exchange has occurred. All work below the Bull Creek OHWM will occur during the ODFW-preferred IWWW for Yaquina River tributaries (July 1 – September 15). Construction at the Big Elk Creek site is currently planned for the late summer and fall of 2017 after the Bull Creek site is constructed. The limited amount of work below the OHWM of Big Elk Creek will occur during a requested early extension of the ODFW-preferred IWWW for the Yaquina River estuary (September 15 – October 31). The ODFW-preferred IWWW for the Yaquina River estuary is November 1- February 15. Completing in-water work prior to the preferred IWWW will avoid working during periods with a higher probability of high flows that could inundate the work area. Given the minimal amount of localized in-water work adjacent to the streambank and relatively short duration for in-water work, adverse impacts to fish from in-water work occurring during the proposed IWWW extension is not expected. Final planting, seeding, and site stabilization at both sites will be completed in late 2017 and early 2018.

5. LOCATION

<u>BULL CREEK SITE</u>
COUNTY: Lincoln
ROAD CROSSING (if applicable)**:** Private Timberland Road
RIVER/STREAM: Bull Creek
TRIBUTARY OF: Big Elk Creek
BASIN: Siletz-Yaquina
COORDINATES[a]**:** Longitude: 123.8268°W Latitude: 44.5497°N

<u>BIG ELK CREEK SITE</u>
COUNTY: Lincoln
ROAD CROSSING (if applicable)**:** Harlan Road
RIVER/STREAM: Big Elk Creek
TRIBUTARY OF: Yaquina River
BASIN: Siletz-Yaquina
COORDINATES[a]**:** Longitude: 123.8657°W Latitude: 44.6172°N

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

6. STREAM DESCRIPTION

6A. BARRIER TABLE (*please provide the following information for barriers, which will help determine the benefit of the Mitigation site; indicate measurement units if applicable*)**:**

Section 6 of this waiver application provides details regarding the Bull Creek site only.

	DOWNSTREAM					UPSTREAM			
Locations	3	C/N	2	1	M	1	2	E	*example*
Type	N/A		N/A	N/A	C	N/A	N/A		D
Length	N/A		N/A	N/A	60 ft	N/A	N/A		8 ft
Distance	N/A	0.55 mile	N/A	N/A		N/A	N/A	10,900 ft* 23,593 ft**	1,700 ft
Level	N/A		N/A	N/A	3,2	N/A	N/A		1

LOCATIONS: M = the Mitigation site
* coho salmon
** cutthroat trout

NOTE: The *example* indicates that there is a dam which is 8 feet wide in the stream, is located 1,700 feet from the Mitigation in question, and is a seasonal or partial fish passage barrier for juveniles only.

See **ARTIFICIAL OBSTRUCTION: 6A. BARRIER TABLE** for further details regarding this table.

PLEASE PROVIDE ADDITIONAL DESCRIPTIONS FOR THOSE BARRIERS INCLUDED IN THE BARRIER TABLE OR FOR OTHER BARRIERS AFFECTING NATIVE MIGRATORY FISH MOVEMENT TO OR FROM THE MITIGATION:

There are no passage barriers downstream of the proposed fish passage mitigation site on Bull Creek to its confluence with Big Elk Creek. There are no passage barriers downstream of the Big Elk Creek/Bull Creek confluence on Big Elk Creek to its confluence with the Yaquina River. As such, the Bull Creek culvert proposed for removal is the only passage barrier for anadromous fish that use Bull Creek for completing their life histories.

A single-span timber bridge is located over Bull Creek approximately 550 feet downstream of the culvert proposed for removal. The bridge supports a logging road that accesses Hancock-managed property to the east of the proposed mitigation site and riparian buffers. The channel under the bridge is slightly more confined than the immediate upstream and downstream reaches; however, the bridge is not considered a barrier to passage for any species or life stages. Photos of the bridge are included in Attachment B.

There are no known artificial barriers to fish passage upstream of the culvert proposed for removal. The 2009 ODFW Rapid Bioassessment report lists the presence of an impassible waterfall on the mainstem of Bull Creek, which is the upstream limit of coho salmon distribution and presumably the limit for steelhead distribution (see below for more steelhead information). Accessible cutthroat trout habitat is assumed upstream of the culvert until stream gradient and flows are not suitable to support NMF (i.e., 20% stream gradient or more) per coordination with ODFW.

6B. Summary Table (*please provide the following information relative to the Mitigation, which will help determine its benefit*)**:**

	Downstream	**Upstream**
NMF Species Present Currently	According to Rapid Bioassessment surveys completed in Bull Creek in 2003 and 2009 by ODFW, Bull Creek exhibits some the highest coho salmon rearing densities in the Big Elk Creek subbasin. These surveys also indicated that coho salmon spawning was occurring upstream of the culvert proposed for removal, given juvenile coho salmon presence upstream of the culvert. Steelhead densities were very low during the ODFW surveys despite Bull Creek containing ideal habitat for winter steelhead. Cutthroat trout densities were consistent with other similarly-sized Big Elk Creek subbasins. Juvenile coho salmon and cutthroat trout were observed upstream and downstream of the culvert during field investigations by MB&G staff during surveys of Bull Creek in May and June 2015. Pacific and western brook lamprey are also known to occur downstream of the culvert per ODFW.	NMF observed upstream of the culvert include the same species known to occur downstream in lower densities. Steelhead densities are very low upstream of the culvert; however, juvenile steelhead individuals have been observed. It is unknown whether or not Pacific or western brook lamprey occur upstream of the culvert as salmonid-based stream surveys have not revealed the presence of the species.
NMF Species Present Historically	Given the land use history of the Bull Creek basin, habitat conditions, and current NMF assemblages, it is expected that the existing NMF assemblages downstream of the culvert noted above were also historically present. An Oregon Watershed Enhancement Board document that focuses on assessing the historical watershed conditions in the Yaquina River watershed addresses historical data for Bull Creek. The assessment mentions that “silver fry” (juvenile coho salmon) were observed in lower Bull Creek by the Oregon Fish Commission in 1953. The assessment also included anecdotal historical information from a local farmer that lived on Bull Creek in 1953. According to the farmer, Bull Creek is “primarily a silver (coho salmon) stream and with very few other fish entering it” (OWEB 1999).	It is expected that the historic NMF assemblages downstream of the culvert were also historically present upstream of the current culvert location.
Habitat Quality	The aquatic habitat of Bull Creek	Habitat conditions upstream of the

	from the culvert downstream to the Big Elk Creek confluence is comprised of a low gradient channel that exhibits a high level of complexity and substrate variation. Substrate composition is composed primarily of sand (30%) and gravel (28%) and secondarily of cobble and bedrock (ODFW 2011). The valley form is narrow and constrained by steep hillslopes along Bull Creek from the confluence of Big Elk Creek to approximately 2,000 upstream. The average gradient in this reach is 3%. From this point upstream to the culvert the valley broadens with a larger floodplain. The gradient in this stream reach is 0.8% and many side channels, high flow channels, and other off-channel habitat elements are present. During MB&G's field surveys in 2015 approximately 20 large wood assemblages were counted in the stream downstream of the culvert to the Big Elk Creek confluence. These wood assemblages were placed to enhance channel complexity and in-stream habitat and appear to have achieved these goals. During a 2011 habitat survey completed by ODFW in lower Bull Creek, the average wood volume per 100 meters was approximately 60 meters³. The riparian corridor downstream of the culvert is dominated by red alder and an understory dominated by salmonberry, elderberry, willows, and various native forbs and herbaceous species. The average stream shade percentage for both reaches is 85% per the ODFW 2011 survey.	culvert are very similar to downstream conditions. Immediately upstream of the culvert the Bull Creek channel is narrow with a large amount of sand and other fine substrate material that has been deposited due to the culvert's size relative to the stream's active channel width. Approximately 80 feet upstream of the culvert, the channel broadens as does its floodplain terraces and hillslopes. Habitat in Bull Creek from this point upstream is similar to downstream conditions until the mainstem of the creeks divides into many small tributaries with steep gradients. The first upstream tributary to enter the mainstem occurs approximately 600 feet upstream of the culvert. Approximately 1,000 feet upstream of this tributary confluence the mainstem of Bull Creek divides into two large tributaries with dendritic headwater drainage patterns.
Flows	Bull Creek is a perennial stream with flows typical of other similarly-sized coastal subbasins. The rainfall patterns in the late fall, winter, and spring result in high runoff volumes and flow flashiness. These rain-driven flows increase quickly and decrease quickly during and after storm events. Flow conditions are a critical element to the existing passage problem at the culvert. When flows are low and the scour pool below the culvert is several	Flow conditions upstream of the culvert are similar to conditions downstream of the culvert.

	feet below the culvert outlet, the culvert is a complete upstream barrier. When flows are high and the scour pool raises to the height of the culvert outlet upstream passage is possible; however, flow velocities in and exiting the culvert could prevent upstream passage for some species and/or life forms.	
Water Quality	The 2003 and 2009 ODFW Rapid Bioassessment report for Bull Creek discusses Bull Creek having very favorable water temperatures for supporting salmonid life histories. The favorable water quality conditions are linked to the high level of coho salmon production in the system per the ODFW report. The creek is well shaded by a dense riparian canopy and the lack of disturbance in the upper watershed (i.e., no road infrastructure or timber harvesting) results in favorable water quality conditions downstream and upstream of the culvert proposed for removal. The road network downstream of the culvert is denser than upstream of the culvert. As such, it is reasonable to expect that a higher level of sediment loading may at times occur in the reaches downstream of the culvert compared to upstream of the structure.	The lack of development and recent timber extraction upstream of the culvert provides extremely high water quality conditions in Bull Creek upstream of the culvert and supports favorable water quality conditions downstream of the culvert.
Water Right Availability	N/A	N/A
Land Use/Zoning	Per the Lincoln County land use code, the land use/zoning downstream of the culvert is Timber Conservation. This use designation is focused on forest practices including reforestation of forest land, road construction and maintenance, harvesting of a forest tree species, application of chemicals, and disposal of slash. All of the land downstream of the culvert is in private ownership and is managed for industrial timber production per Oregon Department of Forestry and Lincoln County forest practices and zoning rules respectively.	The land use/zoning upstream of the culvert is Timber Conservation. Approximately 800 feet upstream of the culvert the land ownership changes from private to Federal forest land managed by the Siuslaw National Forest under late successional reserve management guidelines.
NMF = native migratory fish		

PLEASE PROVIDE ADDITIONAL DETAILS REGARDING THE INFORMATION PROVIDED IN THE SUMMARY TABLE (*such as species listed under the state or federal ESA and descriptions of the stream channel and riparian habitat*)**:**

As noted above, Bull Creek has some of the highest coho salmon rearing densities in the Big Elk Creek subbasin. A comparison of the 2003 and 2009 ODFW Rapid Bioassessment data for the Big Elk Creek basin shows Bull Creek contained the second highest average coho salmon rearing densities in all of Big Elk Creek tributaries. Rearing densities in Bull Creek during the 2003 surveys were the highest of all Big Elk Creek tributaries. Coho salmon in the Yaquina River basin are listed as threatened under the Federal Endangered Species Act. As such, Bull Creek is an important coho salmon spawning and rearing tributary and is a key component to recovery of the Oregon Coast Coho Salmon Evolutionarily Significant Unit.

As noted earlier in this document, ODOT proposes to purchase the 52-acre parcel and donate the parcel to the Siuslaw National Forest. This action will result in the parcel going into late successional reserve management by the USFS after forest stand restoration (thinning) work funded by ODOT to set the parcel on a late successional forest trajectory. Late successional reserves were established in the NW Forest Plan as land allocations managed primarily to protect and enhance habitat for late-successional and old-growth forest related species, namely the federally listed northern spotted owl. As such, transition of this parcel to late successional reserve management is expected to mitigate the watershed processes permanently lost from the PME project and provide an ecological benefit to local upland, riparian, and aquatic resources. The 52-acre parcel includes approximately 13.4 acres of riparian habitat on the mainstem of Bull Creek and a Bull Creek tributary that joins the mainstem downstream of the culvert proposed for removal. These areas are identified in the Bull Creek Fish Passage and Riparian Buffer Map in Attachment A. Approximately 38.6 acres of upland habitat occurs on the 52-acre parcel, which is dominated by a Douglas fir forest. The parcel was last harvested in 2000 and the current forest is approximately 15 years old. The topography of the parcel is relatively steep, sloping to the mainstem of Bull Creek on its east side and to a Bull Creek tributary on its west side. The road that crosses Bull Creek where the culvert will be removed ascends to the highest point of the parcel where cable yarding has occurred in the past during timber harvest efforts.

6C. PROVIDE THE SOURCE FOR INFORMATION CONTAINED IN THE BARRIER AND SUMMARY TABLES: (Note: information from these sources is included in other sections of this waiver application)

- Coordination with ODOT, ODFW, Hancock, USFS, and other agency staff
- Site visits
- Map review
- GIS data review (i.e., ODFW, BLM, Hancock, and USGS National Hydrogaphy Dataset data)
- 1991 ODFW Yaquina Basin Fish Management Plan
- 1999 OWEB Watershed Assessment Guidebook Compnent II Historical Conditions Assessment
- 2003 and 2009 Bull Creek ODFW Rapid Bioassessment Survey Reports
- 2005 ODFW Coastal Multi-Species Conservation and Management Plan
- 2008 U.S. Fish and Wildlife Pacific Lamprey Life Cycle Fact Sheet
- 2009 Washington Department of Fish and Wildlife Fish Passage and Surface Water Diversion Screening Assessment and Prioritization Manual
- 2011 ODFW Aquatic Inventory Project Restoration Monitoring Stream Habitat Report for Bull Creek
- 2015 National Marine Fisheries Service (NMFS) Proposed ESA Recovery Plan for Oregon Coast Coho Salmon (*Oncorhynchus kisutch*)

7. Describe How the Mitigation Relates to Any Existing Fish Management Plans, Including the Oregon Plan:

The proposed ESA Recovery Plan for Oregon Coast Coho Salmon (NMFS 2015) lists several factors and strategies for recovery of coastal coho salmon populations that are integrated into PME project fish passage and habitat mitigation elements. Recovery Factor A in the plan lists reduced stream complexity, degraded water quality, and blocked/hindered fish passage as a primary limiting factor for recovery. The plan documents several key strategies for population recovery in the mid-coast stratum which includes the Yaquina River basin. Recovery strategies for this region identified in the plan include the following goals that mirror the expected benefits of the proposed mitigation:

- *"Implement the Strategic Action Plans to protect and restore ecosystem processes and functions and coho salmon habitats. Activities should include restoring habitat capacity for rearing juvenile coho salmon by increasing large wood loading, beaver habitat, and wetland/off-channel connectivity, by increasing native riparian vegetation to provide bank stability and shade stream reaches, and improving available spawning habitat to support productivity."*
- *"Collaborate with governmental and non-governmental organizations and others to identify, and implement, actions that will protect and restore watershed processes, provide stream complexity for juvenile rearing, connect side channels, wetland and off-channel habitats, and reduce fine sediment levels."*
- *"Improve wood recruitment to support long-term increases in habitat complexity by 900 improving timber harvest activities and agricultural practices."*
- *"Increase habitat complexity by increasing large wood, boulders, or other instream structure and conducting riparian planting projects."*
- *"Improve floodplain connectivity by increasing beaver abundance and reducing or limiting development of channel confining structures, including roads and infrastructure."*

Primary watershed actions identified in the plan for private timberlands in the mid-coast stratum include:

- *"Increase protection of riparian reserves and no-touch buffer widths."*
- *"Eliminate the construction of permanent new roads. Decommission roads where practicable."*
- *"Increase placement of large wood into stream channels."*

Secondary watershed actions identified in the plan for fish passage access in the mid-coast stratum include:

- *"Continue efforts to improve fish passage at dams, culverts, and other identified fish passage barriers in all populations. Assess remaining fish passage barriers and develop an implementation strategy and schedule."*

The proposed mitigation relates directly to several objectives outlined in the ODFW's 1991 Yaquina Basin Fish Management Plan. Specifically, the mitigation addresses Objective 4 listed in the plan, which states, "*Restore and enhance riparian and in-stream habitats to help achieve natural production objectives for fish in the basin."* Passage barriers are listed as key problem for addressing Objective 4. The removal of the Bull Creek culvert will support this objective. Objective 4 also lists the following as a limiting factor for management and sustainability of the Yaquina Basin fish resource, "*Land management activities have reduced the age and species diversity of riparian plant communities that contribute to fish production in many tributaries*." The riparian restoration proposed at the Big Elk Creek site as well as the establishment of riparian buffers along Bull Creek will provide localized improvements to existing riparian plant communities' age and species diversity. Objective 3 of the plan addresses protection of freshwater habitat. Objective 3 includes the following problem statement, "*Current forest practices rules and guidelines may not adequately protect some streams, particularly smaller streams (class 2 by ODF classification, class 4 by USFS classification, and order 1 and 2 by BLM classification).*" For the most part, current Oregon forest practice rules are consistent with the rules that were in place in 1991 when the plan was prepared. The preservation of riparian buffers along Bull Creek that exceed current forest practice buffer widths and the transition of the 52-acre parcel from industrial timber production to late successional reserve management will address the Objective 3 problem statement listed above on a localized scale by minimizing the potential effects of timber production and extraction on the freshwater habitat in Bull Creek. The proposed mitigation will support and enhance the long-term viability of Bull Creek serving as a critical spawning and rearing headwater tributary in the Yaquina Basin for coho salmon, cutthroat trout, and to a lesser degree steelhead, which is an intrinsic management objective in the plan.

The proposed mitigation supports the mission of the Oregon Plan for Salmon & Watersheds. The following is the Oregon Plan's mission statement, "*Restoring our native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits.*" The proposed mitigation elements focus on improving salmonid habitat quality and connectivity in the Bull Creek and Big Elk Creek subbasin. As such, the mitigation is expected to benefit coho salmon given the proposed improvements in the Bull Creek and Big Elk Creek subbasins. Coho salmon are a focal species of the Oregon Plan given it was developed as a proactive response to the eventual federal listing of Oregon Coast coho salmon in the 1990s.

8. DESCRIBE ANY KNOWN RESTORATION OR LAND USE PLANS WHICH MIGHT HAVE AN IMPACT ON THE MITIGATION *(e.g., is the watershed included within an expanded Urban Growth Boundary or does a Local Comprehensive Plan limit future development in the watershed)***:**

There are no known restoration or land use plans that could have an impact on the proposed mitigation sites. The Bull Creek mitigation site is zoned Timber Conservation and the Big Elk Creek site is zoned Agriculture Conservation by Lincoln County. The proposed mitigation to be conducted at both sites is consistent with Lincoln County zoning and land use rules. The NW Forest Plan late successional reserve standards and guidelines will influence USFS' management of the 52-acre parcel with a focus of establishing late successional coniferous forest.

9. IF THE MITIGATION ENTAILS PROVIDING PASSAGE AT AN EXISTING ARTIFICIAL BARRIER, WHAT IS THE EXPECTED DATE OF REPLACEMENT OR MAJOR REPAIR FOR THE STRUCTURE IF IT WERE NOT USED AS MITIGATION:

The current owner of the culvert on Bull Creek proposed for removal does not have a plan for replacing the culvert. If culvert conditions warrant, the culvert would likely be repaired or replaced in the next 25-30 years, just prior to the next timber harvest on the 52-acre parcel that is accessed by the culvert and road. The repair or replacement would be completed per Oregon Department of Forestry forest practice rules for stream crossings on private timberland.

10. DOES THE MITIGATION INCLUDE ANY ACTIVITY THAT IS A REQUIREMENT OR CONDITION OF ANY OTHER AGREEMENT, LAW, PERMIT, OR AUTHORIZATION *(if "Yes", describe)***:**

The proposed mitigation has been developed to also satisfy regulatory permitting requirements for the PME project that are administered by the National Marine Fisheries Service (NMFS), U.S. Army Corps of Engineers (USACE), and Oregon Department of State Lands (DSL). Specifically, the mitigation has been developed to satisfy Section 7 of the Endangered Species Act for PME project impacts to Federally listed coho salmon (NMFS), to satisfy Clean Water Act requirements for PME project impacts on jurisdictional wetlands and waters of the U.S. (USACE), and to satisfy Oregon Removal/Fill Law requirements for PME project impacts on jurisdictional wetlands and waters of the state (DSL).

11. DESCRIBE HOW THE MITIGATION WILL BE FUNDED *(include a cost estimate, funding sources, and whether funds are currently secured)***:**

ODOT is funding the proposed fish passage mitigation activities and mitigation funding has been secured. The mitigation is expected to cost approximately $3 million. This estimate includes mitigation stakeholder coordination, mitigation design, permitting, construction, land purchases, and long-term stewardship of the sites.

12. DESCRIBE HOW THE MITIGATION WILL BE EVALUATED, MONITORED, AND MAINTAINED:

The design-build team implementing the mitigation work will closely monitor mitigation construction so that the mitigation elements are implemented per mitigation plans, design criteria, and permit conditions. The mitigation will be monitored at the completion of construction (as-built monitoring) to ensure the mitigation elements were constructed per project plans and design and performance criteria. The sites will then be evaluated, monitored, and maintained by the design-build team for up to five years after construction to determine if the sites are stable, native plantings are establishing, invasive weeds are controlled, wetland functions are meeting mitigation plan criteria, and in-stream channel restoration at the Bull Creek crossing is consist with intended post-construction conditions. On-site amendments to these mitigation elements will occur if they are not performing per mitigation planning documents and permit conditions.

After the expected five-year post-construction, permit-driven monitoring and maintenance period, long-term site stewardship will be conducted by The Wetland Conservancy or similar land trust (land steward) in perpetuity. The land steward will monitor each site, exclusive of the 52-acre parcel under USFS management, at least once a year to ensure that the terms of the site deed restrictions are being met. This will include making sure no mitigation vegetation is removed or damaged, the sites are free of trash and liter, no grading, excavating or other earthwork has occurred, and to ensure mitigation site signage is present and properly positioned. The land steward will provide maintenance to the sites if any of the elements mentioned above are not meeting mitigation plan and permit conditions.

The 52-acre parcel to be donated to USFS will be evaluated, monitored, and maintained by the USFS after ownership of the land is transitioned to USFS. The USFS will manage the land per the standards and guidelines outlined in the NW Forest Plan's late successional reserve management designation. This may involve additional forest restoration activities conducted by the USFS over time as the site continues on a late successional forest trajectory.

MAP(S)

- *Please attach one or more maps indicating the Artificial Obstruction, Mitigation, the streams on which they are located, and other barriers in those streams. A 7.5 minute USGS quad map is sufficient.*

☒ -- Map(s) included

PHOTOS

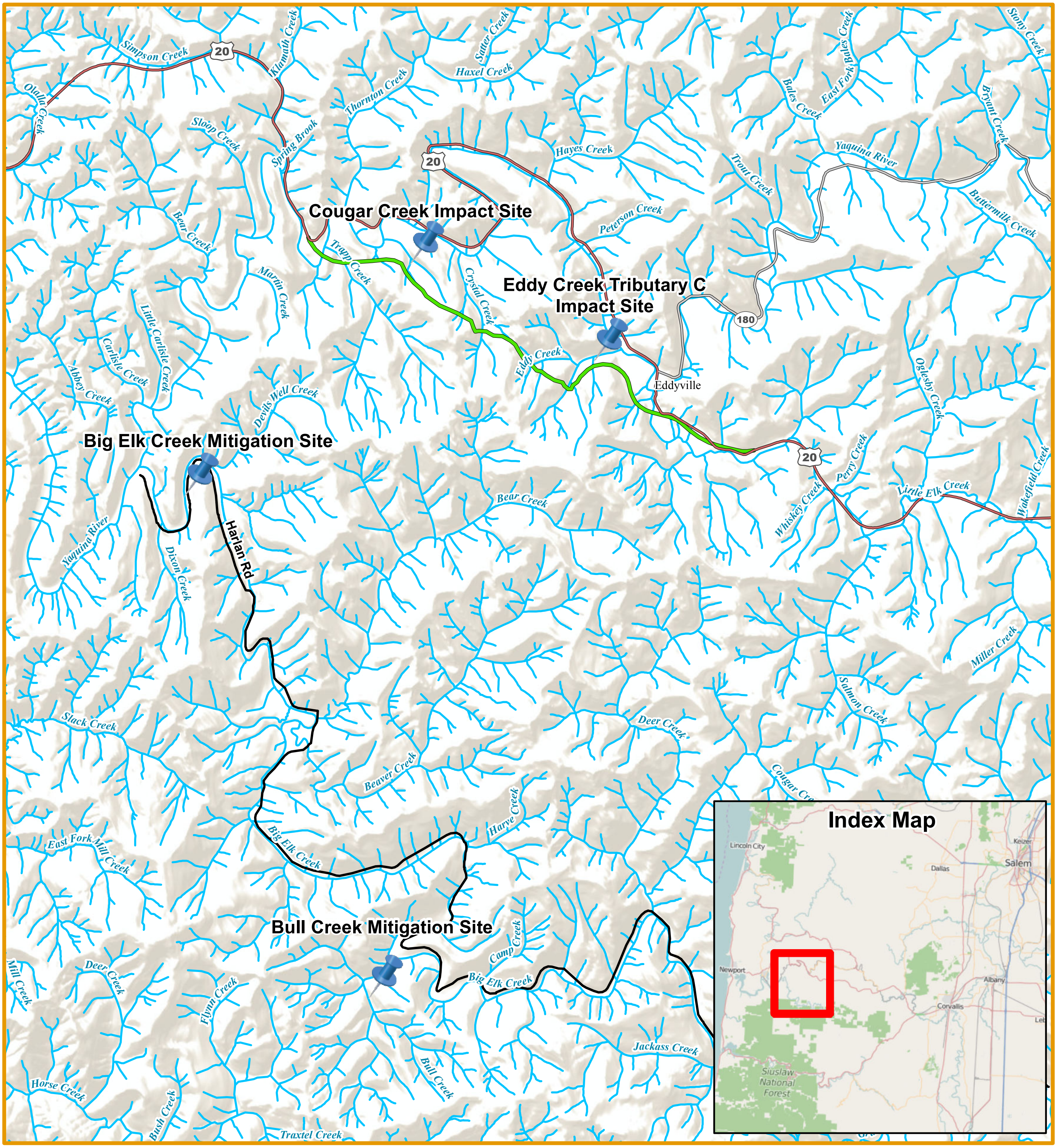
- *Please include photographs of the following* (*.JPG files are preferred):*

☒ -- Artificial Obstruction
☒ -- Mitigation Site(s)
☒ -- up- and downstream habitat at the Artificial Obstruction and Mitigation Site(s)
☒ -- other barriers up- and downstream of the Artificial Obstruction and Mitigation Site(s)

Please submit this application electronically to the ODFW Fish Passage Coordinator at greg.d.apke@state.or.us and send one signed original paper copy of the application to the ODFW Fish Passage Coordinator at 3406 Cherry Avenue NE, Salem, OR 97303.

Attachment A

Impact and Mitigation Site Maps



Fish Passage Impact and Mitigation Overview

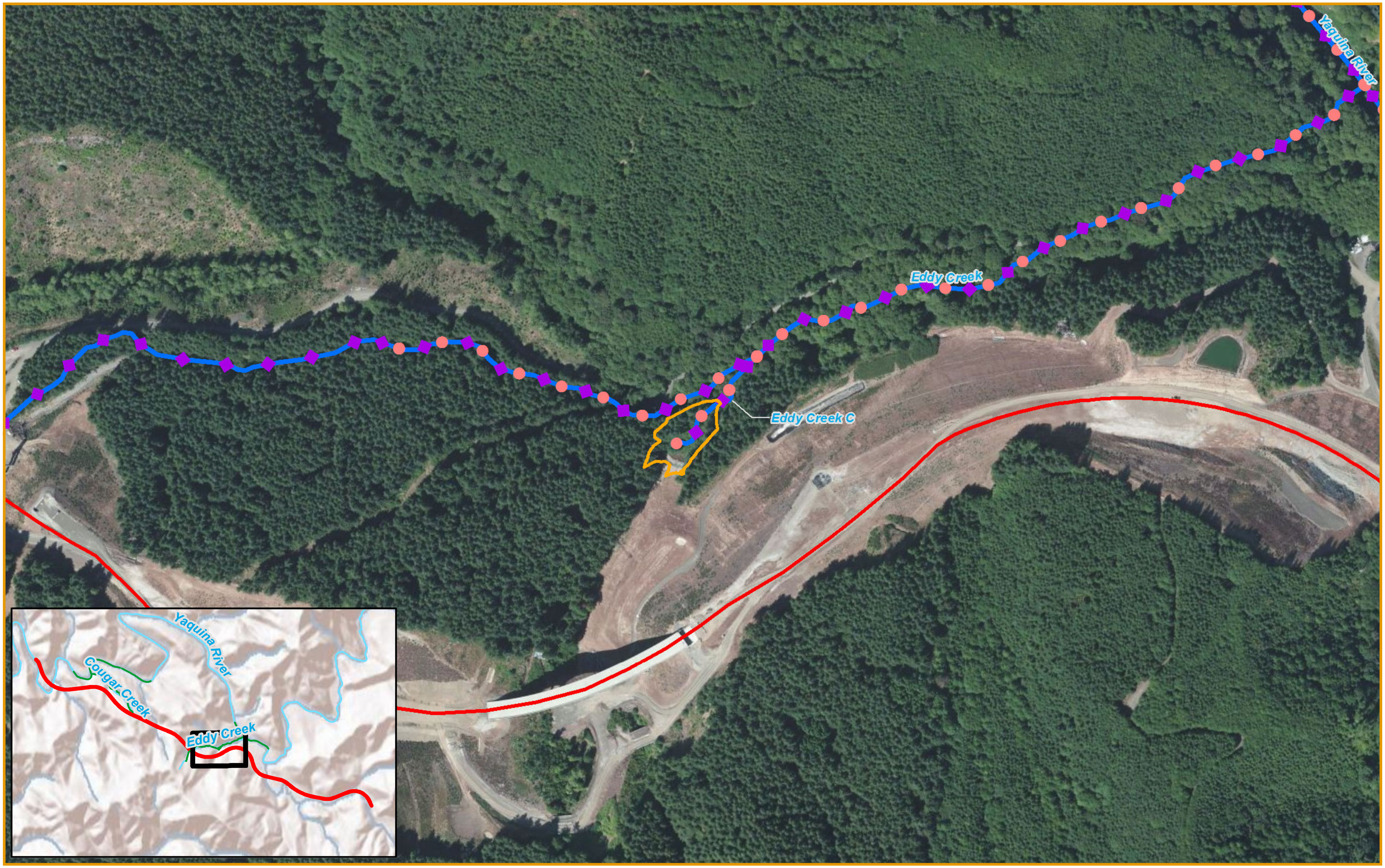
Project Sites
Project Corridor
Stream
Interstate Highway
US Highway
State Highway
Other Roads

MB&G

Source: Basemap from ESRI. Reproduced for infomational purposes and may not be suitable for legal, engineering or surveying purposes. Conclusions drawn from such information are the responsibility of the user.

0 0.5 1 2 Miles

Phase 9 Fish Passage Waiver Application
FFO – US20 PME: UPRR-Eddyville Project
Lincoln County, Oregon



Eddy Creek C
Fish Passage Impact Site

Phase 9 Fish Passage Waiver Application
FFO – US20 PME: UPRR-Eddyville Project
Yaquina Turnkey Mitigation
Lincoln County, Oregon

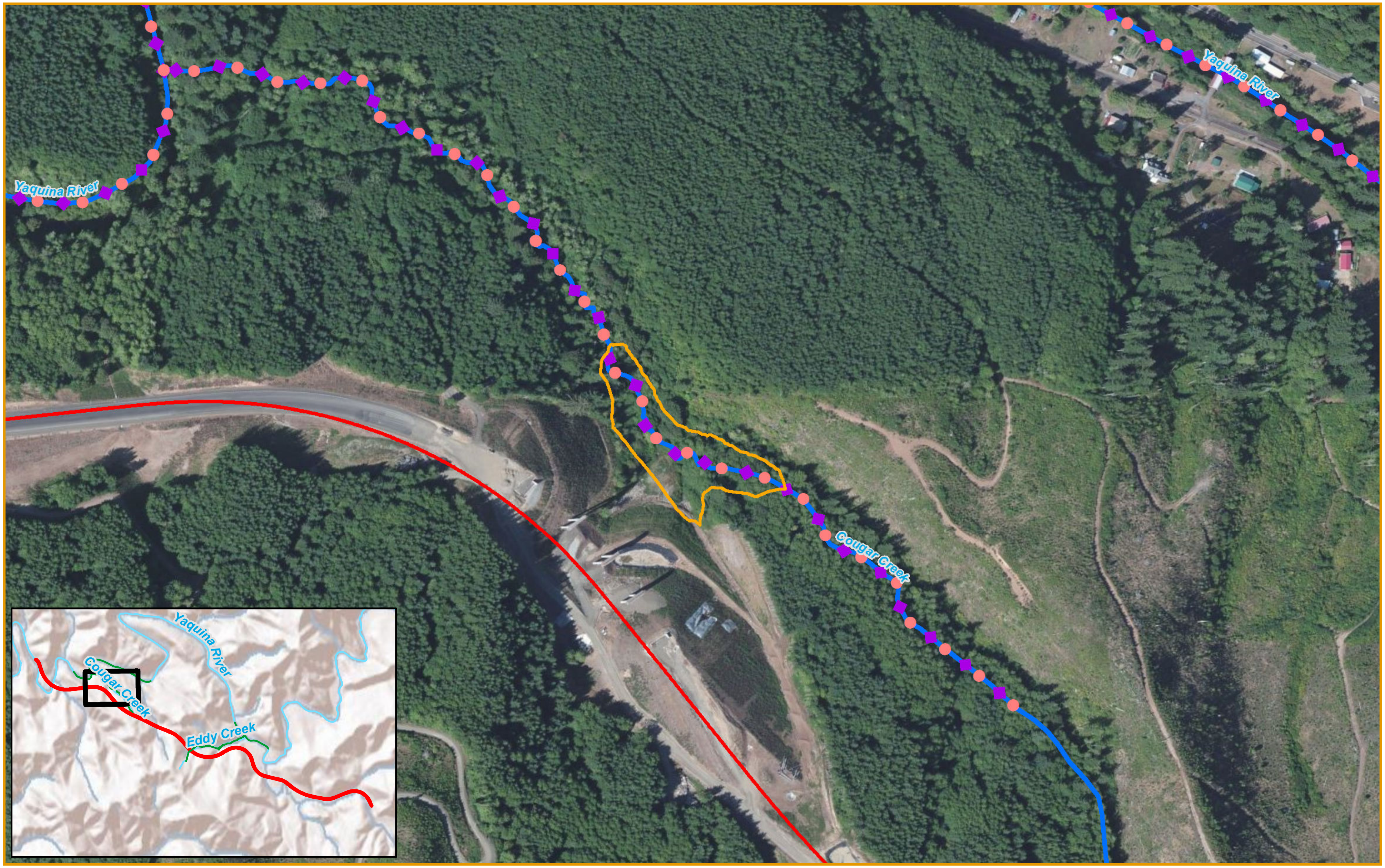
Rock Buttress Impact Area (0.676 acres)
New US 20 Alignment
Stream

Native Migratory Fish Distribution
Coho Salmon and Cutthroat Trout
Cutthroat Trout Only

MB&G

Source: Aerial imagery from Bing, fish distribution from ODFW and NOAA. Reproduced for informational purposes and may not be suitable for legal, engineering or surveying purposes. Conclusions drawn from such information are the responsibility of the user.

1 inch = 400 feet
0 200 400 feet



Cougar Creek
Fish Passage Impact Site

Phase 9 Fish Passage Waiver Application
FFO – US20 PME: UPRR-Eddyville Project
Yaquina Turnkey Mitigation
Lincoln County, Oregon

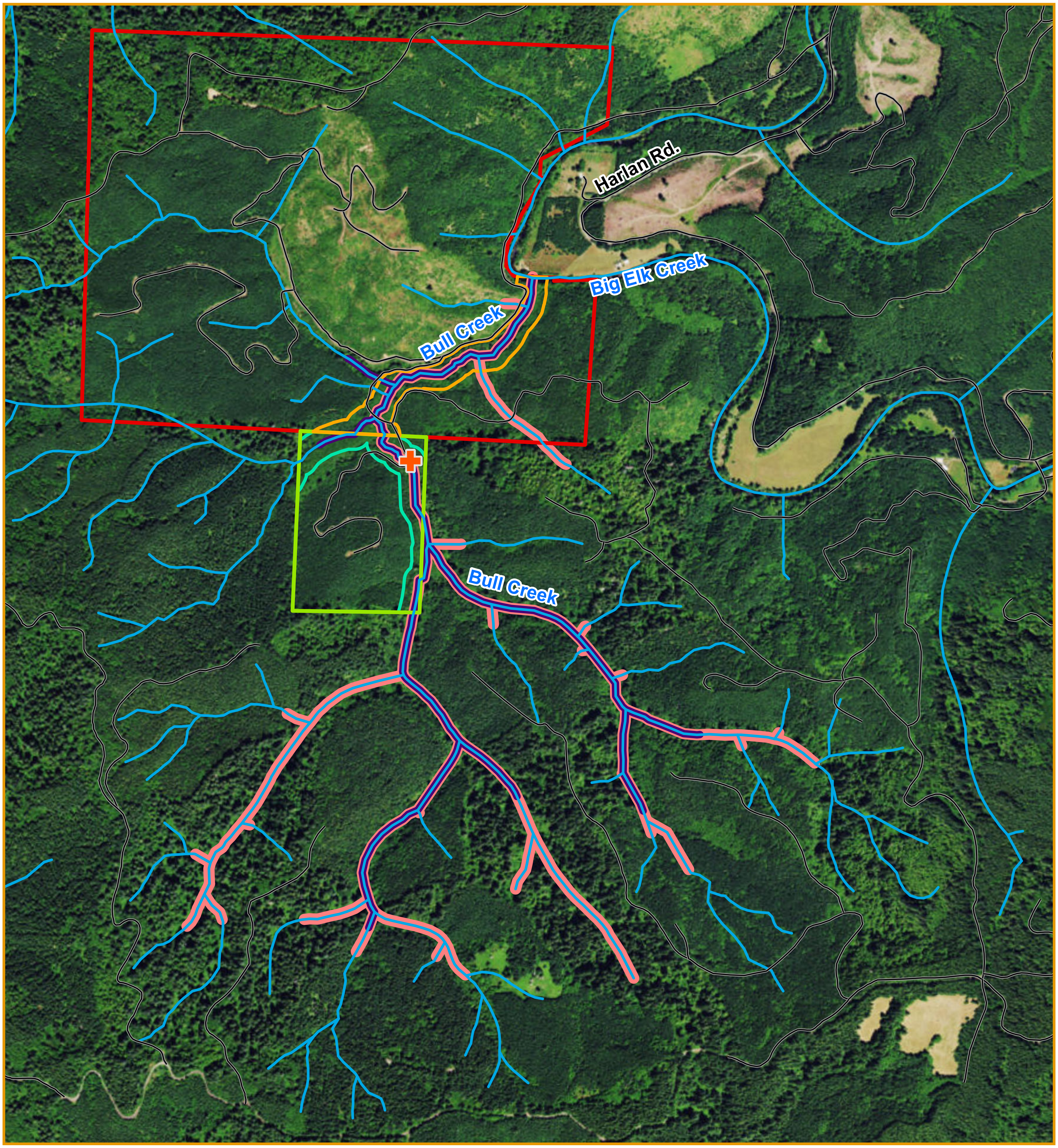
Rock Buttress Impact Area (2.42 acres)
New US 20 Alignment
Stream

Native Migratory Fish Distribution
Coho Salmon and Cutthroat Trout

MB&G

Source: Aerial imagery from Bing, fish distribution from ODFW and NOAA. Reproduced for informational purposes and may not be suitable for legal, engineering or surveying purposes. Conclusions drawn from such information are the responsibility of the user.

1 inch = 400 feet
0 200 400 feet



Bull Creek Fish Passage and Riparian Buffer Map

Phase 9 Fish Passage Waiver Application
FFO – US20 PME: UPRR-Eddyville Project
Lincoln County, Oregon

- Nestucca Forests LLC parcel
- Portion of parcel to be donated to USFS
- Culvert to be removed
- Riparian Buffer Area - 16.60 acres
- Riparian Area within 52 acre parcel - 13.44 ac
- Coho Rearing Habitat - 10,900 ft above existing culvert
- Cutthroat Trout Distribution - 23,593 ft above existing culvert
- Streams
- Roads

N

MB&G

Source: Aerial imagery from ESRI.
Reproduced for informational purposes and may not be suitable for legal, engineering or surveying purposes. Conclusions drawn from such information are the responsibility of the user.

0 250 500 1,000 1,500 feet

Attachment B

Impact and Mitigation Site Photographs

1

2

MB&G

FFO – US20 PME: UPRR-EDDYVILLE PROJECT
PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS

Mason, Bruce & Girard, Inc.
Photo Date:
July 10, 2015

1. View of the existing rock buttress on Eddy Creek C. The tributary is located in a pipe below the rock channel.
2. View of the Eddy Creek C rock buttress culvert outlet. The proposed rock buttress extension will extend the existing buttress 216 feet downstream beyond this point.

3

4

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: July 10, 2015	3. View of a portion of Eddy Creek C proposed to be filled by the rock buttress extension. 4. View of a portion of Eddy Creek C proposed to be filled by the rock buttress extension.

5

6

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: July 10, 2015	5. View of a portion of Eddy Creek C drainage proposed to be filled by the rock buttress extension. 6. View of the downslope extent of the existing rock buttress at Cougar Creek and buttress drainage pipe. This pipe does not drain Cougar Creek; Cougar Creek is located in the riparian area in the photo background.

7

8

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: July 10, 2015	7. View of existing Cougar Creek rock buttress drainage features. These features drain to the pipe shown in Photo 6. 8. View of the portion of the Cougar Creek drainage proposed for additional rock buttress construction.

9

10

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: July 10, 2015	9. View of the Cougar Creek channel where rock buttress and culvert construction is proposed. 10. View of the Cougar Creek channel where rock buttress and culvert construction is proposed.

11

12

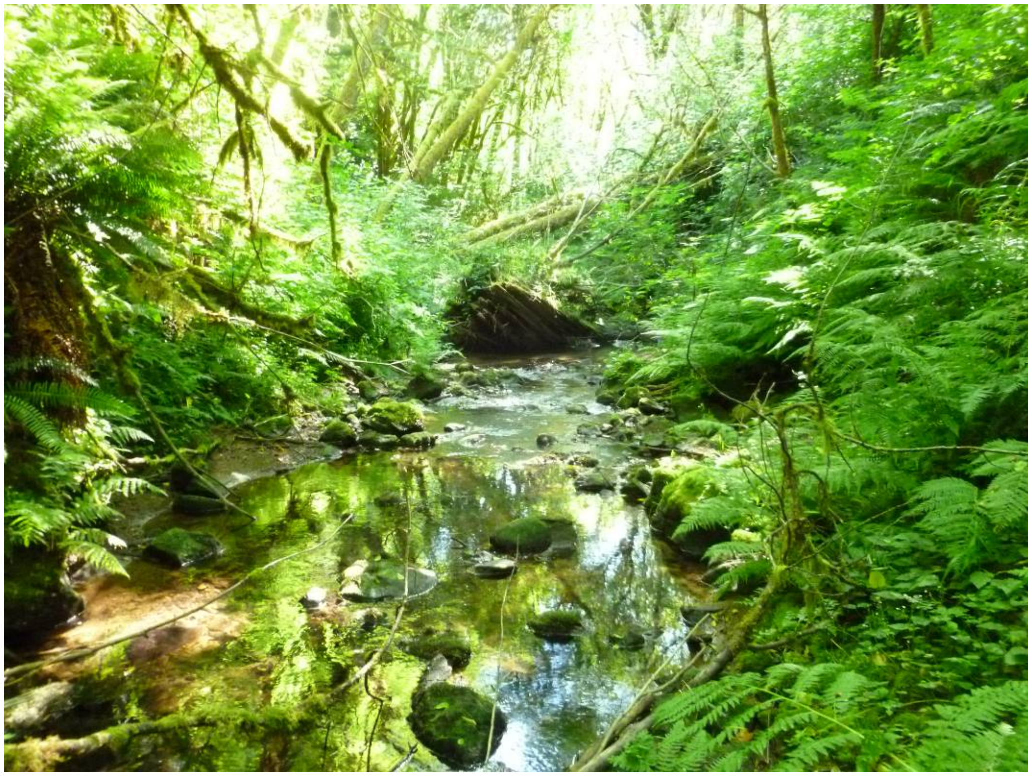
MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: June 26, 2015	11. View of the existing Bull Creek culvert and outlet pool. 12. View of the existing Bull Creek culvert and outlet pool.

13

14

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: June 26, 2015	13. View of the existing Bull Creek culvert inlet. 14. View of Bull Creek road and the Bull Creek crossing (at red arrow).

15



16

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: June 26, 2015	15. View of habitat conditions in Bull Creek downstream of the Bull Creek culvert. 16. View of habitat conditions in Bull Creek downstream of the Bull Creek culvert.

17

18

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: June 26, 2015	17. View of juvenile coho salmon rearing in Bull Creek downstream of the Bull Creek culvert. 18. View of the Bull Creek road bridge and Bull Creek downstream of the Bull Creek culvert.

19

20

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: June 26, 2015	19. View of Bull Creek immediately upstream of the Bull Creek culvert. 20. View of habitat conditions in Bull Creek upstream of the Bull Creek culvert.

21

22

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: June 26, 2015	21. View of habitat conditions in Bull Creek upstream of the Bull Creek culvert. 22. View of habitat conditions in Bull Creek upstream of the Bull Creek culvert.

23

24

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Dates: June 26, 2015 and May 1, 2015	23. View of Bull Creek road in the 52-acre parcel proposed for ownership and use transition. 24. View of the Big Elk Creek riparian/floodplain and wetland mitigation site and Harlan Road.

25

26

MB&G	FFO – US20 PME: UPRR-EDDYVILLE PROJECT PHASE 9 FISH PASSAGE WAIVER APPLICATION PHOTOGRAPHS
Mason, Bruce & Girard, Inc. Photo Date: June 30, 2015	25. View of the Big Elk Creek riparian/floodplain and wetland mitigation site immediately after it was mowed for site surveys. 26. View of Big Elk Creek at the Big Elk Creek mitigation site.

27

27. View of Big Elk Creek at the Big Elk Creek mitigation site.

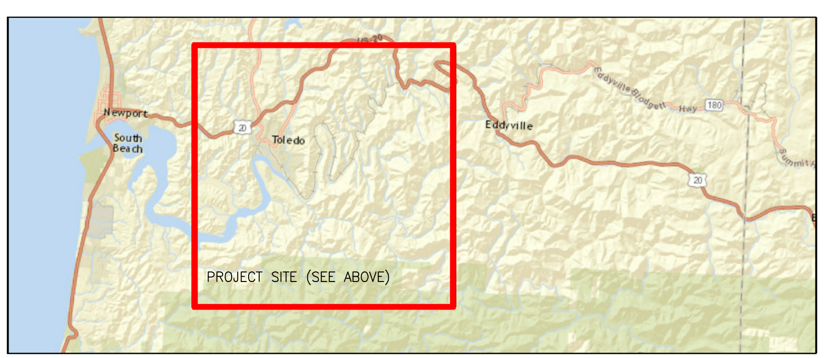
Attachment C

Preliminary Mitigation Sites Design Plans

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

PROJECT SITE MAP



VICINITY MAP

PROJECT AREA MAP

NOT TO SCALE

SHEET INDEX

SHEET	TITLE
G01	COVER SHEET AND INDEX
G02	GENERAL NOTES AND LEGENDS
G03	EROSION CONTROL DETAILS
G04	EROSION CONTROL DETAILS
G05	ALTERNATIVE WORK AREA ISOLATION DETAILS
BE01	BIG ELK EXIST. CONDITIONS AND TREE REMOVAL PLAN
BE02	BIG ELK GRADING PLAN (SOUTH)
BE03	BIG ELK GRADING PLAN (NORTH)
BE04	BIG ELK PROFILES
BE05	BIG ELK TYPICAL SECTIONS
BE06	BIG ELK TYPICAL SECTIONS AND DETAILS
BE07	BIG ELK CREEK SITE REVEGETATION PLAN
BE08	BIG ELK CREEK SITE REVEGETATION PLAN
BE09	BIG ELK CREEK SITE REVEGETATION PLAN
BE10	BIG ELK CREEK SITE REVEGETATION PLAN
BC01	BULL CREEK EXISTING CONDITIONS AND DEMOLITION PLAN
BC02	BULL CREEK GRADING PLAN AND PROFILE
BC03	BULL CREEK TYPICAL SECTIONS AND DETAILS
BC04	BULL CREEK SITE REVEGETATION PLAN
BC05	BULL CREEK SITE REVEGETATION PLAN

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/26/15

ODOT US20 PME TURNKEY MITIGATION PROJECT
LINCOLN COUNTY, OREGON
COVER SHEET AND INDEX

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
G01
Sheet No.

Plotted: Aug 26, 2015 - 1:34pm melaniem L:\Project\17500\17545\CADD\ACAD\General\G01.dwg Layout Name: G01

GENERAL LEGEND

	EXISTING	PROPOSED
TAXLOT		
EASEMENT		
RIGHT-OF-WAY		
EDGE OF GRAVEL		
FIBER OPTIC LINE	FO FO	
CENTERLINE		
OFFSET LINE		
MAJOR CONTOUR		
MINOR CONTOUR		
GRADING LIMITS		
SECTION LINE		
HIGHEST MEASURED TIDE LINE	OHW	
MEAN HIGH TIDE LINE	MHT MHT	
WETLAND		
CULVERT		
TREE		
SURVEY CONTROL POINT		
MONITORING WELL		
WETLAND FLAG		
LARGE WOOD ASSEMBLAGE		

EROSION CONTROL AND WORK AREA ISOLATION LEGEND

FLOW DIRECTION

WORK AREA ISOLATION

TEMPORARY IMPACT LIMITS

STAGING AREA

GENERAL NOTES

1. TOPOGRAPHIC BASEMAP PREPARED IN JULY-AUGUST 2015. PROJECT COORDINATES ARE STATE PLANE, NORTH ZONE, NAD83(2011)(EPOCH 2010) AND PROJECT ELEVATIONS ARE NAVD88(GEOID12B), UNITS IN INTERNATIONAL FEET. RIGHT-OF-WAY AND PROPERTY LINES SHOWN ARE APPROXIMATE. ADDITIONAL PROPERTY LINES DERIVED FROM GIS SHAPEFILE DATA OBTAINED FROM LINCOLN COUNTY GIS DEPARTMENT, AND IS SHOWN FOR GRAPHICAL PURPOSES ONLY.
2. ALCOVE, WETLAND, AND OVERFLOW CHANNEL ELEVATIONS ON THE BIG ELK CREEK SITE ARE BASED ON LIMITED HYDROLOGIC MONITORING DATA AND ARE SUBJECT TO REVISION.
3. WATER CONVEYED TO THE LOWER WETLAND ALCOVE IS EXPECTED TO BE PROVIDED BY SURFACE WATER AND/OR GROUNDWATER.
4. WATER CONVEYED TO THE UPPER WETLAND WILL BE PROVIDED BY DIRECT PRECIPITATION AND HILLSLOPE RUNOFF. A LOW-PERMEABILITY LINER (CLAY, BENTONITE, OR SIMILAR MATERIAL) WILL LIKELY BE NECESSARY TO LIMIT INFILTRATION RATES.

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/26/15

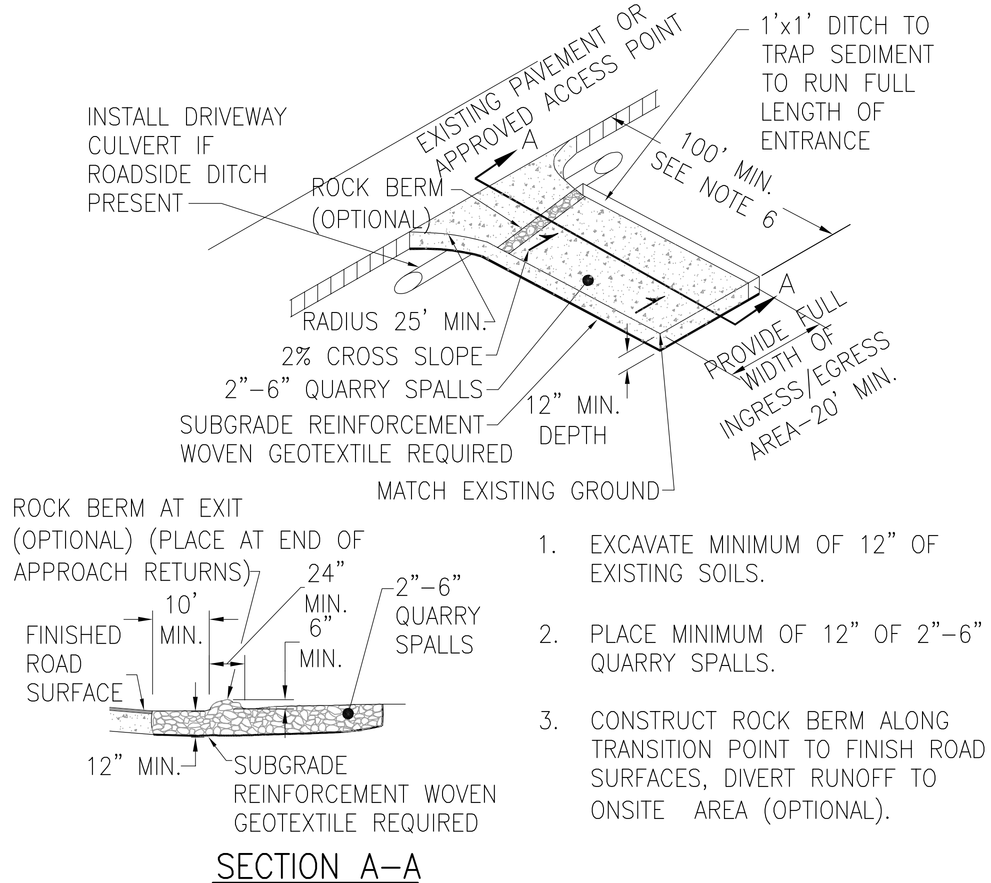
ODOT US20 PME TURNKEY MITIGATION PROJECT
LINCOLN COUNTY, OREGON
GENERAL NOTES AND LEGENDS

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
G02
Sheet No.

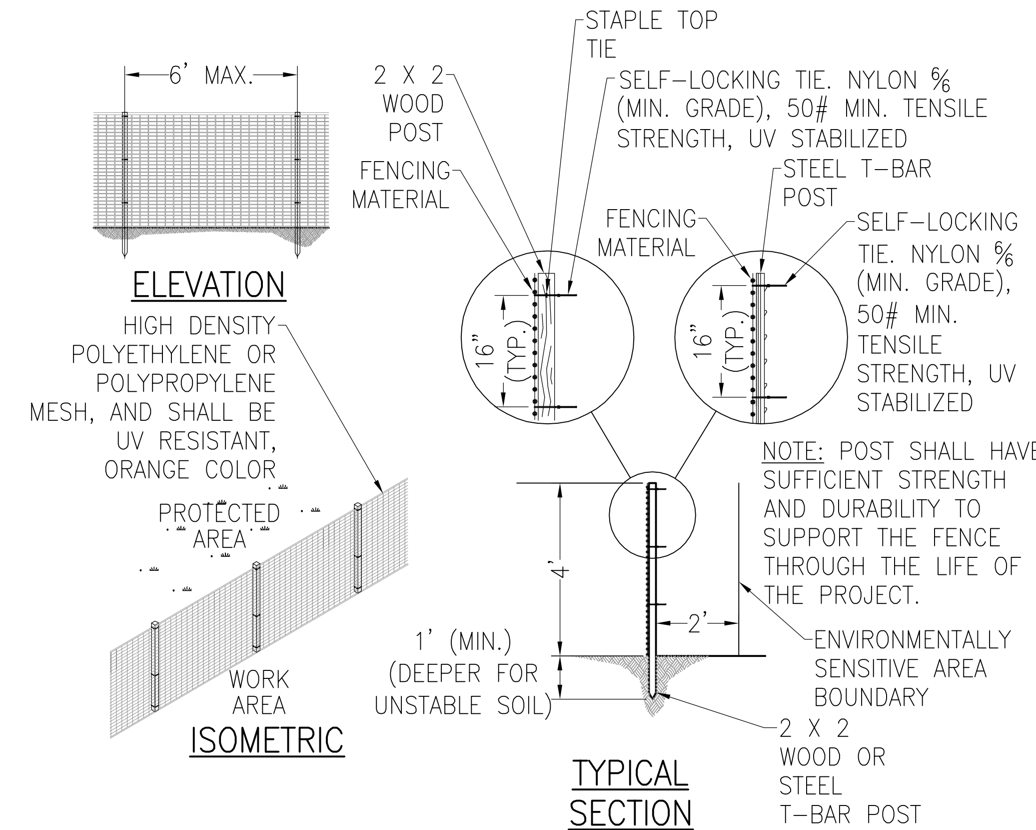
Plotted: Aug 26, 2015 - 1:44pm omic L:\Project\17500\17545\CADD\ACAD\General\G02.dwg Layout Name: G02



1. EXCAVATE MINIMUM OF 12" OF EXISTING SOILS.
2. PLACE MINIMUM OF 12" OF 2"-6" QUARRY SPALLS.
3. CONSTRUCT ROCK BERM ALONG TRANSITION POINT TO FINISH ROAD SURFACES, DIVERT RUNOFF TO ONSITE AREA (OPTIONAL).

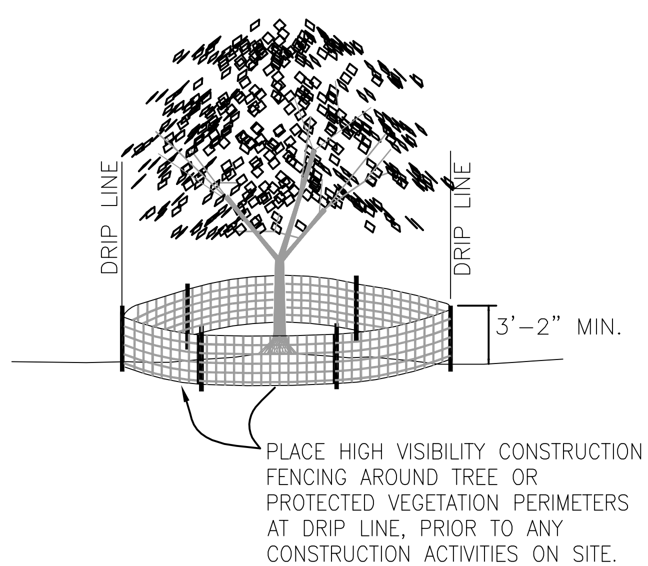
1 STABILIZED CONSTRUCTION ENTRANCE

NTS



2 HIGH VISIBILITY FENCE

NTS



3 VEGETATION PROTECTION

NTS

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/26/15

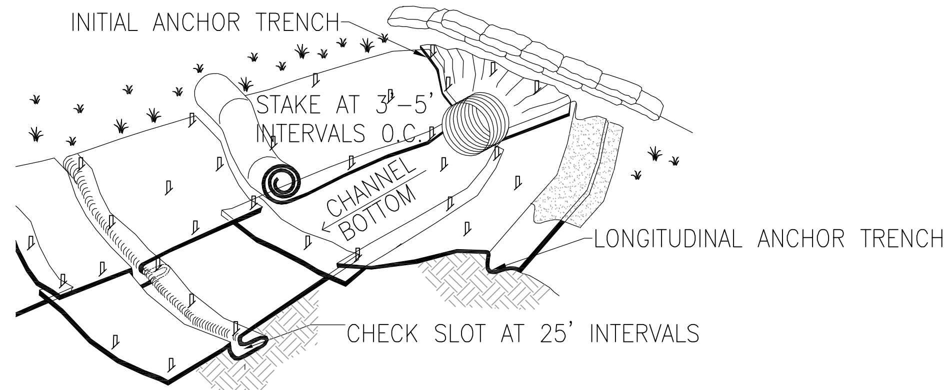
ODOT US20 PME TURNKEY MITIGATION PROJECT
LINCOLN COUNTY, OREGON
EROSION CONTROL DETAILS

otak
HanmiGlobal Partner

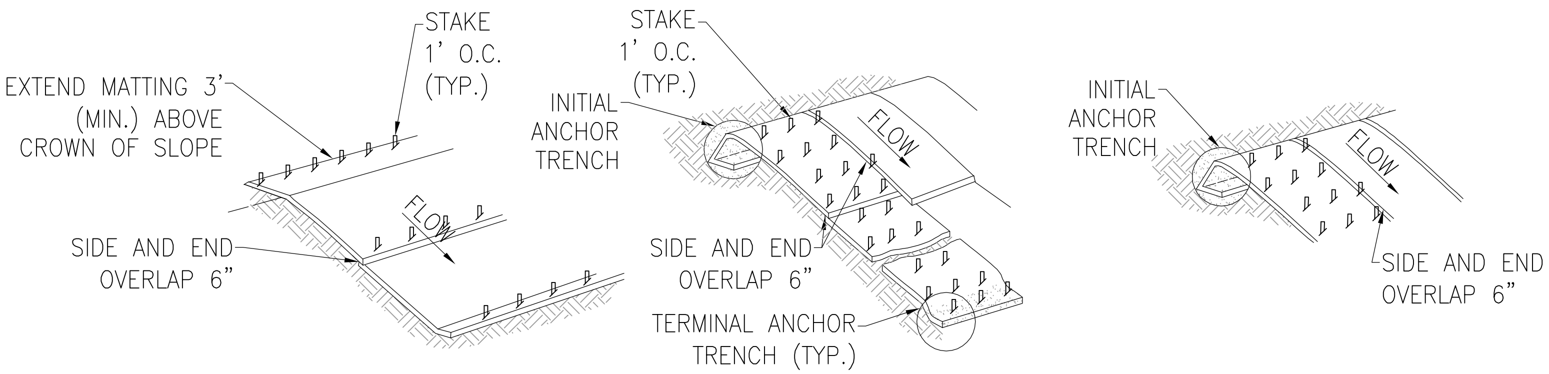
Datum: NAVD 88

17545
Project No. Drawing No.
G03
Sheet No.

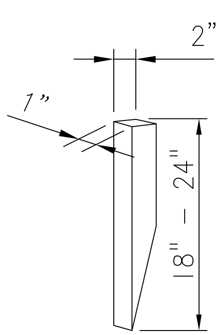
Plotted: Aug 26, 2015 - 1:42pm amic L:\Project\17500\17545\CADD\ACAD\General\G03-G05.dwg Layout Name: G03



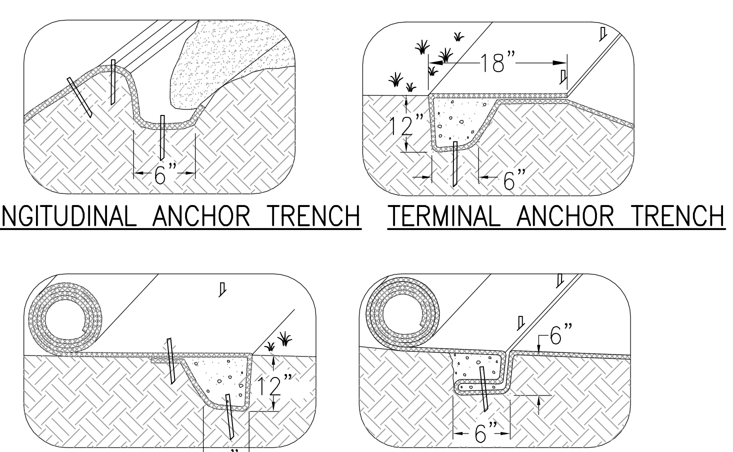
CHANNEL INSTALLATION – ISOMETRIC VIEW



SLOPE INSTALLATION – ISOMETRIC VIEW



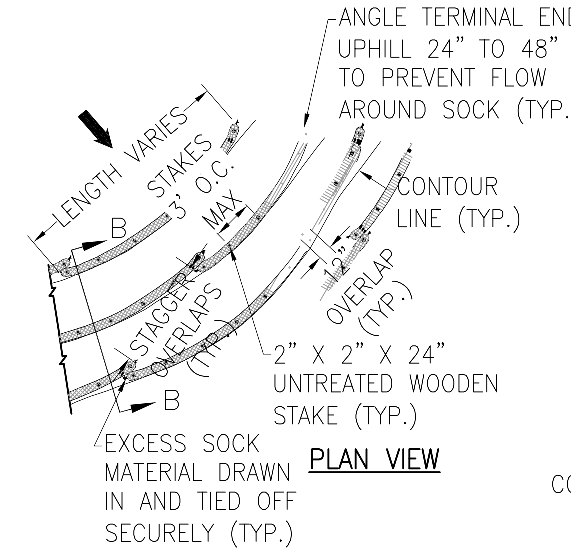
WOOD STAKES



NOTE:
BIODEGRADABLE MATTING WILL BE INSTALLED ON SLOPES AT 4H:1V OR STEEPER, UNLESS SHOWN OTHERWISE ON THE PLANS.

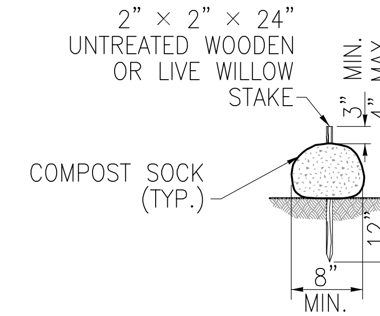
1 BIODEGRADABLE EROSION CONTROL MATTING

NTS

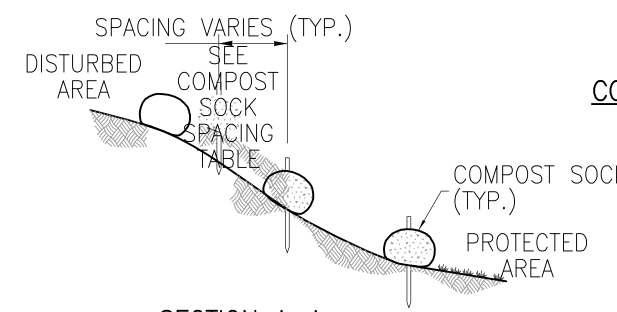


PLAN VIEW

8" DIAMETER COMPOST SOCK SPACING TABLE	
SLOPE	MAXIMUM SPACING
1H : 1V	10' – 0"
2H : 1V	20' – 0"
3H : 1V	30' – 0"
4H : 1V	40' – 0"



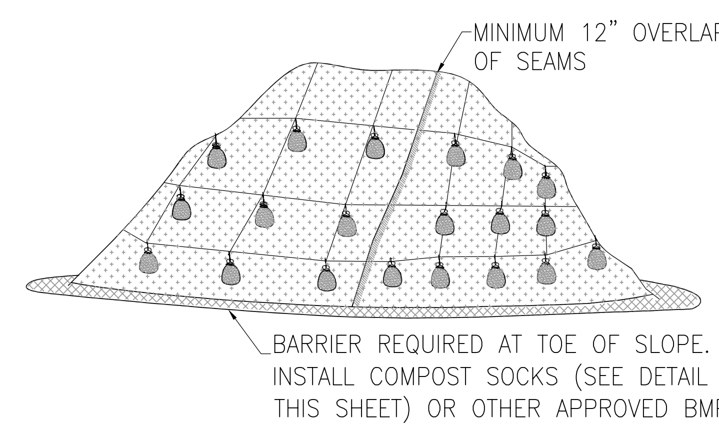
COMPOST SOCK DETAIL



SECTION A–A

2 COMPOST SOCK

NTS



3 PLASTIC SHEETING

NTS

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/26/15

ODOT US20 PME TURNKEY MITIGATION PROJECT
LINCOLN COUNTY, OREGON
EROSION CONTROL DETAILS

otak
HanmiGlobal Partner

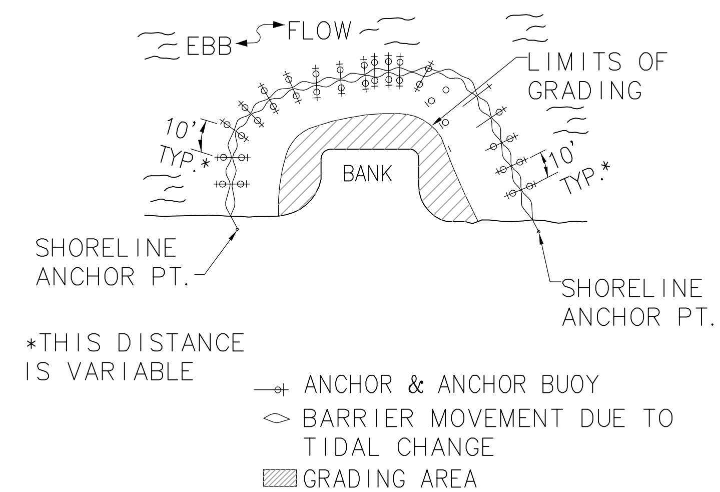
Datum: NAVD 88

17545
Project No. Drawing No.

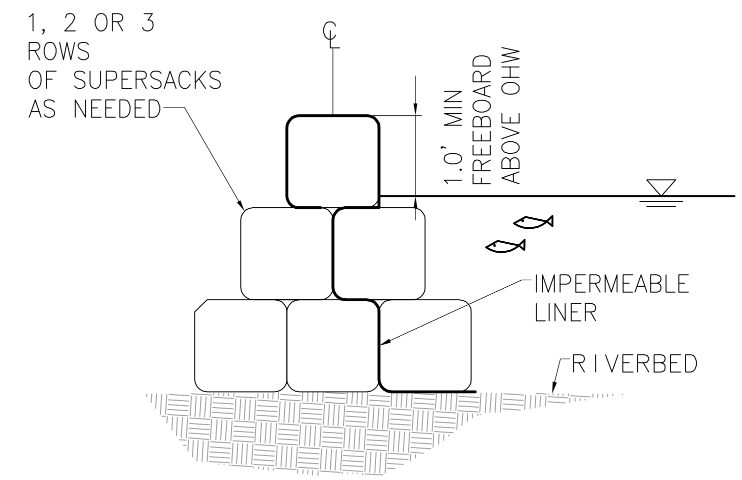
G04
Sheet No.

Plotted: Aug 26, 2015 – 1:40pm omic L:\Project\17500\17545\CADD\ACAD\General\G03-G05.dwg Layout Name: G04

NOTE: WORK ISOLATION MEASURES MAY VARY DUE TO FIELD CONDITIONS AND ENGINEER'S RECOMMENDATIONS.



PLAN VIEW

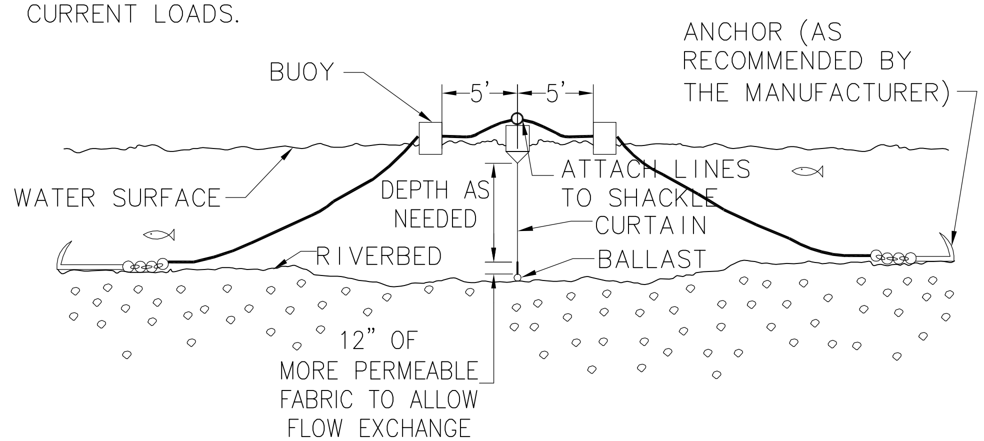


NOTE: THIS BARRIER WILL NOT PREVENT SUBSURFACE FLOW FROM ENTERING WORKING ZONE. CONTINUED PUMPING MAY BE REQUIRED IF ISOLATED WORK AREA NEEDS TO BE DEWATERED.

2 SANDBAG BARRIER

NTS

NOTE: ANCHORING WITH BUOYS, AS SHOWN, REMOVES ALL VERTICAL FORCES FROM THE CURTAIN. HENCE, THE CURTAIN WILL NOT SINK FROM WIND OR CURRENT LOADS.

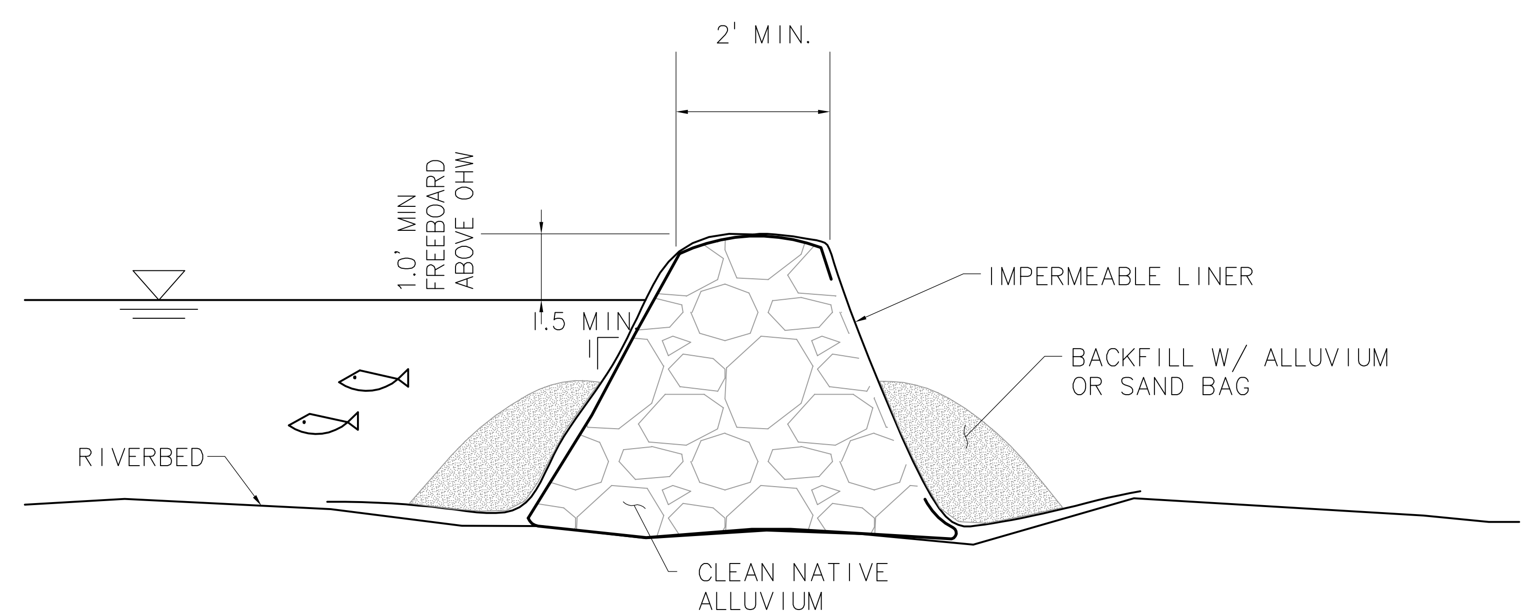


BARRIER SHALL BE SECURED WITH ANCHOR AND BUOY SYSTEM TO RESIST OVERTOPPING DURING TIDAL CYCLE.

SECTION VIEW

1 TURBIDITY CURTAIN

NTS



NOTE: THIS BARRIER WILL NOT PREVENT SUBSURFACE FLOW FROM ENTERING WORKING ZONE. CONTINUED PUMPING OF ISOLATED AREA WILL LIKELY BE REQUIRED.

3 BERM

NTS

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/26/15

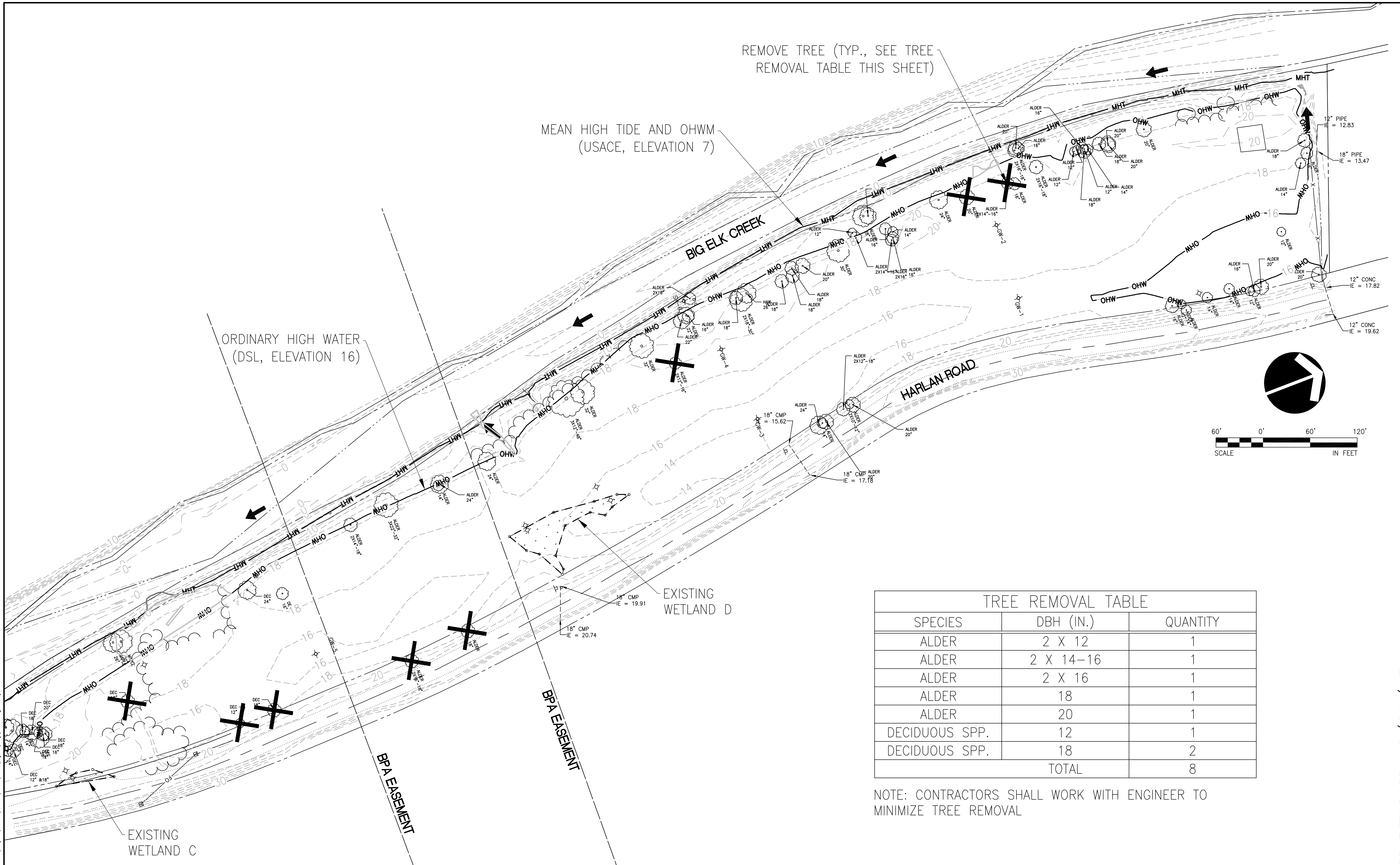
ODOT US20 PME TURNKEY MITIGATION PROJECT
LINCOLN COUNTY, OREGON
ALTERNATIVE WORK AREA ISOLATION DETAILS

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
G05
Sheet No.

Plotted: Aug 26, 2015 - 2:14pm omic L:\Project\17500\17545\CADD\ACAD\General\G03-G05.dwg Layout Name: G05



TREE REMOVAL TABLE		
SPECIES	DBH (IN.)	QUANTITY
ALDER	2 X 12	1
ALDER	2 X 14–16	1
ALDER	2 X 16	1
ALDER	18	1
ALDER	20	1
DECIDUOUS SPP.	12	1
DECIDUOUS SPP.	18	2
	TOTAL	8

NOTE: CONTRACTORS SHALL WORK WITH ENGINEER TO MINIMIZE TREE REMOVAL

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/26/15

ODOT US20 PME TURNKEY MITIGATION PROJECT

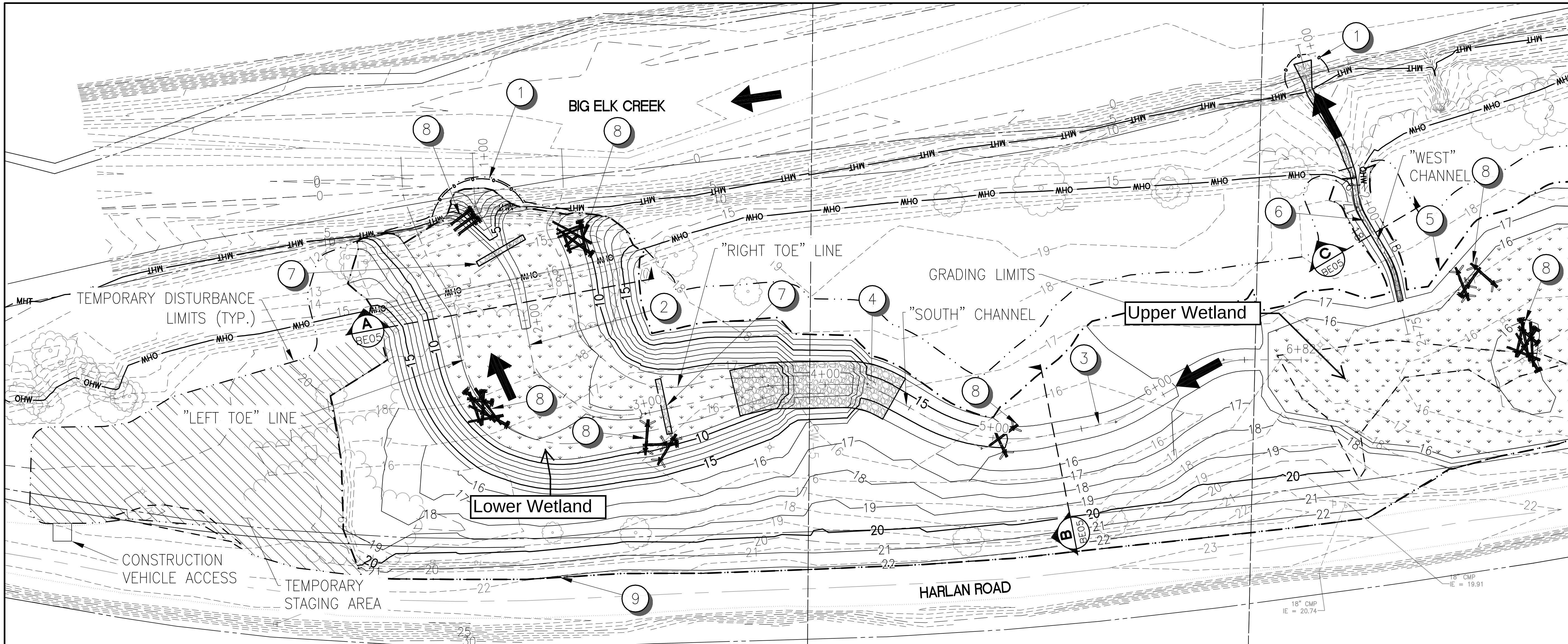
LINCOLN COUNTY, OREGON

BIG ELK EXIST. CONDITIONS AND TREE REMOVAL PLAN

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
BE01
Sheet No.



NOTES:

1. INSTALL WORK AREA ISOLATION AND EROSION CONTROL MEASURES (SEE DETAILS ON SHEETS G03–G05).
2. CONSTRUCT ALCOVE AND LOWER WETLAND (SEE PROFILE ON SHEET BE04 AND TYPICAL SECTION A ON SHEET BE05).
3. CONSTRUCT OVERFLOW CHANNEL (SEE PROFILE ON SHEET BE04 AND TYPICAL SECTION B ON SHEET BE05).
4. INSTALL SOIL RIPRAP TO LIMITS SHOWN IN SOUTH OVERFLOW CHANNEL TO PREVENT EROSION AND SCOUR (SEE DETAIL F ON SHEET BE06).
5. CONSTRUCT UPPER WETLAND (SEE TYPICAL SECTION D ON SHEET BE06).
6. CONSTRUCT WEST OVERFLOW CHANNEL (SEE PROFILE ON SHEET BE04 AND TYPICAL SECTION C ON SHEET BE05). INSTALL ROCK AS SHOWN TO PREVENT BED EROSION AND SCOUR.
7. CONSTRUCT ROCK GRADE CONTROL IN ALCOVE LOW–FLOW CHANNEL AND ACROSS BENCH TO PREVENT INCISION AND HEADCUTTING.
8. CONSTRUCT LARGE WOOD ASSEMBLAGE TO INCREASE HABITAT DIVERSITY AND PROVIDE HYDRAULIC COMPLEXITY.
9. PLACE EXCESS EXCAVATED MATERIAL ALONG SLOPE AS SHOWN.
10. STABILIZE SITE WITH NATIVE VEGETATION (PER REVEGETATION PLANS).

GROUND DISTURBANCE TABLE

TYPE	AREA (AC.)
TEMPORARY	1.2
PERMANENT	3.9
TOTAL	5.1

NOTE: GROUND DISTURBANCE ARES INCLUDE IMPACTS BEYOND LIMITS OF JURISDICTIONAL RESOURCES.

WETLAND CREATION TABLE

FEATURE	AREA (AC.)
LOWER WETLAND	0.3
UPPER WETLAND	1.2
TOTAL	1.5

30' 0' 30' 60'
SCALE IN FEET

PRELIMINARY DESIGN 08/26/15

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

BIG ELK GRADING PLAN (SOUTH)

Datum: NAVD 88

MB&G MASON, BRUCE & GIRARD, INC. Natural Resource Consultants Since 1921

otak HanmiGlobal Partner

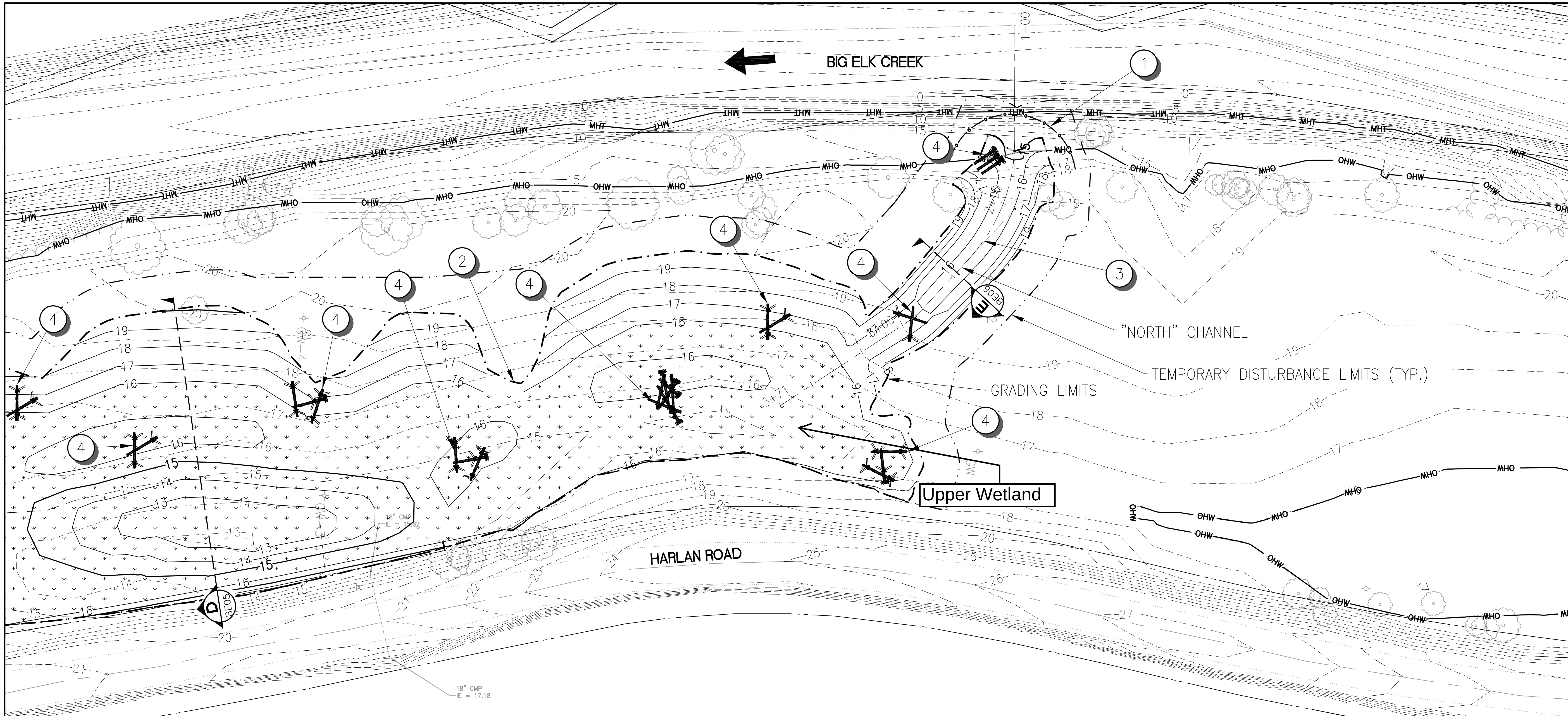
NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

17545
Project No. Drawing No.
BE02
Sheet No.

Plotted: Aug 26, 2015 – 1:27pm omic L:\Project\17500\17545\CADD\ACAD\BigElk\Dwg\BE02–BE05.dwg Layout Name: BE02

MATCHLINE BE02



NOTES:

1. INSTALL WORK AREA ISOLATION AND EROSION CONTROL MEASURES.
2. CONSTRUCT UPPER WETLAND (SEE TYPICAL SECTION D ON SHEET BE06).
3. CONSTRUCT NORTH OVERFLOW CHANNEL (SEE PROFILE ON SHEET BE04 AND TYPICAL SECTION E ON SHEET BE06).
4. CONSTRUCT LARGE WOOD ASSEMBLAGE TO INCREASE HABITAT DIVERSITY AND PROVIDE HYDRAULIC COMPLEXITY.
5. STABILIZE SITE WITH NATIVE VEGETATION (SEE REVEGETATION PLANS).

SCALE: 30' 0' 30' 60' IN FEET

PRELIMINARY DESIGN 08/26/15

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G MASON, BRUCE & GIRARD, INC. Natural Resource Consultants Since 1921

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

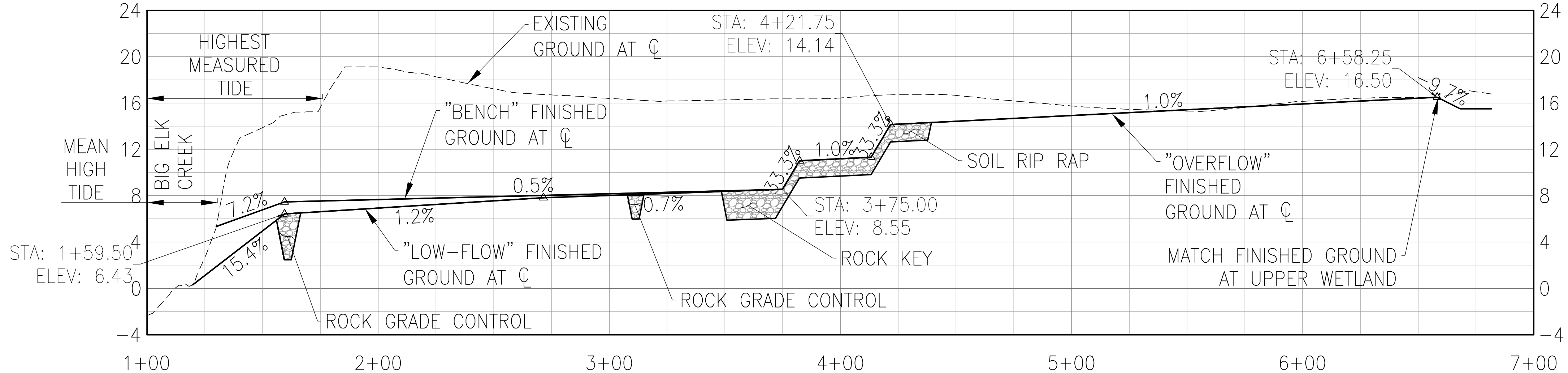
BIG ELK GRADING PLAN (NORTH)

otak HanmiGlobal Partner

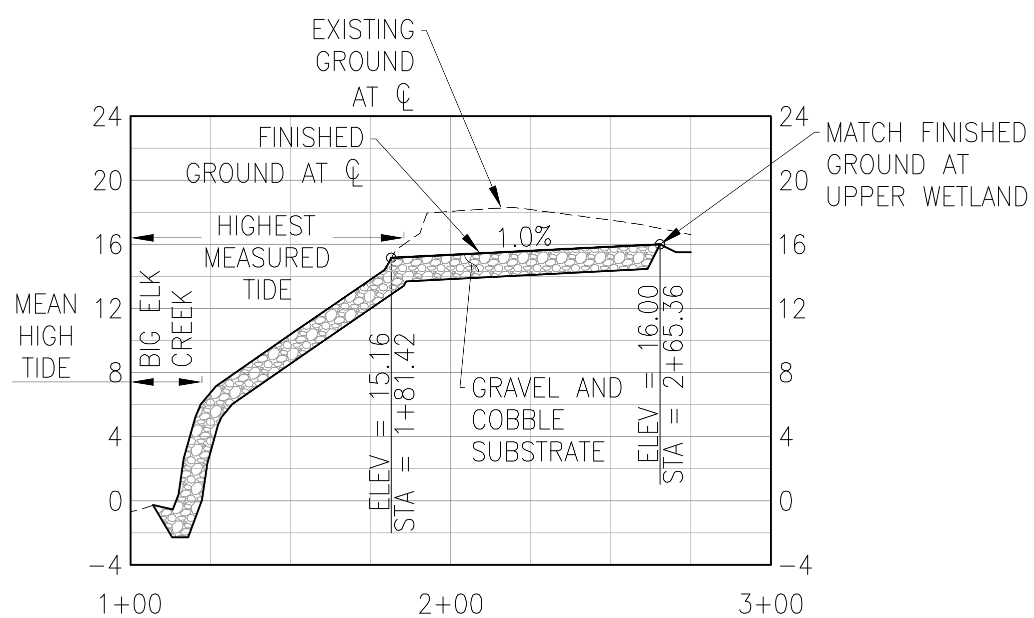
Datum: NAVD 88

17545
Project No. Drawing No.
BE03
Sheet No.

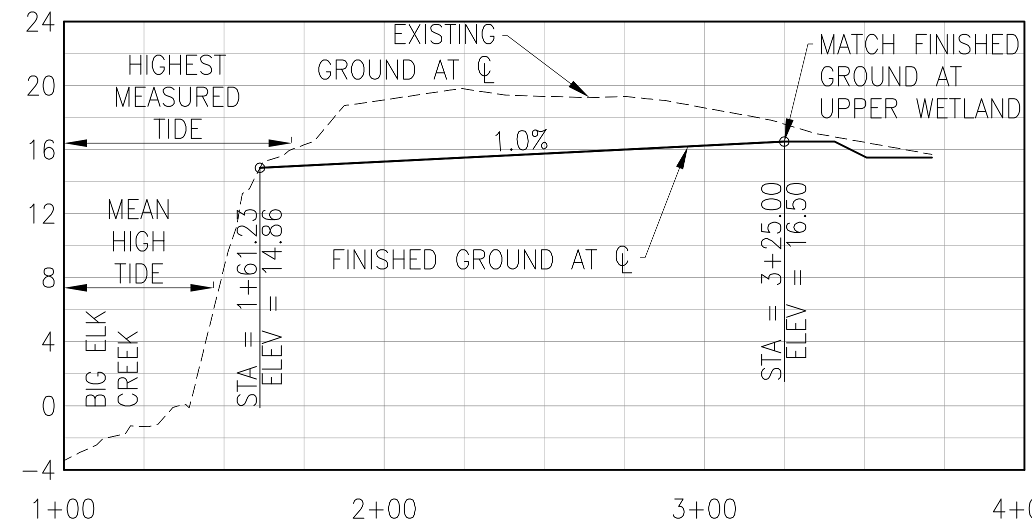
Plotted: Aug 26, 2015 – 2:50pm melaniem L:\Project\17500\17545\CADD\ACAD\BigElk\Dwg\BE02-BE06.dwg Layout Name: BE03



ALCOVE, LOWER WETLAND, AND SOUTH OVERFLOW CHANNEL PROFILE
HORIZ. 1" = 30'
VERT. 1" = 6'



WEST OVERFLOW CHANNEL PROFILE
HORIZ. 1" = 30'
VERT. 1" = 6'



NORTH OVERFLOW CHANNEL PROFILE
HORIZ. 1" = 30'
VERT. 1" = 6'

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/25/15

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

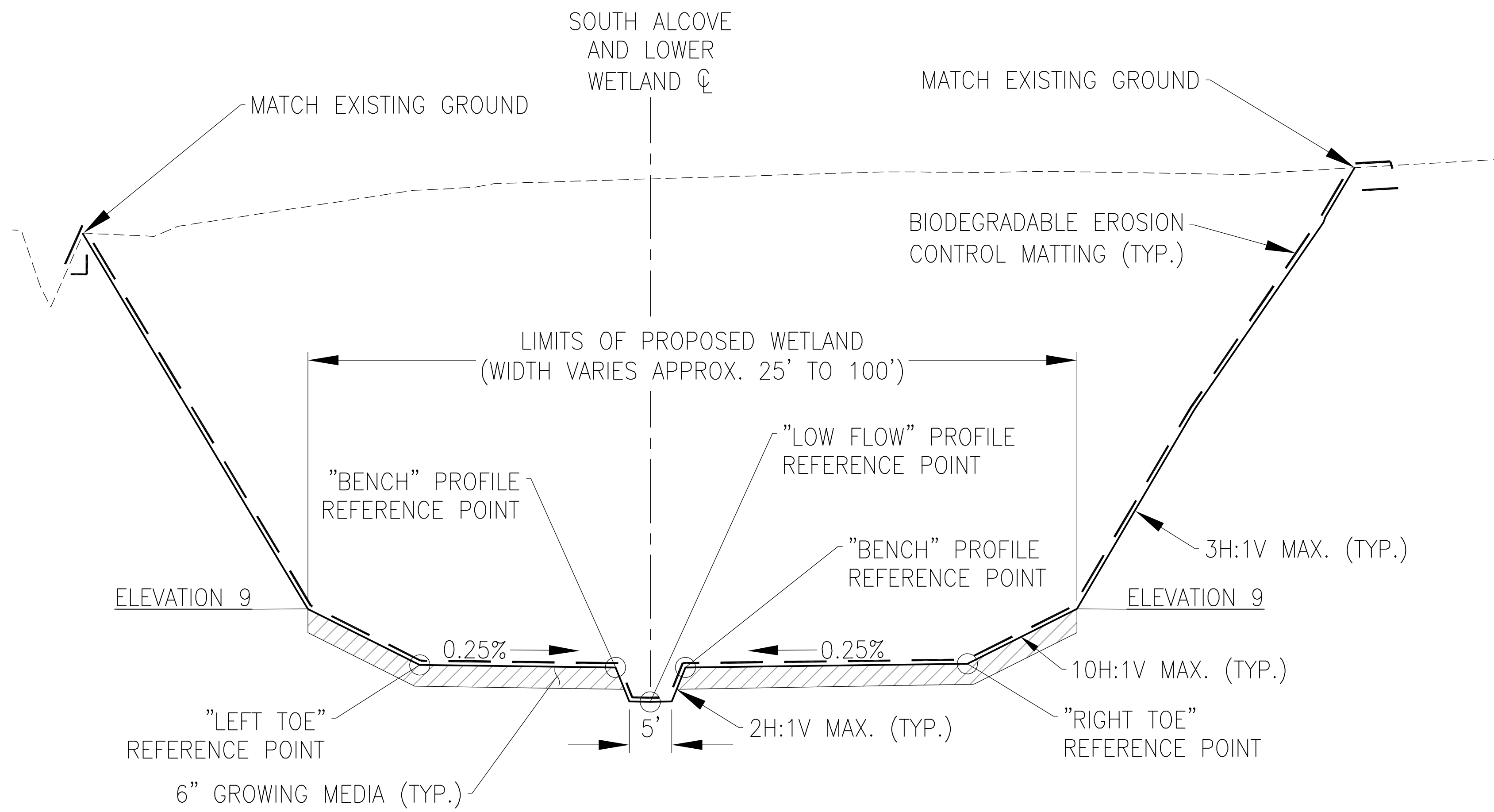
BIG ELK PROFILES

otak
HanmiGlobal Partner

Datum: NAVD 88

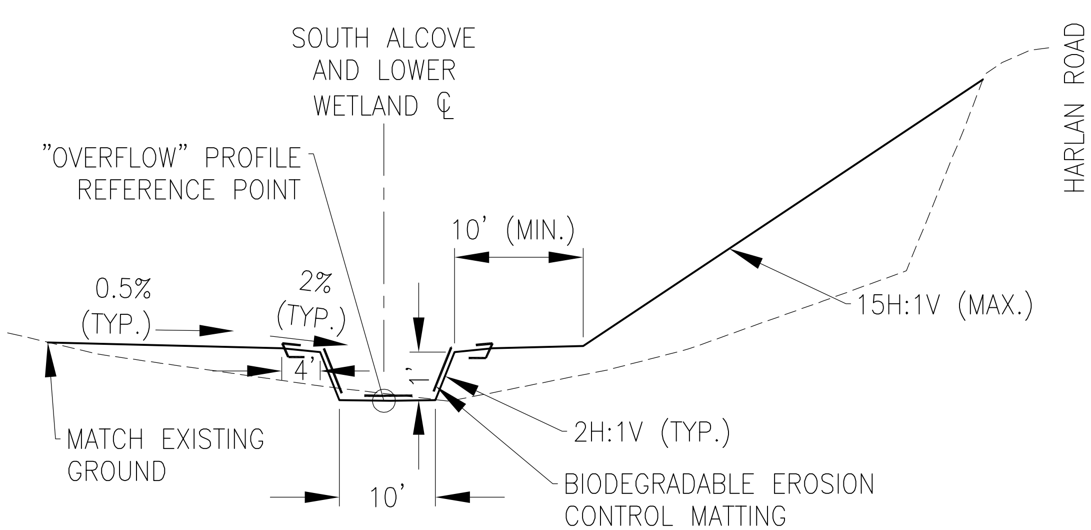
17545
Project No. Drawing No.
BE04
Sheet No.

Plotted: Aug 26, 2015 - 12:28pm melaniem L:\Project\17500\17545\CADD\ACAD\BigElk\Dwg\BE02-BE05.dwg Layout Name: BE04



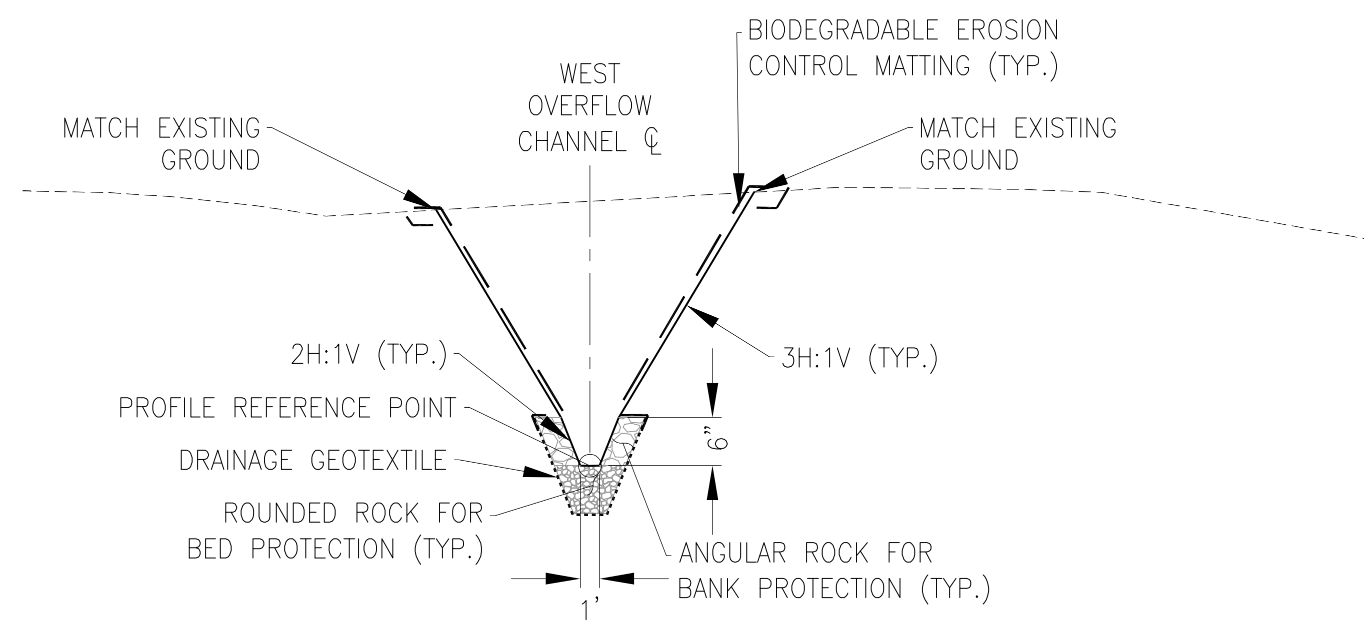
(A) TYPICAL SOUTH ALCOVE AND LOWER WETLAND SECTION

NOT TO SCALE, VERTICALLY EXAGGERATED



(B) TYPICAL SOUTH OVERFLOW CHANNEL SECTION

NOT TO SCALE, VERTICALLY EXAGGERATED



(C) TYPICAL WEST OVERFLOW CHANNEL SECTION

NOT TO SCALE, VERTICALLY EXAGGERATED

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/25/15

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

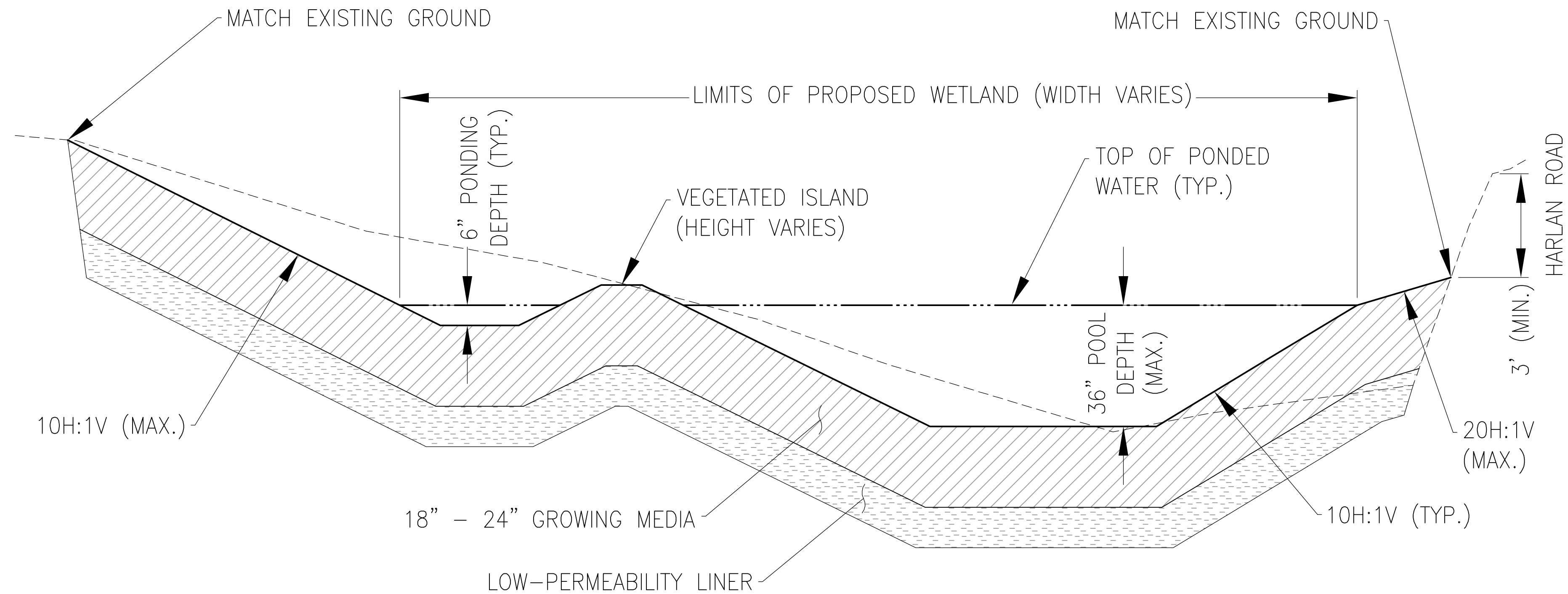
BIG ELK TYPICAL SECTIONS

otak
HanmiGlobal Partner

Datum: NAVD 88

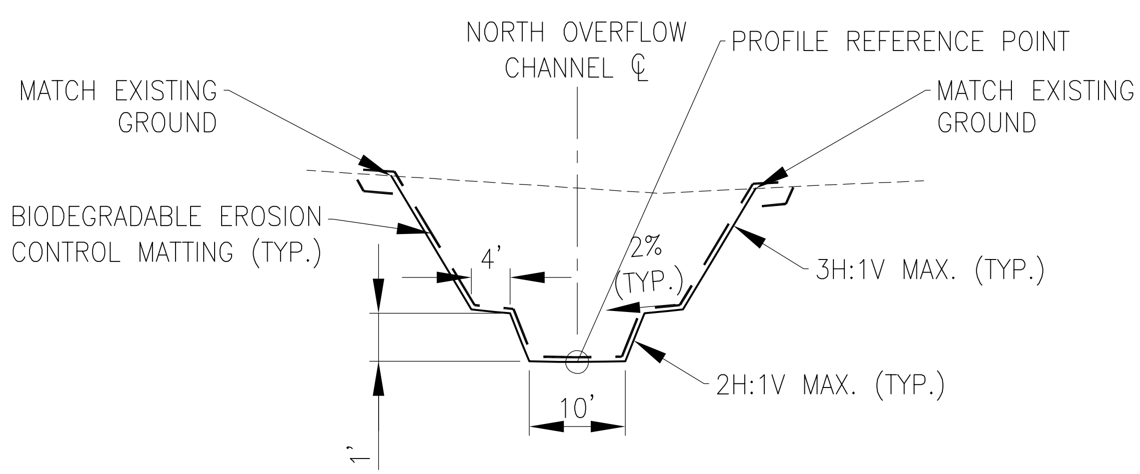
17545
Project No. Drawing No.

BE05
Sheet No.



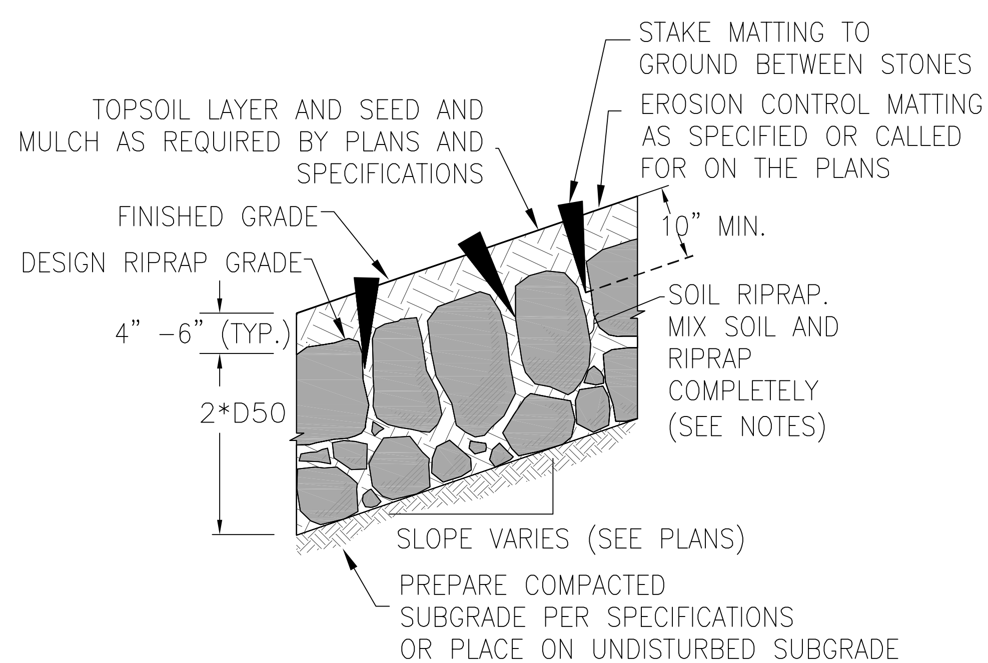
D TYPICAL UPPER WETLAND SECTION

NOT TO SCALE, VERTICALLY EXAGGERATED



E TYPICAL NORTH OVERFLOW CHANNEL SECTION

NOT TO SCALE, VERTICALLY EXAGGERATED



TYPICAL SECTION

NOTES:

1. SOIL RIPRAP DETAILS ARE APPLICABLE TO AREAS. SLOPED REFER TO THE SITE PLAN ACTUAL LOCATION AND LIMITS.
2. MIX UNIFORM ALLY 65% RIPRAP BY WITH 35% OF APPROVED SOIL BY VOLUME PRIOR TO PLACEMENT.
3. PLACE STONE–SOIL MIX TO RESULT IN SECURELY INTERLOCKED ROCK AT THE DESIGN THICKNESS AND GRADE. COMPACT AND ALL LEVEL TO ELIMINATE VOIDS AND ROCKS PROJECTING DESIGN ABOVE RIPRAP TOP GRADE.
4. CRIMP OR TACKIFY MULCH OR USE APPROVED HYDROMULCH AS CALLED FOR IN THE PLANS AND SPECIFICATIONS.

F SOIL RIPRAP TYPICAL DETAIL

NOT TO SCALE

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
MCM	MCM	MGR		AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/26/15

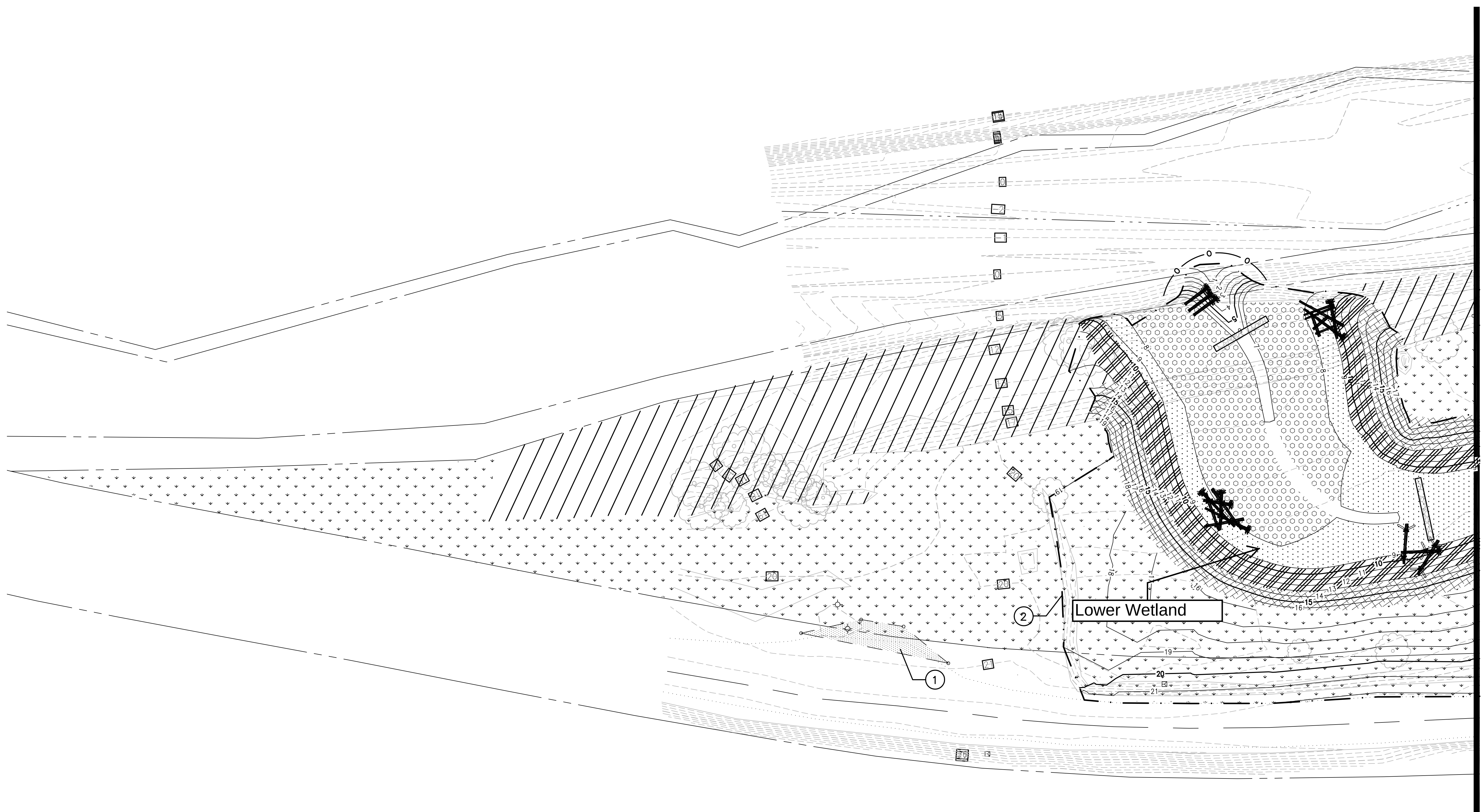
ODOT US20 PME TURNKEY MITIGATION PROJECT
LINCOLN COUNTY, OREGON
BIG ELK TYPICAL SECTIONS AND DETAILS

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
BE06
Sheet No.

Plotted: Aug 26, 2015 – 2:45pm omic L:\Project\17500\17545\CADD\ACAD\BigElk\Dwg\BE02–BE06.dwg Layout Name: BE06



PLANTING LEGEND

- UPLAND SITE REVEGETATION
- RIPARIAN/ BERM AREA REVEGETATION
- UPPER SIDE BANKS
- LOWER SIDE BANKS
- ALCOVE WETLAND - UPPER EMERGENT AREA
- ALCOVE WETLAND - LOWER EMERGENT AREA
- UPPER WETLAND - EMERGENT AREA
- UPPER WETLAND - SHRUB SCRUB AREA

SHEET KEY NOTES

1. WETLAND 'C': SEED WITH WETLAND SEED MIX
2. GRADING LIMITS (TYP.)

PRELIMINCARY DESIGN 08/25/15

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
LH	DF	LH		AUGUST 25, 2015

Laura Herbon
Landscape Architect LLC
laura@herbonlandarch.com

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

ODOT US20 PME TURNKEY MITIGATION PROJECT

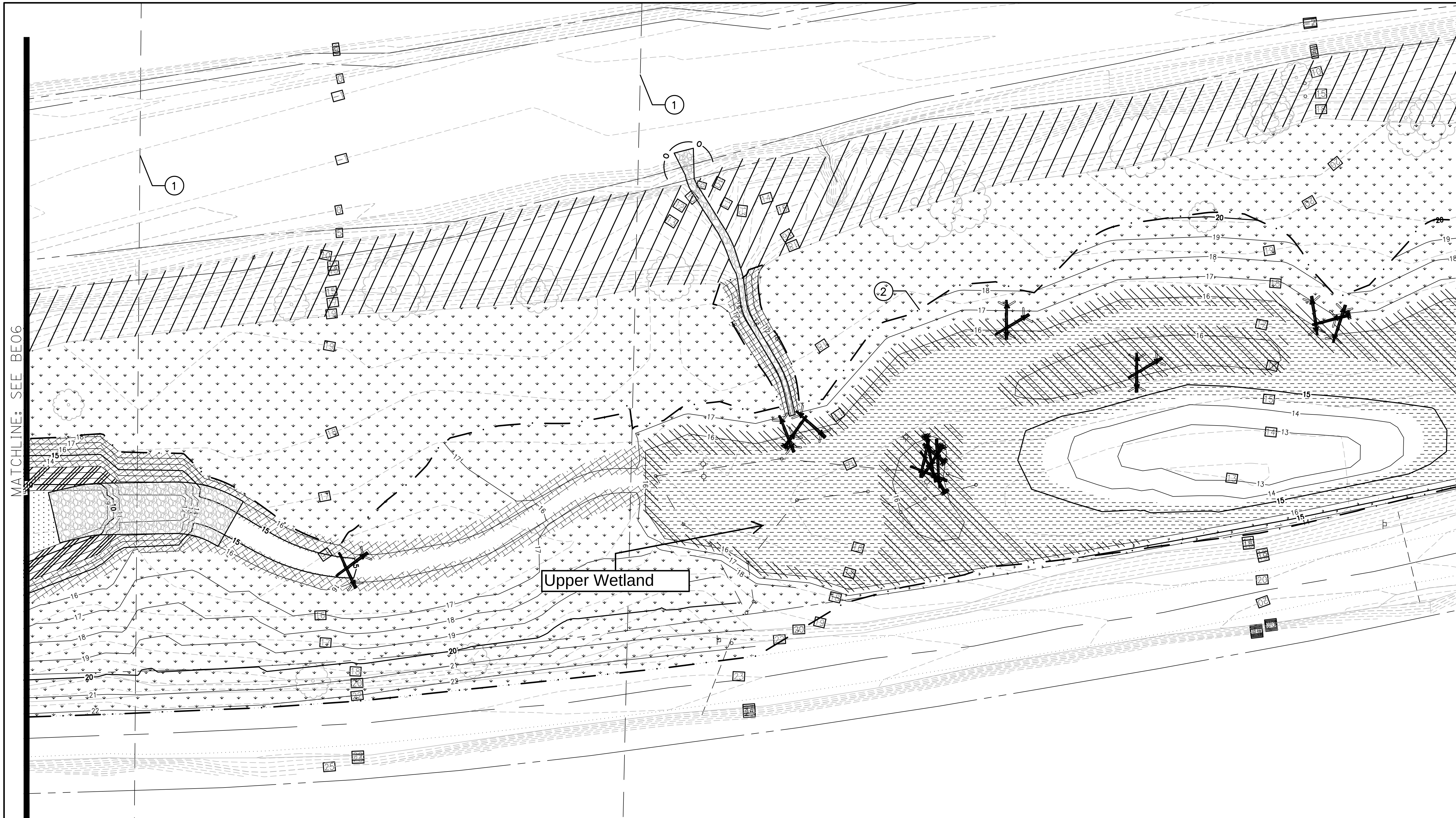
LINCOLN COUNTY, OREGON

BIG ELK CREEK SITE REVEGETATION PLAN

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
BE07
Sheet No.



PLANTING LEGEND

- UPLAND SITE REVEGETATION
- RIPARIAN/ BERM AREA REVEGETATION
- UPPER SIDE BANKS
- LOWER SIDE BANKS
- ALCOVE WETLAND - UPPER EMERGENT AREA
- ALCOVE WETLAND - LOWER EMERGENT AREA
- UPPER WETLAND - EMERGENT AREA
- UPPER WETLAND - SHRUB SCRUB AREA

SHEET KEY NOTES

1. WETLAND 'C': SEED WITH WETLAND SEED MIX
2. GRADING LIMITS (TYP.)

0 25 50

PRELIMINCARY DESIGN 08/25/15

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
LH	DF	LH		AUGUST 25, 2015

Laura Herbon
Landscape Architect LLC
laura@herbonlandarch.com

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

ODOT US20 PME TURNKEY MITIGATION PROJECT

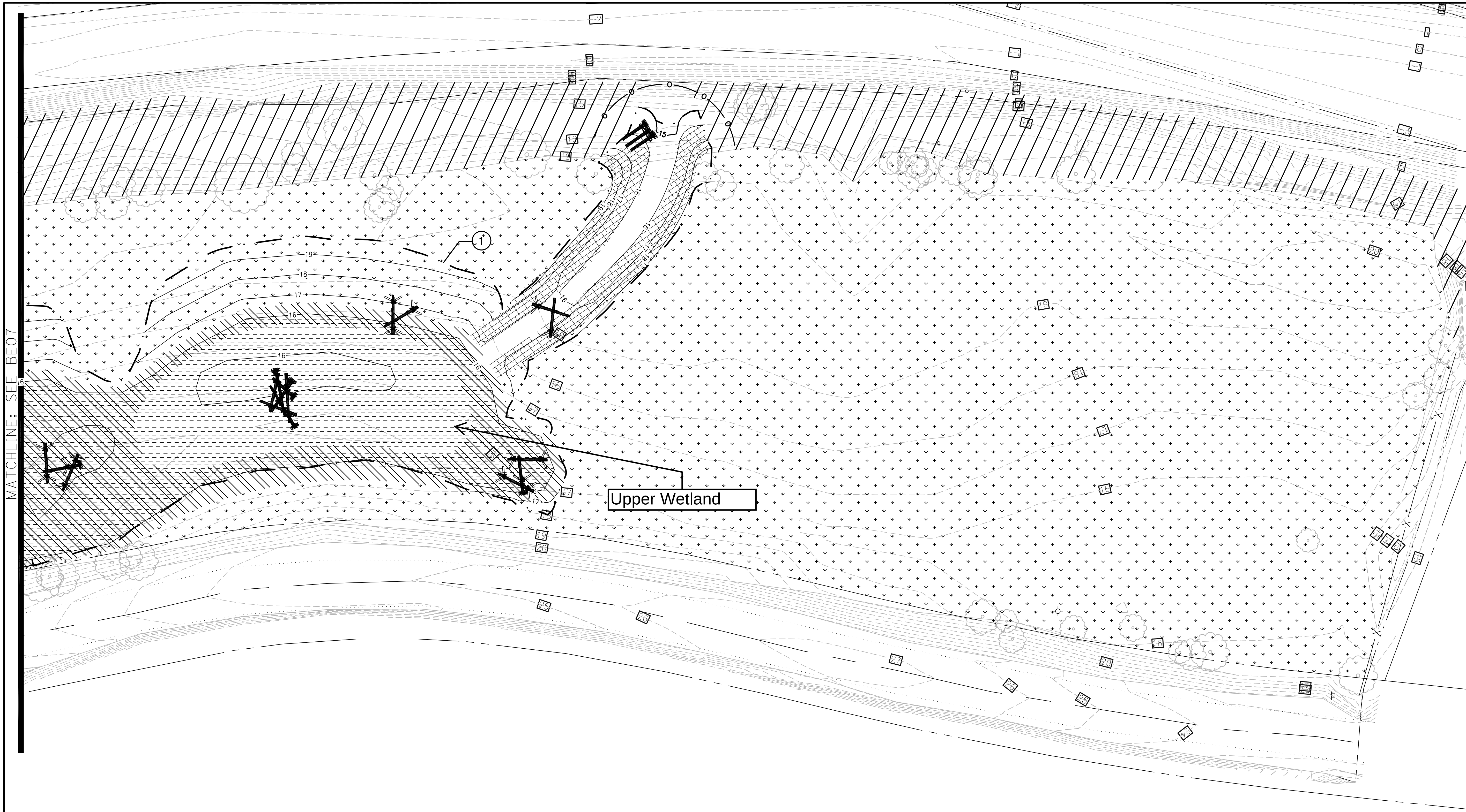
LINCOLN COUNTY, OREGON

BIG ELK CREEK SITE REVEGETATION PLAN

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
BE08
Sheet No.



PLANTING LEGEND

- UPLAND SITE REVEGETATION
- RIPARIAN/ BERM AREA REVEGETATION
- UPPER SIDE BANKS
- LOWER SIDE BANKS
- ALCOVE WETLAND - UPPER EMERGENT AREA
- ALCOVE WETLAND - LOWER EMERGENT AREA
- UPPER WETLAND - EMERGENT AREA
- UPPER WETLAND - SHRUB SCRUB AREA

SHEET KEY NOTES

(1) GRADING LIMITS (TYP.)

0 25 50

PRELIMINCARY DESIGN 08/25/15

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

BIG ELK CREEK SITE REVEGETATION PLAN

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
LH	DF	LH		AUGUST 25, 2015

Laura Herbon
Landscape Architect LLC
laura@herbonlandarch.com

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
BE09
Sheet No.

PRELIMINARY PLANT LIST

%	BOTANICAL NAME	COMMON NAME	CONDITION
UPLAND SITE REVEGETATION (240,510 SF OR 5.52 ACRES):			
TREES: 10' O.C. SPACING = 2761 STEMS TOTAL			
40%	ACER MACROPHYLLUM	BIGLEAF MAPLE	BARE ROOT
15%	FRANGULA PURSHIANA	CASCARA	BARE ROOT
30%	FRAXINUS LATIFOLIA	OREGON ASH	BARE ROOT
15%	SAMBUCUS RACEMOSA	RED ELDERBERRY	BARE ROOT
SHRUBS: 3' O.C. SPACING OVER HALF THE AREA = 15,427 STEMS TOTAL			
30%	HOLODISCUS DISCOLOR	OCEAN SPRAY	BARE ROOT
40%	ROSA NUTKANA	NOOTKA ROSE	BARE ROOT
30%	SYMPHORICARPOS ALBUS	COMMON SNOWBERRY	BARE ROOT
RIPARIAN/ BERM AREA REVEGETATION (71,937 SF OR 1.65 ACRES):			
TREES: 10' O.C. SPACING, EXCEPT SALIX @ 3' O.C. = 1666 STEMS TOTAL			
30%	ACER MACROPHYLLUM	BIGLEAF MAPLE	BARE ROOT
20%	FRANGULA PURSHIANA	CASCARA	BARE ROOT
20%	FRAXINUS LATIFOLIA	OREGON ASH	BARE ROOT
5%	SALIX LASIANDRA	PACIFIC WILLOW	LIVE CUTTING
5%	SALIX SCOULERIANA	SCOULER'S WILLOW	LIVE CUTTING
20%	SAMBUCUS RACEMOSA	RED ELDERBERRY	BARE ROOT
SHRUBS: 3' O.C. SPACING OVER HALF THE AREA = 4614 STEMS TOTAL			
25%	PHYSOCARPUS CAPITATUS	PACIFIC NINEBARK	BARE ROOT
25%	ROSA NUTKANA	NOOTKA ROSE	BARE ROOT
25%	RUBUS SPECTABILIS	SALMONBERRY	BARE ROOT
25%	SYMPHORICARPOS ALBUS	COMMON SNOWBERRY	BARE ROOT
UPPER SIDE BANKS (15,166 SF):			
TREES: 12' O.C. SPACING = 122 STEMS TOTAL			
30%	FRANGULA PURSHIANA	CASCARA	BARE ROOT
40%	FRAXINUS LATIFOLIA	OREGON ASH	BARE ROOT
30%	SAMBUCUS RACEMOSA	RED ELDERBERRY	BARE ROOT
SHRUBS: 3' O.C. SPACING = 1946 STEMS TOTAL			
50%	PHYSOCARPUS CAPITATUS	PACIFIC NINEBARK	BARE ROOT
25%	ROSA NUTKANA	NOOTKA ROSE	BARE ROOT
25%	SYMPHORICARPOS ALBUS	COMMON SNOWBERRY	BARE ROOT
LOWER SIDE BANKS (5727 SF):			
TREES: 2' O.C. SPACING = 1653 STEMS TOTAL			
50%	SALIX LASIANDRA	PACIFIC WILLOW	LIVE CUTTING
50%	SALIX SCOULERIANA	SCOULER'S WILLOW	LIVE CUTTING
ALCOVE WETLAND - UPPER EMERGENT AREA (5955 SF):			
HERBACEOUS PLANTS: AVERAGE 18" O.C. SPACING = 3056 PLANTS TOTAL			
5%	ASTER SUBSPICATUS	DOUGLAS ASTER	BR PLUG
25%	CAREX LYNGBYEI	LYNGBYEI SEDGE	BR PLUG
25%	CAREX OBNUPTA	SLOUGH SEDGE	BR PLUG
15%	JUNCUS BALTICUS	BALTIC RUSH	BR PLUG
15%	SCIRPUS ACUTUS	HARDSTEM BULRUSH	BR PLUG
15%	SCIRPUS MICROCARPUS	RED TINGE BULLRUSH	BR PLUG
ALCOVE WETLAND - LOWER EMERGENT AREA (7332 SF):			
HERBACEOUS PLANTS: AVERAGE 18" O.C. SPACING = 3763 PLANTS TOTAL			
20%	CAREX LYNGBYEI	LYNGBYEI SEDGE	BR PLUG
20%	JUNCUS BALTICUS	BALTIC RUSH	BR PLUG
20%	SCIRPUS ACUTUS	HARDSTEM BULRUSH	BR PLUG
20%	SCIRPUS AMERICANUS	THREE-SQUARE RUSH	BR PLUG
20%	SCIRPUS MARITIMUS	SEACOAST BULRUSH	BR PLUG

PRELIMINARY PLANT LIST CONTINUED

%	BOTANICAL NAME	COMMON NAME	CONDITION
UPPER WETLAND - EMERGENT AREA (50,600 SF):			
HERBACEOUS PLANTS: 12" O.C. SPACING = 50,427 PLANTS TOTAL			
5%	CAREX DENSA	DENSE SEDGE	BR PLUG
5%	CAREX STIPATA	SAWBEAKED SEDGE	BR PLUG
5%	CAREX (UTRICULATA) ROSTRATA	BEAKED SEDGE	BR PLUG
20%	CAREX OBNUPTA	SLOUGH SEDGE	BR PLUG
5%	ELEOCHARIS PALUSTRIS	CREEPING SPIKE RUSH	BR PLUG
5%	JUNCUS BALTICUS	BALTIC RUSH	BR PLUG
5%	JUNCUS ENSIFOLIUS	DAGGERLEAF RUSH	BR PLUG
5%	JUNCUS PATENS	SPREADING RUSH	BR PLUG
5%	JUNCUS TENUIS	SLENDER RUSH	BR PLUG
10%	SCIRPUS ACUTUS	HARDSTEM BULRUSH	BR PLUG
20%	SCIRPUS MICROCARPUS	RED TINGE BULLRUSH	BR PLUG
10%	SCIRPUS TABERNAEMONTANI	SOFTSTEM BULLRUSH	BR PLUG
UPPER WETLAND - SHRUB SCRUB AREA (27,984 SF):			
SHRUBS: 2' O.C. (SALIX) OR 3' O.C. (OTHER SPP.) SPACING = 6282 STEMS			
20%	CORNUS SERICEA	CREEK DOGWOOD	LIVE CUTTING
20%	SPIRAEA DOUGLASII	DOUGLAS SPIRAEA	BARE ROOT
30%	SALIX HOOKERIANA	HOOKER WILLOW	LIVE CUTTING
30%	SALIX SITCHENSIS	SITKA WILLOW	LIVE CUTTING

PRELIMINARY SEED MIXES

LBS PLS/ ACRE	BOTANICAL NAME	COMMON NAME
WETLAND SEED MIX:		
3.5	AGROSTIS EXARATA	SPIKE BENTGRASS
7.0	BECKMANNIA SYZIGACHE	SLOUGHGRASS
7.0	DESCHAMPSIA CESPITOSA	TUFTED HAIRGRASS
1.5	JUNCUS BUFONIUS	TOAD RUSH
RIPARIAN SEED MIX:		
1.0	AGROSTIS EXARATA	SPIKE BENTGRASS
0.0007	ALNUS RUBRA	RED ALDER
8.0	BROMUS CARINATUS	CALIFORNIA BROME
8.0	DANTHONIA CALIFORNICA	CALIFORNIA OATGRASS
10.0	ELYMUS GLAUCUS	BLUE WILDRYE
4.0	FESTUCA RUBRA RUBRA	NATIVE RED FESCUE
8.0	HORDEUM BRACHYANTHERUM	MEADOW BARLEY

PLANTING NOTES

1.0 SEED ALL EMERGENT WETLAND AREAS EXCEPT UPPER WETLAND LOW EMERGENT (6" - 12" DEPTH) WITH WETLAND SEED MIX.

2.0 SEED ALL DISTURBED BARE GROUND (GRADED) AREAS OF THE SITE, INCLUDING NEWLY CREATED CHANNEL BOTTOMS WITH RIPARIAN SEED MIX. SEED ALSO WEED MANAGEMENT AREAS THAT HAVE EXPOSED SURFACE SOILS WITH RIPARIAN SEED MIX.

3.0 IN RIPARIAN/ BERM AREA, ENHANCEMENT PLANTINGS TO OCCUR WITHIN EXISTING NATIVE VEGETATION. INSTALL WOODY PLANTINGS GENERALLY AT DESIGNATED SPACING AROUND EXISTING NATIVE VEGETATION. ADJUST PLANT LAYOUT TO MINIMIZE DISTURBANCE TO EXISTING VEGETATION.

4.0 GENERALLY LAYOUT PLANTINGS AT SPACING INDICATED HEREIN. INSTALL ALL NATIVE PLANTS IN SAME SPECIES GROUPINGS THAT RESEMBLE NATURAL PLANT DISTRIBUTIONS.

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
XXX	XXX	XXX		AUGUST 25, 2015

Laura Herbon
Landscape Architect LLC
laura@herbonlandarch.com

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

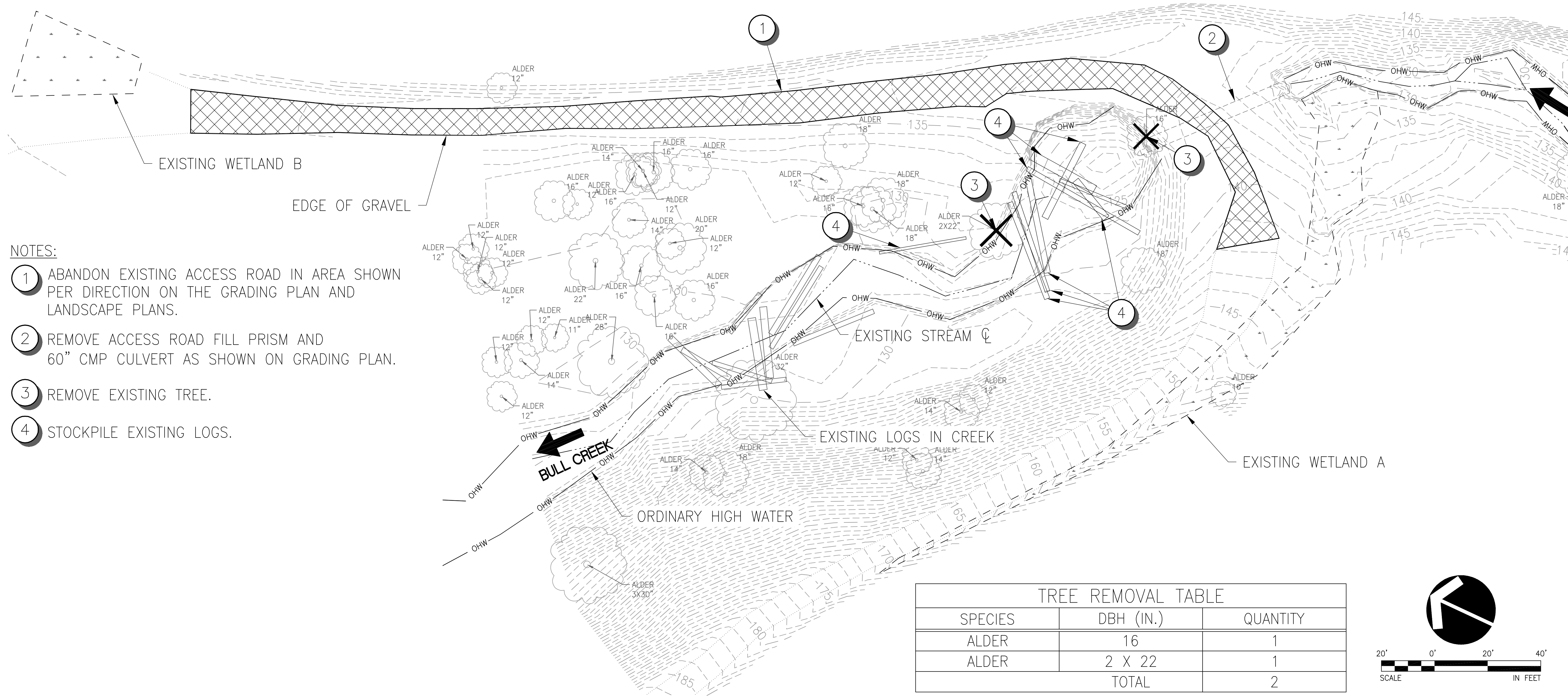
PRELIMINCARY DESIGN 08/25/15

ODOT US20 PME TURNKEY MITIGATION PROJECT
LINCOLN COUNTY, OREGON
BIG ELK CREEK SITE REVEGETATION PLAN

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
BE10
Sheet No.



NOTES:

1. ABANDON EXISTING ACCESS ROAD IN AREA SHOWN PER DIRECTION ON THE GRADING PLAN AND LANDSCAPE PLANS.
2. REMOVE ACCESS ROAD FILL PRISM AND 60" CMP CULVERT AS SHOWN ON GRADING PLAN.
3. REMOVE EXISTING TREE.
4. STOCKPILE EXISTING LOGS.

TREE REMOVAL TABLE		
SPECIES	DBH (IN.)	QUANTITY
ALDER	16	1
ALDER	2 X 22	1
	TOTAL	2

SCALE 20' 0' 20' 40' IN FEET

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
TM	TM	AMC	8/4/15	AUGUST 21, 2015

MB&G MASON, BRUCE & GIRARD, INC. Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/26/15

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

BULL CREEK EXISTING CONDITIONS AND DEMOLITION PLAN

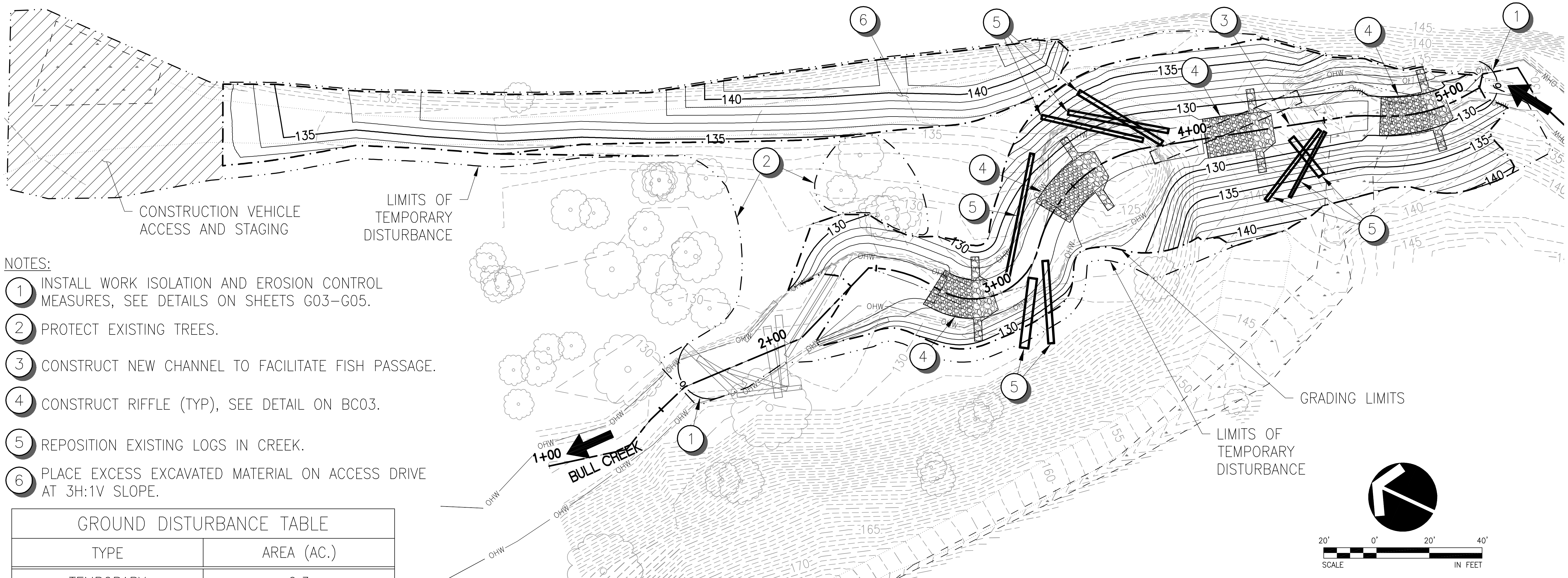
otak HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.

BC01
Sheet No.

Plotted: Aug 26, 2015 – 12:37pm amic L:\Project\17500\17545\CADD\ACAD\BullCreek\Dwg\BC01.dwg Layout Name: BC01



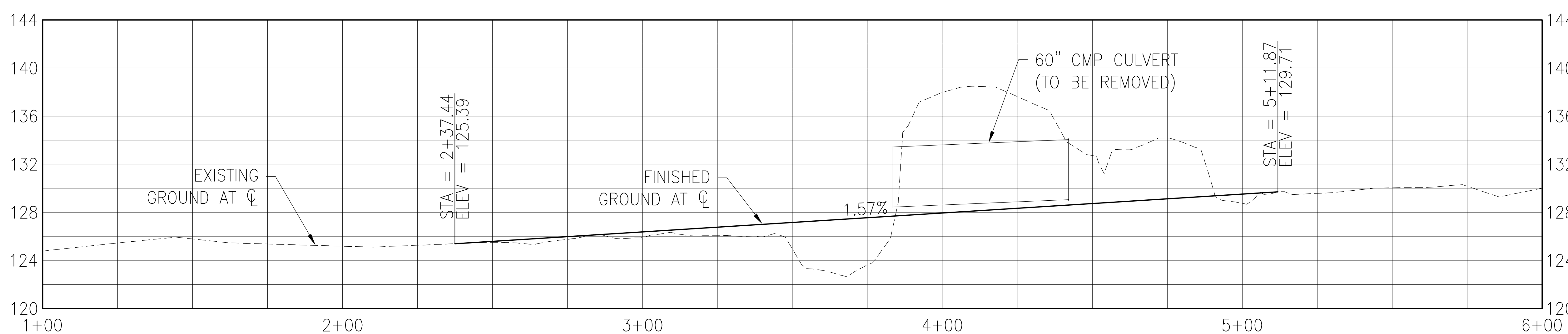
NOTES:

1. INSTALL WORK ISOLATION AND EROSION CONTROL MEASURES, SEE DETAILS ON SHEETS G03–G05.
2. PROTECT EXISTING TREES.
3. CONSTRUCT NEW CHANNEL TO FACILITATE FISH PASSAGE.
4. CONSTRUCT RIFFLE (TYP), SEE DETAIL ON BC03.
5. REPOSITION EXISTING LOGS IN CREEK.
6. PLACE EXCESS EXCAVATED MATERIAL ON ACCESS DRIVE AT 3H:1V SLOPE.

GROUND DISTURBANCE TABLE	
TYPE	AREA (AC.)
TEMPORARY	0.3
PERMANENT	0.5
TOTAL	0.8

NOTE: DISTURBANCE AREAS INCLUDE IMPACTS BEYOND LIMITS OF JURISDICTIONAL RESOURCES.

CHANNEL CREATION TABLE	
FEATURE	AREA (AC.)
BULL CREEK	0.02



PROPOSED STREAM CL PROFILE

HORIZ. 1" = 20'

VERT. 1" = 5'

PRELIMINARY DESIGN 08/26/15

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

BULL CREEK GRADING PLAN AND PROFILE

NO.	DATE	BY	REVISION COMMENTS

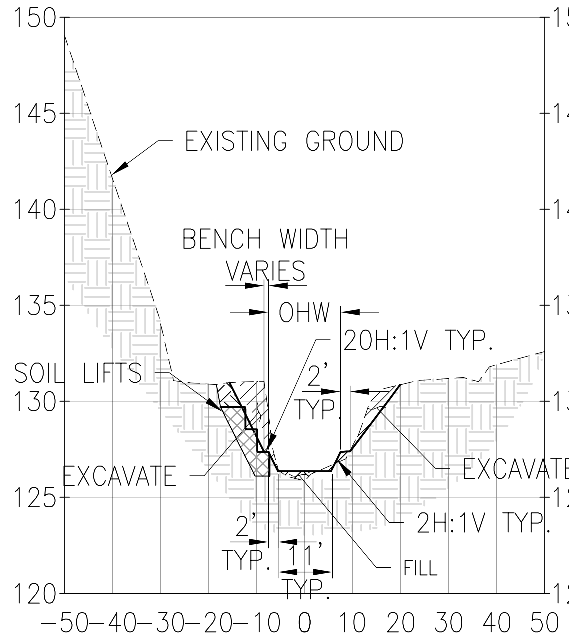
Design	Drawn	Checked	Date	Initial Issue Date:
TM	TM	AMC	8/4/15	AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

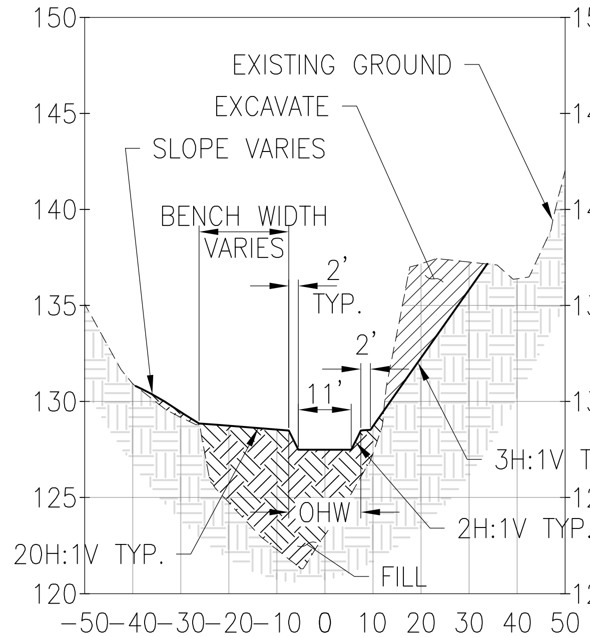
otak
HanmiGlobal Partner

Datum: NAVD 88

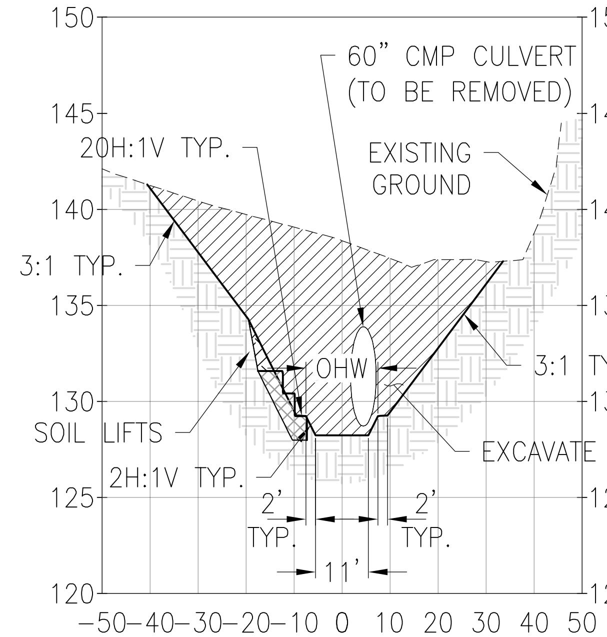
17545
Project No. Drawing No.
BC02
Sheet No.



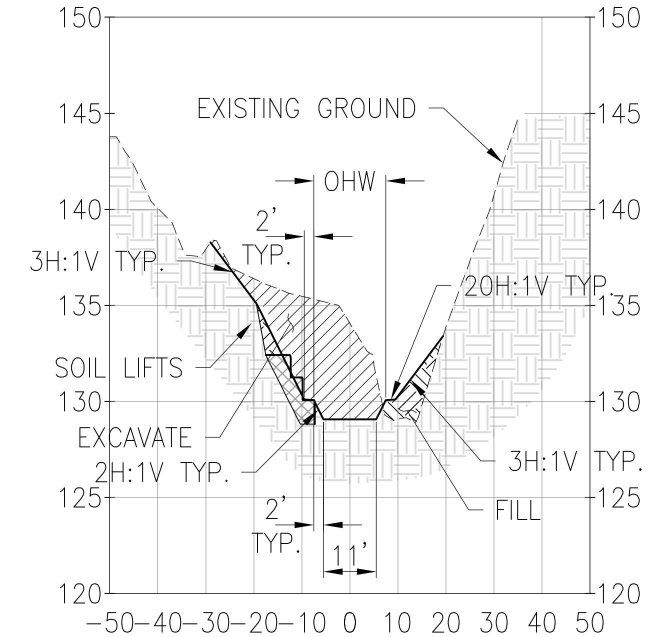
BULL CREEK
STA. 2+35 – STA. 3+25



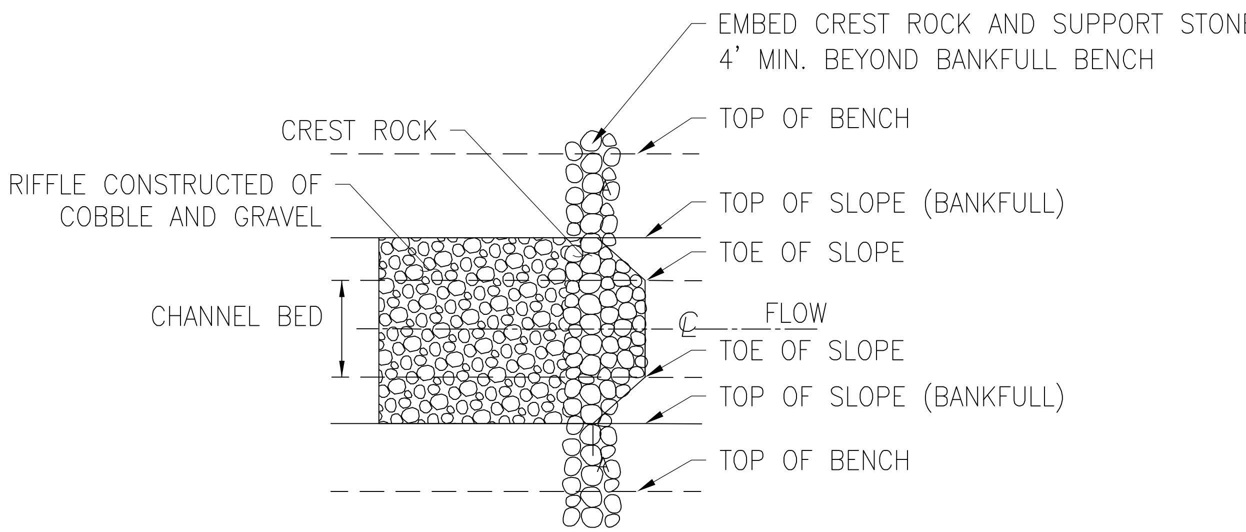
BULL CREEK
STA. 3+25 – STA. 3+80



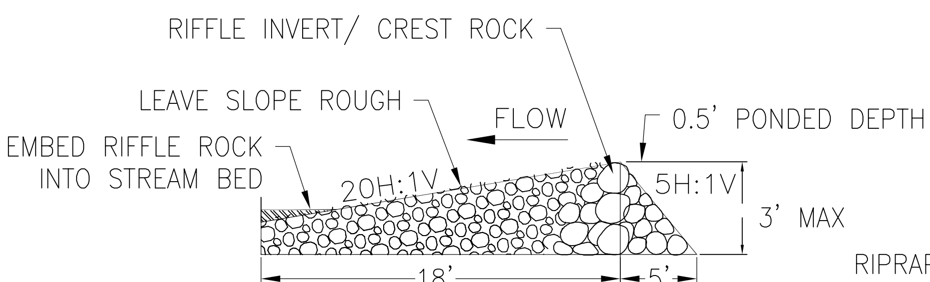
BULL CREEK
STA. 3+80 – STA. 4+40



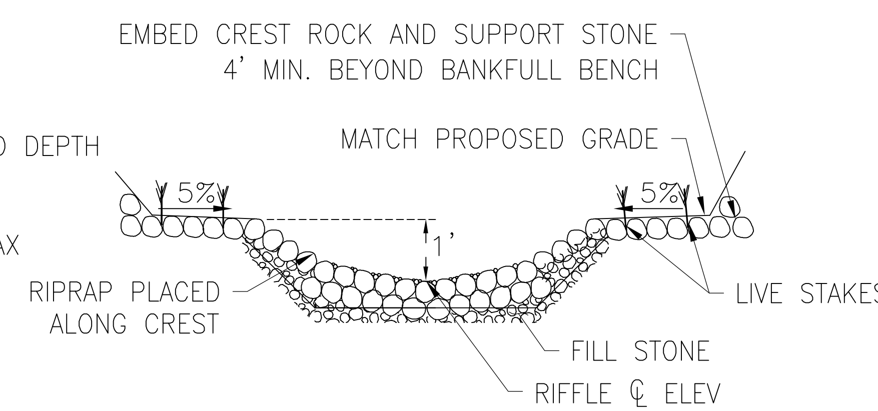
BULL CREEK
STA. 4+40 – STA. 5+10



PLAN



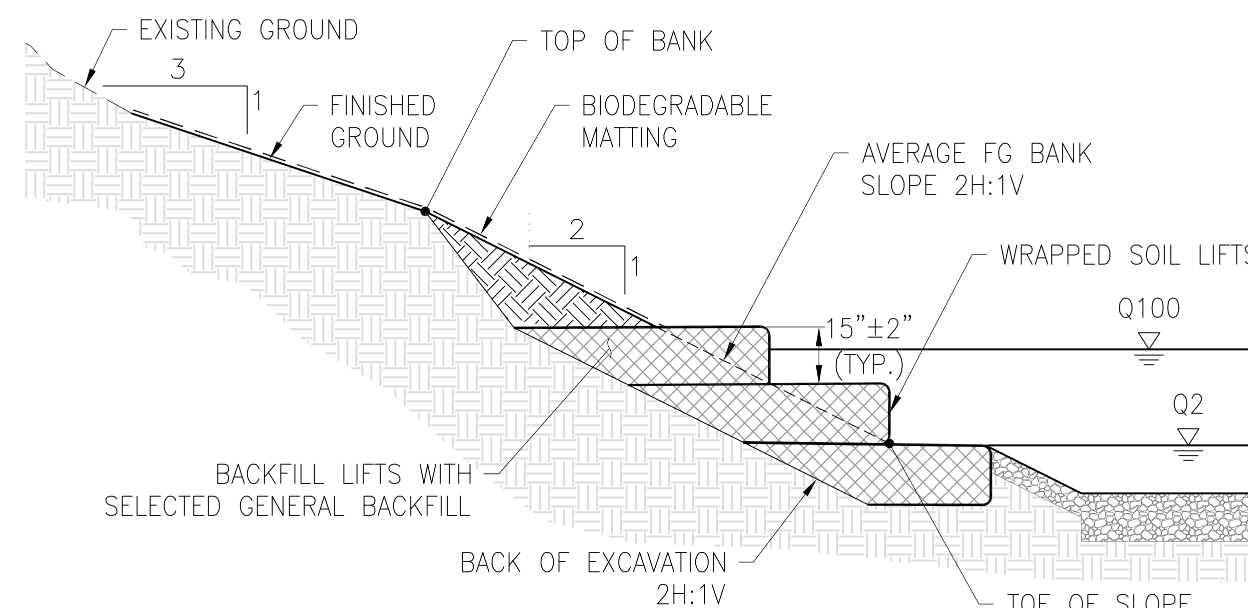
PROFILE



SECTION A–A

1 ROCK RIFFLE

NTS



NOTE: BIODEGRADABLE MATTING SHALL BE INSTALLED AT THE BULL CREEK SITE ANYWHERE THAT SOILS ARE DISTURBED. SOIL LIFTS WILL BE USED TO CONSTRUCT FILL SLOPES BELOW THE 100-YEAR FLOOD ELEVATION. ALL DISTURBED AREAS WILL BE STABILIZED WITH DENSE NATIVE VEGETATION PER PLANTING PLANS

2 SOIL LIFTS

NTS

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
TM	TM	AMC	8/4/15	AUGUST 21, 2015

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINARY DESIGN 08/26/15

ODOT US20 PME TURNKEY MITIGATION PROJECT
LINCOLN COUNTY, OREGON

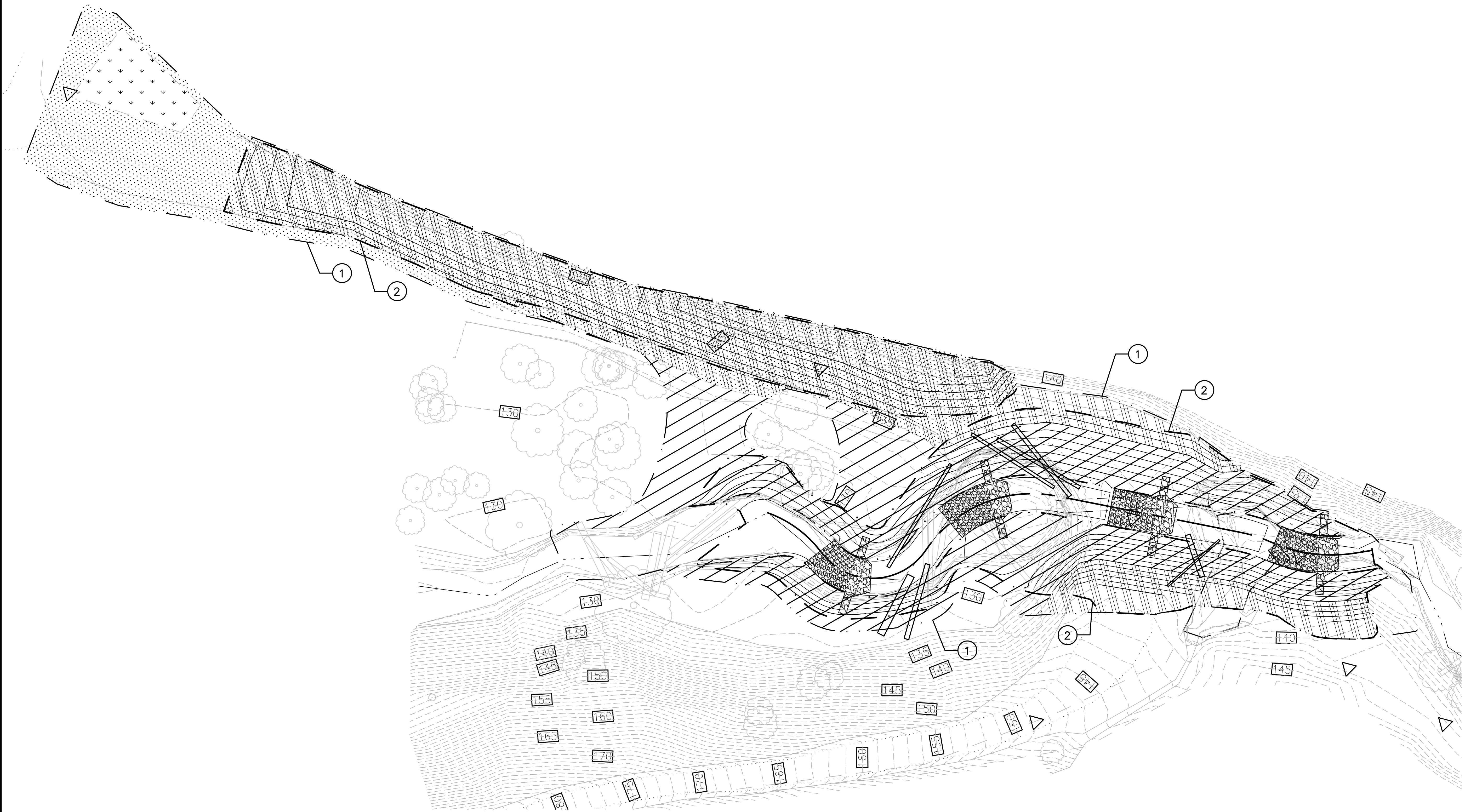
BULL CREEK TYPICAL SECTIONS AND DETAILS

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
BC03
Sheet No.

Plotted: Aug 26, 2015 – 2:53pm amic L:\Project\17500\17545\CADD\ACAD\BullCreek\Dwg\BC02-BC03.dwg Layout Name: BC03

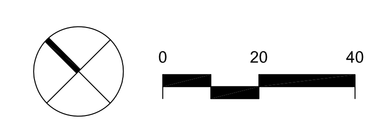


PLANTING LEGEND

- UPPER BANKS
- LOWER BANKS
- UPLAND DISTURBED AREA: SEED WITH SUNMARK SEEDS NATIVE UPLANDS MIX
- WETLAND 'B': SEED WITH WETLAND SEED MIX

SHEET KEY NOTES

1. LIMIT OF DISTURBANCE
2. GRADING LIMITS (TYP.)



NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
LH	DF	LH		AUGUST 25, 2015

Laura Herbon
Landscape Architect LLC
laura@herbonlandarch.com

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINCARY DESIGN 08/25/15

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

BULL CREEK SITE REVEGETATION PLAN

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
BC04
Sheet No.

PRELIMINARY PLANT LIST

%	BOTANICAL NAME	COMMON NAME	CONDITION
UPPER BANKS (11,626 SF):			
TREES: 10' O.C. SPACING = 133 STEMS TOTAL			
25%	ACER MACROPHYLLUM	BIGLEAF MAPLE	BARE ROOT
20%	FRANGULA PURSHIANA	CASCARA	BARE ROOT
10%	PSEUDOTSUGA MENZIESII	DOUGLAS FIR	BARE ROOT
20%	SAMBUCUS RACEMOSA	RED ELDERBERRY	BARE ROOT
25%	THUJA PLICATA	WESTERN RED CEDAR	BARE ROOT
SHRUBS: 3' O.C. SPACING OVER HALF THE AREA = 746 STEMS TOTAL			
40%	RUBUS PARVIFLORUS	THIMBLEBERRY	BARE ROOT
20%	POLYSTICHUM MUNITUM	SWORDFERN	CONTAINER
40%	RUBUS SPECTABILIS	SALMONBERRY	BARE ROOT
LOWER BANKS (11,929 SF):			
TREES: 10' O.C. SPACING = 137 STEMS TOTAL			
40%	ACER MACROPHYLLUM	BIGLEAF MAPLE	BARE ROOT
30%	FRANGULA PURSHIANA	CASCARA	BARE ROOT
30%	SAMBUCUS RACEMOSA	RED ELDERBERRY	BARE ROOT
SHRUBS: 3' O.C. SPACING, 1/2 THE AREA = 765 STEMS TOTAL			
50%	RIBES BRACTEOSUM	STINK CURRANT	BARE ROOT
50%	RUBUS SPECTABILIS	SALMONBERRY	BARE ROOT
HERBACEOUS PLANTS: 2' O.C. SPACING, 1/4 THE AREA = 861 PLANTS			
25%	ATHYRIUM FELIX-FEMINA	LADY FERN	CONTAINER
25%	BLECHNUM SPICANT	DEER FERN	4" BAND
25%	LYSICHITON AMERICANUS	SKUNK CABBAGE	4" BAND
25%	TOLMEIA MENZIESII	PIGGY BACK PLANT	4" BAND

PRELIMINARY SEED MIXES

LBS PLS/ ACRE	BOTANICAL NAME	COMMON NAME
BANK SEED MIX (ESTIMATED 15,058 SF):		
4.4	AGROSTIS EXARATA	SPIKE BENTGRASS
21.9	ELYMUS GLAUCUS	BLUE WILDRYE
UPLAND DISTURBED AREA SEEDING (13,019 SF) SEED WITH SUNMARK SEEDS NATIVE UPLANDS SEED MIX:		
4.4	AGROSTIS EXARATA	SPIKE BENTGRASS
4.4	BROMUS CARINATUS	CALIFORNIA BROME
21.9	ELYMUS GLAUCUS	BLUE WILDRYE
13.1	FESTUCA RUBRA RUBRA	NATIVE RED FESCUE
WETLAND SEED MIX 1024 SF):		
3.5	AGROSTIS EXARATA	SPIKE BENTGRASS
7.0	BECKMANNIA SYZIGACHE	SLOUGHGRASS
7.0	DESCHAMPSIA CESPITOSA	TUFTED HAIRGRASS
1.5	JUNCUS BUFONIUS	TOAD RUSH

PLANTING NOTES

1.0 SEED ALL LOWER BANK PLANTING AREAS WITH BANK SEED MIX. SEED UPPER BANK AREAS OUTSIDE OF SOIL PLA

2.0 SEED ALL OTHER DISTURBED BARE GROUND (GRADED) AREAS OF THE SITE WITH NATIVE UPLANDS SEED MIX.

3.0 GENERALLY LAYOUT PLANTINGS AT SPACING INDICATED HEREIN. INSTALL ALL NATIVE PLANTS IN SAME SPECIES GROUPINGS THAT RESEMBLE NATURAL PLANT DISTRIBUTIONS.

NO.	DATE	BY	REVISION COMMENTS

Design	Drawn	Checked	Date	Initial Issue Date:
XXX	XXX	XXX		AUGUST 25, 2015

Laura Herbon
Landscape Architect LLC
laura@herbonlandarch.com

MB&G
MASON, BRUCE & GIRARD, INC.
Natural Resource Consultants Since 1921

PRELIMINCARY DESIGN 08/25/15

ODOT US20 PME TURNKEY MITIGATION PROJECT

LINCOLN COUNTY, OREGON

BULL CREEK SITE REVEGETATION PLAN

otak
HanmiGlobal Partner

Datum: NAVD 88

17545
Project No. Drawing No.
BC05
Sheet No.

Attachment D

FFO-US20: UPRR - Eddyville (Phase 3) Section Geotechnical Data Report

Report - March 2014

Geotechnical Data Report

FFO-US20: UPRR - Eddyville (Phase 3) Section
Corvallis-Newport Highway,
Lincoln County, Oregon

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

GEOTECHNICAL DATA REPORT
GRADING & DRAINAGE

FFO-US20 PME: UPRR - EDDYVILLE
PHASE 3
CORVALLIS – NEWPORT HIGHWAY
LINCOLN COUNTY, OREGON

March 4, 2014

Cornforth Consultants, Inc.
10250 SW Greenburg Road, Suite 111
Portland, Oregon 97223

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ATTACHED APPENDICES

1 INTRODUCTION

This document is the Geotechnical Data Report for the Phase 3 construction of earthwork cuts and fills, ground anchors, and surface and subsurface drainage measures within the 2014/2015 contract for the US20: UPRR – Eddyville section of the Highway 20 relocation project. The project site is near Eddyville, Oregon, flanking south of the existing US Hwy 20, and crossing coastal mountain terrain from approximately 1 to 7 miles to the west of Eddyville (Figure 1).

1.1 Purpose

The purpose of this Geotechnical Data Report (GDR) is to provide descriptions of the subsurface conditions that are anticipated at the project for proposed construction of cuts, embankments, buttresses, ground anchors, and surface and subsurface drainage measures as partial mitigation against future landslide movement associated with the new highway construction. This data report is a compilation of the available geotechnical data including boring logs, core photographs, test pit logs, laboratory testing summaries, instrument monitoring results, and pre-production ground anchor testing. Core samples are available for viewing by contacting the Engineer.

1.2 Report Organization

This report is organized in sections, as follows:

- Section 2 describes the geotechnical project setting.
- Section 3 describes the construction phasing and approach.
- Section 4 describes the subsurface conditions, including various material types, material properties, groundwater conditions and ground movement.
- Sections 5 through 21 describe unique characteristics for each feature and provide a summary of existing constructed elements and those to be accomplished in Phase 3.

Appendices contain the geotechnical data as outlined in the Table of Contents.

2 GEOTECHNICAL PROJECT SETTING

The project is in the central Oregon Coast Range within the Yaquina River watershed. The project crosses the Yaquina River on the west end and Little Elk Creek on the east end at about elevation 100 feet. The project crosses five other drainages known as Trapp Creek, Cougar Creek, Crystal Creek, Eddy Creek Tributaries A and B, and Eddy Creek Tributaries C and D. The maximum elevation of the new road grade will be about 500 feet at the divide between Crystal and Eddy A and B. The slopes traversed by the project vary from about 15 degrees up to 42 degrees. Adjacent to the project, the Coast Range rises to elevation 1,400 feet on Barber Butte about 4,000 feet to the south of Eddy Creek Tributary C.

The US20: UPRR to Eddyville project is subject to Oregon coastal weather patterns which include moderate summer temperatures; prolonged periods of wet season; intense coastal fall, winter and spring storms; freezing; and occasional rain-on-snow events. The dry season window for earthwork is limited due to the coastal weather influences. Precipitation and temperature measured at the project is provided on Figure 2. Precipitation was measured by a prior contractor from January 2006 to early May 2012 using a graduated cylinder rain gauge located near the Eddyville construction office. These measurements were collected manually on a daily basis, except for weekends, when they may or may not have been taken depending on availability of construction personnel. When weekend readings were not taken daily, cumulative weekend readings from nearby regional weather stations were used to estimate 24-hour precipitation amounts at the site. Since mid-September 2012, measurements have been made using an automated rain gage of a Vantage Vue® Weather Station, also mounted at the construction office. For the period of June 5 to September 12, 2012, precipitation data in Figure 2 is from a Newport Weather Station identified as MD1265. Temperature data for 2012/13 on Figure 2 is from the Vantage Vue weather station, plus normal daily temperatures from the NOAA weather station in Newport identified as USW0002485. The daily normal is compiled from 1981-2010 data.

The project area is within the Coast Range geologic province, and the bedrock geology is primarily comprised of rhythmically-bedded siltstone and sandstone of the Tyee Formation (Figure 3). 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 have affected the geologic materials include uplift, tilting/folding, and faulting and fracturing. Weathering and erosion have also affected the geologic materials.

Geologic materials at the project have properties that are prone to landsliding. The rhythmically bedded stratigraphy of the Tyee Formation contains interbedded siltstone and sandstone that have been gently tilted and slightly faulted. The structural dip of the bedding is generally between 12 and 22 degrees in the direction of Azimuth 300 to 350 degrees, generally to the northwest. In this material, potential physical boundaries of landslides include:

- Siltstone interbeds, which have been stressed during tectonic activity.
- Tectonic discontinuities that cut across the bedding.

- Erosional surfaces that daylight or encroach low strength interbeds or discontinuities.

With the landslide prone geology, triggers of ground movement include erosion cutting through the layered stratigraphy, groundwater/precipitation and seismic activity. Manmade cuts or fills, and changes to surface or groundwater conditions, also trigger ground movement.

3 CONSTRUCTION PHASING AND APPROACH

3.1 Project Features

The geotechnical project features are located across four drainage basins in the coastal mountain terrain that is crossed by a partially constructed highway alignment. The project features are located in the following geographic areas, which are primarily associated with drainage basins, as well as being known by previous construction designations.

Table 1: Project Geographic Features

Geographic Area	2014 Project Stationing	Previous 2005 Designation
Yaquina River (Meadows)	"S" 732+00 to "S" 743+00	Fill 14
Trapp Creek/Cougar Creek Divide	"S" 760+00 to "S" 768+00	Cut 7
Lower Cougar Creek	"S" 768+00 to "S" 784+00	Box Slide, Big Slide, Fill 11, Fill 12, Landslide 1, Cut 7 (east)
Cougar Creek	"S" 784+00 to "S" 801+00	Fill 10, Landslide 2
Upper Cougar Creek	"S" 801+00 to "S" 823+00	Cut 6 (west)
Western Crystal Creek	"S" 823+00 to "S" 830+00	Cut 6 (east), Fill 9 (west)
Crystal Creek	"S" 830+00 to "S" 847+00	Fill 9 (east), Fill 8
Upper Crystal Creek	"S" 847+00 to "S" 856+00	Cut 5
Eddy Creek Tributaries A & B	"S" 856+00 to "S" 876+00	Fill 7, Fill 6
Eddy Creek Divide	"S" 876+00 to "S" 886+00	Cut 4
Eddy Creek Tributary C	"S" 886+00 to "S" 897+00	Fill 5, Fill 4 (west)
Eddy Creek Tributary D	"S" 897+00 to "S" 907+00	Fill 4 (east), Landslide 3
Eddy Creek/Yaquina River Divide	"S" 907+00 to "S" 916+00	Cut 3
Yaquina River (Eddyville)	"S" 912+00 to "S" 925+00	Fill 3

3.2 Construction Phasing

The redesigned project is taking a phased approach to complete the highway realignment. Below are descriptions of the major phases.

- Phase 1 – Structure demolition, trench drains and horizontal drains (2012/2013. Completed).
- Phase 1A – Horizontal drains, initial blanket drains, and instrument cables/conduits and housing (2013. Completed).
- Phase 2 – Culverts, embankment foundations, rockfill toe keys, underdrains, test fills, horizontal drains and collection/discharge pipes (2013. Completed).

- Phase 3 – Earthwork for the revised highway alignment to construct cuts and fills, underdrains, trench drains, blanket drains, earth buttresses, ground anchor slide mitigation, cut slope rockfill buttresses, horizontal drains and collection/discharge pipes, surface drainage systems, subbase reinforcement, subgrade stabilization, and instrument cables/conduits and housing (2014/2015).
- Phase 4 – Subgrade, pavement, Elk Undercrossing structural plate culvert, remaining planned geotechnical mitigations including a buttress at Cut 9 and rockfall barriers, and other possible supplemental geotechnical mitigations to further manage potential instabilities (2016).

3.3 Prior Site Activities

Construction for the realignment project began in 2006 with development of a haul road across the rugged terrain, which included several temporary bridges. Present access through the project is provided by the existing haul roads.

Constructed features include soil and rock cuts, embankments, landslide buttresses and shear keys, subsurface drainage systems, temporary access roads, surface and below-ground concrete and steel foundation units for partially constructed bridges (the superstructures for these bridges have been removed), erosion control systems, and geotechnical instrument monitoring systems. The remaining bridge substructures include: two concrete caps on pile foundations, driven pipe piles at the former bridge abutments, and drilled shafts at the former interior bents. Physical evidence of the surface features can be readily observed; however the shear keys, subdrainage systems and the former bridge foundations from earlier construction are largely buried. Onsite soils are erodible and an erosion and sediment control (ESC) system has been used to control runoff, mitigate potential erosion, and protect nearby riparian areas, wetlands and creeks.

Excavations in overburden materials and rock included the placement of same materials into embankment fills. During earlier construction phases, several instabilities occurred in cuts and fills, some of which are still evident. While permanent embankment fills were compacted, some landscape areas and temporary fills may have only been dozer-shaped and cat-tracked at the surface.

Prior slide mitigation measures have included reconstructed fill slopes, rock inlays, toe berms, buttresses, shear keys beneath embankment fills, ground anchors in rock, weep drains and horizontal drains. Shear keys have been constructed with native materials or imported durable rock. There have been numerous horizontal drains installed at multiple areas across the project alignment. The outer portions of these drains are exposed in the cut and fill slopes and a temporary buttress area; however, the drain lengths are buried underground.

Underdrains consisting of rock fill were constructed in old drainage channels. In some cases the rockfill was enveloped with geotextile. Drain pipes were installed within some of the underdrains. Permanent and temporary culvert pipes were installed beneath embankment and crane pad fills.

Numerous geotechnical instruments located throughout the project will be actively monitored.

Currently there is no construction activity, other than periodic geotechnical instrument monitoring and maintenance, together with monitoring and maintenance of erosion control features.

3.4 Phase 3 Construction Scope

Phase 3 is a near-balanced cut/fill project that consists of approximately 2.4 million CY of excavation to be utilized in embankments. Additional material excavated from fill placed at Yaquina Meadows may be incorporated into the project. Embankments constructed with common material will include horizontal layers of localized geogrid reinforcement and composite drain board strips in designated areas/zones. Geogrids will also be installed with subbase reinforcement in select areas. Remaining buttresses, underdrains, trench drains and blanket drains will be installed.

Surface drainage systems include ditches, channels, culverts, slope drains, and riprap protection and dissipation blankets. Collection and discharge pipes will be installed to route collected water from horizontal drains and trench drains to drainage channel locations and to minimize infiltration into each slide mass. Permanent access roads to horizontal drains and major culvert inlets and outlets will be included.

Cut slope mitigations that will be constructed in Phase 3 include buttresses, rock inlays, and several remaining horizontal drain arrays.

Ground anchor landslide stability mitigations are planned for Cut 7 and Eddy Creek Tributary C slide areas. High-capacity anchors require bonding the distal end of the tendons into bedrock beneath landslide shear zones and stressing the tendons against concrete bearing blocks or steel plates at the ground surface.

Geotechnical instrument systems, cable conduits and instrumentation monitoring units will be expanded in Phase 3, in addition to providing protection for geotechnical instruments.

An “unsuitable material” fill area exists at Cut 4 RT to accept materials that are not suitable for highway embankment construction, which will be expanded in Phase 3.

3.5 Geotechnical Instrumentation and Construction Monitoring

Instrumentation of the many landslide-prone areas is an integral component of this project from design and through construction. Many instruments exist that will be continually monitored during construction. Additional instruments are planned, particularly to measure the settlement and deformation at culverts, embankment and cut slope hillsides.

Stability and groundwater will be monitored during construction to verify design assumptions and evaluate impacts (observational approach). The instrumentation system will be used for measuring foundation and embankment deformations as fill is placed, both landslide movement and settlement. Settlement sensors were installed near culverts and under recent test fills to measure the settlement along the culvert profile and at the test fills to evaluate possible impacts to the culverts as well as main embankment fill areas. Other settlement sensors will be added in this phase beneath new fills, between the 2014 and 2015 fills, and at the top of the 2015 fills. Other instrumentation on the project includes existing and new weirs to measured horizontal drain discharge, and new load cells and strain gauges associated with ground anchors. Rock cutslopes are also being monitored for groundwater level and displacement.

4 SUBSURFACE CONDITIONS

Characterization of the subsurface conditions at the project is presented in this chapter as a general overview of: geotechnical subsurface material units, ground movements, and groundwater conditions. The site-specific conditions of various project features are discussed in more detail in the following Chapters 5 through 21, each chapter of which is devoted to each of the features.

4.1 Geotechnical Investigation Data

Geotechnical data included in this report for the project consists of boring logs, core photographs, test pit logs, laboratory data summaries, groundwater level data, and ground movement data. A Site Plan Index is shown on Figure 4. A borehole and instrumentation legend identifying the status of active or inactive/abandoned borings is included on Figure 5. Site plans of specific areas along the new highway alignment are shown on Figure 6 through Figure 15.

Multiple exploration programs have been conducted for this project starting in 2004. The locations of the borings and test pits are shown on the Site Plans. Summary Boring Logs, associated core photographs and Summary Test Pit Logs, where applicable, are shown in Appendix A, Appendix B and Appendix C. The boring designations have varied over time depending on the firm logging the borings, and the identified "groups" relate to the different firms. Details on boring identifications are provided on the cover sheets of the above-referenced appendices. Additional explorations may be initiated and completed during construction. If new explorations are completed, the Site Plans would be updated during construction and provided to the Contractor, along with the additional relevant summary boring logs, if requested.

4.2 Subsurface Material Units

Exploratory borings and site grading have encountered materials that are separated into ten geotechnical engineering units identified as embankment/buttress fill, subdrain fill, shear key fill, durable rock fill, excess excavated and "unsuitable material" fill, colluvium/slide debris, weathered rock slide debris, Tyee Formation, basalt dike and prior construction material stockpiles. Summary descriptions of the material units are included in the following paragraphs. Detailed descriptions are included on summary boring logs, laboratory testing summaries and instrument monitoring plots included in the following text and the attached appendices.

In addition to the above-referenced native materials and construction fill units, there are also rockfill and common material stockpiles leftover from previous construction phases that may be utilized or encountered during the current construction tasks. These materials are also briefly discussed in the following text.

4.2.1 Embankment Fill and Buttress Fill

Embankment fill and buttress fill materials are sand, silt and clay; mixed with gravel, cobbles and scattered boulders, to depths of over 170 feet. This material generally consists of interlayered soil that ranged from stiff to very stiff clayey silt, to medium dense to dense silty sand, and to dense gravel- to cobble-sized rock fragments. All of the encountered materials contain varying percentages of gravel-sized fragments of sandstone and siltstone. Occasional to trace amounts of organic material were also encountered, especially at the base of the fill unit. Generally, the different types of fill were encountered in layers that ranged from approximately 0.5 feet up to approximately 35 feet. The source of the fill material is local excavations in the Tyee Formation and its overburden that were made for construction of the existing Highway 20 realignment.

4.2.2 Subdrain/Underdrain Fill

At select areas beneath some of the embankment fills, subdrains and cut-off trenches consisting of geotechnical-wrapped, gravel-sized, angular, durable, imported basalt rock fill were constructed.

4.2.3 Shear Key Fill

Material contained within previously constructed shear keys consists primarily of compacted siltstone and sandstone rock of the Tyee Formation that has been excavated for construction of the highway alignment. Geotechnical borings have been performed through shear keys, encountering stiff to very stiff, sandy, slightly clayey silt, and medium dense sandy silt with gravel-sized rock fragments. Cut-off trenches of subdrain fill were also constructed within the upslope side of the shear keys.

4.2.4 Durable Rock Fill

Material used to construct horizontal-drain pads, access roads, blanket drains, trench drains, etc. is constructed of imported durable rock fill. This material generally consisted of compacted, hard (R4), dark gray, fresh basalt rock.

4.2.5 Excess Excavated and "Unsuitable Material" Fill

Excess excavated material, including unsuitable material, is stockpiled at select locations along the project. Excess excavated material is stockpiled at Yaquina Meadows, and test pits at the stockpile encountered slightly clayey, sandy silt with numerous gravel-, cobble-, and boulder-sized fragments of siltstone and sandstone. Unsuitable material is placed in select areas along the project including, but not limited to, the following approximate locations: "S 737+00 to 740+00, ~200' RT; "S" 773+00, ~200' RT; "S" 779+00 RT, ~200' RT; "S" 877+00 to 883+00, ~200' RT; and "S" 885+00 ~400' RT.

4.2.6 Colluvium/Slide Debris

Underlying the fill, and at the ground surface away from the fill, is colluvium/slide debris. This material unit was encountered in thicknesses that ranged from 12 to 75 feet, and generally consisted of intermixed medium stiff, clayey silt and loose to medium dense silty sand. Occasionally this unit contains gravel- to boulder-sized fragments of weathered sandstone. Wet clayey zones occasionally occur within the slide debris.

4.2.7 Weathered Rock Slide Debris

Underlying the colluvium/slide debris is a layer of displaced and weathered rock material of highly fractured and displaced Tyee Formation. This material ranges from moderately to highly weathered, slightly to heavily sheared, bedded to intermixed siltstone and sandstone, with the "intermixed" in a clayey silt matrix. The more coherent bedded material is extremely soft (R0) to very soft (R1) siltstone, and very soft (R1) to soft (R2) sandstone, both of which exhibit progressive degrees of extension or dilation. The rock can be relatively massive (blocks up to 8- and 10-foot size) to 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 generally coincide with the top of the siltstone 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. Note that the extent of weathering, dilation and disintegration of the slide debris is interpreted to be dependent on the amount of landslide movement that has occurred over geologic time.

4.2.8 Tyee Formation

Underlying the slide debris is rock (bedrock) of the Tyee formation, which includes sandstone and siltstone with shale occasionally within the siltstone. The sandstone is a fresh gray color and ranges from a soft to a medium hard rock (R2 to R3). The fracture characteristic is typically massive, but it occasionally contains isolated zones of highly fractured material. Individual beds of sandstone range from approximately 1 to 10 feet thick. Small pockets of siltstone are occasionally contained within the sandstone. Occasionally, a deep slide zone encompasses slab-like blocks of relatively fresh Tyee Formation rock, which is identified as Tyee Formation Slide Debris where identified in boring logs.

Siltstone is a fresh dark gray color and a soft rock (R2). The siltstone is typically slightly fractured, but can also be moderately to highly-fractured. It often separates along thin (¼- to ½-inch), parallel layering, which is associated or parallel to the bedding. Much of the siltstone has a tendency to slake. Individual beds of siltstone range from less than 1 to approximately 6 feet thick. Siltstone tends to grade to shale at the top of the siltstone beds.

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. Individual beds of shale range from less than 1 to approximately 3 feet thick. For purposes of discussion in this report, the shale/siltstone is collectively referred to as siltstone.

4.2.9 Basalt Dike

One intrusive basalt dike was encountered in Cut 6 on the project. It is approximately 10 feet wide and it dips approximately 80 degrees to the northeast and trends approximately northwest-southeast. This material consists of hard (R4), dark gray, slightly weathered basalt, which is slightly vesicular and has secondary mineralization in the vesicles.

4.2.10 Prior Construction Material Stockpiles

There are three existing stockpiles of buttress rock (6″-1″) on the site remaining from Phases 1 and 2.

- Buttress rock (6″-1″) stockpiled at the west end of the project (Cut 7) currently acts as a temporary buttress against the right cut face. This material originates from the Iron Mountain quarry near Newport. The buttress was constructed during Phase 1 and was not modified during Phase 2. Anchor drilling for the cut slope anchors in Phase 3 is expected to contaminate this material with fines. It is expected that the material will be removed in stages as rows of cut slope anchors are installed and tensioned. Due to the anticipated contamination, this material has been designated for placement only as "Agency-supplied stone embankment".

- An additional buttress rock (6″-1″) stockpile at the west end (Fill 11) originates from Cedar Creek quarry near Newport. This excess buttress rock was stockpiled during Phase 2.
- Buttress rock (6″-1″) stockpiled at the east end (Cut 3) originates from the Wild Rose quarry near Philomath. This excess buttress rock was stockpiled during Phase 2 as well. Both the Cedar Creek and Wild Rose buttress rock stockpiles are designated for use as Agency-supplied buttress rock.
- Stone Embankment stockpiled at the east end (Cut 3) originates from the Wild Rose quarry near Philomath. This excess stone embankment was stockpiled during Phase 2 when excess stone embankment fill was trimmed from the rockfill buttress at Cut 3 right. This stockpile is designated for use as Agency-supplied stone embankment.

4.3 Materials Testing

Laboratory testing has been performed on select samples collected during the multiple exploration programs conducted since 2004. Summaries of the testing that are relevant to this construction are provided in the following paragraphs.

Water contents were generally determined for a majority of the samples collected in borings. Water contents typically range 10 percent plus or minus of the optimum compaction moisture. Refer to the individual boring logs for specific water content results.

Atterberg limits were performed on the soil matrix of many samples collected across the project. Since the onsite fill materials are derived from the Tyee Formation sedimentary rocks, material classifications based on the Atterberg limits are generally similar. In general, the materials are ML (low plasticity silt), with occasional zones of MH (elastic silt), SM (silty sand) and CL (lean clay). The following summarize the typical range of plasticity values, based on about 250 tests:

- Plastic Limit 15-72% (average approx. 35%)
- Liquid Limit 38-89% (average approx. 49%)
- Plasticity Index NP-51% (average approx. 14%)

Gradation of non-bedrock materials can range from mostly fine-grained to mostly coarse-grained, and many variations in between. The non-bedrock materials consist of colluvium, slide debris and fill materials. A broad range of rock fragment sizes exist within these materials, as described in Section 4.1 Overview of Subsurface Material Units.

Numerous density tests were performed during initial earthwork for this project from 2008 to 2010. The unit weight of onsite fill materials ranged from 103 to 152 pcf (wet density), with an average of about 119 pcf. The test results indicate that at least 95 percent of maximum dry density (Standard Proctor) was generally achievable on fill materials up to 7 percent wet of optimum moisture content. However, the dry densities tended to decrease for fill materials wetter than 4 percent over optimum moisture content.

In 2013, the unit weight of fill materials constructed from onsite materials during Phase 2 ranged from 100 to 152 pcf (wet density), with an average of about 120 pcf. Compaction test results (Standard Proctor) during Phase 2 indicate that optimum moisture content ranged from 11 to 18 percent with dry unit weights ranging from 100 to 118 pcf.

Compaction testing (Standard Proctor) on fill materials at Yaquina Meadows in 2013 indicates optimum moisture content ranged 19 to 26 percent with maximum dry unit weights of 96 to 104 pcf. Existing moisture contents at the Yaquina Meadows fill site are approximately 2 to 4 percent wet of optimum moisture content, and locally contains wetter soils.

The results of slake durability tests indicate that both sandstone and siltstone rock have a wide range of potential degradation. The results of all material testing indicate a range of Slake Durability Index (SDI) of 0 to 98. The siltstones tend to be typically more degradable than the sandstones. Shale was not tested but is expected to have low to extremely low durability. All native rock on the project is classified as non-durable by the Agency.

Unconfined Compressive Strength (UCS) tests indicate that both fresh sandstone and siltstone have a wide range of strengths, generally in the 500 to 5,500 psi range. Unit weights of tested sandstone and siltstone range from 140 to 160 pounds per cubic foot with weathering ranging from highly weathered to fresh, respectively. Weathered sandstone and siltstone have lower strength values, generally ranging from 0 to 4,000 psi. A more specific summary of the UCS testing is provided in the following table.

Table 2: Summary of Unconfined Compressive Strength Tests

Material	UCS Range (psi) (n = number of tests)
Fresh Sandstone	409 – 5,258 (n = 28)
Weathered Sandstone	268 – 3,849 (n = 29)
Fresh Siltstone	869 – 3,800 (n = 26)
Weathered Siltstone	0 – 1,100 (n = 3)
Sandstone and Siltstone interbedded	248 – 3,245 (n = 13)

4.4 Groundwater

Groundwater data has been recorded nearly continuously since late 2007 at a number of piezometers installed at the project. Data from the installations is provided in the latest Instrument Monitoring Report for January 2014 (Appendix D). Groundwater levels vary widely within the colluvium/slide debris, weathered rock slide debris and Tyee Formation. A comprehensive assessment of the local effects of groundwater dewatering as a result of the previously installed horizontal drain installations is in progress.

Seasonal variations generally range from 1 to 20 feet with one instrument exhibiting a 35-foot seasonal variation. Spikes in groundwater due to storms generally vary from 1 to 15 feet, with one instrument that exhibits 50- to 60-foot spikes. Spikes in groundwater induced by drilling geotechnical borings or horizontal drains have varied from 2 to 115 feet. Refer to the plots of specific instruments for the different areas included in the instrument monitoring report in Appendix D.

In general, unconfined and confined aquifers are present within the subsurface materials. Unconfined aquifers are within the colluvium/slide debris and perched on in-place Tyee Formation. Locally confined aquifers occur within the weathered rock slide debris (confined by the surrounding colluvium/slide debris). Confined aquifers also occur within faults/fractures within the Tyee Formation. The majority of the groundwater appears to be within the unconfined aquifers, while fracture flow appears to be a prominent source of groundwater within the weathered rock slide debris.

Subsurface drainage measures to collect and convey groundwater were built during the prior construction at embankment, buttress and temporary fills. Underdrains of geotextile-wrapped drain rock were installed in old creek drainages that have been infilled. Cut-off drains of geotextile-wrapped drain rock were also installed on the upslope side of shear keys.

Individual fractures within the in-place rock are anticipated to produce water at flow rates on the order of 1 to 20 gallons per minute (gpm) based on observations of groundwater flow from springs at in-place rock, and performance of nearby residential water wells in the same rock.

Fracture flow from the Weathered Rock Slide Debris could be on the order of tens to hundreds of gpm based on past excavations for shear keys through slide debris at two of the landslide features (Eddy C and Cougar) and previously completed horizontal drains. Pressurized pockets of fractured rock within the subsurface may also occur and flow temporarily at higher rates.

Average groundwater flow from horizontal drains in the Colluvium/Slide Debris is anticipated to be on the order of less than 1 to about 10 gpm, based on past excavations into the soil and flow rate monitoring data from individual drains. Some of the existing drains did not intercept groundwater flow paths, resulting in little to no discharge. However, some of the drains have encountered significant short-term groundwater flows (in excess of 100 gpm) that decreased over time to the average rates referenced above.

Drilling of new horizontal drains through the Weathered Rock Slide Debris must be prepared to control sediment-charged groundwater emitting at high flow rates from the drains, with flows increasing during rainy periods and diminishing over time until hydrostatic pressures adjust and the water flows clean.

4.5 Ground Movement

Ground deformation at the project includes landslide movement, fill slope instabilities, rock cut slope blasting over-break and displacement, rockfall, settlement, and erosion.

Landslide movements have been recorded with manual slope inclinometers installed at the project and with In-Place Inclinometers installed at select locations. Data from the installations is charted and included in Appendix D. Ground movements have also occasionally been visible at the ground surface.

Shallow- to deep-seated landslides have been reactivated by both excavations and fills. Existing deep-seated landslides have moved at rates of up to ¼-inch per month during wet periods. Recent installation of horizontal drains, which included drilling with air and water to facilitate cuttings return, resulted in areas of local, temporary landslide movement that significantly slowed or stopped when drilling was completed.

Embankment fill slopes have experienced instabilities, including shallow slumps, sloughing and erosion. Infiltration, groundwater seepage and steep slopes were contributing factors.

Rock cut slope instabilities include over-break from blasting and displacement where the rock structure is adverse with the steep cut slope angle. Rock cut failures (slides) occur where weak rock layers have been exposed in the cut face. Rock excavation removes the resisting force and allows rock blocks to move. Rock cut failures can occur rapidly, but are typically preceded by formation of a headscarp tension crack upslope of the cut slopes.

Rockfall occurs on cut slopes. Siltstone layers erode relatively quickly and undermine sandstone layers, which topple and fall from the cut slopes.

Constructed materials experience settlement during and following construction. The added load of the fill materials also causes underlying soil materials to settle. A component of horizontal deformation accompanies the associated settlement.

The soil materials on the project are highly susceptible to erosion if unprotected against weather and surface water.

5 Station "S" 732+00 to 743+00 (Yaquina Meadows, Fill 14)

Yaquina Meadows is a flood plain on the inside of a sharp bend in the Yaquina River. Site conditions have been investigated with the following geotechnical borings, test pits and instruments (Figure 6). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 3: Yaquina Meadows Explorations

Appendix	Boring Designation
A	BH-15, BH-16, BH-17, BH-56, BH-57, BH-58
B	RRBH05-1, RRBH05-2, YRBH05-1
C	F14-01, TP14-1(2012), TP14-2(2012), TP14-1, TP14-2, TP14-3, TP14-4, TP-14-5, TP14-6

5.1 Subsurface Materials

Materials at the Yaquina Meadows area include unsuitable material, embankment fill, alluvium, colluvium and Tyee Formation. Materials excavated from new through-cuts to the east, including some "unsuitable material", were placed in a broad fill stockpile right of the highway alignment during initial construction in 2006-2009. Alluvium and colluvium underlie the fill stockpile and elsewhere underlie the ground surface. Embankment fill was also placed on top of a thin (3-foot) layer of alluvium, which directly overlies decomposed Tyee Formation sandstone. Tyee Formation rock is exposed as portions of the Yaquina River's bed.

5.2 Groundwater

Groundwater conditions are anticipated to be shallow in the flood plain of Yaquina River. During the wet season groundwater levels can be at the ground surface, with local areas of ponded surface water. With distance away from the river, as the ground surface rises in elevation, the groundwater depth is anticipated to increase, possibly to depths on the order of 5 to 15 feet.

5.3 Ground Deformation

The LT embankment fill slope experienced several localized slumps and sloughing following initial construction. No deep-seated landslides were observed.

Settlement likely occurred at the embankment fills; however, the amounts are not known.

5.4 Construction and Geotechnical Mitigation

Fill 14 was constructed using onsite materials. Localized slope failures in the LT embankment slope were mitigated in 2013 by excavating the failed slope material and replacing it with rock inlays consisting of imported buttress rock (6″-1″) with geotextile backing. The excavated material was placed to form a berm at the toe of the embankment slope, which included underdrains to allow discharge of groundwater from the rock inlays.

A wetland mitigation site is planned, which will require existing fills to be removed from Yaquina Meadows and either placed in highway embankments or in “unsuitable material” disposal sites, depending on the material quality. The lower zone of fill material is shaped as a berm between the Yaquina River and the highway embankment (Fill 14). This older fill was constructed in 2009 using materials from Cut 7, primarily overburden materials but also including pockets of boulders. A stockpile of 6″-1″ buttress rock was placed on top of the older fill on the south side of the new highway alignment, which was subsequently utilized during Phase 2 construction in the summer of 2013.

An “unsuitable material” site is located on the north side of Fill 14 of the new highway. This area was mitigated in 2013 with a rock inlay in the embankment slope and the excavated material was placed as a toe berm, which required underdrains that will need to be preserved and extended as necessary.

6 Station "S" 760+00 to 768+00 LT (Cut 7 LT)

Cut 7 is a through-cut between Trapp Creek to the west and the Cougar Creek drainage to the east. Site conditions on the left side of the cut have been investigated with the following geotechnical borings and instruments, as well as observations and measurements of the face of the cut slopes (Figure 7). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 4: Cut 7 LT Explorations

Appendix	Boring Designation
A	BH-23, BH-25, TPS-2
B	C7PZ05-1, C7PZ05-3, C7TP05-1, C7TP05-2

6.1 Subsurface Materials

The cut exposes colluvium/slide debris and weathered rock slide debris from an ancient landslide that toes into Trapp Creek to the west, and underlying sandstone and siltstone beds of the Tyee Formation. This sedimentary rock is relatively nondurable and slakes readily, resulting in frequent rockfall and talus accumulations.

6.2 Groundwater

Groundwater springs have been observed within the upper reach of a small tributary to Trapp Creek, on the west side of Cut 7 RT. Based on these springs and piezometers installed in Cut 7, groundwater is anticipated to be perched above the Tyee Formation and confined within rock fractures. However, the through-cut has interrupted the flow path and the LT cut slope is relatively dry. Very little groundwater is anticipated within the excavation for the LT cut slope.

6.3 Ground Deformation

The left side of Cut 7 exhibits slaking and rockfall due to undermining of sandstone layers, but does not appear to be sliding.

6.4 Construction and Geotechnical Mitigation

The initial construction slope of 1V:0.5H in the sedimentary rock has resulted in significant erosion, slaking, raveling and undermining that produce rockfall.

The LT ditch was temporarily filled in 2012 to detour construction traffic due to the placement of a temporary rockfill buttress against the RT cut slope slide. The ditch fill includes a temporary bypass pipe.

The mitigation work to be performed in Phase 3 consists of laying the cut back to flatter slope angles. Blasting plans will need to be designed to prevent excessive vibration and energy impacting or reactivating landslides and to minimize over-break in the finished cut slope face.

7 Station "S" 760+00 to 768+00 RT (Cut 7 RT Slide)

Cut 7 is a through-cut between Trapp Creek to the east and Yaquina River/Cougar Creek to the east. Site conditions on the right side of the cut have been investigated with the following geotechnical borings and instruments, as well as observations and measurements of the cut face (Figure 7). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 5: Cut 7 RT Slide Explorations

Appendix	Boring Designation
A	BH-24, TPS-3
B	C7PZ05-2, C7TP05-3, C7TP05-4, C7TP05-5
C	C7-10, C7-11, C7-12

7.1 Subsurface Materials

The cut exposes colluvium/slide debris and weathered rock slide debris from an ancient landslide that toes into Trapp Creek to the west, and underlying sandstone and siltstone beds of the Tyee Formation. A deep slab of Tyee Formation slide debris was uncovered on the right side of the through-cut, which resulted in renewed movement. A temporary, durable rock fill buttress was placed in 2012 to restrain the exposed toe of the deep slab of Tyee Formation slide debris.

7.2 Groundwater

Groundwater springs have been observed within the upper reach of a small tributary to Trapp Creek, on the west side of Cut 7 RT. Seepage zones are exposed in the rock cut face. Based on these springs and piezometers installed in Cut 7, groundwater is anticipated to be perched above the Tyee Formation and confined within rock fractures. Perched groundwater is anticipated to occur at depths of possibly 15 to 40 feet flowing through colluvium/slide debris and weathered rock slide debris. Deeper, confined groundwater is flowing through fractures in the Tyee Formation at greater depths on the order of 60 to 90 feet. Horizontal drains installed in Cut 7 RT have produced groundwater flows of 0 to 4 gallons per minute (gpm), the higher flows occurring shortly after rain storms. Closer to Trapp Creek, groundwater is anticipated to be relatively shallow within the colluvium/slide debris and underneath embankment fill.

7.3 Ground Deformation

In mid-2012, a large slab of rock encompassing nearly the entire right side of the cut was observed to have moved out of the slope approximately 5 inches. Based on measurements from subsequently installed crack meters, the movement was interpreted to have occurred slowly if not seasonally since grading of the cut in 2009. A movement rate of 0.1 inches per month was measured in August 2012. Movement has been occurring on one or two bedding planes that daylight near the base of the cut.

The upslope limit of movement has not manifested, and is anticipated to be within 200 to 300 feet of the cutslope. To reduce the risk of catastrophic cut slope movement, a temporary rockfill buttress was placed in the east-bound lane/ditch to provide lateral support against the cut slope.

7.4 Construction and Geotechnical Mitigation

The existing through-cut was made with a compound slope angle, using 1V:0.5H for the rock cut and 1V:1.5H for the cut slope in overburden material.

A temporary rockfill buttress (imported durable rock) was constructed (Fall 2012) within the roadway shoulder and east-bound travel lane to decrease the risk of catastrophic failure during construction. Horizontal drains were installed in early 2013. This temporary buttress has decreased the rate of slide movement, as no excessive movement has been detected in the instruments this past winter.

Ground anchors will be installed to mitigate this slide block. Each ground anchor will be proof tested and a few ground anchors will be performance tested. Final loads applied during stressing of ground anchors will be determined by the Engineer based on overall mitigation performance. Strain gauges and load cells will be installed on designated ground anchors for monitoring loads in the anchors.

Existing instruments and conduits/cables and enclosures will need to be protected to prevent damage or interruption of instrument readings.

Existing horizontal drains will need to be protected during excavation of the buttress and cut-back to reduce the stick-out from the finished cut slope face.

8 Station "S" 768+00 to 784+00 (Box Slide, Big Slide; Cut 7 East; Fills 11 and 12)

Box Slides and Big Slides are located at the Cougar Creek confluence with the Yaquina River. Both slides toe into the Yaquina River, while Big Slide primarily toes into Cougar Creek. The highway alignment crosses the upper portion of Box Slide and the middle of Big Slide. Site conditions in the area of these slides have been investigated with the following geotechnical borings and instruments (Figure 8). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 6: Box Slide and Big Slide Explorations

Appendix	Boring Designation
A	BH-25, BH-26, BH-27, BH-28, BH-29, TP-6, TP-7, TPS-4
B	ALTP05-1, ALTP05-2, C7TP05-6, L1IN05-1, L1IN05-2, L1IN06-1, L1PZ05-1, L1TP05-1, L1TP05-2, L1TP05-3, L1TP05-4
C	C7-01, C7-02, C7-03, C7-04, C7-05, C7-06, C7-07, C7-08, C7-09, F11-01, F11-02, F11-03, F11-04, F11-05, F11-06, F11-07, F12-01, F12-02, F12-03

8.1 Subsurface Materials

The lower Cougar Creek area includes landslides known as Big Slide and Box Slide, which are crossed by relatively small highway cuts and embankment Fills 11 and 12, and the eastern portion of Cut 7. Subsurface materials include: embankment fills, unsuitable material, buttress fill, colluvium/slide debris, weathered rock slide debris, Tyee Formation slide debris, and Tyee Formation rock. Big Slide is a very large and very deep-seated translational block and earthflow, and Box Slide is a smaller slide that abuts the west side of Big Slide. The slides toe into the Yaquina River and the lower section of Cougar Creek, and the heads originate on the ridge to the south. Geologically the slides are mature and highly dilated with extension from their point of origin. Underlying the colluvium/slide debris is the sandstone and siltstone of the Tyee Formation. Relatively small embankment fills were constructed crossing natural drainage swales on Big Slide, as well as a ridge on the east side of Big Slide. Unsuitable material was placed in a relatively small area right of the highway between Big Slide and Box Slide. A buttress fill was placed right of the highway alignment where it crosses Box Slide.

8.2 Groundwater

No groundwater springs have been observed in the areas of Fills 11 and 12. Based on piezometers in the area, groundwater is variable across the area, ranging from 10 to over 100 feet below the ground surface. The shallowest groundwater levels are measured in the apparent landslide graben of Big Slide, and expected beneath the natural drainage swales.

8.3 Ground Deformation

Settlement likely occurred at the embankment fills; however, the amounts are not known. Results from measuring one slope inclinometer installed through Fill 12 (F12-03) in 2012 indicate that approximately 0.5-inch of downslope creep movement of the fill has occurred overlying the deeper slide debris.

8.4 Construction and Geotechnical Mitigation

Roadway grading consisted of cuts and fills. A buttress was constructed of native materials to support the upper portion of the Box Slide. Fill 12 was keyed into the original ground surface.

Excavation will be necessary to modify the RT cut slope to accommodate the revised highway alignment.

A culvert and slope drain will be constructed down the LT fill slope at about "S" 773+00.

9 Station "S" 784+00 to 801+00 (Cougar Creek Slide Area; Fill 10)

The highway realignment crosses the Cougar Creek Slide area obliquely, from the toe of the slide up to the upper limits of the slide as the highway moves into Cut 6 to the east. The Cougar Creek landslide is moving on multiple shear zones, including the contact between slide debris and weathered Tyee Formation, and at a bedding contact within fresh Tyee Formation. The toe of the slide is pushing into the Cougar Creek main stem channel and underlying materials. The eastern side of the slide includes a ridge to the east of the construction area, which is also actively moving. Geologically the slide is a mature and deeply eroded translational earthflow; however, it overlies a relatively new, translational slide block. Site conditions have been investigated with the following geotechnical borings, test pits and instruments (Figure 9). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 7: Cougar Creek Slide Explorations

Source	Boring Designation
Group A	BH-30, BH-31, BH-32, TP-8
Group B	CCBH05-1,CCBH05-2, CCBH05-3, CCIN10-1, CCIN10-2, CCIN10-3, CCIN10-3A, CCIN10-4, CCIN10-5, CCIN10-6, CCIN12-1, CCIN12-1P, CCIN12-2, CCIN12-2P, CCIN12-3, CCIN12-3P, CCIN12-5, CCIN12-6, L2PZ05-1, L2PZ05-2, L2TP05-1, L2TP05-2
Group C	CCSKI-1, CCSKI-2, CCSKI-3, F10-01, F10-02, F10-03, F10-04, F10-05, F10-06, F10-07, F10-09, F10-10, F10-11, F10-12, F10-14, F10-16, F10-18, F10-19, F10-20, F10-21, F10-22, F10-23, F10-24, F10-25, F10-26, F10-27, F10-28, F10-29, TP10-1, TP10-2

9.1 Subsurface Materials

Cougar Slide material consists predominantly of colluvium/slide debris, with a lesser volume of weathered rock slide debris, overlying a slightly weathered to fresh block of Tyee Formation slide debris. Embankment fill, shear key fill, buttress fill, subdrain/underdrain, cut-off drain, trench drain, and grouted imported durable rip-rap boulder materials, are also in the area. Buried pipes include an old Cougar Creek Tributary 1 bypass pipe; a new 78-inch diameter culvert; horizontal drains and HDPE discharge pipes; drain pipes in trench drains and sub-drains; and conduit carrying cable to geotechnical instruments.

9.2 Groundwater

Groundwater springs have been observed within the drainage channels and at the headwaters of most of the tributaries to Cougar Creek. Groundwater flow from most of these springs has not been measured but is estimated at 1 to possibly 25 gpm, and the amounts are expected to be higher in relation to seasonal precipitation. Due to the construction prior to 2010, some tributaries have been buried or diverted from their original course.

Fracture flow, apparently at tens of gpm, was encountered during the shear key excavation, and was subsequently routed through a cut-off drain and culvert outlet to the adjacent stream.

Two underdrain systems were installed; one in Tributary 1 and the other in Tributary 2. The burial of these tributaries may have also altered the subsurface flow of groundwater underneath these tributaries.

Piezometers at the Cougar Slide have recorded groundwater levels 6 to 135 feet below the ground surface, the depth of which varies widely and is dependent on the depth and location of the piezometer sensors. Typically, the groundwater level varies within the landslide material from approximately 5 to 25 feet above the base of the landslide. Recorded spikes in groundwater levels due to storms typically range from 1 to 17 feet.

Piezometers and horizontal drains installed in existing embankment and underdrains encountered a build-up of pore water pressures and migration of subsurface water into embankment fill. In particular, large water pressures have been measured near the buried Cougar Tributary 2 underdrain. However, this condition may have improved in 2013 when a previous diversion from Tributary 3 to Tributary 2 was rerouted back to the original Tributary 3 channel.

Previous horizontal drain array installations have been completed on five (5) drill pads at this slide location, with a combined total of 131 individual drain installations. Recorded spikes in groundwater levels due to recent horizontal drain drilling ranged from 5 to 115 feet. Following initial high discharge rates immediately after drilling, the flow rates monitored from the drain arrays have varied from less than 1 to approximately 170 gpm, with moderate to high flow rate increases following storm events.

9.3 Ground Deformation

Landslide movements have been measured in the local slide and the ridge to the northeast. No movement has been measured upslope of the highway embankment, nor in the ridge to the west. The landslide has two active shear zone depths, based on measurements in existing inclinometers. A majority of inclinometers in this slide have detected deep-seated ground deformation, except no deep-seated movement has been detected at F10-05 which is located at the upslope margins of the highway embankment, and F10-08, F10-13, F10-15 and F10-25 which are on the west flank of the slide near Fill 11. Movement rates have been measured from 0.01 to 0.25 inches per month. Movement rates fluctuate seasonally, with faster rates during wetter months.

Landslide activity is exacerbated by infiltration from runoff collection and discharge pipes, including lateral spreader pipes, which causes an increase in groundwater pressures near the landslide toe and in the actively sliding ridge to the north of the embankment.

Horizontal drain installation, with rotary drilling using air and water pressure, caused short-term landslide movements measured locally in the area of specific instruments. The local movements occurred only in the area of specific drain installation, but were measured as high as approximately 0.5 inches, but typically 0.1 to 0.2 inches or less, on the landslide basal shear zone.

Embankment fill slope instabilities (slumps and sloughing) occurred on the west and north (LT) slopes of Fill 10. Infiltration, groundwater seepage and steep fill slopes were contributing factors.

Settlement has occurred within and underneath the embankment fills and buttress fill. Settlement monitoring between September 2009 and July 2011 at Fill 10 suggests at least 20 inches of total settlement occurred beneath the top of the embankment over this time frame near station “S” 792+00. The total height of the embankment at this location was estimated to be about 85 feet. The settlement that occurred during the construction of the embankment is not known. Settlement that may have occurred after July 2011 is also not known.

9.4 Construction and Geotechnical Mitigations

Initial construction in 2006 through 2010 included underdrains and embankment placement, primarily in the east portion of the Cougar drainage. At that time, the embankments were sized for bridge approaches, and bridge substructure foundations and columns were constructed. Embankment slope failures were covered with plastic sheeting.

Concrete bridge columns were demolished in 2012. Deep foundations of the bridge (drilled shafts and pipe piles) remain below the ground surface.

A shear key was previously constructed (2008) and was reportedly founded on weathered Tyee underlying the upper shear zone. The base of this shear key is approximately 150 to 200 feet south of the main creek channel. In 2012, the excavation for trench drain TD-5 was enlarged and extended upslope to assist draining the shear key. Subsequent horizontal drains (CC-C) were also drilled through the shear key.

A small rockfill toe key was constructed in 2012 next to the main stem creek channel and east of trench drain TD-5 (where the depth to the upper shear zone is relatively shallow. i.e., less than 15 feet). A second toe key was constructed summer 2013 on the west side of the fill toe area to improve foundation support. The toe of the Phase 2 embankment consists of imported durable buttress rock (6″-1″) material to provide increased strength and drainage capacity. Underdrains were sized to provide a minimum of 100 sq ft cross-sectional area, and were constructed using imported durable 6″-3″ drain rock and a 6-inch perforated pipe for added flow capacity. The blanket drain between the existing ground and embankment fill was constructed to prevent groundwater from flowing into the new embankment fill.

A 78-inch diameter culvert and flume were constructed during Phase 2 in 2013. The main culvert is a structural plate culvert located above the Cougar Creek Tributary 1 channel. Two underdrain pipes were also placed beneath the 78-inch arch plate culvert.

Deep horizontal drains (five arrays: CC-A, CC-B, CC-C, CC-D, and CC-E) and shallow trench drains were installed in 2012 and 2013 to reduce groundwater levels. Horizontal drain collection systems were installed in Phase 2 to drain arrays CC-D and CC-E to tight-line collected water from the horizontal drains and trench drains to minimize water infiltration into the landslide and increasing groundwater pressures. CC-E collection system will be buried by new embankment fill, and CLSM will be used as backfill around the CC-E drain array collection system pipes. New collection systems are planned for CC-B and CC-D (extended).

Existing weirs will be cleaned to restore their function and repositioned in designated locations.

Toe geogrid will be placed within the north slope of the new buttress. Geogrid reinforcement will also be constructed across the embankment width. Geogrids are also planned for subbase reinforcement.

Horizontal drain board strips are to be placed within the common fill. Staged embankment construction is required in Phase 3 to spread the fill loading over two years.

Ditches that cross sensitive portions of the landslide and those that impact underlying trench drains will be sealed with an impervious HDPE liner.

Instrumentation modifications include removal of the cableway and routing of those cables through a new conduit pipe, and a few more conduits will be added to connect instruments with readout devices in cabinets mounted on steel posts.

10 Station "S" 801+00 to 823+00 LT (Cut 6 LT)

The highway realignment crosses the divide between Cougar Creek to the west and Crystal Creek to the east in the project area known as Cut 6. Besides the main drainage divide, the cut crosses three tributaries of Cougar Creek (nos. 2, 3 and 4). Each of the tributaries appears to contain a local ancient landslide; however, other than minor raveling and rockfall, the left side of Cut 6 has not exhibited significant instabilities because the through-cut has essentially removed load and groundwater from upslope of Cut 6 LT. Site conditions in this area have been investigated with the following geotechnical borings, as well as with observations and measurements of the face of the cut slopes (Figure 10). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 8: Cut 6 LT Explorations

Appendix	Boring Designation
B	C6TP05-1, C6TP05-15
C	C6-14, C6-18, C6-19

10.1 Subsurface Materials

The through-cut exposes colluvium/slide debris, weathered rock slide debris, Tyee Formation slide debris, and Tyee Formation, all of which are associated with a series of coalescing ancient landslides that head within the ridge to the south and toe into Cougar Creek.

10.2 Groundwater

Groundwater springs have been observed in the headwaters of Cougar Creek Tributaries 2 and 3. The spring heading Tributary 3 was excavated during highway construction in 2008/2009 and a 6-inch diameter drain pipe was buried to divert the spring water to Tributary 2, which was then rerouted in 2013 back to Tributary 3. This drain pipe has been observed to flow year round approximately 20% full, and with an increased flow rate of approximately 300 to 400 gpm following storm events.

Groundwater at Cut 6 is perched within the colluvium/slide debris and weathered rock slide debris, and confined within fractures in the Tyee Formation. The relatively shallow, perched groundwater is measured in piezometers, and it also drains through a buttress embankment in drain pipes placed in a rock buttress constructed in 2009. Deeper groundwater flows in fractured Tyee Formation.

The through-cut has interrupted the flow path and the exposed portion of the LT cut slope is relatively dry. Very little groundwater is anticipated within the excavation for the upper LT cut slope. However, flows could become significant when the elevation of the excavation is near the existing haul road and below, particularly where the formation is highly fractured or faulted.

10.3 Ground Deformation

Other than raveling and rockfall on the rock cut slope, no landslide movements have been detected in recent years on the LT side of Cut 6.

10.4 Construction and Geotechnical Mitigation

The primary excavation of the existing LT cut slope was made between 2006 and 2009. In 2010, the LT cut slope was excavated further to accommodate a highway alignment shift LT, necessitated by buttress construction RT. Soil overburden, slide debris, weathered rock and fresh rock zones are exposed. Blasting was required.

Spring drain pipes and culverts exist beneath current road grade.

The mitigation work to be performed in Phase 3 consists of excavation to shift and lower the through-cut further left. Blasting will need to be designed to prevent excessive vibration and energy impacting or reactivating landslides and to minimize over-break in the finished cut slope face.

Dewatering is anticipated during excavation below existing grade, based on flows observed from the spring drain near the west end of Cut 6, flows observed during excavation for the foundation of the buttress at the MLK Slide, the fractured and faulted zones, and measurements of groundwater levels throughout Cut 6. Permanent drainage systems will be installed beneath the pavement in zones where significant groundwater can occur.

Subgrade stabilization may be necessary at the west end of Cut 6 where overburden materials are anticipated. Zones of soft and wet soil may be encountered.

11 Station "S" 801+00 to 823+00 RT (Cut 6 RT Slides)

The highway realignment crosses the divide between Cougar Creek to the west and Crystal Creek to the east in Cut 6. Besides the divide between the main drainages, the cut also crosses Cougar Creek Tributaries 2, 3, 4 and 5. Each of the tributaries contains a local ancient landslide, all of which are associated with a series of coalescing ancient landslides that head within the ridge to the south. Besides raveling and rockfall on the rock cut slopes, Cut 6 RT is the location of a large, recent rock slide identified as the MLK Slide. Site conditions in this area have been investigated with the following geotechnical borings and instruments, as well as with observations and measurements of the face of the cut slopes (Figure 10). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 9: Cut 6 RT Slides Explorations

Appendix	Boring Designation
A	BH-33, BH-34, BH-35, BH-36, TP-9, TPS-5
B	C6BH05-1, C6IN12-1, C6PZ05-1, C6PZ05-2, C6PZ05-3, C6PZ05-4, C6PZ05-5, C6PZ05-6, C6TP05-2, C6TP05-3, C6TP05-4, C6TP05-5, C6TP05-6, C6TP05-7, C6TP05-8, C6TP05-9, C6TP05-10, C6TP05-11, C6TP05-12, C6TP05-13, C6TP05-14, C6TP05-16, C6TP05-18
C	C6-01, C6-02, C6-03, C6-04, C4-04A, C6-05, C6-06, C6-07, C6-08, C6-10, C6-11, C6-15, C6-16, C6-17, C6-18, C6-19, C6-20, C6-21, C6-22, C6-23, C6-24, C6-25, C6-26, C6-27, C6TP12-1, C6TP12-2, C6TP12-3, C6TP12-4, C6TP12-5, C6TP12-6, C6TP12-7, C6TP12-8, C6TP12-9, C6TP12-10

11.1 Subsurface Materials

The through-cut exposes colluvium/slide debris, weathered rock slide debris, Tyee Formation slide debris, and Tyee Formation. Buttress rock was placed to mitigate nested slides within the colluvium/slide debris and weathered rock slide debris above the Tyee Formation, and a rock slide in highly fractured Tyee Formation rock during construction in 2009. Drain pipes were placed at the time to capture wet/spring areas that were also encountered within the slide debris.

A durable rock buttress was constructed in 2012 to mitigate the MLK Slide and subsequent retrogression further upslope. The foundation for the rockfill buttress was excavated 5 to 20 feet below existing haul road grade to reach relatively hard rock, the deeper excavation of which occurred between Stations "S" 815+00 and "S" 817+00. Also in the floor of the through-cut, varying thicknesses of fractured sandstone and siltstone exist due to blasting in 2009. Several test pits and borings have been completed in the floor of the through-cut, which reveal the depth of the fractured rock.

A local area of embankment fill was constructed in 2009, where the highway crosses Cougar Creek Tributary 5 and the main stem.

Drain pipes in Cut 6 include the culverts, horizontal drains, drain pipes through buttress fills, and a drain pipe that captures a spring at the west end of Cut 6 (Cougar Creek Tributary 3).

11.2 Groundwater

Groundwater springs have been observed in the headwaters of Cougar Creek Tributaries 2 and 3. The spring heading Tributary 3 was excavated during highway construction in 2008/2009 and a 6-inch diameter drain pipe was buried to divert the spring water to Tributary 2, which was then rerouted in 2013 back to Tributary 3. This drain pipe has been observed to flow year round approximately 20% full, and with an increased flow rate of approximately 300 to 400 gpm following storm events. The spring heading Tributary 2 is upslope of Cut 6 and was not impacted by the construction; however, an underdrain was constructed in Tributary 2 and buried by Fill 10. Groundwater springs are also anticipated upslope of Cut 6 at the main stem of Cougar Creek.

Groundwater at Cut 6 is perched within the colluvium/slide debris and weathered rock slide debris, and confined within fractures in the Tyee Formation. The relatively shallow, perched groundwater is measured in piezometers, and it also drains through a buttress embankment in drain pipes placed in a rock buttress constructed in 2009. Deeper groundwater, flowing in fractured Tyee Formation, is also measured in piezometers and observed at the cut face when it flows from fractures during and following rain storms. The shallow groundwater levels range in depth from 5 to 30 feet, while the deeper groundwater levels range from 40 to 120 feet below ground surface.

Previous horizontal drain array installations have been completed on seven (7) drill pads at this cut slope location, with a combined total of 194 individual drains. Spiking groundwater pressures due to recent horizontal drain drilling are recorded by piezometers. Following initial high discharge rates immediately after drilling the horizontal drains, the flow rates decreased and are varied at each array from less than 1 gpm to approximately 10 gpm, with increases following storm events.

11.3 Ground Deformation

Ground movements at Cut 6 have varied since grading started in 2006. Shallow sloughing of colluvium/slide debris and weathered rock slide debris occurred during grading of slopes in 2006, 2007, 2008 and 2009, and a buttress fill was constructed above Tyee Formation on the cutslope to mitigate the 2009 cutslope failures. Fractured Tyee Formation rock slid from the cutslope near “S” 806+00 to 809+00 in September 2009 and buttress fill combined with a highway alignment shift to the left was constructed. One deep slope inclinometer (C6-04) was installed above the cutslope and the buttress fill in late 2010 and subsequent seasonal creep movements have been measured at a depth of 102 feet within the Tyee Formation. The movements are occurring at the base of a sandstone bed, on a thin layer of sheared siltstone, which daylights in the cutslope behind the buttress fill.

In January 2011 a large rock slide catastrophically failed from the cutslope at “S” 815+00 to 817+50, partially burying the through-cut. The failure, known as the MLK slide, occurred on a bedding plane bounded by two local faults. Subsequently in early 2012, the slide retrogressed further upslope, but at a shallower depth and within the weathered rock slide debris. A durable rockfill buttress was built in 2012 to mitigate the rock slide area. An inclinometer installed in the rockslide following the construction of the rockfill buttress has not recorded further slide movement.

Horizontal drain installation caused short-term movements in localized areas of the rock cutslope measured in the range of 0.1- to 0.15-inch (C6-04, C6-11 and C6-17).

Initial data from new instruments in the middle and east cut slope sections shows no active slide movement and reduction of groundwater pressure in the vicinity of the west buttress.

11.4 Construction and Geotechnical Mitigation

The excavation of the existing RT cut slope was made between 2006 and 2009. Contacts between Tyee Formation bedding contain weak materials that form shear zones inclined down towards the highway. When cut slope excavations are made, rock bedding and shear zones are exposed and toe resistance is removed, creating a potential for movement.

Along the upper portion of the west half of Cut 6, a buttress was previously constructed to resist movement of the slide debris (soil overburden slide debris, above the Tyee Formation rock) that was uncovered during initial construction in 2009. Near the west end of Cut 6, the rock slope failed due to an adverse combination of faulting, jointing, weathering, and concentration of groundwater flow. The rocky slide debris fell into the roadway and subsequently was regraded to form a 1V:1.5H sloped buttress. Several short horizontal drains were installed in 2009. These western buttresses are providing marginal improvement in stability, thereby lessening the risk of a catastrophic movement.

Elsewhere in Cut 6, the 1V:0.5H rock cut exposes bedding, faulting, joints and blast damage. In some locations, rock beds appear to have moved following blasting during the construction of the rock cut (based on offsets of presplit holes). The dip of the Tyee bedding has been altered by faulting and uplift, resulting in locally steeper bedding.

Five arrays of horizontal drains (C6-A, C6-B, C6-C, C6-D and C6-E) were installed in the western and middle portions of Cut 6 in Phases 1, 1A, and 2 (2012-2013).

A rockfill buttress was constructed at the MLK Slide in 2012. The buttress construction included the removal of a portion of the failed rock mass, founding the buttress on harder rock about 5 to 20 feet below existing road grade, and replacement with imported durable rockfill. An array of horizontal drains (C6-F) was installed in this buttress location (Phase 1A). Regrading of the upper graben (subsidence of upper slide mass) was accomplished to fill scarp cracks and depressions and to promote surface drainage in Phase 2 (summer 2013).

Mitigation measures for the eastern portion of Cut 6 include horizontal drains and buttresses to achieve slight improvements in stability to reduce the risk of catastrophic movement. Three arrays of horizontal drains (C6-G, C6-H and C6-I) were installed in 2013.

All horizontal drains in each of the arrays in Cut 6 will be maintainable, with drain pipes exposed in the slope face. Drainage will discharge into nearby ditches.

The grade will be lowered approximately 20 feet and the highway alignment shifted left, which will require excavation into interbedded siltstone and sandstone. Blasting will need to be designed to prevent excessive vibration and energy impacting or reactivating landslides and to minimize over-break in the finished cut slope face. Sequencing for blasting will be required to reduce potential damage to the finished RT cut slopes.

Dewatering is anticipated during excavation below existing grade, based on flows observed from the spring drain near the west end of Cut 6, flows observed during excavation for the foundation of the buttress at the MLK Slide, fractured and faulted zones, and measurements of groundwater levels throughout Cut 6. Permanent drainage systems will be installed at the pavement subgrade level in zones where significant groundwater can occur.

A rockfill buttress will be constructed against the east rock cut slope, east of the MLK Slide buttress, to provide lateral support after the highway grade is lowered. Existing horizontal drains that will be covered by the buttress fill will need to be extended out of the finished buttress slope for future maintenance. An access road will be constructed to maintain the horizontal drains. Several more arrays of horizontal drains will be installed in areas at the toe of the lowered Cut 6 where significant groundwater discharge is expected.

The buttress foundation area is located on adversely dipping rock bedding (with potential shear zones) and foundation preparation will be necessary. While ripping will likely be necessary to develop the buttress foundation, blasting is not anticipated.

The Cut 6 Middle section will not be buttressed, but rather will have a fallout area and barrier. An access road will be constructed to maintain the horizontal drains in the western and middle sections of Cut 6, and the drains will be provided collection systems and discharge pipes (C6-A, C6-B, C6-C, C6-D, and C6-E).

Instrumentation modifications include the installation of conduits to extend instrument cables on the cut slope and ground surface and route them to monitoring readout devices in a cabinet to be mounted on a steel post.

12 Station "S" 823+00 to 830+00 (Western Crystal Creek Area)

Rising to the east to its highest elevation, the realignment leaves the Cougar Creek Drainage and crosses unnamed tributaries of Crystal Creek in the Western Crystal Creek Area. East of this section, the realignment enters the relatively broad valley of Crystal Creek, which is the Crystal Creek slide. Similar to the Cut 6 area to the west, the Western Crystal Creek Area crosses local slides that are within a broader ancient landslide area; however, different from the Cut 6 area is that the slides are deeper-seated, and the realignment includes overburden cuts RT and embankment fills LT. Site conditions have been investigated with the following geotechnical borings and instruments, as well as with observations and measurements of the face of the cut slopes (Figure 10). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 10: Western Crystal Creek Explorations

Appendix	Boring Designation
A	BH-37, TP-10
B	C6TP05-17, CRBH05-1, CRBH05-2, CRBH05-3, CRIN06-1, CRIN12-1, CRPZ06-1
C	C6-09, C6-12, C6-13, F9-03, F9-04

12.1 Subsurface Materials

Materials in the West Crystal area consist of colluvium/slide debris and weathered rock slide debris overlying Tyee Formation at depths of approximately 100 feet. The overburden soil and rock debris is part of a deep-seated ancient landslide that appears to have failed cutting across the bedding and moved toward the east into Crystal Creek. Small cuts on the right side expose the colluvium/slide debris. A sequence of sheared rock is exposed in the right cut slope near "S" 822+50 120′ RT, which appears to be a fault zone that defines the west end of the West Crystal area.

12.2 Groundwater

Groundwater springs have been observed in the West Crystal area up slope of the highway near "S" 828+50 300′ RT. Groundwater levels have been measured at depths that vary from near the ground surface to approximately 90 feet. Horizontal drain array installations have been completed on two (2) drill pads with a combined total of 41 individual drains. The higher groundwater levels and outflow rates from horizontal drains have been measured within the western side of West Crystal, closer to Cut 6 and a fault that separates West Crystal from Cut 6.

12.3 Ground Deformation

Ground movements at the West Crystal area have not been observed, with one exception. During horizontal drain installation in May 2013, ground movements of 0.75 and 1.6 inches were measured in the slope inclinometer C6-12. No movements were measured before or after horizontal drain installation.

12.4 Construction and Geotechnical Mitigation

The initial construction (2009) included the east end of the Cut 6 through-cut, along with small fills in local drainages. Foundation preparation removed soft and organic materials from the drainage channels prior to placing embankment fill.

New fills that are needed in conjunction with the highway alignment shift will extend into two drainages LT within old slide debris. Rockfill toe keys, underdrains and benched blanket drains are planned.

Excavation will be necessary to modify the existing RT cut slope to accommodate the realigned highway. Existing horizontal drains will need to be protected during excavation and cut-back to reduce the stick-out from the finished cut slope face. Encountering springs and seepages should be anticipated during excavating.

13 Station "S" 830+00 to 848+00 (Crystal Creek Slide Area; Fill 8)

The Crystal Creek Landslide complex is primarily the eastern slopes of the Crystal Creek valley. The landslide encompasses eroded remnants of a giant, ancient landslide that encompasses the middle and upper reaches of the drainage basin, and the highway realignment crosses through the middle reach of the drainage basin. The area of the ancient landslide within the Crystal Creek drainage is much broader than that which impacts the highway, as the realignment obliquely crosses a portion of it from the toe and up the right/northern margin.

The overall length of the landslide complex is approximately 1,800 feet, extending from Cut 5 on the east down to the slide toe in the downstream Crystal Creek channel to the northwest, with a width of possibly 500 to 600 feet. The slide is a highly eroded, translational block and earthflow slide. Geologically the slide is mature, but with active shear zones. Site conditions have been investigated with the following geotechnical borings, test pits and instruments (Figure 11). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 11: Crystal Creek Slide Explorations

Appendix	Boring Designation
A	BH-38, BH-39, BH-40, BH-41
B	CRBH05-1, CRBH05-2, CRBH05-3, CRBH05-4, CRBH05-5, CRBH05-6, CRIN06-1, CRIN10-1, CRIN10-2, CRIN10-2A, CRIN10-3, CRIN10-4, CRIN12-2, CRIN12-3, CRIN12-4, CRPZ06-1, CRTP05-1
C	F8-01, F8-02, F8-03, F8-04, F8-05, F8-05A, F8-06, F8-07, F8-08, F8-09, F8-10, F8-11, F8-12, F8-13, F8-14, F8-15, F8-16, F8-17, F8-18, F8-19, F8-20, F8-21, F8-22, F8-23, F8-24, F8-25, F8-26, F8-27, F8-28, F8-29, F8-30, F8-31, F8-32, F8-33, F8-34, F9-01, TP8-01, TP8-02

13.1 Subsurface Materials

Materials in the Crystal Creek Slide area consist of colluvium/slide debris overlying weathered rock slide debris, along with embankment fill and buttress fill. The weathered rock slide debris is wide spread and buried beneath the colluvium/slide debris. Embankment fill, buttress fill, subdrains/underdrains, and trench drain materials are also in the area. Buried pipes include an old Crystal Creek bypass pipe; a new 78-inch diameter culvert; drain pipes in the subdrains, underdrains and trench drains; horizontal drains and HDPE discharge pipe; and conduit carrying cable to geotechnical instruments.

13.2 Groundwater

Groundwater seepage areas have been observed in the headwaters of Tributaries 2 and 4, and in a swale buried by the toe of Fill 9. Due to the recent construction, these tributaries have been buried or diverted from their original course. Groundwater seeps are occurring on the lower slopes of Fill 8 from the highway alignment to within 100 feet north of the alignment. Rate of seepage from this area varies seasonally and is estimated from 1 to possibly 10 gpm.

Underdrains were installed in the main stem of Crystal Creek, and two tributaries on the north side of the embankment, Tributary 2 and Tributary 4. Buttress fill buries the underdrains.

Piezometers at the Crystal Slide have recorded groundwater levels 22 to 123 feet below the ground surface, the depth of which is dependent on the depth and location of the piezometer sensor. Typically the groundwater level varies within the landslide material from 2 to 35 feet above the base of the landslide. Recorded spikes in groundwater due to storms typically range from approximately 1 to 12 feet.

Previous horizontal drain array installations for this slide location have been completed on eight (8) drill pads, including two to the east in Cut 5. The arrays include a combined total of 230 individual drain installations. Recorded spikes in groundwater levels due to recent horizontal drain drilling ranged from 10 to 70 feet. Following initially high rates (after drilling), the flow rates monitored from the drain arrays have ranged from less than 1 to approximately 210 gpm, with moderate to high flow rate increases following storm events. The largest flow rate increases and variations after storm events have mostly occurred on two of the drain arrays (CR-C and CR-D). The other six arrays show a more moderate increase in discharge flows following larger storm events.

13.3 Ground Deformation

The Crystal Creek Landslide is active along its apparent entire length, approximately 1,800 feet extending above Cut 5, with a width of possibly 500 to 600 feet. The upslope and easterly extent of the active landslide are uncertain. The active slide apparently has one active shear zone and is moving in the direction of the ancient landslide. A majority of inclinometers in this slide have detected ground deformation, with the exception of CRIN12-3, CRIN12-4 and F8-20. Movement rates have been measured from 0.01 to 0.1 inches per month. Movement rates fluctuate seasonally, with faster rates during wetter months.

Horizontal drain installations have caused short-term landslide movements measured locally in the area of specific instruments. The local movements occurred only in the area of the specific drain installations, but were measured as high as approximately 0.1-inch on the landslide basal shear zone.

Settlement has occurred within and underneath the embankment fills and buttress fill. Settlement monitoring between September 2009 and July 2011 at Fill 8 suggests at least 7 inches of total settlement occurred beneath the top of the embankment over this time frame near station “S” 842+00. The total height of the embankment at this location was estimated to be about 85 feet. The settlement that occurred during the construction of the embankment is not known. Settlement that may have occurred after July 2011 is also not known.

During construction of a 40-foot tall test embankment in 2013 in the Crystal drainage area near

Station “S” 839+00, total foundation settlement of approximately 17 inches was measured with a settlement sensor, which was placed at the base of the test embankment prior to fill placement. The test embankment was constructed in 8 weeks and primary settlement was complete within 4 weeks thereafter. The test fill experienced internal compression following construction of approximately 1- to 2.5-inches over a period of 5 months.

A localized shallow slump developed in the west slope of the test fill, approximately 20 feet wide.

13.4 Construction and Geotechnical Mitigation

Initial construction in 2006 through 2010 included underdrains and embankment placement, primarily in the east portion of the Crystal drainage. At that time, the embankments were sized for bridge approaches, and bridge foundations and columns were constructed.

Concrete bridge columns were demolished in 2012. Deep foundations (drilled shafts and pipe piles) for the abandoned bridge remain below the ground surface.

Long and deep horizontal drains (five arrays: CR-A, CR-B, CR-C, CR-D, CR-E, and CR-F) and several shallow trench drains were installed in Phases 1 and 2 (2012 to 2013) to reduce groundwater levels.

A 78-inch diameter, structural plate culvert was constructed during Phase 2 in 2013 above the Crystal Creek channel.

Several underdrains were installed summer 2013 to augment and improve drainage from older underdrains (buried segments of Crystal Creek Tributaries 2 and 4). A blanket drain was constructed on the existing buttress during spring 2013. An underdrain was constructed beneath the 78-inch diameter culvert and connected with blanket drains on both sides. Underdrains and a rockfill toe key were constructed using imported durable 6″-3″ drain rock for added flow capacity. Underdrains were sized to provide a minimum of 100 sq ft cross-sectional area, and included 6-inch perforated pipes. The toe of the embankment was constructed summer 2013 with imported durable buttress rock (6″-1″) material to provide increased strength and drainage capacity.

In 2013 the horizontal drain arrays were fitted with collection header and discharge pipes to prevent infiltration into the slide mass (CR-A, CR-B, CR-C, CR-D, CR-E, and CR-F). CLSM was used as backfill around the buried CR-E collection system pipes to provide uniform support and to reduce the potential for leakage. Discharge pipes were installed to tight-line collected water from the horizontal drains and trench drains in order to prevent water from infiltrating into the landslide and causing increases in groundwater pressures.

As previously discussed, a portion of the highway embankment (station “S” 837+50 to 842+00) was constructed in Phase 2 as a test fill and for utilization of excavated materials. This 40-foot high fill and its construction approach were evaluated through monitoring of piezometers, inclinometers and settlement sensors. Common fill was also placed over the completed and backfilled 78-inch diameter culvert between Station “S” 834+50 and 836+50, utilizing excavated material from the top of Fill 8 and Fill 7.

Blanket drains constructed in 2013 on slopes are partially complete. A cover of geotextile (Riprap Type "3") is necessary before common fill can be placed over the sloping blanket drains. Additional blanket drain, extensions of underdrains and buttress fill are planned for Phase 3.

An interceptor trench drain is planned at the transition between Cut 5 and the Crystal Creek embankment section after the grade is lowered (15 to 20 feet).

Horizontal drain board strips are to be placed within the common fill in select zones. Staged embankment construction over two years is required in Phase 3.

Geogrid will be placed for subbase reinforcement.

Ditches that cross sensitive portions of the landslide and those that impact underlying trench drains will be sealed with an impervious HDPE liner.

Instrumentation modifications include conduits to connect instruments with readout devices in cabinets mounted on steel posts. New embankment settlement sensors are planned at the end of both the first and second construction season.

14 Station "S" 848+00 to 856+00 LT (Cut 5 LT Slides)

Cut 5 is a through-cut between the Crystal Creek drainage to the west and the Eddy Creek Tributary A & B drainage to the east. Cut 5 LT exposes the margin of the Crystal Creek Slide, which includes an infilled ancient graben in the westerly portion of the cut, and Tyee Formation rock that underlies the slide debris in the easterly portion of the cut. Two active slide areas are occurring, one in each of the cut portions. Site conditions have been investigated with the following geotechnical borings and instruments, as well as with observations and measurements of the cut face (Figure 11). Detailed descriptions of the subsurface materials are provided in Appendices B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 12: Cut 5 LT Slides Explorations

Appendix	Boring Designation
B	C5IN12-1, C5TP05-3
C	C5-06, C5-08, C5-09, C5-10, C5-11

14.1 Subsurface Materials

The westerly portion of Cut 5 LT is a soil cut slope in sandy, clayey silt with local organics, portions of which appear to be colluvium filling an ancient depression. The eastern portion of Cut 5 LT is in weathered rock slide debris and Tyee Formation rock, both of which underlie the colluvium. Fractured rock with mineralization was encountered in exploratory borings deeper in the cutslope, which indicates that faulted rock and fault gouge material is likely underlying portions of the slope.

14.2 Groundwater

Groundwater seeps and springs occur at three general areas of Cut 5 LT. In the western portion groundwater seeps occur within and above the clayey soil of the apparent ancient slide graben. In the eastern portion, groundwater seeps occur on the west side of the rock cut slope, at the transition between the weathered rock slide debris of the ancient landslide to the buried graben. One piezometer records artesian pressure 4 to 10 feet above the ground surface (existing haul road grade), measured underneath the toe of the Cut 5 RT slide. The third area is a groundwater spring area that is currently buried east of the cut slope near "S" 856+50 100' LT, but within the designed Phase 3 cut.

One array of horizontal drains was installed into Cut 5 LT. The array (C5-A) included 25 individual drain installations. Recorded spikes in groundwater levels due to recent horizontal drain drilling ranged 5 to 10 feet. Following installation, piezometers in Cut 5 LT have measured a reduction in groundwater level, decreasing as much as 30 feet.

14.3 Ground Deformation

During excavation in 2008 through 2009, Cut 5 LT experienced recurring failures in the eastern portion of the cut within the colluvium and weathered rock slide debris, overlying the Tyee Formation. These failures were mitigated at the time by laying back the slope and recompacting the soil in the cut slope; however, slope inclinometer monitoring indicates that the slide is continuing to experience creep-rate movement. Following excavation of the western portion of Cut 5 LT, a slump developed in the colluvium materials of the cut slope. This local slide has not been mitigated.

14.4 Construction and Geotechnical Mitigation

Slope instability exists on the LT side of the Cut 5 through-cut. One array of horizontal drains (C5-A) was installed in Phase 2 (2013) to reduce groundwater pressures on the north side.

In Phase 3, the through-cut will be lowered and shifted north (LT) to accommodate the revised highway alignment, resulting in a deeper cut LT.

Rock inlays are planned for controlling seepage areas that are encountered in LT soil cuts. The size of the rock inlays will depend on the actual limits of seepage zones encountered.

Dewatering is anticipated during excavation below existing grade, based on piezometer measurements of groundwater levels. Permanent drainage systems will be installed at the pavement subgrade in zones where significant groundwater can occur.

One additional array of horizontal drains is planned near the toe of the finished LT cut (C5-C).

Zones of soft and wet soil may be encountered, probably at the west and east ends of the through-cut. Subgrade stabilization will be necessary where soft/wet overburden materials are encountered in the finished road subgrade.

15 Station "S" 848+00 to 856+00 RT (Cut 5 RT Slide)

Cut 5 is a through-cut between the Crystal Creek drainage to the west and the Eddy Creek Tributary A & B drainage to the east. Cut 5 RT exposed slide debris within the upper portion of the Crystal Creek Landslide. During excavation the slide area reactivated and a buttress fill was built to mitigate the movement; however, slide movement is continuing to be recorded with slope inclinometers. The slide mass is moving obliquely toward the highway along a shear zone that is located near the existing ditch level in the western portion of the buttress, and below the current road elevation further to the west. The western portion of the cut is in Tyee Formation rock that underlies the slide materials and embankment buttress. Site conditions have been investigated with the following geotechnical borings and instruments, as well as with observations and measurements of the cut face (Figure 11). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 13: Cut 5 RT Slides Explorations

Appendix	Boring Designation
A	BH-42, TP-11, TP-18, TPS-6
B	C5PZ05-1, C5TP05-1, C5TP05-2, C5TP05-4
C	C5-01, C5-02, C5-03, C5-04, C5-05, C5-07

15.1 Subsurface Materials

The westerly portion of Cut 5 RT is in colluvium slide debris and weathered rock slide debris, which is material within the upper portion of the ancient Crystal Creek landslide. The eastern portion of Cut 5 RT is Tyee Formation, which is material underlying the landslide. A buttress of compacted native rock is within the cut slope, overlying the Tyee Formation. Two landslide shear zones were encountered during excavations for the buttress.

15.2 Groundwater

Seeps were observed emitting from the weathered rock slide debris during excavation for the buttress. Artesian groundwater pressures are measured with a piezometer installed in C5-04 within highly fractured rock 45 feet beneath the base of the weathered rock slide debris, at the contact between Tyee Formation slide debris and in-place Tyee Formation. The upper piezometer in C5-04 indicates groundwater levels close to the existing haul road grade.

One array of horizontal drains was installed into Cut 5 RT. The array (C5-B) included 27 individual drain installations. The drains have caused a slight decrease in groundwater levels upslope of the highway; however, high groundwater levels and artesian conditions persist in the haul road area.

15.3 Ground Deformation

During excavation in 2008, the upper portion of the Crystal Creek slide was reactivated and slide movement was observed along a siltstone-sandstone contact within the weathered rock slide debris, approximately 10 to 20 feet above the top of Tyee Formation in Cut 5 RT. Slope inclinometer monitoring indicates that even with the 2009 buttress, the slide mass continues to move year-round, with increased rate in the wet winter months. Recent movements in C5-04 and C5-02 indicate a movement rate of about <0.01 inch per month, and in F8-05A of approximately 0.02 inch per month.

Horizontal drain installations have caused short-term landslide movements measured locally in the area with specific instruments. The horizontal drain installations have caused approximately 0.75-inches of short-term landslide movement (causing inclinometer CRIN12-2 to become sheared).

15.4 Construction and Geotechnical Mitigation

The excavation of the Cut 5 through-cut was made between 2006 and 2009. Soil overburden, slide debris, weathered rock and fresh rock zones are exposed. This is an existing area of active translational slump moving obliquely towards the RT cut slope. Movement is also occurring at an infill buttress that was constructed in 2009.

One array of horizontal drains (C5-B) was installed in Phase 1 (2012) to reduce groundwater pressures on the south side within the active translational slump. To minimize infiltration into the landslide, a maintainable horizontal drain collection system and discharge pipe was installed in Phase 2 to direct collected groundwater into the TD-10 trench drain pipe to the west. The collection pipe is temporarily supported by sand bags, and in Phase 3 the pipe will be provided permanent support by placing and compacting a continuous foundation of filter rock.

The through-cut will be lowered and shifted north in Phase 3 to accommodate the revised highway alignment. A supplemental rockfill buttress is planned on the RT for Phase 3. Foundation preparation consists of removing slide debris and overburden to expose undisturbed rock beneath the lower slide shear zone. Buttress foundations are located on adversely dipping rock bedding.

Dewatering is anticipated during excavation below existing grade, based on piezometer measurements of groundwater levels. Permanent drainage systems will be installed at the pavement subgrade in zones where significant groundwater can occur.

Trench drains will be constructed near the west end of Cut 5. Trench drains will also be constructed at the east end of Cut 5.

Subgrade stabilization will be necessary where soft/wet overburden materials are encountered in the finished grade. Zones of soft and wet soil may be encountered, particularly at the west and east ends of Cut 5.

16 Station "S" 856+00 to 876+00 (Eddy Creek Tributary A & B Area; Fills 6 and 7)

The highway realignment crosses an embankment in this area that buries the upper reach of Eddy Creek Tributary A, and crosses the middle reach of Eddy Creek Tributary B. Steep-sloped valley sides in this area attest to the creeks eroding into apparently in-place Tyee Formation; however, an ancient landslide complex, with the upslope head to the southeast, also moved toward the northwest into the valley. Slope inclinometer monitoring indicates the ancient landslide materials have not been reactivated; however, the embankment materials are deforming the underlying colluvium slide debris and causing downslope tilt. Site conditions have been investigated in this area with the following geotechnical borings and instruments (Figure 12). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 14: Eddy Creek Tributary A & B Explorations

Appendix	Boring Designation
A	BH-43, BHS-3, BHS-4, TP-12, TP-13
B	ALTP05-3, ALTP05-4, EBBH05-1, EBBH05-2, EBBH05-3, EBBH05-4, EBBH05-5, EBIN10-1, EBIN10-2, EBIN10-3, EBIN10-5, EBIN10-6, EBIN10-7, EBIN12-1, EBPZ10-1, EBPZ12-1, EBPZ12-2, EBPZ12-3, EBTP05-1
C	EBIN10-4, F6-01, F6-02, F6-03, F6-04, F6-05, F6-06, F6-07, F6-08, F6-09, F6-10, F7-01, F7-02, F7-03, F7-04, F7-05, F7-06, F7-07, F7-08, F7-09, F7-10, F7-11, TP7-01, TP7-02, TP7-03, TP6-01, TP6-02, TP6-03

16.1 Subsurface Materials

The Eddy A and Eddy B slide areas consist predominantly of colluvium/slide debris, which is interpreted as deeply eroded remnants of giant earthflows. However, a large block or blocks of fractured rock slide debris are also buried by Fill 6. Embankment fill, buttress fill, subdrain/underdrain, trench drain, and blanket drain materials are also in the area. Buried pipes include an old Eddy B bypass pipe (plugged at upstream end); new 48- and 78-inch diameter culverts; an older 36-inch culvert under the east side of Fill 6; drain pipes in the subdrains, underdrains and trench drains; horizontal drains and HDPE discharge pipe; and conduit carrying cable to geotechnical instruments.

16.2 Groundwater

Groundwater springs and seepage areas have been observed in the headwaters of all the upper tributaries of Tributary A. Due to the recent construction, the tributaries have been buried by Fill 7. Underdrains were installed in the main stem of Tributary A and the lower reaches of each of the smaller upper tributaries.

Groundwater springs have been observed in an eastern tributary to Tributary B upslope of Fill 6. A culvert was installed to divert water in this tributary underneath Fill 6, and an underdrain was also installed in the buried drainage channel. High groundwater conditions were observed in a piezometer that was buried by the toe of Fill 6, and seepage is currently occurring on the lower slopes of Fill 6.

Piezometers at the Eddy A/B area have recorded groundwater levels 0 to 163 feet below the ground surface, and artesian levels 0 to 35 feet above the ground surface, the depth of which is dependent on the position of the piezometer sensor. The groundwater level within the colluvium/ancient landslide material is anticipated to vary from 10 to 40 feet above the approximate top of the in-place Tyee Formation. Recorded spikes in groundwater due to storms typically range from approximately 1 to 15 feet. Artesian groundwater was measured in one instrument and observed flowing from a fracture in weathered sandstone exposed in a road ditch cut into the slope south of Eddy A and Fill 7.

The previous horizontal drain array installation work at this slide has included eight (8) drill pads, and a total of 225 individual drain installations. Recorded spikes in groundwater levels due to recent horizontal drain drilling ranged from 2 to 75 feet. The flow rates monitored from the drain arrays, following initially higher rates, have ranged from less than 1 to over 200 gpm, with moderate to high increases following storm events in four of the drill arrays (EB-D, EB-E, EB-F and EB-G). The other seven drain pad sites have shown only a slight increase in flow rates following significant storm events.

16.3 Ground Deformation

A majority of existing inclinometers have detected ground deformations after embankment fills were placed, where deformations have continued for over a year. It appears that the active subsurface deformation is limited to the footprint of the highway embankment fills. The “tilt” in the inclinometer data appears to reflect embankment deformation, and consolidation and settlement of the underlying foundation soils. Movement rates fluctuate seasonally, with faster rates during wetter months. Deformations are generally not in the direction of the structural dip of the Tyee Formation, as with the direction of most other slide movements in the region, but appear to be trending toward areas of low relief, i.e., the stream channels. In addition, in the Fill 7 area there have been some strains along deeper Tyee Formation bedding and possible ancient shear zones.

Fill 6 is also experiencing primarily “tilt” movements due to deformation associated with consolidation of embankment fill and underlying foundation soils. Recent winter deformation is at a rate of less than 0.01 inches per month, and movement rates fluctuate seasonally, with faster rates during wetter months.

Horizontal drain installations have not caused landslide movements in the Eddy A & B area; however, Fill 6 experienced increased “tilt” deformation during horizontal drain installation in late 2012. Fill 7 generally did not experience increased deformation during horizontal drain installation, except possibly in instruments EBIN10-3 and F7-02.

Embankment fill slopes have experienced localized slumps and sloughing, particularly along the LT (north) side and the end slopes. Infiltration, groundwater seepage and steep fill slopes were contributing factors.

Settlement has occurred within and underneath the embankment fills and buttress fill. Settlement monitoring between July 2008 and July 2011 at Fill 7 suggests at least 36 inches of total settlement occurred beneath the top of the embankment over this time frame near station “S” 864+00. The total height of the embankment at this location was estimated to be about 185 feet. Settlement monitoring between October 2009 and July 2011 at Fill 6 suggests at least 5 inches of total settlement occurred beneath the top of the embankment over this time frame near station “S” 873+00. The total height of the embankment at this location was estimated to be about 50 feet. The settlement that occurred during the construction of these embankments is not known. Settlement that may have occurred after July 2011 is also not known.

16.4 Construction and Geotechnical Mitigation

Initial construction in 2006 through 2010 included underdrains and embankment placement, in both the Eddy A and Eddy B drainages. At that time, the embankments were sized for bridge approaches, and bridge foundations and columns were constructed. Embankment slopes were covered with plastic sheeting or fiber mesh where shallow slumps and sloughing occurred. A small portion of the north side of Fill 6 embankment slope was reconstructed with an inlay.

Concrete bridge columns were demolished in 2012. Bridge foundations (drilled shafts and pipe piles) remain below the ground surface.

Long and deep horizontal drains (eight arrays: EB-A, EB-A2, EB-B, EB-C, EB-D, EB-E, EB-F, and EB-G) and a network of shallow trench drains were installed in Phases 1, 1A, and 2 (2012/2013) to reduce groundwater impacts.

Some of the horizontal drain arrays were fitted with collection header and discharge pipes to minimize infiltration of drain out flow into the slide mass. CLSM was used as backfill at drain arrays EB-A2 and EB-C to provide uniform support around the collection pipes and to reduce the potential for leakage. Discharge pipes were installed to tight-line collected water from the horizontal drains and trench drains to prevent water infiltrating into the landslide and causing increased groundwater pressures. The new 12-inch solid-wall HDPE discharge pipe for EB-E was constructed in Phase 2 to connect to the main drain alongside the 78-inch culvert, and the inlet was terminated with a stub-out short of the EB-E pad, for future connection to the header pipe in Phase 3. The EB-E array, as well as the EB-G array, will be buried in Phase 3, requiring CLSM backfill.

Portions of the blanket drain were constructed in Phases 1 and 2. Underdrains using imported durable 6″-3″ drain rock were installed in Eddy A and Eddy B drainage channels prior to fill construction in summer 2013 (Phase 2). Underdrains were sized to provide a minimum of 100 sq ft cross-sectional area, and included two 6-inch perforated pipes. The toe of the buttress was constructed with imported durable buttress rock (6″-1″) material and geogrid layers to provide increased strength and drainage capacity.

Buttress fills will be increased using common material on top of the existing rockfill toes in both the

Eddy A and Eddy B drainage channels to provide stability for the highway embankment.

A portion of the highway embankment on the west side of the WOW Road was constructed in Phase 2 for utilization of excavated materials, which also allowed for evaluation of the modified approach for embankment construction.

Two culverts were constructed during Phase 2 in 2013. The main culvert is a 78-inch diameter structural plate culvert that traverses the Eddy Creek Tributary B channel. A 48-inch diameter CMP was installed near the inlet of the 78-inch diameter culvert to connect flow from a minor tributary to Eddy B. The channel leading to the 78-inch culvert inlet will be reconstructed to eliminate leakage of creek water into the subsurface.

The temporary haul bridge was removed and the haul road was reconstructed with imported stone embankment material and realigned slightly.

Blanket drains constructed in 2013 on slopes are partially complete. A cover of geotextile (Riprap Type “3”) is necessary before common fill can be placed over the blanket drains. Additional blanket drains, extensions of underdrains and buttress fill are planned for Phase 3.

Horizontal drain board strips are to be placed within the common fill in select zones. Staged embankment construction is required in Phase 3 to spread the fill loading over two years.

Access roads will be incorporated into the embankment design to facilitate both short-term and long-term needs. Permanent access will be constructed for maintenance of the culvert outlet and the horizontal drains.

Geogrids will be installed for subbase reinforcement.

Ditches that cross underlying trench drains will be sealed with an impervious HDPE liner.

Instrumentation modifications include conduits to connect instruments with readout devices in cabinets mounted on steel posts. New embankment settlement sensors are planned at the end of both the first and second construction season.

17 Station "S" 876+00 to 886+00 LT (Cut 4 LT)

Cut 4 is a through-cut between the Eddy Creek Tributaries A & B to the west and Eddy Creek Tributaries C & D to the east. Tyee Formation rock exposed in the cut underlies colluvium slide debris and weathered rock slide debris that is part of an ancient landslide complex that moved in a north-northwest direction into the Tributary A & B valley. The Tyee Formation rock exposed in the cut also formed a backstop or toe to a giant ancient landslide that at one time had moved in a north-northwest direction from Baber Butte, which is approximately 1 mile to the south-southeast, to Eddy Creek Tributary C. This ancient slide toe is visible in the cut slope where the materials change at "S" 882+00 from rock on the west to colluvium slide debris on the east. Site conditions have been investigated with the following geotechnical borings and instruments, as well as with observations and measurements of the cut face (Figure 13). Detailed descriptions of the subsurface materials are provided in Appendix C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 15: Cut 4 LT Explorations

Appendix	Boring Designation
C	C4-01, C4-08, C4-09

17.1 Subsurface Materials

Cut 4 LT consists of west and east portions that contain different material conditions. To the west of "S" 882+00, the cut is in colluvium slide debris, overlying weathered rock slide debris, which in turn overlies Tyee Formation. To the east is colluvium slide debris with boulders of weathered rock. Clayey soil with buried ancient trees was encountered at the contact between the two different portions of the cut. This area is of considerable interest to academic institutions that research ancient climate.

17.2 Groundwater

Groundwater springs in the area of Cut 4 have not been observed, with exception of one spring to the east and left of the cut, above the left bank of Eddy Creek Tributary C. Groundwater at Cut 4 LT is expected to be perched within the colluvium/slide debris and weathered rock slide debris, and confined within fractures in the Tyee Formation. The through-cut has interrupted the flow path and the exposed portion of the LT cut slope is relatively dry. Groundwater flows can become significant when the elevation of the excavation is near existing haul road grade and below, particularly where the formation is highly fractured or faulted.

17.3 Ground Deformation

Other than raveling and rockfall on the rock cut slope, no landslide movements have been detected in recent years on the LT side of Cut 4.

17.4 Construction and Geotechnical Mitigation

The existing through-cut was constructed between 2006 and 2009. The cut slope was made 1V:0.5H in rock, which experienced some rockfall and raveling. Overburden slopes were made 1V:1.5H, which performed reasonably well on the LT side of the highway. Soft/wet soil zones were over-excavated and stabilized. In particular, zones of soft and wet material were encountered at the transition from rock cut to soil cut at the east side of Cut 4.

After excavation in Phase 3 reaches new subgrade elevations, zones that are soft and/or wet may require subgrade stabilization. Where soft/wet zones are encountered in the finished cut slope, rock inlays may be required.

Due to the significant shift of the highway alignment to the LT and the bedding dip of the Tyee Formation, the height of rock in the new LT cut face will be less than in the existing LT cut face.

18 Station "S" 876+00 to 886+00 RT (Cut 4 RT)

Cut 4 is a through-cut between the Eddy Creek Tributaries A & B to the west and Eddy Creek Tributaries C & D to the east. Tyee Formation rock exposed in the cut underlies colluvium slide debris and weathered rock slide debris that is part of an ancient landslide complex that moved in a north-northwest direction into the Tributary A & B valley. The Tyee Formation rock exposed in the cut also formed a backstop or toe to a giant ancient landslide that at one time had moved in a north-northwest direction from Baber Butte, which is approximately 1 mile to the south-southeast, to Eddy Creek Tributary C. This ancient slide toe is visible in the cut slope where the materials change at "S" 882+00 from rock on the west to colluvium slide debris on the east. Site conditions have been investigated with the following geotechnical borings and instruments, as well as with observations and measurements of the cut face (Figure 13). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 16: Cut 4 RT Explorations

Source	Boring Designation
Group A	BH-44, BH-45, BH-46
Group B	C4BH05-1, C4BH05-2, C4BH06-3, C4BH06-4, C4BH06-5, C4PZ05-1, C4PZ05-2, C4PZ05-3, C4PZ05-4, C4PZ05-5, C4PZ05-6, C4PZ05-7, C4TP05-1, C4TP05-2, C4TP05-3, C4TP05-4, C4TP05-5, C4TP05-7, C4TP05-8
Group C	C4-02, C4-03, C4-04, C4-05, C4-06, C4-07,

18.1 Subsurface Materials

The highway alignment at Cut 4 is through the divide between Eddy Creek Tributary B and Tributary C. The through-cut exposes colluvium/slide debris, weathered rock slide debris, Tyee Formation slide debris, and Tyee Formation, all of which are associated with a series of coalescing ancient landslides that head within the ridge to the south and toe into the corresponding tributaries of Eddy Creek. Clayey soil with buried ancient trees was encountered at the contact between the two different portions of the cut.

A giant block of Tyee Formation slide debris became active within the cut right of the highway alignment during construction excavation in 2009, and was mitigated with near-vertical rock anchors. The eastern end of the cut is entirely within colluvium/slide debris, which also encountered organic material including large logs, and wet/seep areas. In the floor of the through-cut, varying thickness of fractured sandstone and siltstone exists due to blasting in 2009, except in the eastern end of the cut in colluvium/slide debris. Unsuitable material was placed at the bottom of the rock cut slope, right of the highway alignment, which also benefits mitigation of future rockfall.

18.2 Groundwater

Springs or seeps are observed in Cut 4 RT; above the base of the of weathered rock slide debris, along different bedding planes within the slope, at pressure relief drains installed in the rock cutslope during construction in 2009, and in the soil cut on the east end of Cut 4. The seeps indicate that groundwater flows preferentially within fractures and joints within the Tyee Formation, and within zones of colluvium/slide debris. Groundwater levels are measured in piezometers at depths below ground surface ranging from 40 to 125 feet, with one instrument installed in the base of the cut that measures groundwater level at the ground surface during storms.

18.3 Ground Deformation

Ground movement at Cut 4 includes a failure in the overburden, and a rock block slide, both during construction in 2009. Colluvium/slide debris and weathered rock slide debris (overburden) failed near the high point of Cut 4 RT in early 2009 following grading in 2008. During further grading and blasting that deepened the cut in 2009, a rock block slide developed, which resulted in additional grading and installation of near-vertical rock anchors to mitigate against increased rock block sliding. A slope inclinometer was installed approximately 200 feet west of this rock block slide in July 2012 and has recorded 0.02 inches of discrete movement in late 2012. Other failures in the cut include slaking and resulting rockfall. One slope inclinometer was installed in late 2007 prior to grading (C4-02) upslope of Cut 4 RT. One-time movement on the order of 0.08 inches occurred during the summer of 2009 at a depth of approximately 120 feet (C4-02), deep within Tyee Formation. This movement is interpreted to be associated with stress-relief in the cutslope due to the through-cut excavation since ground movement has not continued since. Recently, shallow overburden sliding has been detected in C4-07.

18.4 Construction and Geotechnical Mitigation

The existing through-cut was constructed between 2006 and 2009. The cut slope was made 1V:0.5H in rock, which experienced some rockfall and raveling. Overburden slopes were made 1V:1.5H. A slide that occurred in the overburden (slide debris) portion of the RT cut slope was mitigated by over-excavating the failed material and using a flatter cut slope. Near-vertical rock anchors were installed to stabilize an active rock block in the RT cut in 2009. Currently, no deep slide movement is apparent in the Tyee Formation. However, there appears to be local overburden deformation near C4-07.

Soft/wet soil zones were over-excavated and stabilized. In particular, zones of soft and wet material were encountered at the transition from rock cut to soil cut at the east side of Cut 4. Rock inlays were constructed in spring areas (east end of Cut 4).

During Phase 2 construction in 2013, the area at the toe of the Cut 4 RT slope was used as a disposal site for unsuitable materials. The disposal fill included a chimney drain between the rock cut and disposal fill to intercept groundwater seepage. Cut 4 RT will have a larger fallout area resulting from the left shift of the highway alignment during Phase 3. Therefore, the disposal site will be enlarged for use during Phase 3 construction.

After excavation in Phase 3 reaches new subgrade elevations, zones that are soft and/or wet may require subgrade stabilization. Where soft/wet zones are encountered in the finished cut slope, rock inlays may be required.

19 Station "S" 886+00 to 907+00 (Eddy Creek Tributary C & D Slide Area; Fill 4)

The realignment departs Cut 4 and crosses Eddy Creek Tributaries C and D on an embankment that parallels the right bank of the main stem of Eddy Creek downstream of the confluence with Tributary C. The ancient landslide complex, which toed into the rock in Cut 4 during an early phase of activity, currently toes into Tributary C and the main stem. Tributary D has eroded into the ancient landslide complex. The embankment supporting the highway (Fill 4) is located on the lower portion of the large ancient landslide, and movement has been reactivated in this lower area. Movement over a larger extent is occurring near the western end and mid-section of the embankment toe, whereas slide movement near Eddy Creek Tributary D appears at this time to be localized to the toe of the embankment. Site conditions have been investigated with the following geotechnical borings and instruments (Figure 14). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 17: Eddy Creek Tributary C & D Explorations

Appendix	Boring Designation
A	BH-47, BH-48, BH-49, BH-59, BHS-5, TP-14, TP-15, TPS-7, TPS-8
B	ALTPO5-5, ECBH05-1, ECBH05-4, ECBH06-1, ECIN10-1, ECIN10-2, ECIN10-3, ECIN10-3A, ECIN10-4, ECIN10-5, ECIN10-6, ECIN10-7, ECIN11-1, ECIN11-2, ECIN11-4, ECIN11-6, ECIN12-3, ECIN12-3P, ECIN12-5, ECPZ10-1, ECPZ10-2, ECPZ10-3, ECPZ10-4, ECPZ10-5, L3BH05-1, L3PZ05-1, L3PZ05-2, L3PZ05-3,L3PZ05-4, L3PZ05-5, L3SKI-1, L3SKI-2, L3SKI-3, L3TP05-1, L3TP05-2, L3TP05-3, L3TP05-4, L3TP05-5
C	ECSKI-1, ECSKI-2, ECSKI-3, ECSKI-4, ECSKI-5, ECSKI-6, F4-01, F4-02, F4-03, F4-03A, F4-04, F4-04A, F4-05, F4-06, F4-07, F4-08, F4-09, F4-10, F4-11, F4-12, F4-13, F4-14, F4-15, F4-16, F4-17, F4-17B, F4-18, F4-19, F4-20, F4-21, F4-22, F4-23, F4-24, F4-25, F4-26, F4-26B, F4-27, F4-28, F4-29, F4-30, F4-31, F4-32, F4-33, F5-01, F5-02, F5-03, F5-04, TP4-01, TP4-02

19.1 Subsurface Materials

Materials in the Eddy C & D Slide area consist of colluvium/slide debris overlying weathered rock slide debris, both of which overly Tyee Formation slide debris and Tyee Formation. Local areas of the slide consist of predominantly colluvium/slide debris. Embankment fill, buttress fill, subdrain/underdrain, cutoff drain, trench drain, and shear key materials are also in the area. Buried pipes include an older 60-inch diameter culvert at Tributary D; an older 36-inch diameter culvert between Tributaries C and D; new 48- and 78-inch diameter culverts at Tributary C; an older bypass pipe in Tributary C; drain pipes in the subdrains, underdrains and trench drains; horizontal drains; and conduit carrying cable to geotechnical instruments.

19.2 Groundwater

Springs have been observed in a tributary east of Eddy Creek Tributary C, in a cutslope upslope of Fill 4, and in a cutslope upslope of the highway alignment between Tributary C and a tributary to Tributary C to the east. The upslope springs varied in flow from approximately 1 gpm emitting from colluvium, to 10's of gpm emitting from a deposit of fractured rock landslide debris. Due to construction, the springs in the tributary to Eddy C are buried by temporary fill that was placed for construction access, and the largest spring is captured in a buried drain pipe that carries the water underneath the haul road to Tributary C.

Another spring area was observed during construction of Fill 4 near the toe of the embankment approximately 200 to 300 feet northeast of Station "S" 894+00. Seepage is also currently occurring on the lower slope of embankment Fill 4 near Station "S" 891+50.

Piezometers in the Eddy C Slide have recorded groundwater levels 12 to 104 feet below the ground surface, the depth of which is dependent on the depth and location of the piezometer sensor. Typically, the groundwater level varies within the landslide material from 0 to 34 feet above the base of the landslide. Recorded spikes in groundwater due to storms typically range from 1 to 12 feet.

Piezometers and horizontal drains installed in existing embankment and underdrains encountered a build-up of pore water pressures and migration of subsurface water into embankment fill.

Horizontal drain array installations have been completed at six (6) drill pad sites at this slide location, with a total of 183 individual drain installations. Recorded spikes in groundwater levels due to recent horizontal drain drilling ranged from 5 to 115 feet. The monitored flow rates, following initially higher rates, on the drain arrays have ranged from less than 1 to approximately 215 gpm, with moderate to high flow rate increases in four of the pads following storm events.

19.3 Ground Deformation

Fill 4 is located within a series of nested flow slides and slumps within a larger ancient translational slide. Based on inclinometer measurements, the downslope portion of the large regional slide (the area of the recent construction) has been reactivated; however, the location of the reactivated head scarp is not apparent. Landslide movement rates through the summer season are typically slower; however, movement rates usually increase again with the onset of seasonal precipitation.

A buttress was constructed at the toe of the embankment fill from approximately Station "S" 889+50 to "S" 894+50; however, landslide shear movements continued. The buttress was subsequently enlarged in the fall of 2010 to improve stability. Inclinometers between Tributaries C and D have measured variable rates of slide movement, with recent movement rates in the order of 0.01 inch per month. No movement has been detected on the west side of Eddy Creek Tributary. C.

Slide movement near the Tributary D drainage appears at this time to be localized to the toe of the Fill 4 embankment.

Horizontal drain installations have caused short-term landslide movements ranging from <0.1 to 0.3 inches in local areas within the Eddy C area of the ancient landslide. No movement was caused by installation of the horizontal drains in the area of the Eddy D ancient landslide.

Settlement has occurred within and underneath the embankment fills and buttress fill. Settlement monitoring between October 2009 and July 2011 at Fill 4 suggests at least 5 inches of total settlement occurred beneath the top of the embankment over this time frame near station “S” 893+00. The total height of the embankment at this location was estimated to be about 60 feet. The settlement that occurred during the construction of the embankment is not known. Settlement that may have occurred after July 2011 is also not known.

During construction of a 60-foot tall test embankment in 2013 in the Eddy C drainage area near Station “S” 891+50, total foundation settlement of approximately 5 inches was measured with a settlement sensor, which was placed at the base of the test embankment prior to fill placement. The test embankment was constructed in 5 weeks and primary settlement was complete within 4 weeks thereafter. The test fill experienced internal compression following construction of approximately 1 to 2-inches over a period of 5 months.

19.4 Construction and Geotechnical Mitigation

Initial construction during 2006 through 2010 included underdrains, toe keys, shear keys and embankment placement. At that time, the embankments were sized for bridge approaches, and bridge foundations and columns were constructed, followed by the superstructure and deck in 2010. The haul road includes temporary bridges crossing the Eddy C tributaries.

Underdrains were installed in both Tributary C and the tributary to the east, and are buried by temporary fill and buttress fill.

Shear keys beneath the north (LT) toe of the Fill 4 embankment were constructed in 2008 and 2009 and were reportedly founded on weathered Tyee Formation underlying the upper shear zone. A cut-off drain was installed on the upslope side of a shear key constructed underneath the toe of Fill 4.

The bridge was demolished in 2012. Foundations of the bridge (drilled shafts and pipe piles) remain below the ground surface. Following blasting, two demolished concrete columns became embedded in the crane pad fill (near Station 890+50) where they remain. The temporary haul road bridges are still in service.

Buttressing against the northwestern ridge provides stability to the far western portion of the fill area. This is an area where slide movements have been slowing down with the placement of previous buttresses. The existing buttress and drainage system improved stability. Additional buttressing against the ridge is planned to further increase slide stability.

Long and deep horizontal drains (six arrays: EC-A, EC-D, EC-E, EC-F, EC-G, and EC-H) and shallow trench drains were installed in Phase 1 (2012/2013) to reduce groundwater levels. Slight lowering of the groundwater has been measured. The expected benefit of the horizontal drains is to reduce groundwater pressure increases that are associated with new embankment fill loading, and to improve groundwater flow during storm surges.

To the east of the Eddy Creek Tributary C confluence with the Eddy Creek main stem, the landslide moves along inclined shear zones and toes out in the main Eddy Creek channel. Stability is reduced by seasonal rises in groundwater level, infiltration from storms, and infiltration within the slide toe area. Surface flows will be modified to discharge water away from the slide toe to minimize infiltration into the slide mass.

Some of the horizontal drain arrays were recently fitted with temporary collection header and discharge pipes to reduce infiltration into the slide mass (EC-A, EC-E, EC-F, EC-G and EC-H). In Phase 3, temporary header and discharge pipes will be replaced with permanent solid-wall HDPE header and discharge pipes. Drains at arrays EC-D, EC-E and EC-G will need to be extended through new fill required as part of ground anchor construction.

Two culverts were constructed during Phase 2 in 2013. The main culvert is a 78-inch diameter structural plate pipe within the Tributary C channel. A 48-inch diameter CMP was installed near the inlet of the 78-inch diameter culvert to connect flow from a minor tributary to Eddy C.

An underdrain system was included beneath the 78-inch diameter culvert during Phase 2 construction (summer 2013) and connected with blanket drains on both sides. Underdrains were sized to provide a minimum of 100 sq ft cross-sectional area, and included two 6-inch perforated pipes. Blanket drains were constructed between the existing ground and embankment fill to prevent the flow of groundwater into the new embankment fill (summer 2013).

A rockfill toe key has been constructed near the outlet of the Tributary C culvert, near the confluence of Tributary C and the Eddy Creek main stem. The toe of the embankment was constructed with imported durable buttress rock (6″-1″) material in Phase 2 (along with an underdrain with 6″-3″ drain rock) to provide increased strength and drainage capacity. Existing horizontal drains at EC-D, EC-E, and EC-G will be fitted with extension pipes to daylight through the new embankment slope and anchor installations.

A portion of the highway embankment was constructed in Phase 2 to test the stability of the landslide and to evaluate the constructability of wet fill materials mitigated with composite drain board strips. Movement of the local Eddy C landslide increased as a result of fill placement, and a buttressing fill was subsequently placed over the 78-inch diameter culvert to add slide resistance and slow down the slide movements.

Horizontal drain board strips are to be placed in select zones within the common fill. Staged embankment construction is required in Phase 3 to spread the fill loading over two years.

Ground anchors are planned at the toe of the embankment between Tributaries C and D (approximately Station 893+00 to 902+50) in Phase 3. The arrangement of the anchors (horizontal and vertical spacing) depends on the available space within the constrained embankment toe area, and needs to accommodate various culverts, horizontal drains, irregular topography, and the riparian set-aside area near the Eddy Creek main stem.

A lower access road and working area was constructed in summer 2013 to allow continuous anchor installation operations starting early summer 2014. Each anchor row will need a working surface to accommodate drilling equipment.

The anchors will be installed in holes drilled through the bearing pad, embankment fill, and slide debris, bonding into fresh Tyee Formation bedrock. Each ground anchor will be proof tested and a few ground anchors will be performance tested. Final loads applied during stressing of ground anchors will be determined by the Engineer based on overall mitigation performance. Strain gauges and load cells will be installed on designated ground anchors for monitoring loads in the anchors.

Geogrids will be installed for subbase reinforcement.

Ditches that cross sensitive portions of the landslide and those that impact underlying trench drains will be sealed with an impervious HDPE liner.

Instrumentation modifications include conduits to connect instruments with readout devices in cabinets mounted on steel posts. New embankment settlement sensors are planned at the end of both the first and second construction seasons.

20 Station "S" 907+00 to 916+00 RT (Cut 3 RT Slide)

Cut 3 was excavated in a ridge, between Eddy Creek Tributary D and Yaquina River, which forms the side of a broad ancient landslide. Site conditions have been investigated with the following geotechnical borings and instruments, as well as with observations and measurements of the cut face (Figure 14). Detailed descriptions of the subsurface materials are provided in Appendices A, B and C, and monitoring results from geotechnical instrumentation are provided in Appendix D.

Table 18: Cut 3 RT Explorations

Appendix	Boring Designation
A	BH-50
B	C3APZ05-1, C3PZ05-1, C3PZ05-2, C3TP05-2, C3TP05-4
C	C3-01, C3-02, C3-03

20.1 Subsurface Materials

The cut exposes colluvium/slide debris, weathered rock slide debris, and sandstone and siltstone of the Tyee Formation. A small rock inlay was built in 2010 to mitigate movements observed in Cut 3, and durable rock buttress was constructed in 2013.

20.2 Groundwater

A groundwater spring was observed below Cut 3 near "S"912+00, 40' RT, and is now buried by Fill 3. There is reportedly an underdrain with drain pipe installed to capture and divert the groundwater through Fill 3. A horizontal drain array has also been constructed in Cut 3 RT to lower groundwater in the slope for improving its stability. Flow from the horizontal drains has ranged from 0 to approximately 5 gpm with significant flow increases following storm events. Groundwater conditions are being monitored at Cut 3.

20.3 Ground Deformation

The cut exposed colluvium/slide debris, weathered rock slide debris, and underlying Tyee Formation. During grading of Cut 3 in 2010, a localized rock inlay was built to mitigate reaction of a local block of weathered rock slide debris that is sitting on top of the ancient basal shear zone. Slope inclinometers were installed at the top of the cut in late 2010 and since then have measured deep-seated movements on the order of 0.05 to 0.20 inches. The direction of the deep-seated movement is out of the cutslope. The direction of the dipping beds of the Tyee Formation is sharply oblique to the cutslope and; therefore, the movement appears to be a reaction to the grading.

Horizontal drains and a large rockfill buttress were constructed in 2013. Subsequently, shear movements in the inclinometers have reduced.

20.4 Construction and Geotechnical Mitigation

The through-cut was constructed in stages between 2006 and 2009. Very slow landslide movement was occurring in the Cut 3 slope after initial highway grading. A localized rock inlay was constructed midway on the cut slope to mitigate a nested slide condition.

Horizontal drains were installed in Phase 1 (2012). A large rockfill buttress was installed in 2013 to decrease the risk of catastrophic movement. The buttress was constructed using imported stone embankment material in the west half of Cut 3 since there was available space between the ditch and the toe of the cut slope and the elevation of the shear zone was close to the ditch. However, it was not feasible, nor effective, to construct a buttress on the east half. The buttress on the west half only is a partial mitigation that assumes the east half of the slide will also benefit due to stiffness within the slide mass to transfer loads into the west buttress. An inclinometer was installed through the top of the buttress to verify satisfactory performance of this mitigation.

Improvements to the right ditch will need to avoid and preserve horizontal drains that protrude from the toe of the rockfill buttress.

21 Station “S” 912+00 to 925+00 (Fill 3)

The highway realignment transitions from the hills to the west to the Yaquina River floodplain, the transition of which is made with an embankment, previously identified as Fill 3. Site conditions have been investigated with one test pit (Figure 15). The log of the test pit is provided in Appendix B.

Table 19: Fill 3 Explorations

Appendix	Boring Designation
B	ALTP05-6

21.1 Subsurface Materials

Fill 3 was constructed on alluvium in the Yaquina River floodplain, and colluvium on the adjacent slopes. The Fill 3 materials have not been investigated since slide movements have not been observed.

21.2 Groundwater

A groundwater spring was observed near Station “S” 912+00, 40' RT, and is now buried by Fill 3. There is reportedly an underdrain with drain pipe installed to capture and divert the groundwater through Fill 3. Groundwater investigation and geotechnical instrumentation have not been performed at Fill 3.

21.3 Ground Deformation

Instrumentation has not been installed since slide movements have not been observed.

Settlement has occurred within and underneath the embankment fill. Settlement monitoring between July 2010 and July 2011 at Fill 3 suggests at least 2.5 inches of total settlement occurred beneath the top of the embankment over this time frame. The total height of the embankment at this location was estimated to be about 55 feet. The settlement that occurred during the construction of the embankment is not known. Settlement that may have occurred after July 2011 is also not known.

21.4 Construction and Geotechnical Mitigation

The Fill 3 embankment was constructed in 2009 and 2010.

A stockpile of imported buttress rock (6″-1″) exists near the transition between Fill 3 and Cut 3, approximately Station “S” 912+50 to 915+20 RT. In addition, there is a small stockpile of imported stone embankment material.

The low area to the right of Fill 3 will be filled.

This report is submitted to Oregon Department of Transportation (ODOT) as a bid-document for construction of FFO-US20 PME: UPRR – Eddyville (Phase 3) Section, Corvallis–Newport Highway, Lincoln County, Oregon

CORNFORTH CONSULTANTS, INC.

CERTIFIED
OREGON
CHARLES M. HAMMOND
E-1056
ENGINEERING GEOLOGIST

Charles M. Hammond, P.G., C.E.G.
Senior Associate Geologist

REGISTERED PROFESSIONAL
ENGINEER
9686
OREGON
JULY 14, 1978
GEORGE MACHAN

George Machan, G.E., P.E.
Senior Associate Engineer

EXPIRES: 12/31/2014

Limitations in the Use and Interpretation of this Geotechnical Data 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.

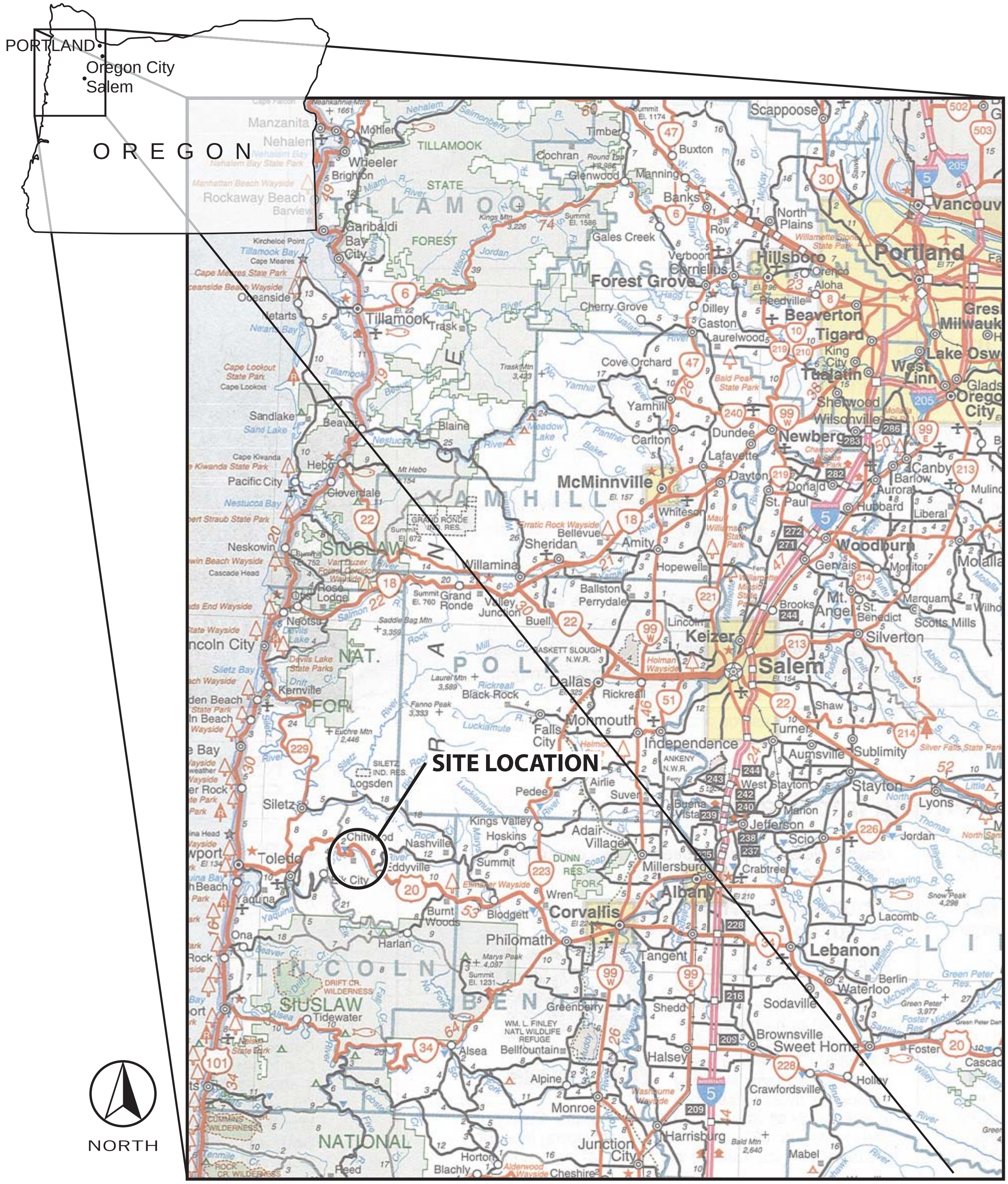
The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. We are not responsible for the validity or accuracy of data obtained from other parties during this or previous studies. The soil descriptions and interfaces between 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.

Our 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.



0 15 30

SCALE IN MILES

CORNFORTH
CONSULTANTS

10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Main 503-452-1100 Fax 503-452-1528

SITE LOCATION

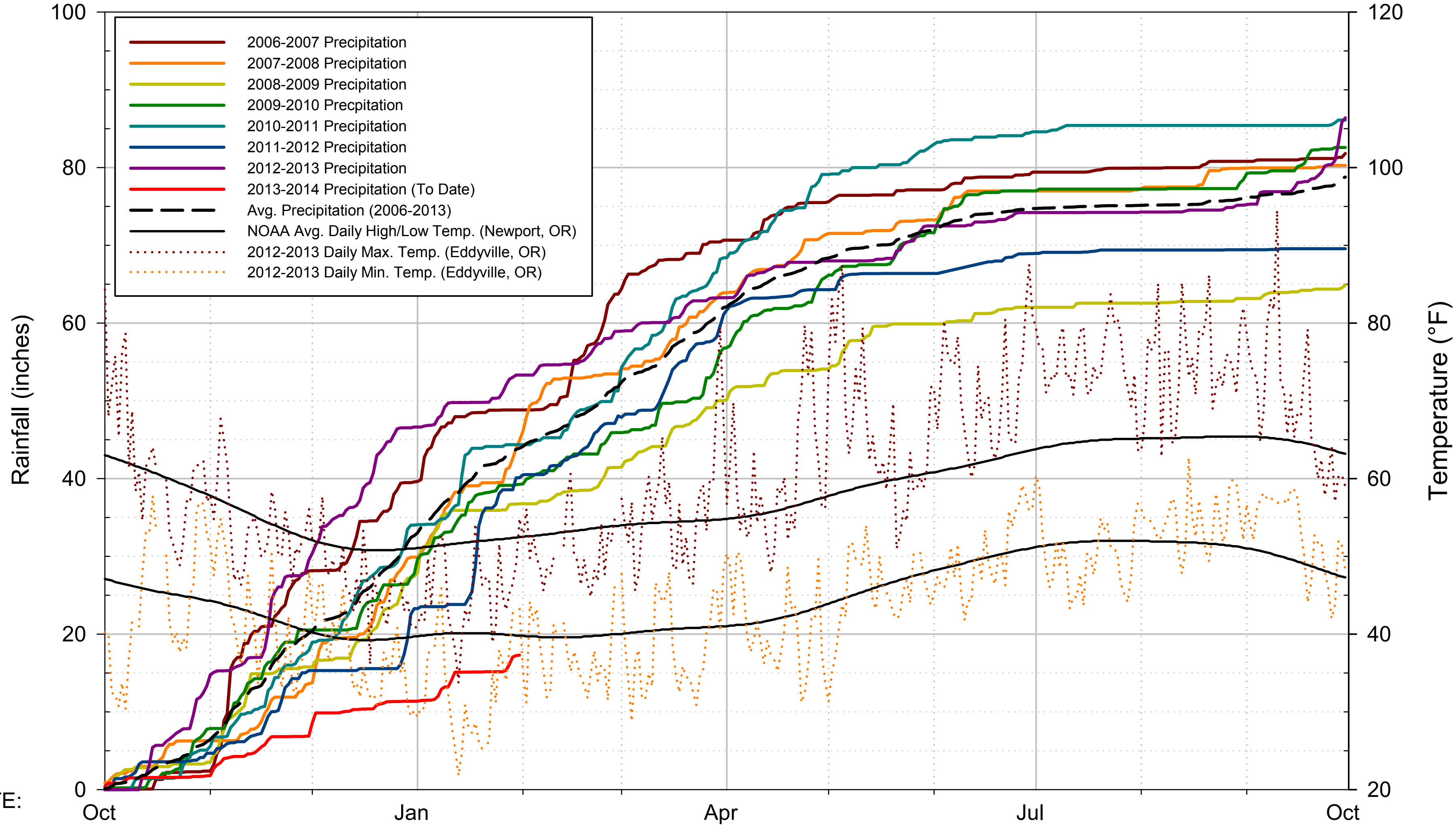
US20 PME: UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 1

2245/1.8/01.AI NAU



NOTE:

Normal daily temp. retrieved from NOAA station USW00024285, Newport, OR, compiling data from 1981-2010.

2012-13 daily max/min temp. recorded by automated weather station at field office.

2006-2008 rainfall data: manually from gauge Mon - Fri.

2009 - Feb, 2012 rainfall data: manually from gauge Mon - Sun.

Feb 2012 - Jun, 2012 rainfall data: from weather station at Fill 4.

Jun, 2012 - Sept, 2012 rainfall data: from Newport MD1265 weather station.

Sept 2012 - present rainfall data: from weather station at field office.

CORNFORTH CONSULTANTS

10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

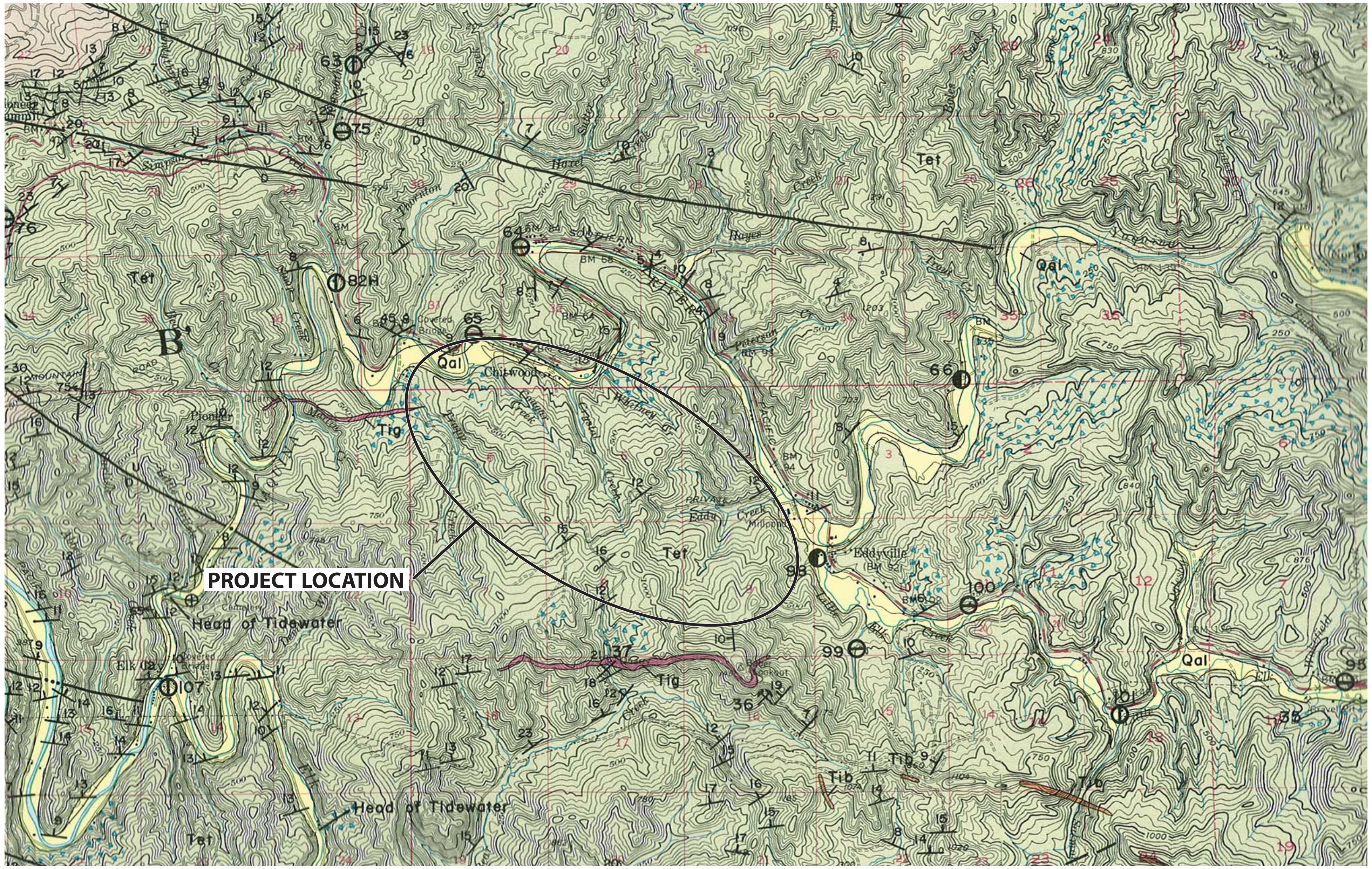
PME PRECIPITATION AND TEMPERATURE

US20 PME: UPRR - EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 2



EXPLANATION

Unconsolidated surficial units

Qal *Alluvial bottom land deposits composed primarily of silt, sand, and gravel.*

Other stratigraphic units

Tet Tyee Formation
rythmically bedded sandstone and siltstone; sandstone is medium-grained, micaceous, and arkosic and forms beds 1 to 15 feet thick; siltstone is micaceous and contains organic matter locally; turbidite structures are widespread.

Intrusive rocks

Tib Intrusive basalt
includes feeder dikes for the Cape Foulweather and Depoe Bay Formations, and the basalt at Yachats and Cascade Head; porphyritic in places.

Tig Gabbro
inclined sheets, sills and dikes of massive gabbro composed largely of plagioclase, ferroaugite, iron-rich olivine, and intergrowths of quartz and alkali feldspar; includes related mafic pegmatites.

GEOLOGIC SYMBOLS

U
D
Faults
Dotted where concealed

Folds
Syncline
Dotted where concealed
Anticline
Dotted where concealed

Contacts
Dotted where concealed

Attitudes
Strike and dip of beds
Horizontal beds

Landslide topography

Mines

NOTE: MODIFIED FROM ENVIRONMENTAL GEOLOGY OF LINCOLN COUNTY, OREGON: DOGAMI BULLETIN 81, SEPT. 1973.

2245/1.9/03.AI NAU

CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Main 503-452-1100 Fax 503-452-1528

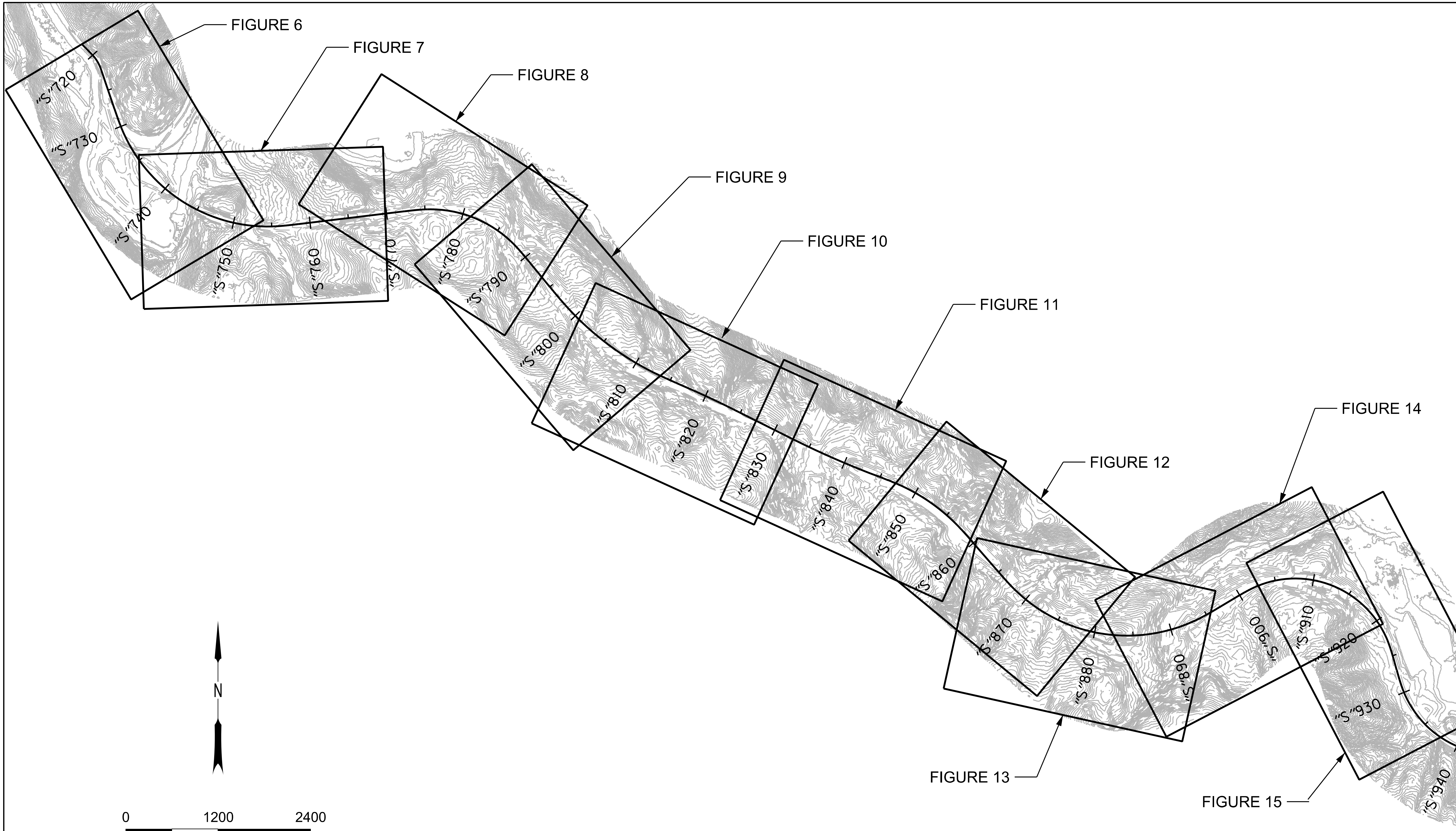
PUBLISHED GEOLOGIC MAP

US20 PME: UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 3



CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

SITE PLAN INDEX

US20 PME:UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014
PROJ. 2245
FIG. 4

G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 4 - Index 3/4/2014 10:30:17 AM dsparby

Borehole and Instrument Symbols

	Group A	Group B	Group C
Active	Borehole	Borehole	Borehole
	Standpipe Piezometer	Standpipe Piezometer	Standpipe Piezometer
		Slope Inclinometer	Slope Inclinometer
		Vibrating Wire Piezometer	Vibrating Wire Piezometer
		Vibrating Wire Piezometer w/ Slope Inclinometer	Vibrating Wire Piezometer w/ Slope Inclinometer
Inactive/ Abandoned	Borehole	Borehole	Borehole
	Standpipe Piezometer	Standpipe Piezometer	Standpipe Piezometer
		Slope Inclinometer	Slope Inclinometer
		Vibrating Wire Piezometer	Vibrating Wire Piezometer
		Vibrating Wire Piezometer w/ Slope Inclinometer	Vibrating Wire Piezometer w/ Slope Inclinometer
		Test Pit	Test Pit

Crackmeter

Settlement Sensor

Settlement Sensor Reservoir

Monitoring and Control Unit (MCU)

Horizontal drain drill pad and array

Plan Limits

Right-of-way (existing)

Right-of-way (proposed)

Fill limits (proposed)

Cut limits (proposed)

Note:
Ground Surface contours inside of ROW are from ODOT, dated December 2, 2013
Ground Surface contours outside of ROW are from ODOT, dated September 22, 2011.
Existing Right of Way and Horizontal Roadway Alignment from ODOT.
Coutour interval: 10 feet

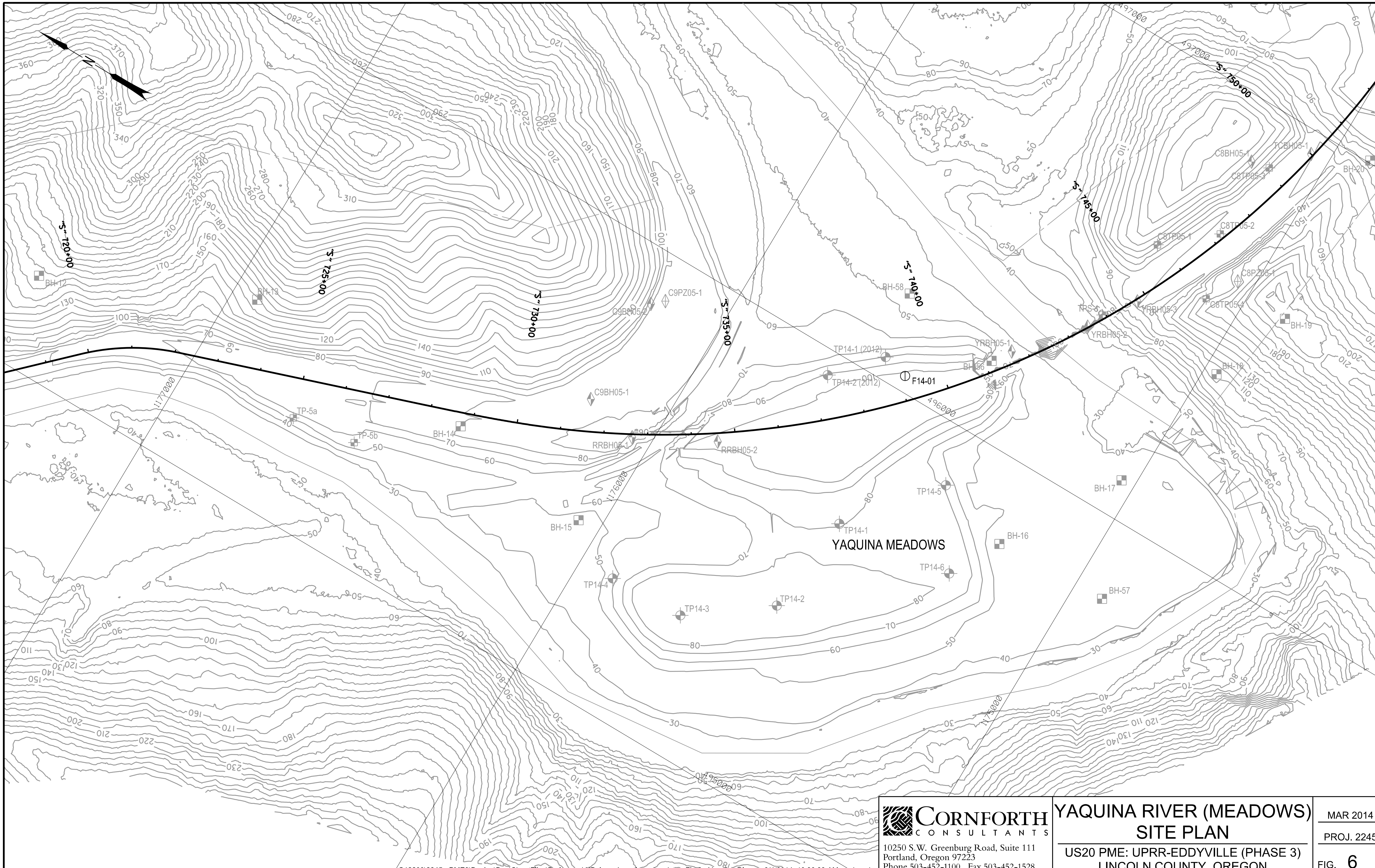
CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

BOREHOLE AND INSTRUMENT LEGEND

US20 PME: UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245



CORNFORTH CONSULTANTS

10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

YAQUINA RIVER (MEADOWS) SITE PLAN

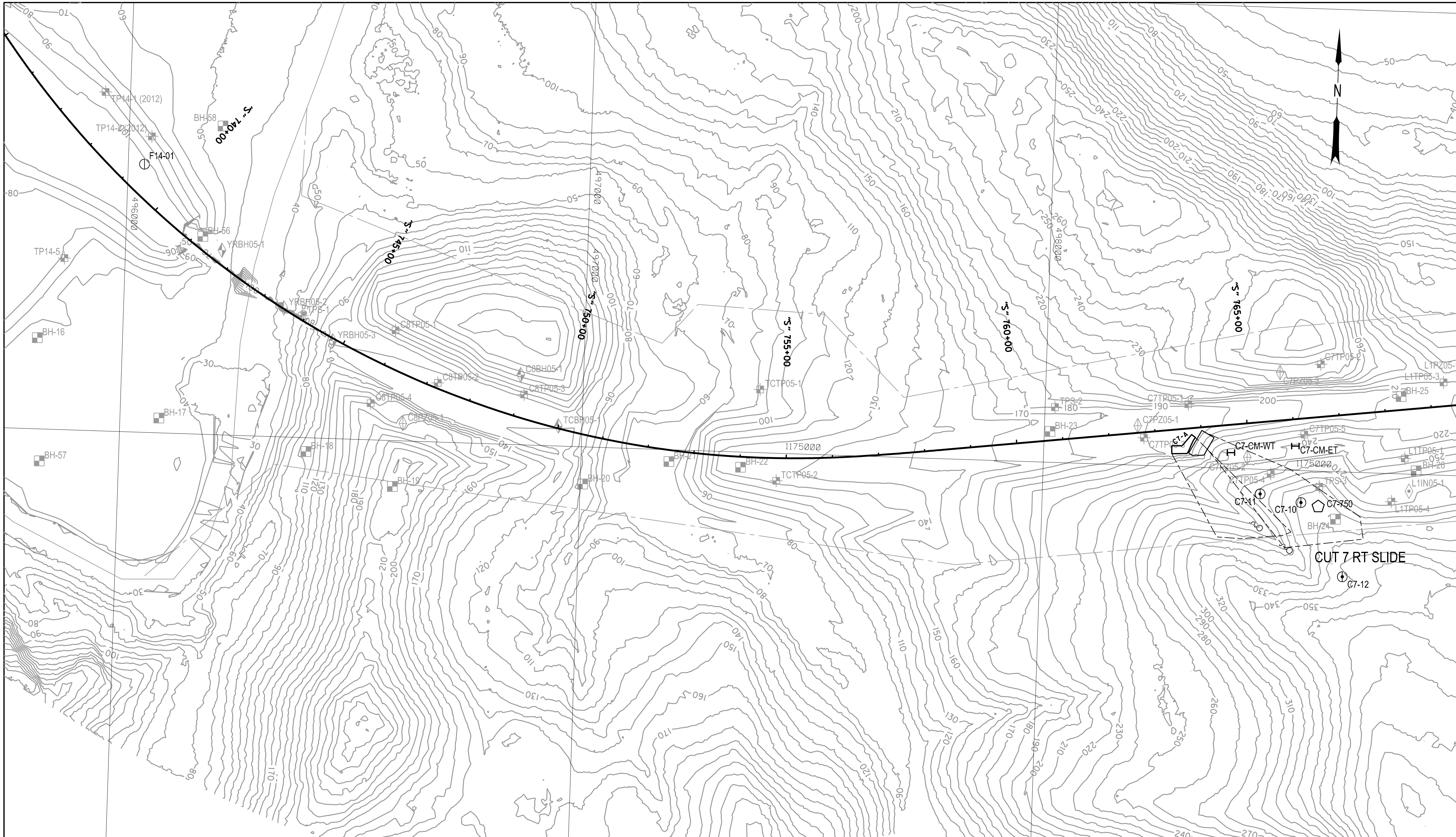
US20 PME: UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 6

G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 6 - Yaquina River 3/4/2014 10:30:33 AM dsparby



G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 7 - Trapp Creek 3/4/2014 10:30:36 AM dsparby

CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

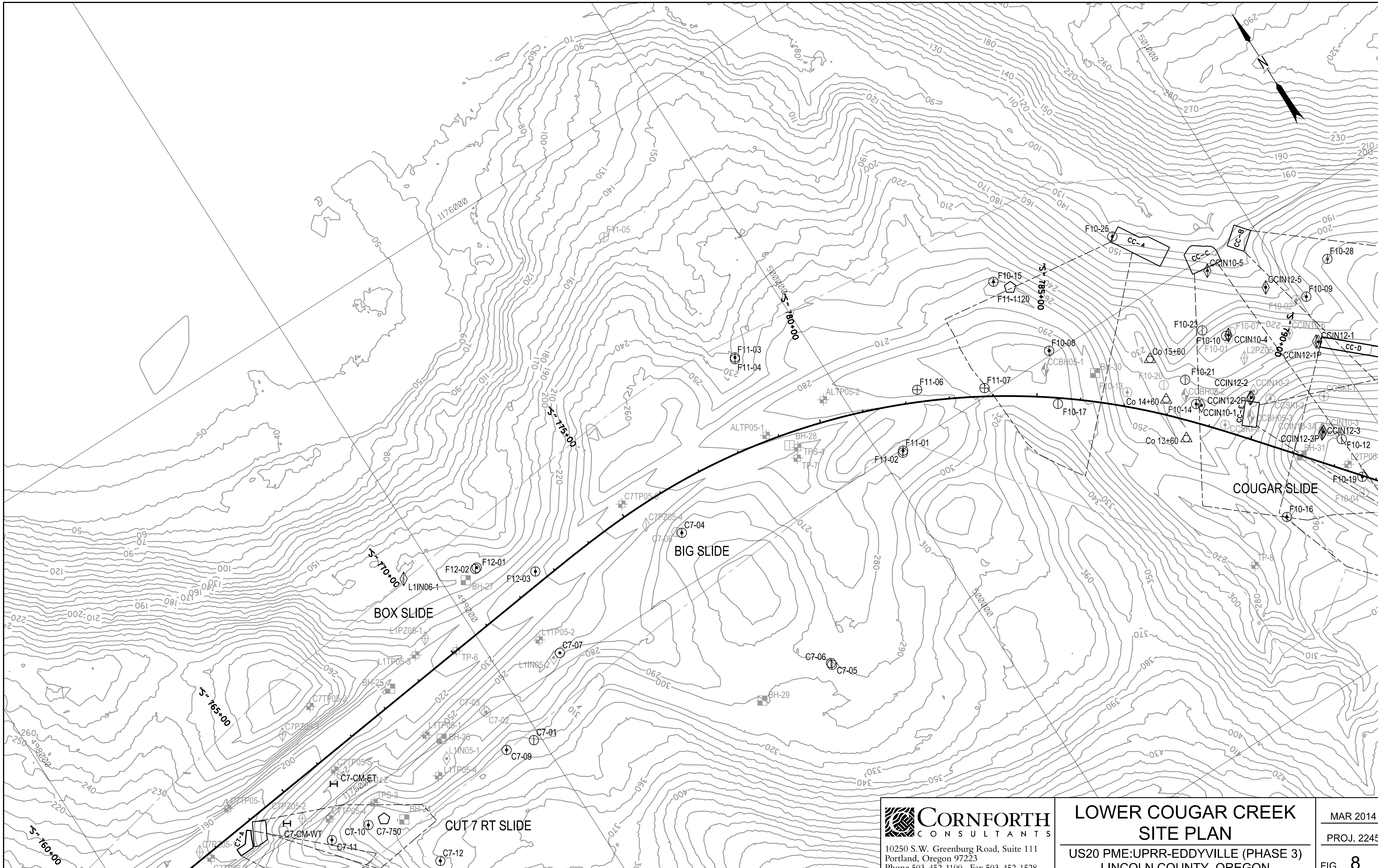
TRAPP CREEK SITE PLAN

US20 PME: UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 7



CORNFORTH CONSULTANTS

10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

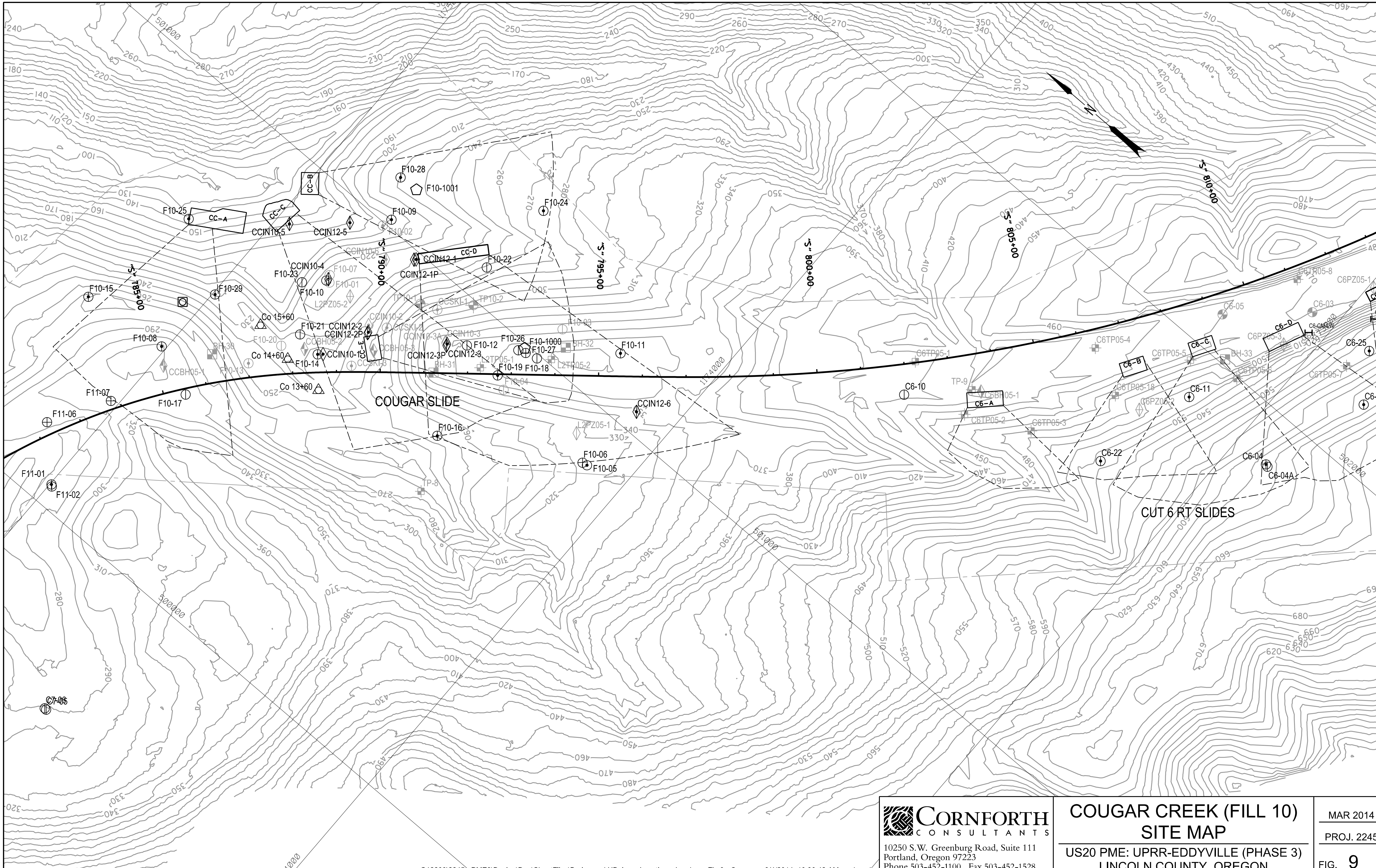
LOWER COUGAR CREEK SITE PLAN

US20 PME:UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 8



G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 9 - Cougar 3/4/2014 10:30:42 AM dsparby

CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

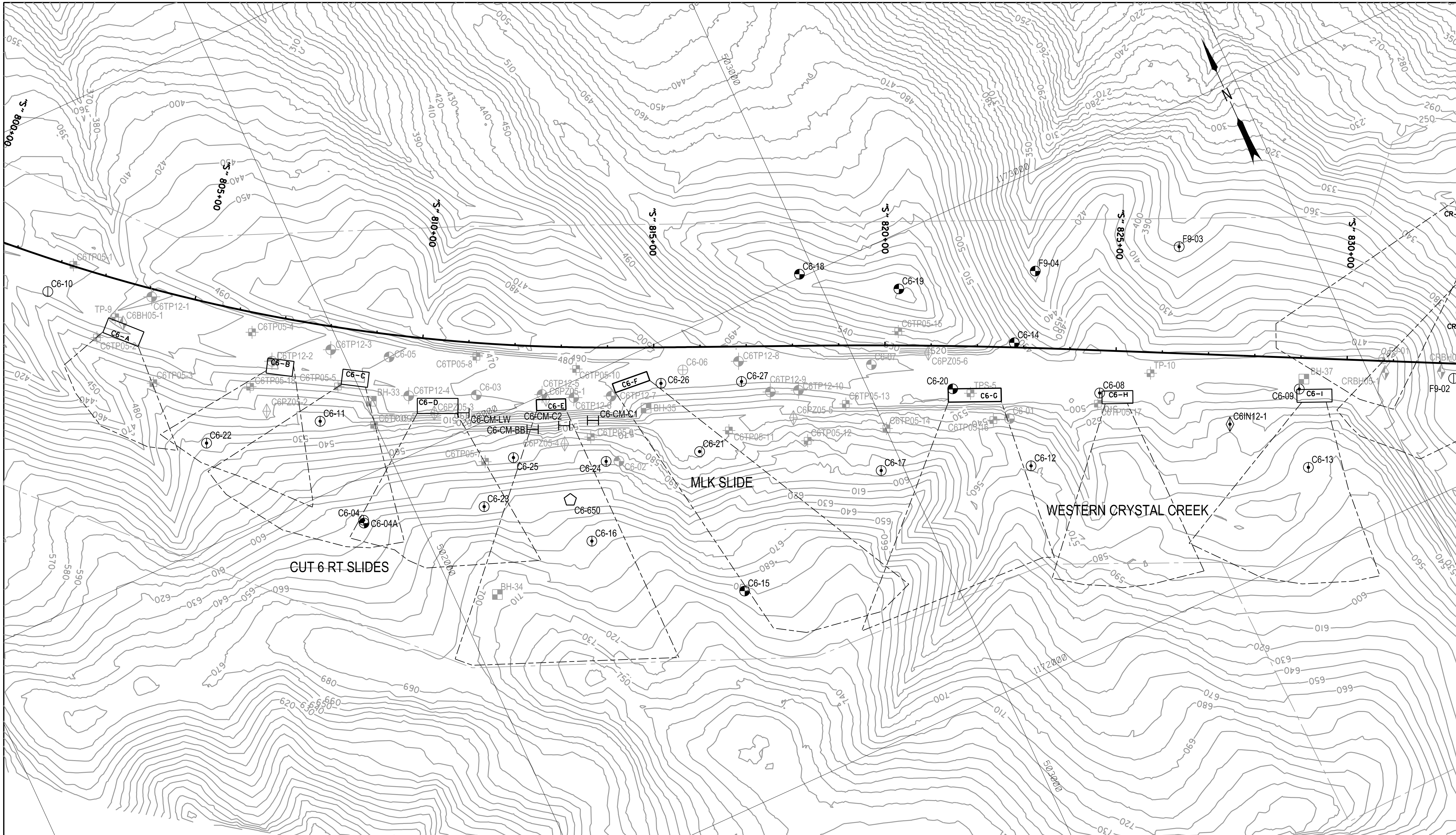
COUGAR CREEK (FILL 10) SITE MAP

US20 PME: UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 9



G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 10 - Cut 6 3/4/2014 10:30:45 AM dsparby

CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

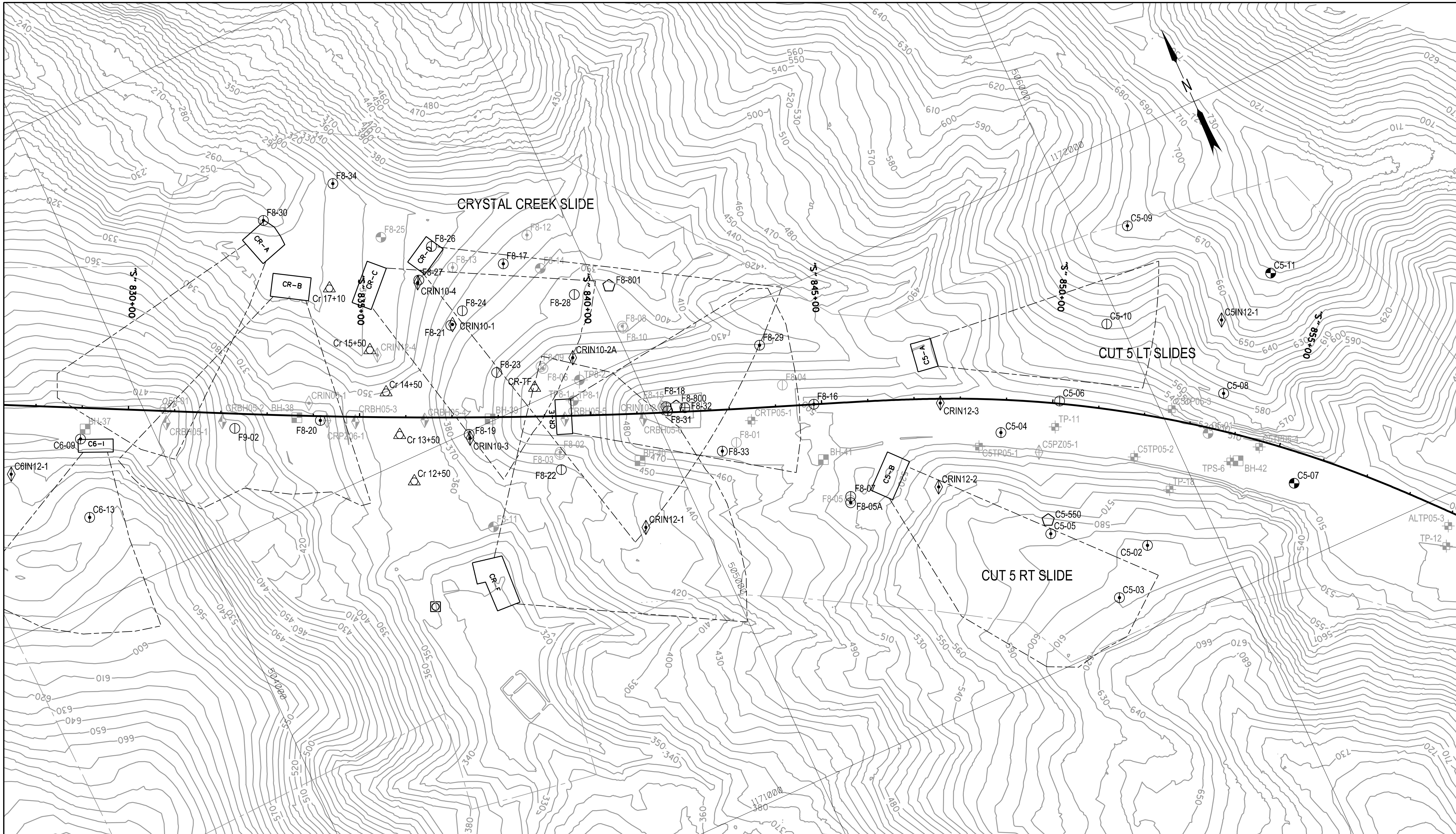
CUT 6
SITE PLAN

US20 PME: UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 10



CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

CRYSTAL CREEK (FILL 8) SITE PLAN

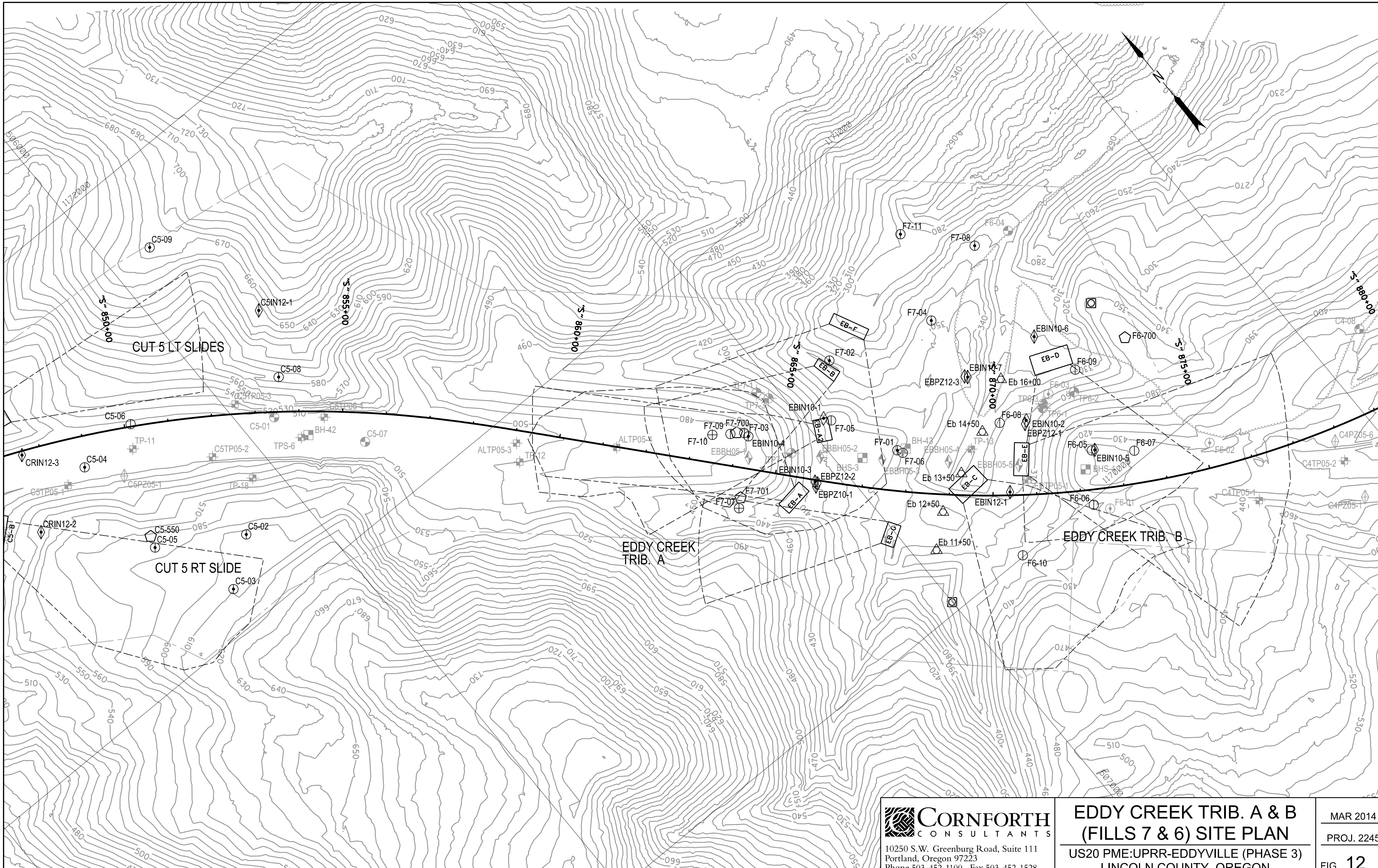
US20 PME:UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 11

G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 11 - Crystal 3/4/2014 10:30:48 AM dsparby



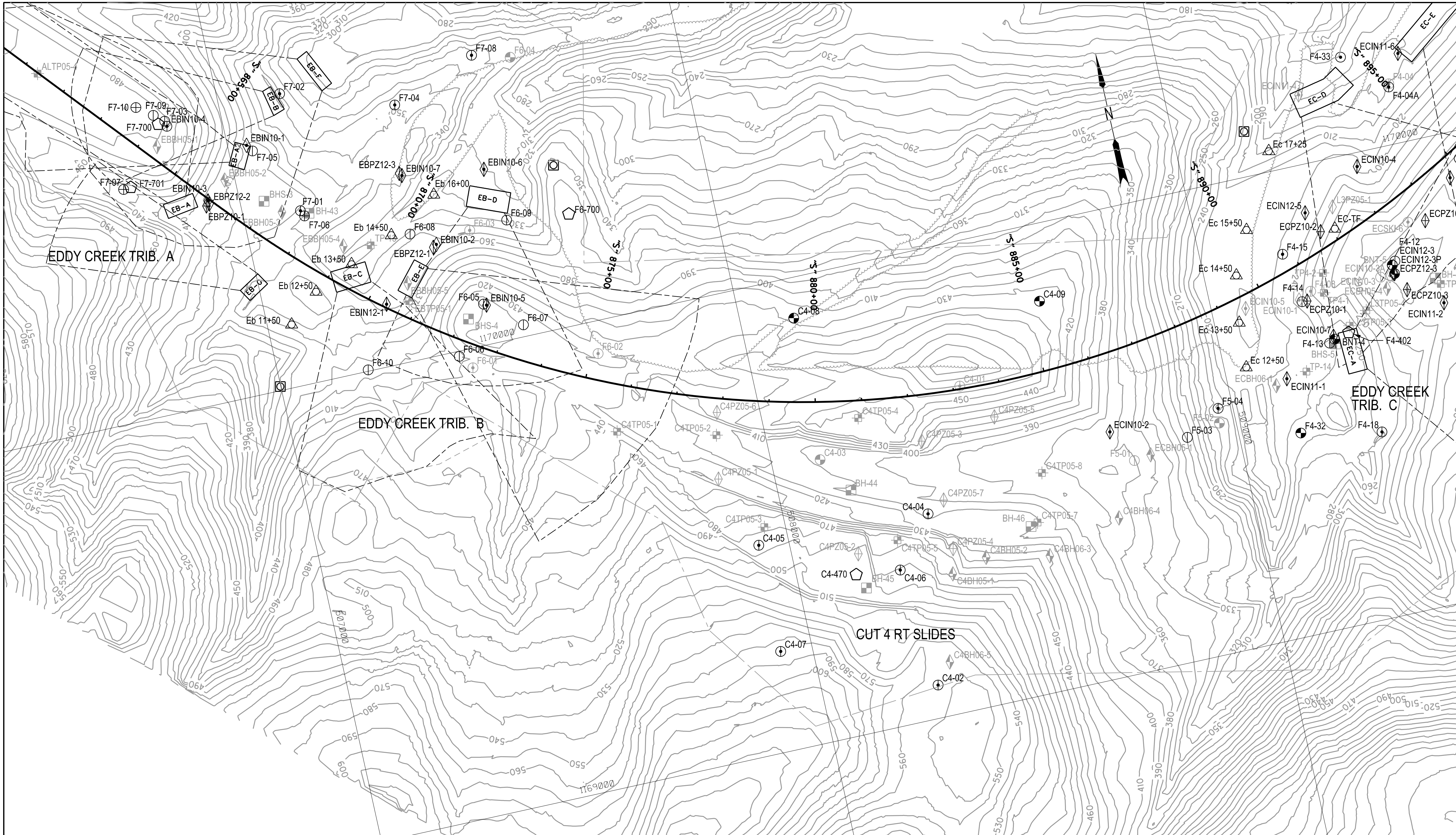
CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

EDDY CREEK TRIB. A & B (FILLS 7 & 6) SITE PLAN

US20 PME:UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014
PROJ. 2245
FIG. 12

G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 12 - EddyAB 3/4/2014 10:30:51 AM dsparby



CORNFORTH
CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

CUT 4
SITE PLAN

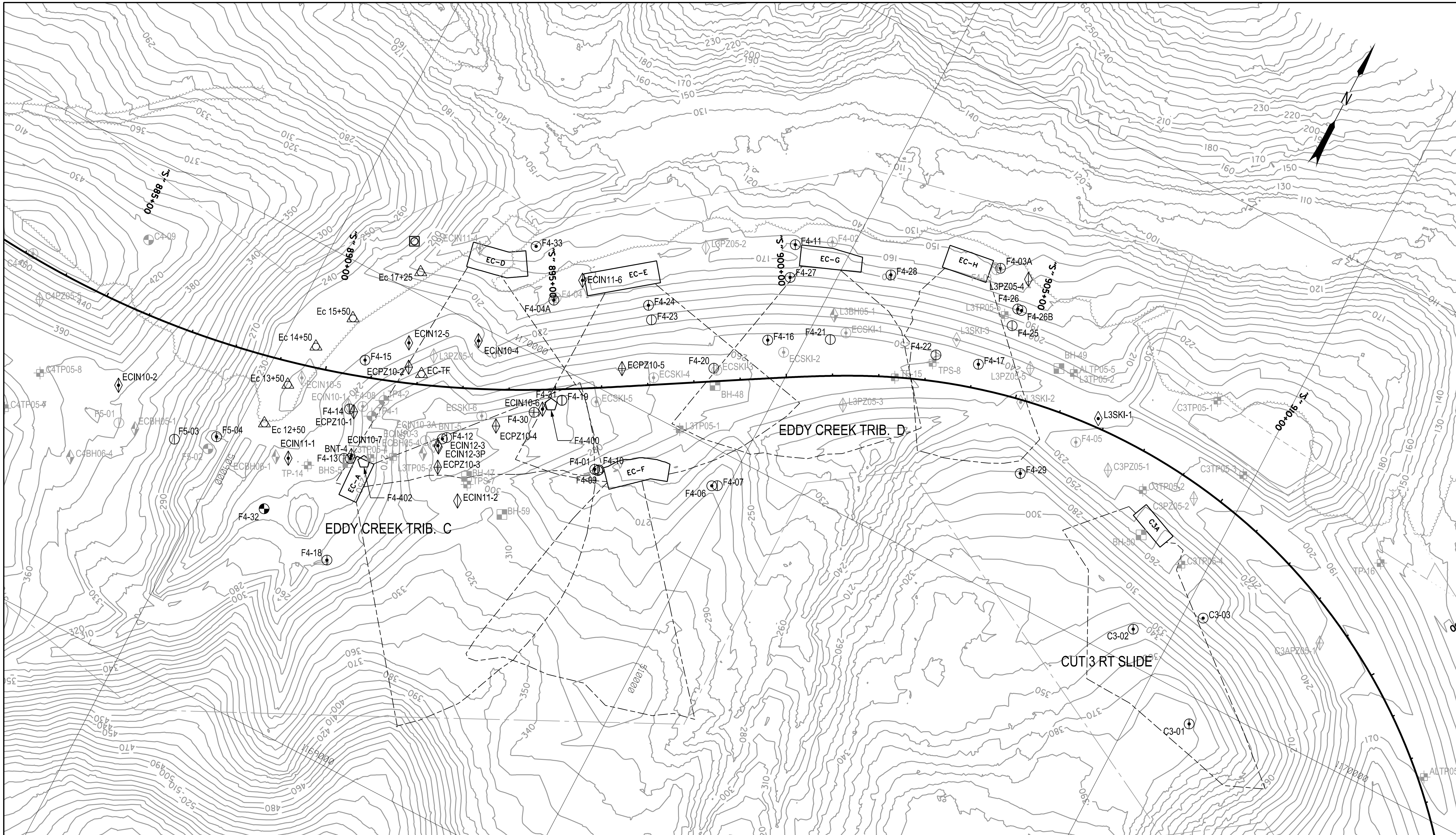
US20 PME:UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 13

G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 13 - Cut 4 3/4/2014 10:46:47 AM dsparby



G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 14 - Eddy C 3/4/2014 10:30:57 AM dsparby

CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

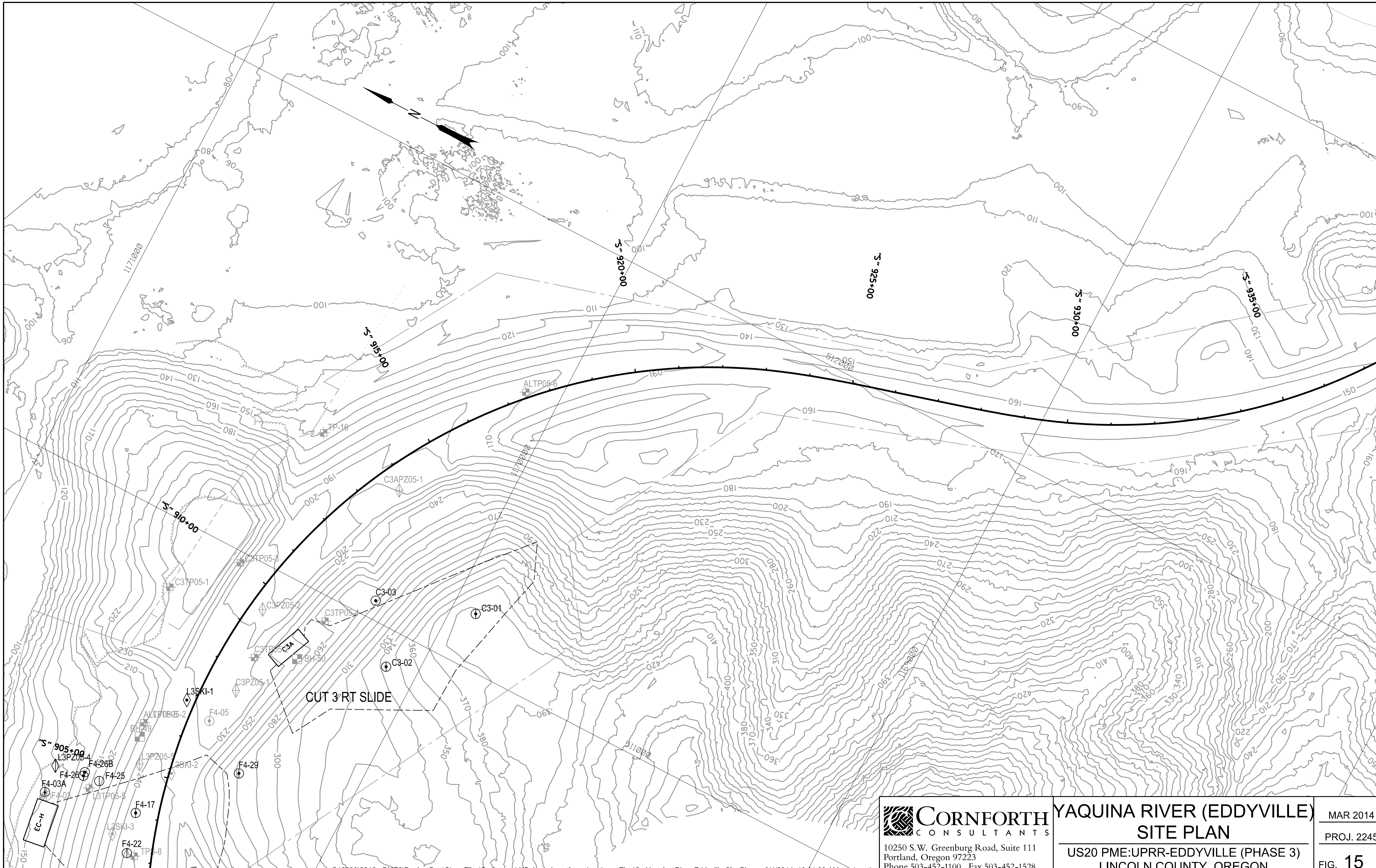
EDDY CREEK TRIB. C & D (FILL 4) SITE PLAN

US20 PME:UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 14



CORNFORTH CONSULTANTS

10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

YAQUINA RIVER (EDDYVILLE) SITE PLAN

US20 PME:UPRR-EDDYVILLE (PHASE 3)
LINCOLN COUNTY, OREGON

MAR 2014

PROJ. 2245

FIG. 15

G:\2200\2245 - PME3\Design\Dgn\SheetFiles\Boring and HD Array Locations-Jan.dgn :: Fig 15 - Yaquina River Eddyville Site Plan 3/4/2014 10:31:00 AM dsparby