GEOTECHNICAL ENGINEERING REPORT

Toppenish Creek 3-Way Diversion Levee Removal and Habitat Restoration

Prepared for: Inter-Fluve, Inc.

Project No. 160325 • May 25, 2018 Final

earth + water

Aspect
CONSULTING

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Aspect Consulting, LLC

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1 Introduction

This report presents the results of a geotechnical engineering study by Aspect Consulting, LLC (Aspect) for the Toppenish Creek 3-Way Diversion Levee Removal and Habitat Restoration project (Project) located within the Yakama Nation Reservation along the mid-section of Toppenish Creek (Site; Figure 1).

This report summarizes the results of the completed field explorations and presents Aspect's geotechnical engineering conclusions and recommendations for the Project.

1.1 Scope of Services and Authorization

Our scope of work included reviewing readily available geologic mapping near the Site, excavating and sampling test pits, performing laboratory testing, completing geotechnical engineering analyses, and preparing this report. Our work was completed in general accordance with our subconsultant agreement with Inter-Fluve, Inc. (Inter-Fluve), authorized on December 9, 2016.

1.2 Project Description

The Project includes the restoration of 1 mile of Toppenish Creek and its floodplain at and near the existing 3-Way diversion and levee on Yakima County Parcel Nos. 16102499990, 16102599990, and 16102511001. Our understanding of the Project was developed through collaborative discussions with Inter-Fluve and Yakama Nation Fisheries staff and through our review of the Project design report and plans (Inter-Fluve, 2017; Inter-Fluve, 2018).

The primary objectives of the restoration Project are to improve geomorphic, hydrologic, and ecological conditions. A secondary Project objective is to increase groundwater recharge across the portions of the alluvial fan north of the Project area. A requirement of the Project is that the restoration activities do not increase flood risks or hazards to the existing surrounding infrastructure and properties. The proposed restoration elements of the Project include:

- Levee Removal
- Diversion Removal
- Floodplain Grading and Revegetation
- New Channel Meander Construction
- Fill Existing Mainstem Channel Segments
- Backwater Alcove Development
- Large Wood Structures and Slash Installation
- Setback Levee Construction

This geotechnical report is focused on the levee removal, setback levee construction, and general construction considerations for the Project. For flood protection and levee design, the Project design flood event is the 100-year flood event with an estimated peak discharge within the creek of 4,519 cubic feet per second (cfs) at the Olney Diversion gage (USGS 12506000) located approximately 2 miles upstream of the Project area. We understand the hydraulic modeling of the Project area simulating the constructed restoration elements indicate that for the 100-year flood event, flood flows are not predicted to leave the creek channel and immediate area.

The existing levee is present along the left bank of the creek from about river mile (RM) 42.7 to 43.0 and will be removed down to the 2-year flood elevation. Although flood flows are not predicted to leave the creek channel, based on guidance from Inter-Fluve, we understand a setback levee is proposed along the left bank of the creek between RM 42.5 and 42.7, setback approximately 180 feet from the creek thalweg. The setback levee may be up to 5-feet tall (above the existing grade of the floodplain) and is required to maintain 2-feet of freeboard above the 100-year flood event. We understand that seepage beneath and through the proposed setback levee prism is acceptable provided the levee is stable under seepage conditions. The proposed grading associated with the Project, including removal of the existing levee embankment and excavations for the new creek channel and alcove, will generate an abundance of material derived from on-Site excavations. A Project objective is to reuse this material generated on-Site for fill, setback levee embankment, and habitat features.

2 Site Conditions

2.1 Geologic Setting

The Site is located approximately 3.5 miles southwest of White Swan on the Yakama Indian Reservation in the Toppenish Basin. The available geologic mapping (Walsh, 1986; DNR, 2017) indicates the Site is underlain by Quaternary Alluvium (Qal) deposits of silt, sand, and gravel. The deposits are largely confined to valley bottoms and locally include lacustrine, paludal, and eolian deposits in depressions. Underlying the alluvium at the Site are flood basalt layers of the Simcoe Mountain Basalts as well as other sub-groups of the Columbia River Basalt Group's (CRBG) Grand Ronde Basalt. The Grand Ronde Basalt is described as Miocene-aged blue-black, dense, and finely crystalline rock that weathers light brown to yellowish brown. Locally, the basalt can be weathered and mantled by reddish brown residual soil that has been formed by the decomposition of the basalt into rock fragments suspended in a silt and clay matrix.

From the results of our explorations and field observations, the soils near the ground surface at the Site are composed of Quaternary Alluvium. The alluvium consists of primarily of sandy gravel with various amounts of silt, cobbles, and boulders.

2.2 Surface Conditions

The Site is undeveloped and stretches 1 mile along the left bank of Upper Toppenish Creek, approximately 8 miles downstream from steeper headwaters where the creek reaches the Toppenish Basin. The Site is bounded by two ridges formed by east-west anticlines: the Ahtanum Ridge to the north and the Toppenish Ridge to the south. The normal and thrust faults composing the two ridges influence eastward channel flow of the creek (Inter-Fluve, 2014).

The downstream end of the Project is delineated by the Wesley Road Bridge. The upstream end of the Project is at approximately RM 43.1, at the boundary between Yakama Nation land and adjacent private property.

Generally, the moderately vegetated topography of the Site slopes from west to east with approximately 20 feet of vertical relief across the Site. Riparian vegetation exists along the banks of the creek and includes moderate deciduous tree cover. Moderate to large trees, various shrubbery, and short grasses exist throughout the Site.

The existing creek channel is constricted by a basalt outcrop and hillside along the right bank and by an earthen levee along the left bank. This constriction has simplified channel complexity, reduced floodplain connectivity, and created incised conditions (Inter-Fluve, 2017).

An approximately 10-foot-tall earthen levee, a concrete diversion structure, and four riprap barbs exist on the Site along the left bank of the creek. The levee, created through the placement of fill, extends within the Project Area approximately 0.3 miles along the creek from RM 42.7 to 43.0, but is discontinuous due to lateral channel migration in isolated areas. The existing concrete diversion structure is at the hydrographic apex of the

Toppenish Creek Alluvial Fan and historically served to split the water into three directions: down the Toppenish Creek channel, into one of the alluvial fan distribution channels heading north, and into the Olney-Kleparty irrigation ditch heading east (Reichmuth et al., 2007). Channel incision within the creek has rendered the diversion structure non-functional for many years. The four riprap barbs are composed of angular boulders.

The existing Site topography and select features are shown on Figure 2, Site Exploration Map.

2.3 Subsurface Conditions

2.3.1 Subsurface Explorations

We completed eight test pit excavations at the Site. The test pit excavations were completed to depths ranging from 6 to 16 feet below the ground surface (bgs). The locations of the completed explorations are shown on Figure 2.

Detailed descriptions of the subsurface conditions encountered in our explorations, as well as the depths where characteristics of the soils changed, are indicated on the exploration logs presented in Appendix A. The depths indicated on the logs where conditions changed may represent gradational variations between soil types. Field exploration methods for the explorations are also included in Appendix A.

2.3.2 Laboratory Testing

Laboratory tests were conducted on selected soil samples to characterize certain engineering (physical) properties of the soils at the Site. Laboratory testing included determination of fines content, grain-size distribution, and compaction characteristics (proctor). The laboratory tests were conducted in general accordance with appropriate ASTM International (ASTM) test methods. Test procedures are discussed in more detail in Appendix B of this report.

2.3.3 Stratigraphy

From our review of Site surface and subsurface conditions, the primary near-surface geologic unit at the Site is Quaternary Alluvium, which underlays a 4- to 9-inch-thick layer of topsoil. The two principal engineering/geologic units encountered in our Site explorations are fill (within the existing levee embankment) and alluvium. A description of the general characteristics of each unit follows.

Fill

We encountered fill beneath the topsoil in exploration TP-3, located on landside of the existing levee embankment. We inferred the fill was associated with elevating the existing levee to approximately 6 feet above ground surface to a total height of approximately 10 feet above the adjacent floodplain. The fill extended from the top of the levee to approximately 6 feet below the top of the levee and primarily consisted of medium dense, slightly moist to moist, light brown to brown, GRAVEL with sand (GP) [1]; fine sand; coarse subrounded gravel; trace cobbles and trace fine roots.

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[1] Soils classified in accordance with the Unified Soil Classification System (USCS), ASTM D2488.

The levee fill exhibits moderate shear strength characteristics, low compressibility, moderate to high permeability, and low moisture sensitivity characteristics due to the lack of fines (soil particles passing the No. 200 sieve).

Alluvium

We encountered alluvium deposits beneath the topsoil in all explorations except for TP-3 where we encountered the alluvium underlying the levee embankment fill. The alluvium extended to depths as deep as 16 feet bgs (the maximum reach of our test pit excavations). The alluvium typically consisted of medium dense, moist, light brown to dark brown, GRAVEL with sand and varying amounts of silt. The USCS designations for the alluvium we encountered in our explorations are GM, GP-GM, and GP. Trace roots up to 0.5-inch diameter, scattered cobbles, and boulders up to 3-foot diameter were present at various depths throughout the alluvium. The alluvium exhibited slight increases in moisture and grain size with depth. We did not observe distinct bedding planes or patterns; the alluvium was typically relatively homogeneous. The lower portions of the deeper explorations were typically very moist to wet (saturated) due to groundwater.

The alluvium deposits exhibit moderate shear strength, low compressibility, high permeability, and low to moderate moisture sensitivity characteristics due to the relatively low percentage of fines.

2.3.4 Hydrogeologic Conditions

At the time of our explorations (April 2018), we encountered groundwater in our deeper explorations at relatively shallow depths ranging from 8 to 15 feet bgs. The alluvium typically increased in moisture content with depth before becoming saturated. Based on visual observations correlating the depth of the groundwater encountered in our explorations with the water levels in the creek, the groundwater within the Project area can be expected to be in hydraulic continuity with the creek and will typically fluctuate with and mirror the creek water levels.

Groundwater levels will vary based on precipitation patterns and Site/near Site usage and may temporarily approach the ground surface during/following periods of heavy precipitation and flood conditions within the creek.

3 Conclusions and Recommendations

Geotechnical evaluations and considerations for the Project include:

- Seepage Evaluations
- Slope Stability Evaluations
- Settlement Evaluations
- Levee Construction and Earthwork Considerations

We utilized guidance from the U.S. Army Corps of Engineers (USACE) for our levee-related evaluations and recommendations. The following sections present the results of the evaluations and geotechnical engineering conclusions and recommendations in support of the Project design.

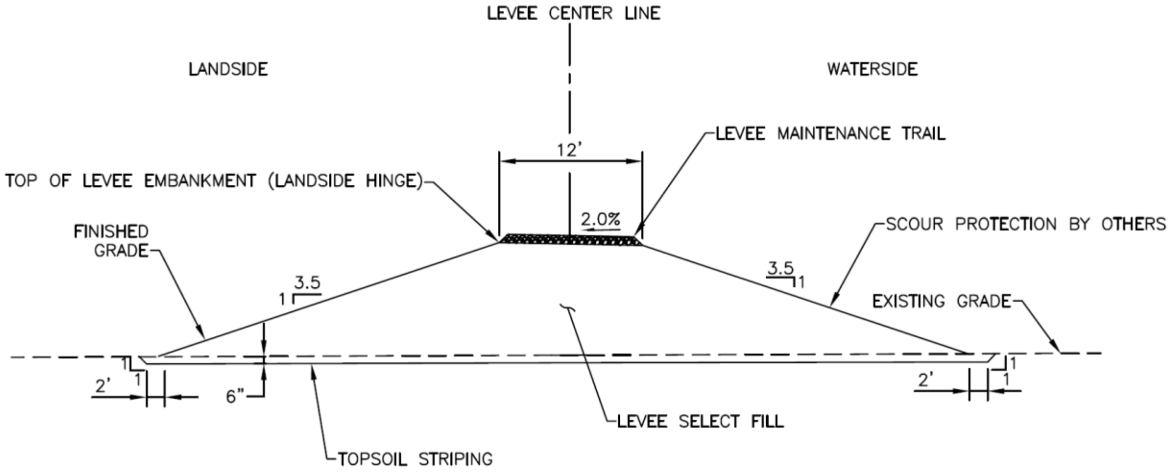
3.1 Typical Setback Levee Section

The recommended typical levee section is based on guidance from:

- USACE EM 1110-2-1913, dated April 30, 2000
- USACE ETL 1110-2-569, dated May 1, 2005
- Collaboration with Inter-Fluve

We recommend a crown width of the levee embankment of 12 feet with crushed rock surfacing for maintenance vehicle access. The levee crown should have a cross slope of 2 percent in the landward direction to avoid water ponding on the embankment material at the levee crown. The levee embankment should have side slopes of 3.5H:1V (horizontal to vertical) or flatter.

We recommend the levee embankment be uniform and consist of the same material type throughout. We anticipate the preferred levee material will consist of alluvium derived from on-Site excavations. We recommend the levee fill consist of levee select fill defined below in Section 4.3.1. The maintenance trail atop the levee crown should be a minimum of 6-inches thick and consist of crushed rock. The recommended typical setback levee section is shown below on the inset figure.



Recommended Typical Setback Levee Section (NTS)

The ground surface along the setback levee alignment should be cleared and grubbed to remove objectionable above ground material and obstructions, such as vegetation, structures and debris. The levee subgrade should then be stripped to an appropriate depth to remove the primary rooted zone, organic topsoil and other objectionable material.

3.2 Soil and Hydrogeologic Properties for Analysis

Soil engineering and hydrogeologic properties were developed based on the results of the completed subsurface explorations, lab testing results, empirical formulas for estimating hydraulic conductivity, back calculations of existing conditions, literature review, and our experience with the local geology.

For levee embankment materials, we assumed a uniform levee embankment consisting of alluvium derived from on-Site excavations. To account for the range and variability of the material, we also varied the engineering properties used in our analyses for sensitivity scenarios and to help verify the assumed engineering properties.

Specific references utilized in the development of the soil engineering and hydrogeologic properties include the Washington State Department of Transportation (WSDOT) Geotechnical Design Manual (GDM; WSDOT, 2015), the Navy Facilities Engineering Command (NAVFAC) Design Manual 7.1 (NAVFAC, 1986), Hazen’s Correlation for Hydraulic Conductivity (Hazen, 1911), and Holtz and Kovacs (1981).

Due to the observed uniformity of the alluvium and the lack of bedding planes and patterns, we have assumed the hydraulic conductivity of the material will be equal in the horizontal and vertical directions.

The soil engineering properties used in our analyses are shown in Table 1 below.

Table 1. Soil Engineering Properties

Engineering Unit	Hydraulic Conductivity (cm/s)[1]	Unit Weight (pcf)[1]	Saturated Unit Weight (pcf)	Strength Parameters	
				Friction Angle (deg)[1]	Cohesion (psf)[1]
Alluvium	1.4	120	125	34	0
Levee Select Fill[2]	0.1	125	130	36	0

Notes:

1) cm/s = centimeters per second; pcf = pounds per cubic foot; psf = pounds per square foot; and deg = degrees
2) Levee fill placed for setback levee embankment in accordance with the fill and compaction construction recommendations contained herein.

3.3 Setback Levee Analysis Section and Geometry

Based on guidance provided by Inter-Fluve, we analyzed a critical section consisting of the typical levee section described in Section 3.1 with a maximum height of 5 feet above the existing floodplain. We utilized the topography perpendicular to the left bank of the creek at approximately RM 42.7 based on the Project design plans (Inter-Fluve, 2018). We assumed a water surface elevation (WSE) 2 feet below the top of the levee resulting in a minimum of 2 feet of freeboard. We did not assume any significant scour within the creek channel or potential channel migration towards the toe of the setback levee. We recommend scour protection along the waterside of the setback levee embankment.

3.3.1 Levee Seismic Design Criteria

The U.S. Geological Survey (USGS) National Seismic Hazard Map data (USGS, 2014) indicates the peak ground acceleration (PGA) associated with the 100-year recurrence-interval earthquake in the Project area is approximately 0.04g (where g is the acceleration of gravity). Based on guidance provided by EC 1110-2-6067 (USACE, 2010), if the PGA is less than 0.10g for the 100-year recurrence-interval earthquake, seismic evaluation of the levee flood control system is not required.

3.4 Seepage Analysis

The seepage analysis was performed assuming steady-state conditions and using the finite element analysis groundwater module within the computer program SLIDE (Rocscience, 2017). The seepage analysis model was constructed with a constant head boundary on the water side of the setback levee equal to the assumed WSE, a no flow boundary along the bottom edge of the model, potential seepage surfaces along the landside ground surface of the levee embankment, and a constant head boundary equal to the ground surface elevation along the landside edge of the model. To reduce the potential for numerical errors due to boundary effects, the seepage model was extended 2,000 feet landward from the creek thalweg.

Through iterative calculations of successive finite element runs, the groundwater analysis module computes the pressure head throughout the model and determines flow directions, gradients, and seepage potential.

3.4.1 Seepage Analysis Results

A graphical output of the seepage analysis results is included in Appendix C. Our analysis results show a maximum exit/uplift gradient of 0.22 (dimensionless) near the ground surface on the landside toe of the setback levee which is less than the 0.50 (dimensionless) criteria suggested by USACE ETL 1110-2-569. Due to the coarse-grained nature of the existing alluvium and proposed setback levee embankment, through seepage and underseepage should be expected during a flood event that results in a WSE above the floodplain. If through seepage and underseepage are not desired, seepage mitigation measures such as seepage berms or subsurface cutoff walls should be considered.

The results of our subsurface explorations indicate the alluvium underlying the setback levee alignment is relatively uniform; however, past flood activities and the construction of flood control and scour mitigation measures create the potential for variability of the near-surface soils and the potential for lenses of relatively higher-permeability coarse-grained soil. These lenses are unpredictable and not readily captured by the individual subsurface explorations completed for this study; therefore, they are not incorporated into the seepage analyses other than an overall conservative formulation of the permeability of the near-surface soils.

3.5 Slope Stability Analyses

Slope stability analyses for the Project were conducted using the computer model SLIDE, which uses 2-D limit equilibrium methods to analyze slope stability. The SLIDE program performs slope stability computations based on the modeled cross-section conditions and calculates a factor of safety (FS) against slope failure, which is defined as the ratio of the resisting forces to the driving forces acting on a soil mass. A FS of one indicates a “just-stable” condition, and a FS less than one would indicate unstable conditions. Spencer’s analysis method was used as the primary analysis in SLIDE as it satisfies both moment and force equilibrium criteria for the potential sliding soil mass.

Failure surfaces were generated and analyzed using a dense, grid-search method and automatic search function within SLIDE that identifies and computes the lowest FS corresponding to the critical failure surface for the given cross section and analysis condition. The failure surfaces generated include both circular failure surfaces and composite surfaces (combination circular and block). The entry (start) location of the failure surfaces was limited to landward of the waterside toe of the setback levee prism and only significant failure surfaces, at least 3 feet thick, were considered. In the context of the Project, shallow failure surfaces that are less than 3 feet thick are considered maintenance issues and not a true slope failure.

We evaluated the static steady state stability case. This case occurs when flood levels remain at or near an assumed WSE long enough so that the levee embankment becomes saturated and a condition of steady-state seepage occurs. We evaluated the stability of both the landside and waterside of the setback levee embankment.

The steady state seepage condition and pore-water pressures were developed through the finite-element model and seepage analysis application within the SLIDE computer program for the assumed WSE.

3.5.1 Slope Stability Analyses Results

The results of the slope stability analyses are shown in Table 2, with graphical outputs included in Appendix C. The computed FS's exceed the minimum FS of 1.4 required by USACE EM 1110-2-1913 for the static (steady state) condition.

Table 2. Summary of Slope Stability Analysis Results

Analysis	Calculated Factor of Safety
Static (Steady State) Landside of Levee	2.0
Static (Steady State) Waterside of Levee	2.6

3.6 Settlement Analysis

Based on the results of our subsurface explorations, the Project area is underlain by relatively uniform, medium dense to dense, cohesionless sand and gravel alluvium that typically exhibits low compressibility characteristics. The setback levee embankment will be less than 5-feet tall. Relatively minor short-term elastic settlements are expected during the placement of fill for the setback levee embankment. Based on the geometry of the typical levee section and an estimated surcharge pressure of 625 psf or less, we estimate the elastic settlement associated with the setback levee will be less than 1 to 2 inches. We anticipate most of the settlement will occur as the load is applied during levee construction. Provided the setback levee subgrade is cleared and grubbed to remove unsuitable foundation material and organics, it is our opinion that settlement and compressible soils are not a significant Project design consideration.

4 Construction Considerations

4.1 Earthwork

Based on the subsurface exploration data across the Project area and our understanding of the Project, it is our opinion that the Contractor should be able to complete planned excavations and earthwork activity with relatively standard construction equipment. We did encounter oversized materials in some of the completed explorations, including cobbles and boulders within the existing levee fill and alluvium. Although not encountered in the explorations, regional experience indicates that other oversized materials such as stumps and logs could be present within the alluvium.

Shallow groundwater conditions should be expected within the lower portions of the proposed excavations during the dry season, and shallow groundwater may be present near the ground surface during the wet season. The Contractor should anticipate wet excavations and soil conditions that may not support excavation equipment. We recommend maintaining working platforms for equipment a minimum of 2 feet above the groundwater level and strategically planning excavations to allow for elevated working platforms and access/haul routes. Other strategies for completing the wet excavations include:

- Using long-reach excavators and/or wide-tracked and low-pressure equipment.
- Leave the existing levee and/or creek bank material in place to act as a natural cofferdam and progress channel/habitat excavations landward from the creek.
- Use hog fuel, rock, and/or geosynthetics to create stabilized temporary access/haul roads and working pads.

4.1.1 Levee Earthwork

We estimate a typical stripping depth (rooted zone) of approximately 6 inches for the setback levee footprint. The stripping depth and overexcavation of unsuitable foundation soils, defined as organic rich and/or highly permeable soil when compared to the surrounding alluvium, may extend up to about 12 inches below the setback levee subgrade for limited portions of the levee alignment. Overexcavation, as needed, should occur within a footprint beneath the levee defined by a 1.5H:1V sloped prism centered under the levee crest, and not necessarily across the entire levee embankment footprint.

While our investigations indicate relatively uniform subgrade conditions along the setback levee alignment, it is standard practice recommended by USACE guidance to complete an inspection trench below the levee. An inspection trench is typically used to verify subgrade conditions, check for relic development features (utilities with highly permeable trench backfill, highly permeable scour mitigation elements like the existing rock barbs), and to confirm that adverse seepage conditions are not present beneath the levee. Given the uniformity of the observed subgrade conditions, we do not consider an inspection trench a requirement for the setback levee; however, if evidence of past soil disturbance, utilities, organic-rich zones, or preferential seepage paths is observed or otherwise known in the area of the setback levee, an inspection trench should be considered.

If used, the depth of the inspection trench should be 6 feet deep or equal to the height of the levee embankment, whichever is less. The inspection trench may be backfilled with excavated soil, provided the soil meets the requirements for levee select fill and can be placed back into the inspection trench to achieve compaction and permeability conditions equal to or better than the surrounding native soils.

4.2 Excavation

The Project will include excavations for removal of the existing levee, channel creation, preparing the setback levee footprint, habitat area creation, the removal of the existing diversion structure, and the partial removal of the existing rock barbs. Saturated soil conditions and elevated soil moisture contents should be anticipated during wet weather periods and at lower elevations within the Project area. Further discussion of potential saturated excavation is included below.

4.2.1 Dry/Saturated Excavations

Excavation of “dry” soil would be desired as it is more cost-effective than excavating wet or saturated soil. We assume that mass excavation would occur during the summer season when creek and groundwater levels are at their lowest. Excavation would begin at or near the creek’s edge, and move landward, which would potentially lower the groundwater level to approximate the creek elevation, thereby maximizing the potential for dry excavation.

4.2.2 Temporary Excavation Slopes

Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the Contractor. All temporary cuts in excess of 4 feet in height that are not protected by trench boxes or otherwise shored, should be sloped in accordance with Part N of Washington Administrative Code (WAC) 296-155 (WAC, 2009).

In general, the near surface soils across the Project Area classify as OSHA Soil Classification Type B. Temporary excavation side slopes are anticipated to stand as steep as 1H:1V, up to a maximum height of 20 feet, within the fill and alluvium. The cut slope inclinations estimated above are for planning purposes only and are applicable to excavations without inflowing groundwater or stormwater.

With time and the presence of seepage and/or precipitation, the stability of temporary unsupported cut slopes can be significantly reduced. Therefore, all temporary slopes should be protected from erosion by installing a surface water diversion ditch or berm at the top of the slope. In addition, the Contractor should monitor the stability of the temporary cut slopes and adjust the construction schedule and slope inclination accordingly. Vibrations created by traffic and construction equipment may cause caving and raveling of the cut slopes. In such an event, the cut slopes should be flattened by the Contractor to prevent loss of ground support.

4.3 Fill Materials

Fill material may also be derived from on-site sources, such as reused material from portions of the planned creek channel and habitat excavations and removal of the existing levee. The soil derived from dry excavation activities for the Project are anticipated to be suitable for re-use on the Project, provided the soil meets the material requirements described below. Soil derived from saturated excavations are anticipated to be less suitable for use as fill on the Project and/or require moisture conditioning (drying) due to the elevated moisture content of these soils.

4.3.1 Setback Levee Embankment

We recommend the setback levee embankment be uniform and consist of the same material type throughout. The requirements for the levee materials are as follows.

Levee Select Fill

Levee select fill may be derived from the on-site excavations or imported, if needed. Levee select fill shall consist of relatively well-graded soil free of organic and deleterious material, and meet the USCS soil type classification of SM, SP-SM, SW-SM, SW, SP, GM, GP-GM, GW-GM, GP, or GW. The gradation of the material should have a maximum particle size of 3 inches.

Levee select fill should be compacted to at least 90 percent of its MDD as determined by ASTM D1557. The material shall be placed in horizontal lifts that do not exceed 12 inches in loose lift thickness.

4.3.2 Common Fill

Common fill may be derived from the on-Site excavations or imported, if needed, and will be used for backfilling the excavation for removing the existing diversion structure, infilling the existing creek channel, and for general fill within the floodplain. Common fill should consist of soil with 3 percent or less organics/deleterious materials and a maximum particle size of 6 inches, except for streambed materials or habitat applications where larger particle sizes are preferred or required. Common fill may consist of any soil type except for soils meeting the USCS soil type classification of OL, OH, CH, MH, or PT. Common fill should be compacted to about 85 percent of its MDD as determined by ASTM D1557. The material shall be placed in horizontal lifts that do not exceed 12 inches in loose lift thickness.

4.3.3 Crushed Surfacing Base Course

Crushed surfacing base course (CSBC) will be used for the maintenance trail atop the setback levee crown. The CSBS will need to be imported and should consist of material meeting the requirements for CSBC as outlined by Section 9-03.9(3) of the WSDOT Standard Specifications (WSDOT, 2018). The CSBC should be compacted to a minimum of 95 percent of its MDD as determined by ASTM D1557.

4.3.4 Compaction

The procedure to achieve the specified minimum relative compaction depends on the size and type of compacting equipment, the number of passes, thickness of the layer being compacted, and certain soil properties. When size of the excavation restricts the use of heavy equipment, smaller equipment can be used, but the soil must be placed in thin enough lifts to achieve the required compaction. A sufficient number of in-place density tests should be performed as the fill is placed to verify the required relative compaction is being achieved.

Generally, loosely compacted soils are a result of poor construction technique or improper moisture content. Soils with a high percentage of silt or clay are particularly susceptible to becoming too wet, and coarse-grained materials easily become too dry, for proper compaction. Silty or clayey soils with a moisture content too high for adequate compaction should be dried as necessary, or moisture conditioned by mixing with drier materials, or other methods.

Fill within the setback levee embankment should be placed in lifts with a maximum thickness of 12 inches (or less if needed to facilitate proper compaction) to help ensure consistent and uniform material placement and compaction.

4.4 Setback Levee Vegetation

We recommend vegetation management on the setback levee be planned and established in accordance with guidance from USACE ETL 1110-2-583 and the Seattle District Variance of 1995. The vegetation on and near the levee must not adversely affect the seepage- and stability-related performance of the levee. The levee crown should be left unvegetated for a gravel-surface maintenance access road. The sides slopes of the levee may be lightly vegetated with grasses and occasional woody vegetation with stems that are less than 4 inches in diameter at maturity. The vegetation on the levee side slopes must allow for regular visual inspection of the condition of the levee surface. The establishment of vegetation over scour protection (riprap) on the waterside of the levee will not be possible at the time of construction.

5 Additional Services

If project developments result in changes to the assumptions made herein, we should be contacted to determine if our recommendations should be revised.

During construction, we are available to provide continuing geotechnical consultation, field monitoring, and materials testing services as required. The integrity of the constructed product depends on proper Site preparation and construction procedures. In addition, engineering decisions may have to be made in the field in the event that variations in subsurface conditions become apparent.

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7 Limitations

Work for this project was performed for Inter-Fluve, Inc (Client), and this report was prepared consistent with recognized standards of professionals in the same locality and involving similar conditions, at the time the work was performed. No other warranty, expressed or implied, is made by Aspect Consulting, LLC (Aspect).

Recommendations presented herein are based on our interpretation of site conditions, geotechnical engineering calculations, and judgment in accordance with our mutually agreed-upon scope of work. Our recommendations are unique and specific to the project, site, and Client. Application of this report for any purpose other than the project should be done only after consultation with Aspect.

Variations may exist between the soil and groundwater conditions reported and those actually underlying the site. The nature and extent of such soil variations may change over time and may not be evident before construction begins. If any soil conditions are encountered at the site that are different from those described in this report, Aspect should be notified immediately to review the applicability of our recommendations.

Risks are inherent with any site involving slopes and no recommendations, geologic analysis, or engineering design can assure slope stability. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the client.

It is the Client's responsibility to see that all parties to this project, including the designer, contractor, subcontractors, and agents, are made aware of this report in its entirety. At the time of this report, design plans and construction methods have not been finalized, and the recommendations presented herein are based on preliminary project information. If project developments result in changes from the preliminary project information, Aspect should be contacted to determine if our recommendations contained in this report should be revised and/or expanded upon.

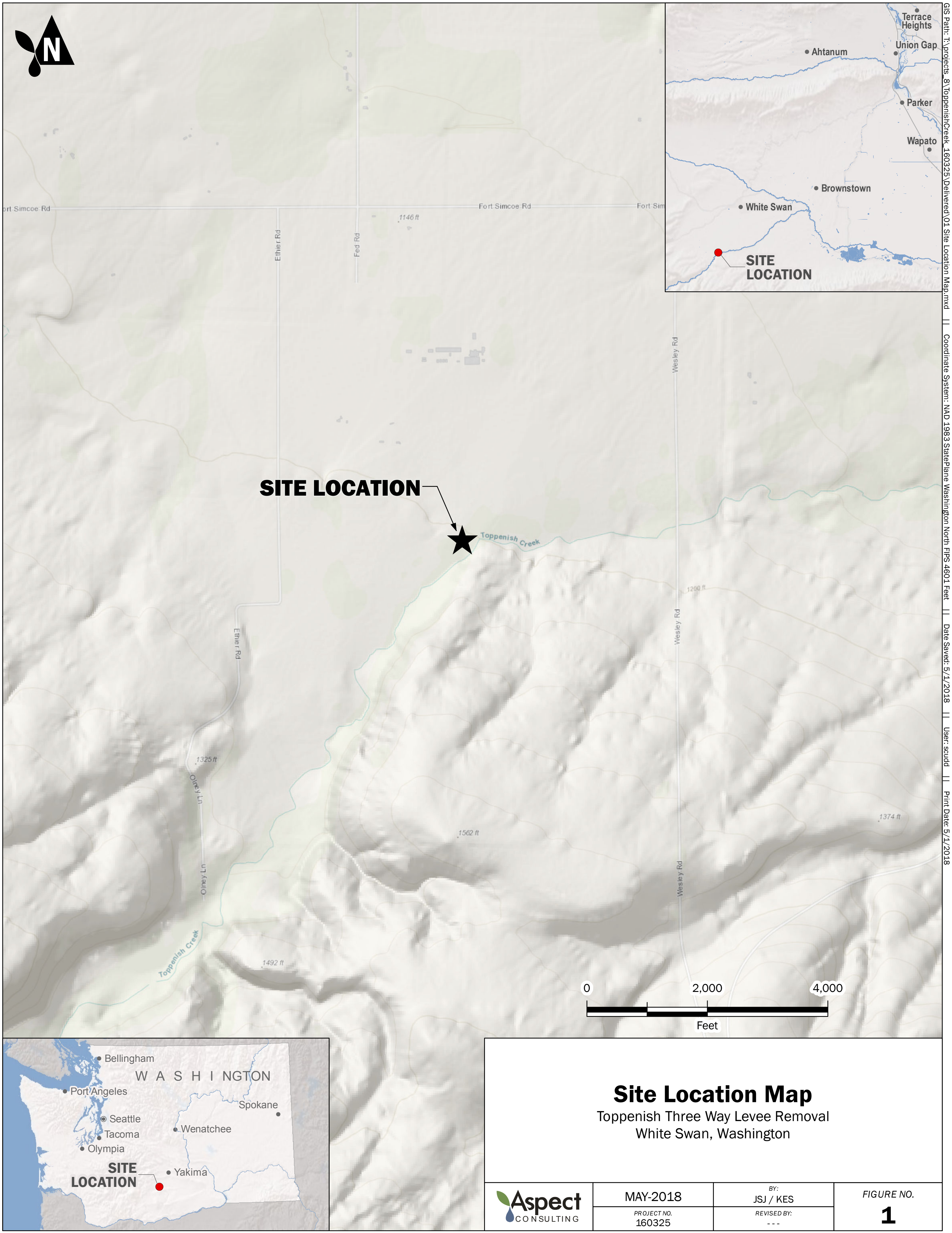
The scope of work does not include services related to construction safety precautions. Site safety is typically the responsibility of the contractor, and our recommendations are not intended to direct the contractor's site safety methods, techniques, sequences, or procedures. The scope of our work also does not include the assessment of environmental characteristics, particularly those involving potentially hazardous substances in soil or groundwater.

All reports prepared by Aspect for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect. Aspect's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

Please refer to Appendix D titled "Report Limitations and Guidelines for Use" for additional information governing the use of this report.

We appreciate the opportunity to perform these services. If you have any questions please call Andrew Holmson, Associate Geotechnical Engineer at (971) 865-5894.

FIGURES



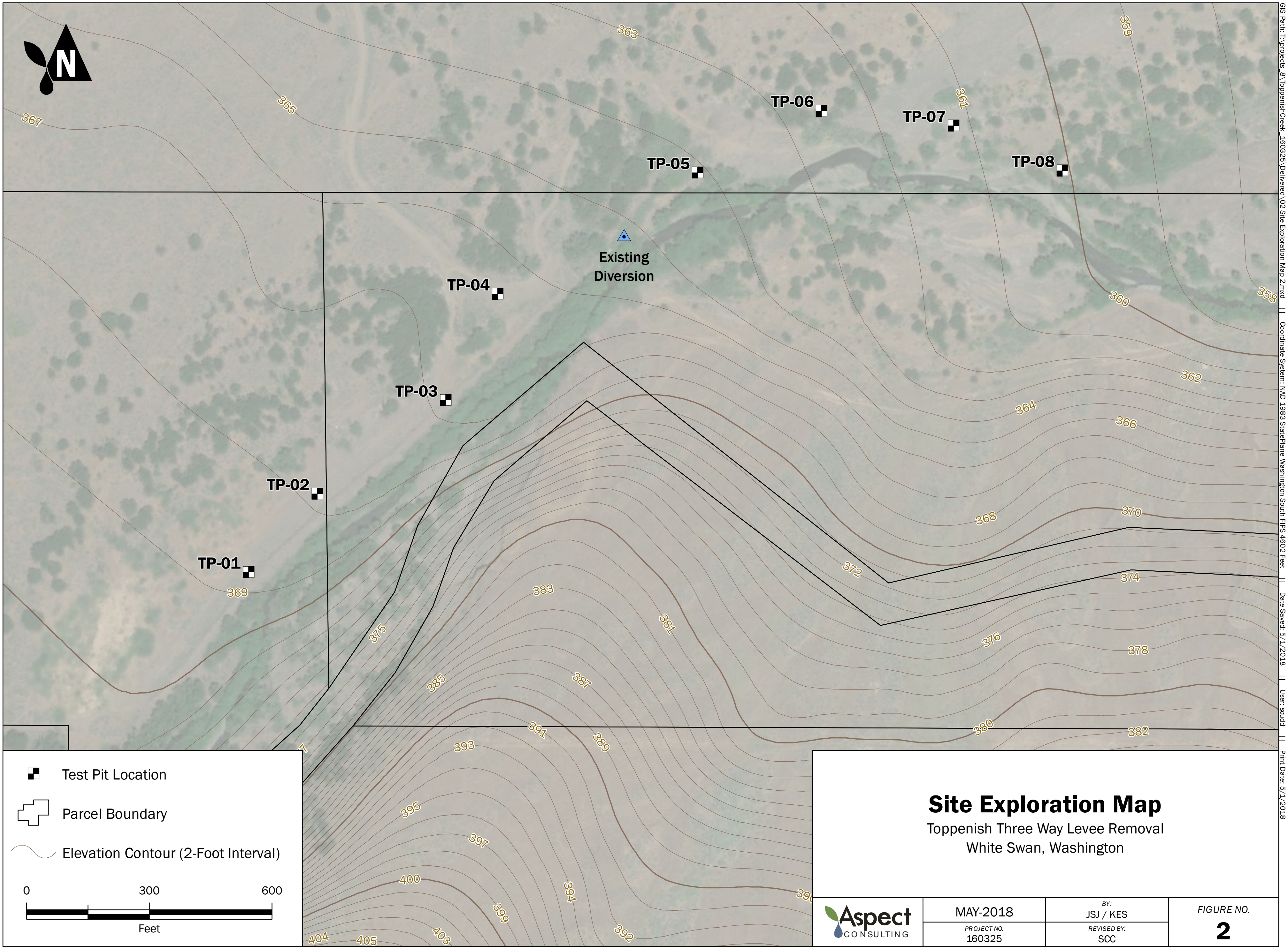
Site Location Map

Toppenish Three Way Levee Removal
White Swan, Washington

Aspect CONSULTING	MAY-2018	BY: JSJ / KES	FIGURE NO.
	PROJECT NO. 160325	REVISED BY: - - -	1

GIS Path: T:\projects_8\ToppenishCreek_160325\Delivered\01 Site Location Map.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 5/1/2018 || User: scudd || Print Date: 5/1/2018

Basemap Layer Credits || Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community



Site Exploration Map

Toppenish Three Way Levee Removal
White Swan, Washington

Aspect CONSULTING

MAY-2018	BY: JSJ / KES	FIGURE NO. **2**	
PROJECT NO. 160325	REVISED BY: SCC		

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

GIS Path: T:\projects_8\ToppenishCreek_160325\Delivered\02 Site Exploration Map 2.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 5/1/2018 || User: scudd || Print Date: 5/1/2018

APPENDIX A

Subsurface Explorations

A. Field Exploration Program

A.1. Test Pits

Test pits TP-1 through TP-8 were excavated under our direction using a Case CX210B trackhoe with a 3-foot-wide toothed bucket operated by TMS Native Construction under subcontract to Aspect. The test pit locations are shown on Figure 2.

Samples were obtained from select soil units for laboratory testing to aid in the determination of subsurface engineering properties for potential material reuse. The relative density/consistency of the soils was evaluated qualitatively with a 0.5-inch-diameter steel t-probe and observation of digging difficulty.

Detailed descriptions of the subsurface conditions encountered in our explorations, as well as the depths where characteristics of the soils changed, are indicated on the soil test pit logs presented in Appendix A. The depths indicated on the log where conditions changed may represent gradational variations between soil types. Soils were classified in general accordance with the ASTM D2488, *Standard Practice for Description and Identification of Soils (Visual and Manual Procedure).* A key to the symbols and terms used on the logs is provided on Figure A-1.

Coarse-Grained Soils - More than 50% (1) Retained on No. 200 Sieve	Gravels - More than 50% (1) of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines (5)	▨	GW	Well-graded gravel and gravel with sand, little to no fines
			▨	GP	Poorly-graded gravel and gravel with sand, little to no fines
		≥15% Fines (5)	▨	GM	Silty gravel and silty gravel with sand
			▨	GC	Clayey gravel and clayey gravel with sand
	Sands - 50% (1) or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines (5)	▨	SW	Well-graded sand and sand with gravel, little to no fines
			▨	SP	Poorly-graded sand and sand with gravel, little to no fines
		≥15% Fines (5)	▨	SM	Silty sand and silty sand with gravel
			▨	SC	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50% (1) or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50		▨	ML	Silt, sandy silt, gravelly silt, silt with sand or gravel
			▨	CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			▨	OL	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		▨	MH	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			▨	CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			▨	OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils			▨	PT	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT (2) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
	Consistency	**SPT (2) blows/foot**
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

FC = Fines Content
G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Consolidation
DD = Dry Density
K = Permeability
Str = Shear Strength
Env = Environmental
PiD = Photoionization Detector

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

(3) Estimated Percentage

Percentage by Weight	Modifier
<5	Trace
5 to 15	Slightly (sandy, silty, clayey, gravelly)
15 to 30	Sandy, silty, clayey, gravelly)
30 to 49	Very (sandy, silty, clayey, gravelly)

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch

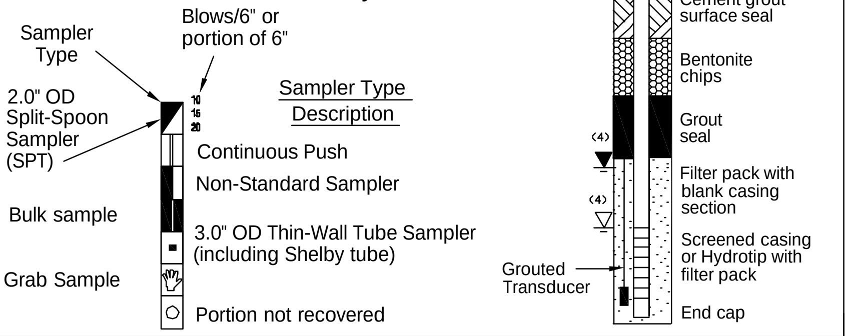
Slightly Moist - Perceptible moisture

Moist - Damp but no visible water

Very Moist - Water visible but not free draining

Wet - Visible free water, usually from below water table

Symbols



(1) Percentage by dry weight

(2) (SPT) Standard Penetration Test (ASTM D-1586)

(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

(4) Depth of groundwater ▽ ATD = At time of drilling ▼ Static water level (date)

(5) Combined USCS symbols used for fines between 5% and 15% as estimated in General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

BGS = below ground surface

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

Aspect CONSULTING

Exploration Log Key

DATE:
DESIGNED BY:
DRAWN BY:
REVISED BY:

PROJECT NO.

FIGURE NO.
A-1

Q:_ACAD Standards\Standard Details\Exploration Log Key A1.dwg

Aspect CONSULTING

Toppenish Three Way Levee Removal - 160325 Geotechnical Exploration Log

Project Address & Site Specific Location			*Coordinates (Lat,Lon WGS84)*	*Exploration Number*
500-1398 Ethier Rd, White Swan, WA 98952, North side of Toppenish Creek			46.32925, -120.77084 (est)	**TP-1**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	
TMS Native Construction	Case CX210B Excavator	Grab	1206'	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Kris	Trackhoe	4/4/2018	NA	15' (ATD)

Depth (feet)	Elev. (feet)	Exploration Completion and Notes	Sample Type/ID	Blows/foot ▲ Water Content (%) ● 0 10 20 30 40 50	Blows/6"	Tests	Description	Depth (ft)
		Test Pit backfilled with excavated soil and tamped into place with excavator bucket.					**TOPSOIL** SILTY GRAVEL (GM); medium dense, slightly moist, light brown; trace, poorly-graded gravel, abundant fine roots.	
	1205						**ALLUVIUM** SILTY GRAVEL (GM); medium dense, moist, dark brown; low pasticity; fine sand; coarse, subrounded gravel; trace, subrounded cobbles; trace fine roots.	
			🖐 S1			FC=5.7%	GRAVEL WITH SILT AND SAND (GP-GM); medium dense, moist, light brown to brown; fine sand; medium gravel; trace cobbles; trace boulders up to 1.25 ft. diameter; subtrace fine roots.	
5			🖐 S2			GS FC=5%	Becomes brown; fine to medium sand; trace cobbles; subtrace boulders below 5 ft. bgs.	5
	1200							
			🖐 S3					
10			🖐 S4			GS FC=4.6%	GRAVEL WITH SAND (GP); medium dense, very moist, brown; fine to coarse sand; coarse gravel; subtrace fine roots.	10
	1195							
15		∇ 4/4/2018	🖐 S5				GRAVEL WITH SILT AND SAND (GP-GM); medium dense, wet, brown; low plasticity; fine to coarse sand; coarse gravel; subtrace fine roots.	15
	1190						Bottom of exploration at 16 ft. bgs. Note: Moderate caving and sloughing of sidewalls below 2 ft.	

Legend

Plastic Limit ⊢—⊣ Liquid Limit

Sample Method: 🖐 Grab sample

Water Level: ∇ Water Level ATD

See Exploration Log Key for explanation of symbols

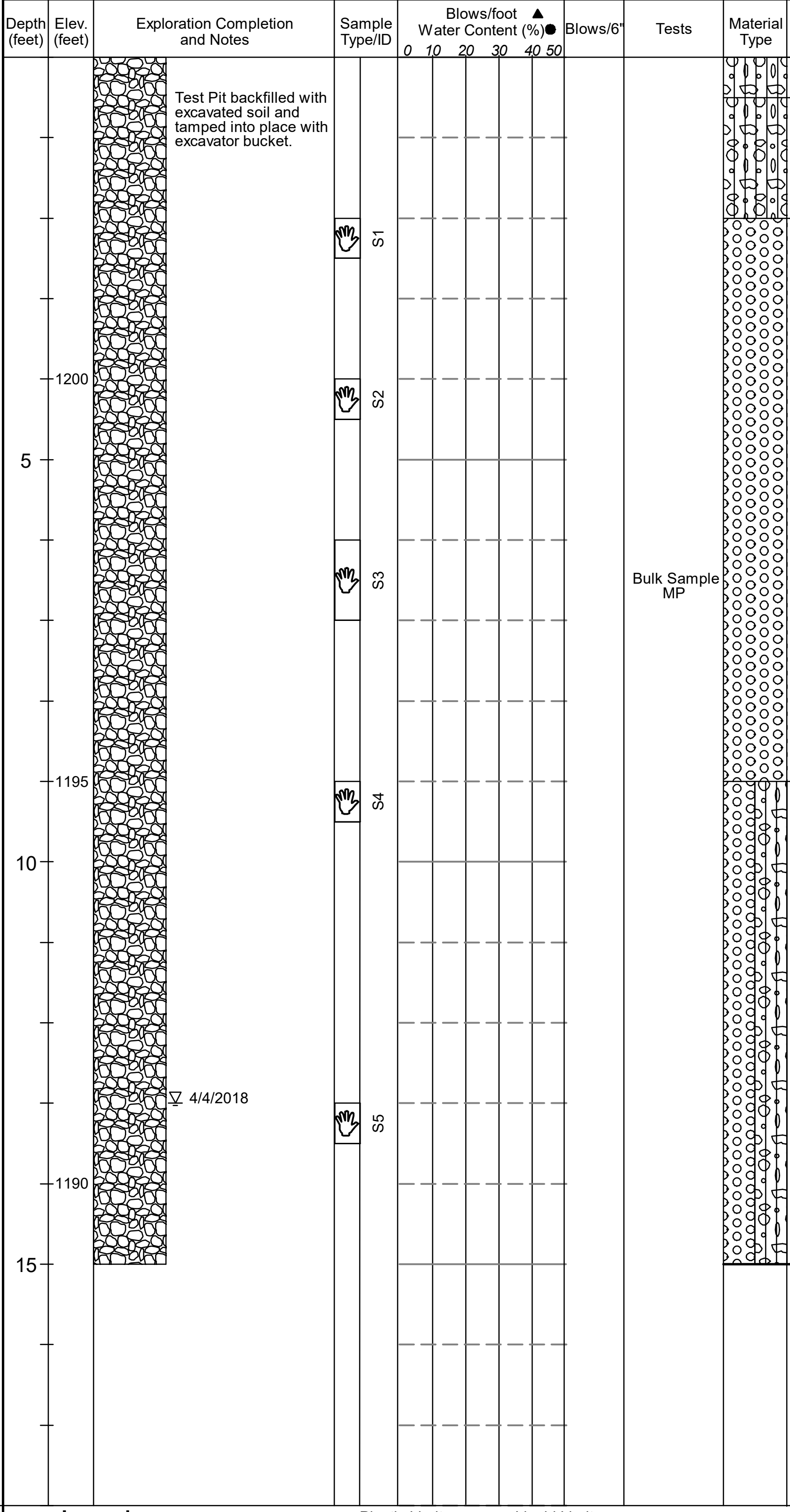
Logged by: JSJ
Approved by: AJH

Exploration Log TP-1

Sheet 1 of 1

Toppenish Three Way Levee Removal - 160325 Geotechnical Exploration Log

Project Address & Site Specific Location			*Coordinates (Lat,Lon WGS84)*	*Exploration Number*
500-1398 Ethier Rd, White Swan, WA 98952, North side of Toppenish Creek			46.32978, -120.77017 (est)	**TP-2**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	
TMS Native Construction	Case CX210B Excavator	Grab	1204'	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Kris	Trackhoe	4/4/2018	NA	13' (ATD)



TOPSOIL

SILTY GRAVEL (GM); medium dense, light brown, slightly moist; trace, poorly-graded gravel; abundant fine roots.

ALLUVIUM

SILTY GRAVEL (GM); medium dense, moist, brown to dark brown; low plasticity; fine sand; coarse, subrounded gravel; trace, subrounded cobbles; trace fine roots.

GRAVEL WITH SAND (GP); medium dense to dense, moist, brown; fine sand; coarse, subrounded gravel; trace, subrounded cobbles; trace boulders up to 1.25 ft. diameter; trace roots, up to 1/4 in. diameter.

Becomes moist to very moist with subtrace boulders below 8 ft. bgs.

GRAVEL WITH SILT AND SAND (GP-GM); medium dense, moist to very moist, brown; low plasticity; fine sand; coarse, subrounded gravel; trace, subrounded cobbles; trace boulders; trace fine roots.

Subtrace boulders up to 3 ft. diameter below 11 ft. bgs.

Becomes wet; subtrace fine roots below 13 ft. bgs.

Bottom of exploration at 15 ft. bgs.

Note: Moderate caving and sloughing of sidewalls below 2 ft.

Depth (ft): 5, 10, 15

Legend

Sample Method: ✋ Grab sample

Plastic Limit ├──┤ Liquid Limit

Water Level: ∇ Water Level ATD

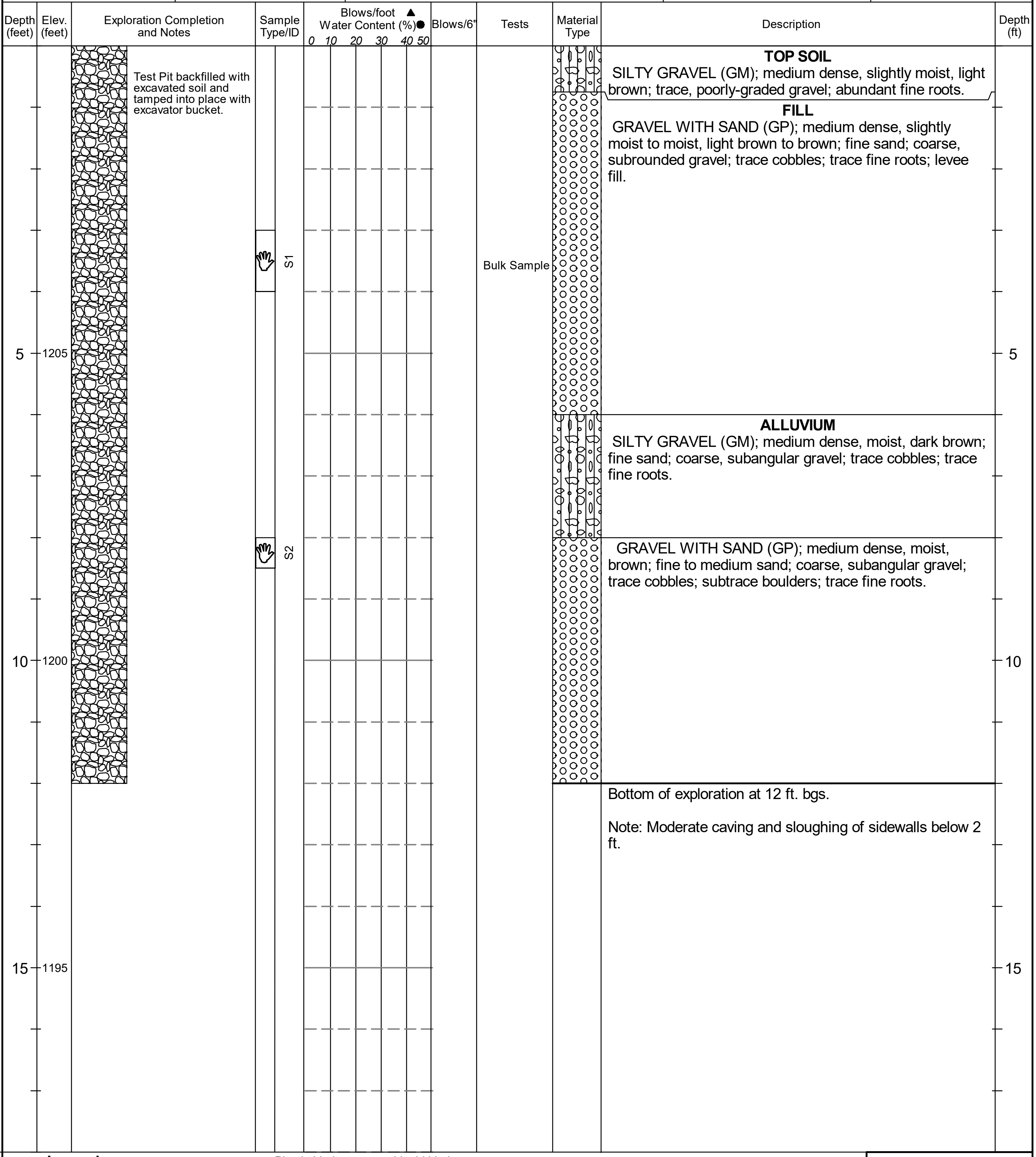
See Exploration Log Key for explanation of symbols

Logged by: JSJ
Approved by: AJH

Exploration Log
TP-2
Sheet 1 of 1

Toppenish Three Way Levee Removal - 160325 Geotechnical Exploration Log

Project Address & Site Specific Location			*Coordinates (Lat,Lon WGS84)*	*Exploration Number*
500-1398 Ethier Rd, White Swan, WA 98952, North side of Toppenish Creek, on the levee			46.33041, -120.76893 (est)	**TP-3**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	
TMS Native Construction	Case CX210B Excavator	Grab	1210'	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Chad	Trackhoe	4/4/2018	NA	No Water Encountered



Test Pit backfilled with excavated soil and tamped into place with excavator bucket.

TOP SOIL
SILTY GRAVEL (GM); medium dense, slightly moist, light brown; trace, poorly-graded gravel; abundant fine roots.

FILL
GRAVEL WITH SAND (GP); medium dense, slightly moist to moist, light brown to brown; fine sand; coarse, subrounded gravel; trace cobbles; trace fine roots; levee fill.

ALLUVIUM
SILTY GRAVEL (GM); medium dense, moist, dark brown; fine sand; coarse, subangular gravel; trace cobbles; trace fine roots.

GRAVEL WITH SAND (GP); medium dense, moist, brown; fine to medium sand; coarse, subangular gravel; trace cobbles; subtrace boulders; trace fine roots.

Bottom of exploration at 12 ft. bgs.

Note: Moderate caving and sloughing of sidewalls below 2 ft.

Legend

Sample Method: Grab sample

Plastic Limit ├──┤ Liquid Limit

Water Level: No Water Encountered

See Exploration Log Key for explanation of symbols

Logged by: JSJ
Approved by: AJH

Exploration Log TP-3

Sheet 1 of 1

Toppenish Three Way Levee Removal - 160325 Geotechnical Exploration Log

Project Address & Site Specific Location 500-1398 Ethier Rd, White Swan, WA 98952, North side of Toppenish Creek			*Coordinates (Lat,Lon WGS84)* 46.33112, -120.76843 (est)	*Exploration Number* **TP-4**
Contractor TMS Native Construction	*Equipment* Case CX210B Excavator	*Sampling Method* Grab	*Ground Surface (GS) Elev. (NAVD88)* 1200'	
Operator Chad	*Exploration Method(s)* Trackhoe	*Work Start/Completion Dates* 4/4/2018	*Top of Casing Elev. (NAVD88)* NA	*Depth to Water (Below GS)* 9' (ATD)

Depth (feet)	Elev. (feet)	Exploration Completion and Notes	Sample Type/ID	Blows/foot ▲ Water Content (%)● 0 10 20 30 40 50	Blows/6"	Tests	Description	Depth (ft)
		Test Pit backfilled with excavated soil and tamped into place with excavator bucket.					**TOPSOIL** SILTY GRAVEL (GM); medium dense, dry to slightly moist, light brown; trace, poorly-graded gravel; abundant fine roots.	
							ALLUVIUM SILTY GRAVEL (GM); medium dense, moist, dark brown; low pasticity; fine sand; coarse, subrounded gravel; trace cobbles; subtrace fine roots.	
							GRAVEL WITH SAND (GP); medium dense to dense, moist, light brown to brown; medium to coarse sand; coarse, subangular gravel; trace cobbles; trace fine roots.	
			✋ S1			GS FC=3.1%		
							Becomes very moist, with lenses of dark gray to black gravel, no roots from 3-5 ft. bgs.	
5	1195							5
							Becomes yellow brown to red brown from 5.5-7 ft. bgs.	
							GRAVEL WITH SILT AND SAND (GP-GM); medium dense to dense, wet, brown; low plasticity; medium to coarse sand; coarse, subangular gravel; trace cobbles; trace boulders up to 1.25 ft. diameter; subtrace fine roots.	
		∇ 4/4/2018						
							Bottom of exploration at 9.5 ft. bgs. Note: Moderate caving and sloughing of sidewalls below 2 ft.	
10	1190							10
15	1185							15

Legend

Sample Method: ✋ Grab sample

Plastic Limit ├──┤ Liquid Limit

Water Level: ∇ Water Level ATD

See Exploration Log Key for explanation of symbols

Logged by: JSJ
Approved by: AJH

Exploration Log
TP-4
Sheet 1 of 1

Toppenish Three Way Levee Removal - 160325 Geotechnical Exploration Log

Aspect CONSULTING

Project Address & Site Specific Location	Coordinates (Lat,Lon WGS84)	Exploration Number
500-1398 Ethier Rd, White Swan, WA 98952, North side of Toppenish Creek	46.33194, -120.76650 (est)	**TP-5**

Contractor	Equipment	Sampling Method	Ground Surface (GS) Elev. (NAVD88)
TMS Native Construction	Case CX210B Excavator	Grab	1198'

Operator	Exploration Method(s)	Work Start/Completion Dates	Top of Casing Elev. (NAVD88)	Depth to Water (Below GS)
Chad	Trackhoe	4/5/2018	NA	8' (ATD)

Depth (feet)	Elev. (feet)	Exploration Completion and Notes	Sample Type/ID	Blows/foot ▲ Water Content (%)● 0 10 20 30 40 50	Blows/6"	Tests	Material Type	Description	Depth (ft)
		Test Pit backfilled with excavated soil and tamped into place with excavator bucket.						**TOPSOIL** SILTY GRAVEL (GM); medium dense, moist, brown; trace, poorly-graded gravel; trace cobbles; abundant fine roots.	
								ALLUVIUM SILTY GRAVEL (GM); medium dense, moist, dark brown; low plasticity; fine sand; coarse, subrounded gravel; subtrace cobbles; trace fine roots.	
								GRAVEL WITH SAND (GP); medium dense, moist, brown; fine to medium sand; coarse, subrounded gravel; trace, subrounded cobbles; trace fine roots.	
	1195		✋ S1						
								Coarse sand; subtrace roots below 4 ft. bgs.	
5									5
			✋ S2			Bulk Sample MP		Trace subrounded to subangular boulders up to 2 ft. diameter; trace roots 1/2-1 in. diameter below 7 ft. bgs.	
	1190	∇ 4/5/2018							
			✋ S3						
10			✋ S4			GS FC=2.5%		Subtrace cobbles and boulders; subtrace roots up to 1/4 in. diameter below 10 ft. bgs.	10
								Bottom of exploration at 10.5 ft. bgs. Note: Moderate caving and sloughing of sidewalls below 2 ft.	
	1185								
15									15

Legend

Sample Method: ✋ Grab sample

Plastic Limit ├──┤ Liquid Limit

Water Level: ∇ Water Level ATD

See Exploration Log Key for explanation of symbols

Logged by: JSJ
Approved by: AJH

Exploration Log
TP-5
Sheet 1 of 1

Aspect CONSULTING

Toppenish Three Way Levee Removal - 160325 Geotechnical Exploration Log

Project Address & Site Specific Location			Coordinates (Lat,Lon WGS84)	Exploration Number
500-1398 Ethier Rd, White Swan, WA 98952, North side of Toppenish Creek			46.33236, -120.76530 (est)	**TP-6**
Contractor	Equipment	Sampling Method	Ground Surface (GS) Elev. (NAVD88)	
TMS Native Construction	Case CX210B Excavator	Grab	1192'	
Operator	Exploration Method(s)	Work Start/Completion Dates	Top of Casing Elev. (NAVD88)	Depth to Water (Below GS)
Chad	Trackhoe	4/5/2018	NA	No Water Encountered

Depth (feet)	Elev. (feet)	Exploration Completion and Notes	Sample Type/ID	Blows/foot ▲ Water Content (%)● 0 10 20 30 40 50	Blows/6"	Tests	Material Type	Description	Depth (ft)
		Test Pit backfilled with excavated soil and tamped into place with excavator bucket.						**TOPSOIL** SILTY GRAVEL (GM); medium dense, slightly moist, light brown; trace, poorly-graded gravel; abundant fine roots.	
								ALLUVIUM GRAVEL WITH SAND (GP); medium dense, moist, brown; fine to medium sand; coarse, subrounded gravel; trace cobbles; trace roots up to 1/2 in. diameter.	
	1190		🖐 S1						
			🖐 S2					Fine sand; pockets of very fine roots from 3.5-5.5 ft. bgs.	
5								Medium to coarse sand; medium to coarse gravel; subtrace cobbles; subtrace roots below 5.5 ft. bgs.	5
			🖐 S3					Observed 2.5 in. diameter root at 6 ft. bgs.	
								Bottom of exploration at 6 ft. bgs. Note: Moderate caving and sloughing of sidewalls below 2 ft.	
	1185								
10									10
	1180								
15									15
	1175								

Legend

Sample Method

🖐 Grab sample

Plastic Limit ├──┤ Liquid Limit

Water Level

No Water Encountered

See Exploration Log Key for explanation of symbols

Logged by: JSJ
Approved by: AJH

Exploration Log TP-6

Sheet 1 of 1

Toppenish Three Way Levee Removal - 160325 Geotechnical Exploration Log

Project Address & Site Specific Location 500-1398 Ethier Rd, White Swan, WA 98952, North side of Toppenish Creek			*Coordinates (Lat,Lon WGS84)* 46.33226, -120.76402 (est)	*Exploration Number* **TP-7**
Contractor TMS Native Construction	*Equipment* Case CX210B Excavator	*Sampling Method* Grab	*Ground Surface (GS) Elev. (NAVD88)* 1191'	
Operator Chad	*Exploration Method(s)* Trackhoe	*Work Start/Completion Dates* 4/5/2018	*Top of Casing Elev. (NAVD88)* NA	*Depth to Water (Below GS)* No Water Encountered

Depth (feet)	Elev. (feet)	Exploration Completion and Notes	Sample Type/ID	Blows/foot ▲ Water Content (%)● 0 10 20 30 40 50	Blows/6"	Tests	Description	Depth (ft)
		Test Pit backfilled with excavated soil and tamped into place with excavator bucket.					**TOPSOIL** SILTY GRAVEL (GM); loose to medium dense, slightly moist, light brown; fine to medium sand; trace, poorly-graded gravel; trace cobbles; abundant fine roots.	
	1190						**ALLUVIUM** GRAVEL WITH SAND (GP); medium dense, moist, light brown to brown; fine to medium sand; coarse, subrounded gravel; trace cobbles; trace boulders up to 1.5 ft. diameter; subtrace fine roots.	
			S1					
			S2			FC=1.8%	Becomes very moist; sand becomes coarse below 2.5 ft. bgs.	
							Subtrace boulders below 4 ft. bgs.	
5								5
			S3					
	1185						Bottom of exploration at 6 ft. bgs. Note: Moderate caving and sloughing of sidewalls below topsoil.	
10								10
	1180							
15								15
	1175							

Legend

Sample Method: 🖐 Grab sample

Plastic Limit ├──┤ Liquid Limit

Water Level: No Water Encountered

See Exploration Log Key for explanation of symbols

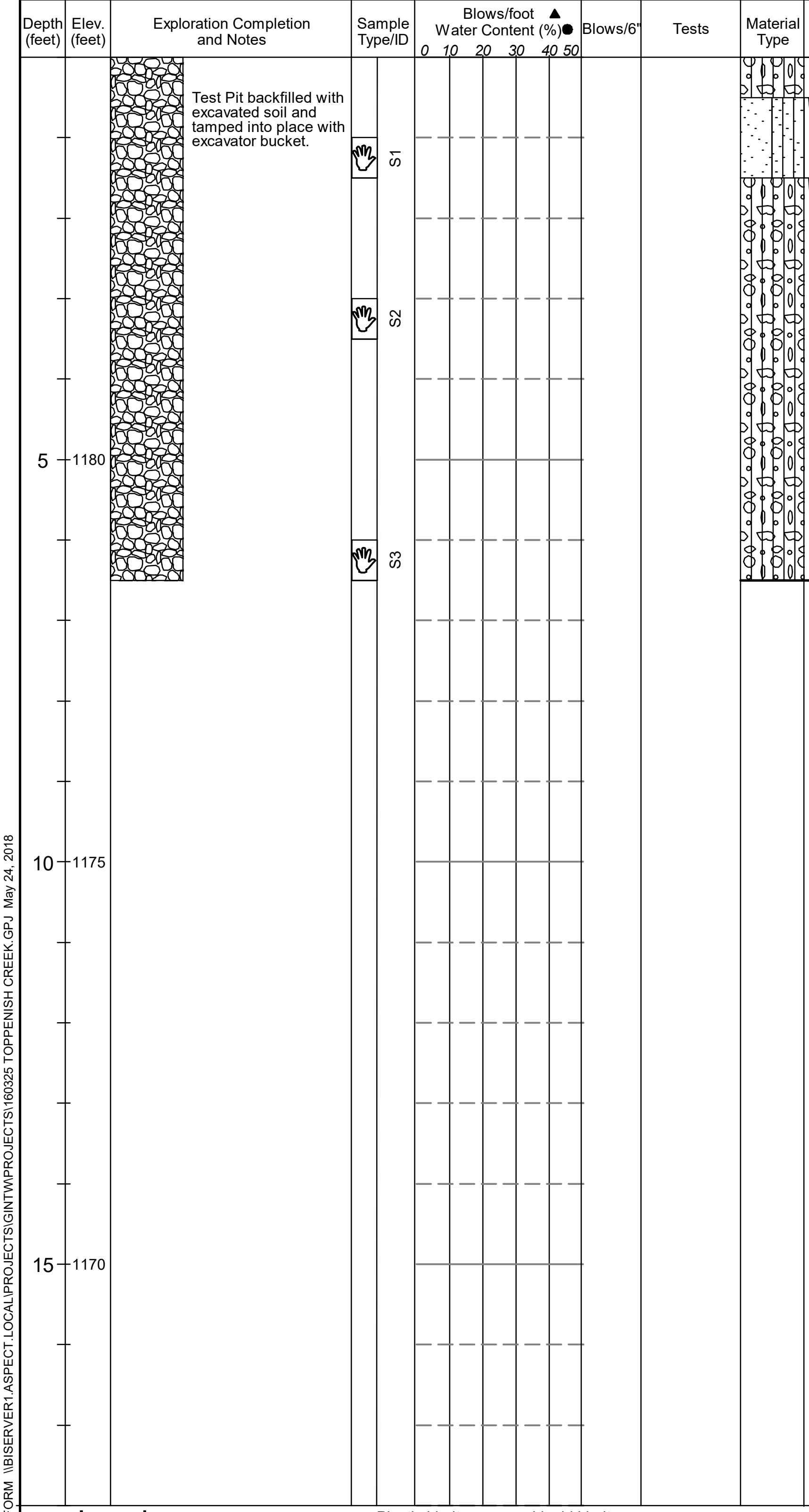
Logged by: JSJ
Approved by: AJH

Exploration Log TP-7

Sheet 1 of 1

Toppenish Three Way Levee Removal - 160325 Geotechnical Exploration Log

Aspect CONSULTING	*Project Address & Site Specific Location* 500-1398 Ethier Rd, White Swan, WA 98952, North side of Toppenish Creek		*Coordinates (Lat,Lon WGS84)* 46.33197, -120.76297 (est)	*Exploration Number* **TP-8**
Contractor TMS Native Construction	*Equipment* Case CX210B Excavator	*Sampling Method* Grab	*Ground Surface (GS) Elev. (NAVD88)* 1185'	
Operator Chad	*Exploration Method(s)* Trackhoe	*Work Start/Completion Dates* 4/5/2018	*Top of Casing Elev. (NAVD88)* NA	*Depth to Water (Below GS)* No Water Encountered



Test Pit backfilled with excavated soil and tamped into place with excavator bucket.

Depth (ft)	Description
	TOPSOIL SILTY GRAVEL (GM); medium dense, moist, brown; fine sand; trace coarse, poorly-graded gravel; abundant fine roots
	ALLUVIUM SAND WITH SILT (SP-SM); medium dense, moist, brown; low plasticity; fine sand; subtrace, fine gravel; trace fine roots.
	SILTY GRAVEL WITH SAND (GM); medium dense, brown to dark brown, moist; low plasticity; fine sand; coarse, subangular gravel; trace cobbles; subtrace fine roots.
5	Becomes dry with trace boulders up to 2 ft. diameter, below 5.5 ft. bgs.
	Bottom of exploration at 6.5 ft. bgs. Note: Moderate caving and sloughing of sidewalls below topsoil.
10	
15	

Legend

Sample Method: ☝ Grab sample

Plastic Limit ├─┤ Liquid Limit

Water Level: No Water Encountered

See Exploration Log Key for explanation of symbols

Logged by: JSJ
Approved by: AJH

Exploration Log
TP-8
Sheet 1 of 1

NEW STANDARD LOG FORM \\BISERVER1.ASPECT.LOCAL\PROJECTS\GINTW\PROJECTS\160325 TOPPENISH CREEK.GPJ May 24, 2018

APPENDIX B

Laboratory Test Results

B. Laboratory Test Methods

Laboratory tests were conducted on selected soil samples to characterize certain engineering (physical) properties of the soils at the Site. Laboratory testing included determination of fines content, grain-size distribution, and compaction characteristics (proctor) testing. The laboratory tests were conducted in general accordance with appropriate ASTM test methods. Test procedures are discussed below.

The fines content (percent passing No. 200 wash) was analyzed in general accordance with ASTM D1140. The grain size distribution of selected samples was analyzed in general accordance with ASTM C117/C136. The compaction characteristics were evaluated in accordance with ASTM D1557 Method B, C. A summary of the lab testing results for this study are included in Appendix B.

Northwest Testing, Inc.
A Division of Northwest Geotech, Inc.
9120 SW Pioneer Court, Suite B, Wilsonville, Oregon 97070 | ph: 503.682.1880 fax: 503.682.2753 | www.nwgeotech.com

TECHNICAL REPORT

Report To:
Ms. Jasmin Jamal
Aspect Consulting
401 Second Ave. South, Suite 201
Seattle, Washington 98104

Date: 4/19/18

Lab No.: 18-083

Project: Laboratory Testing – 160325

Project No.: 3106.1.1

Report of: Amount of material passing the number 200 sieve, sieve analysis, and modified Proctor

Sample Identification

NTI completed amount of material passing the number 200 sieve, sieve analysis, and modified Proctor testing on samples delivered to our laboratory on April 13, 2018 by an Aspect Consulting representative. Testing was performed in accordance with the standards indicated. Our laboratory test results are summarized on the following table and attached pages.

Laboratory Testing

Amount of Material Finer than the No. 200 Sieve (ASTM D1140)		
Sample ID	**Moisture Content (%)**	**Percent Passing the No. 200 Sieve**
TP-1 S-1 @ 1.5 ft.	2.9	5.7
TP-7 S-2 @ 3 ft.	3.9	1.8

Attachments:
Laboratory Test Results
Maximum Density Relationship

Copies: Addressee

Northwest Testing, Inc.
A Division of Northwest Geotech, Inc.

9120 SW Pioneer Court, Suite B, Wilsonville, Oregon 97070 | ph: 503.682.1880 fax: 503.682.2753 | www.nwgeotech.com

TECHNICAL REPORT

Report To: Ms. Jasmin Jamal
Aspect Consulting
401 Second Ave. South, Suite 201
Seattle, Washington 98104

Date: 4/19/18

Lab No.: 18-083

Project: Laboratory Testing – 160325

Project No.: 3106.1.1

Laboratory Test Results

Sieve Analysis of Aggregate (ASTM C117/C136)				
Sieve Size	**TP-1 S-2 @ 5 ft. Percent Passing**	**TP-1 S-4 @ 10 ft. Percent Passing**	**TP-4 S-1 @ 3 ft. Percent Passing**	**TP-5 S-4 @ 10.5 ft. Percent Passing**
3"	100	--	--	100
2"	78	100	100	77
1 ½"	63	79	87	64
1"	43	63	61	45
¾"	35	53	51	36
½"	29	44	40	28
⅜"	27	38	36	25
¼"	26	30	30	22
#4	24	26	26	19
#8	22	18	19	14
#10	21	17	18	13
#16	18	13	14	10
#30	14	10	10	8
#40	12	10	9	7
#50	10	9	7	5
#100	7	7	5	4
#200	5.0	4.6	3.1	2.5

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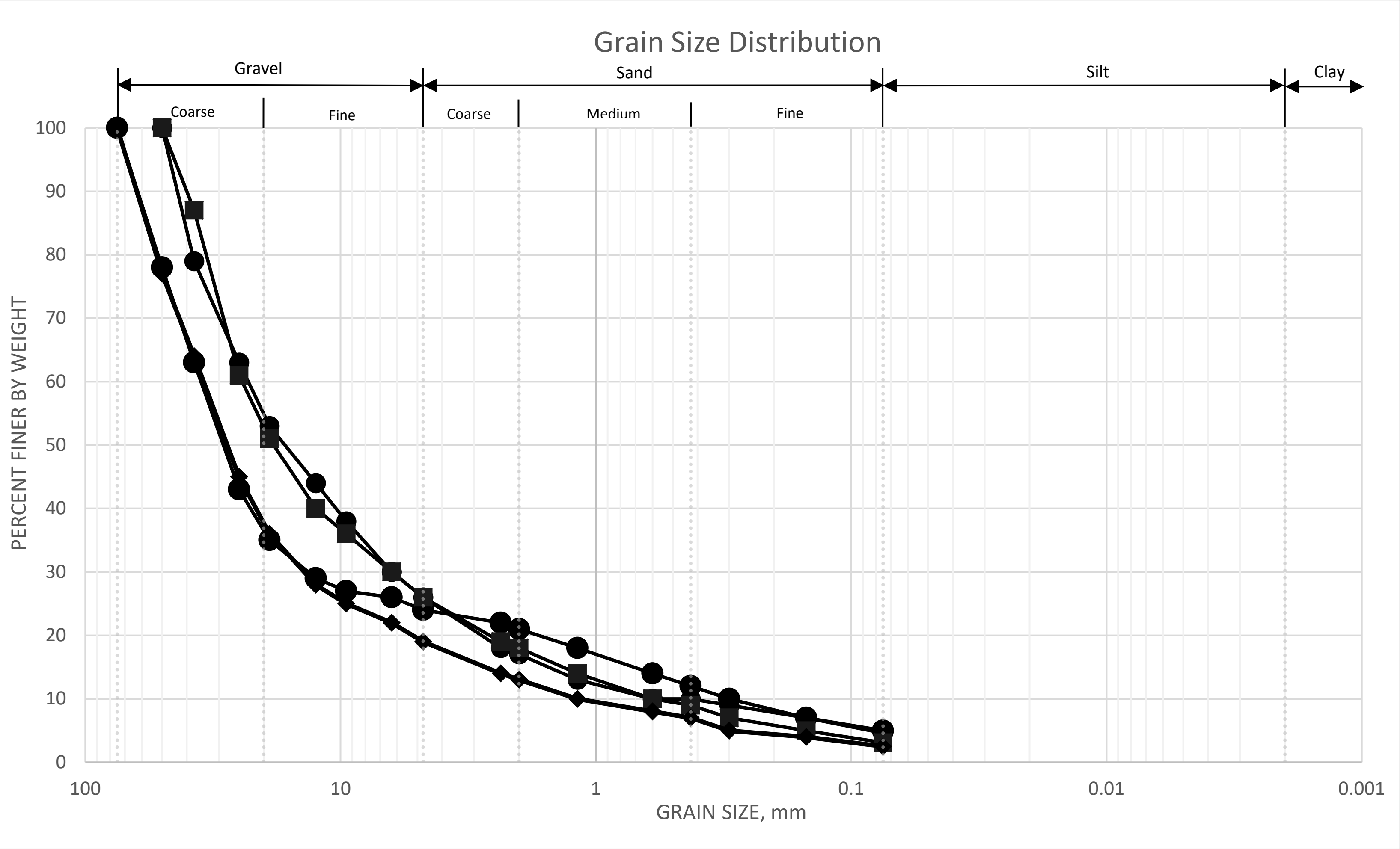
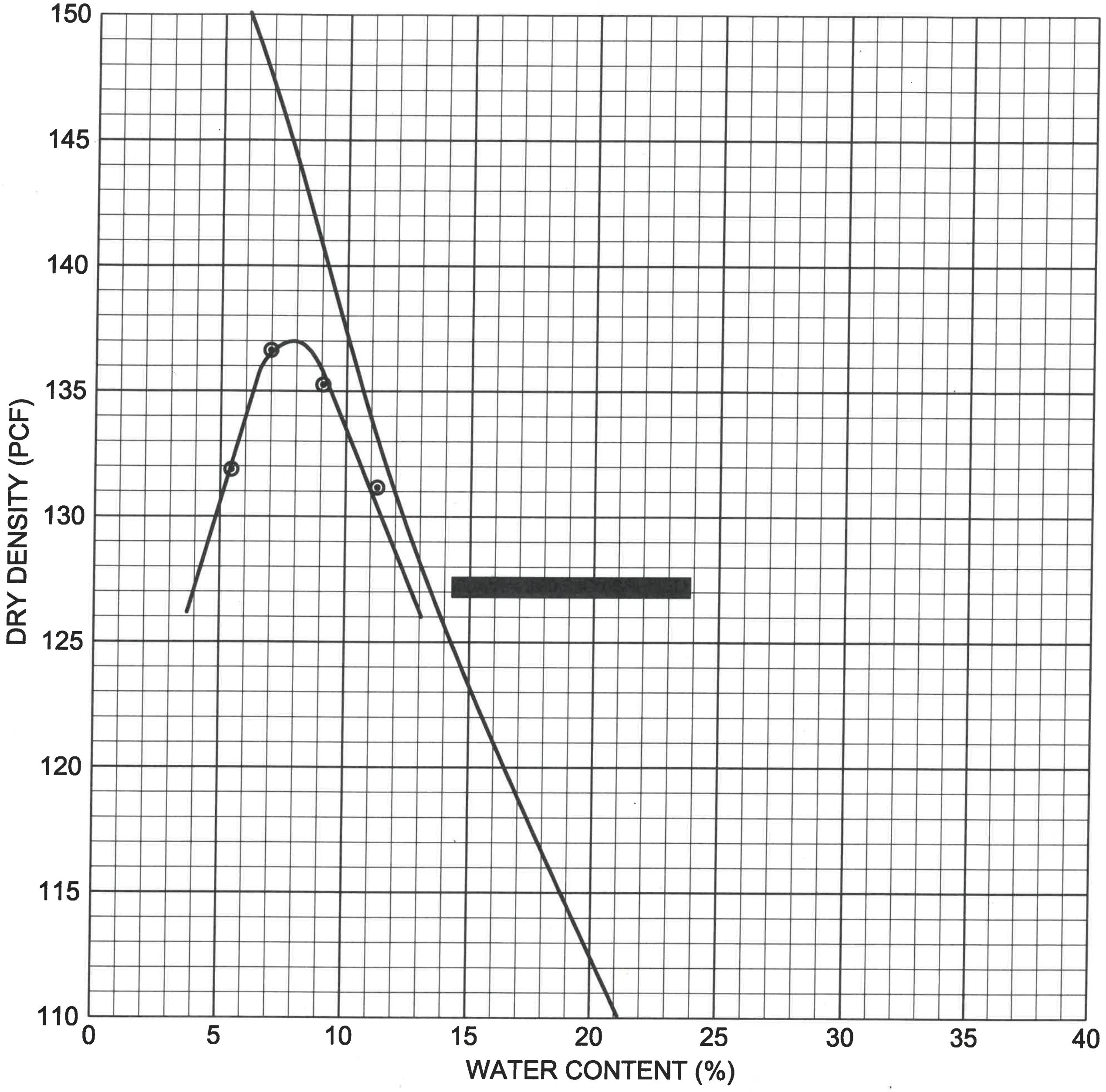
REVIEWED BY: Bridgett Adame



Symbol	Exploration, Sample, Depth	Moisture Content (%)	Silt/Clay Content (%)	Sand Content (%)	Gravel Content (%)	Coefficient of Uniformity, Cu	Coefficient of Curvature, Cc	USCS Soil Type
●	TP-1, S-2, 5ft	N/A	5.0	19.0	76.0	120.0	16.9	GP-GM
■	TP-1, S-4, 10ft	N/A	4.6	21.2	74.0	52.9	4.2	GP
▲	TP-4, S-1, 3ft	N/A	3.1	22.9	74.0	34.2	3.3	GP
◆	TP-5, S-4, 10.5ft	N/A	2.5	16.5	81.0	29.7	5.4	GP

Project Name: Toppenish Creek Three Way Levee Removal
Project Number: 160325
*The sample(s) tested may not include oversized particles and may only be representative of a portion of the sample/site soil conditions.



[redacted]

SOIL TYPE	TEST METHOD	MAXIMUM DRY DENSITY (PCF)	OPTIMUM WATER CONTENT (%)	PERCENT OVERSIZE	CORRECTED MAXIMUM DRY DENSITY (PCF)	CORRECTED WATER CONTENT (%)
TP-2 S-3 @ 6 FT. COMBINED WITH TP-5 S-2 @ 6.5 FT.	ASTM D1557C	137.0	8.0	63	SEE NOTE	SEE NOTE

DATE TESTED: 04/17/18

NOTE: SAMPLE EXCEEDS MAXIMUM AMOUNT OF OVERSIZED MATERIAL (30%) ALLOWED BY ASTM.

MAXIMUM DENSITY TEST RESULTS

PROJECT NO. 3106.1.1	ASPECT CONSULTING LABORATORY TESTING	LAB NO. 18-083

APPENDIX C

Seepage and Slope Stability Analyses

Seepage and Stability Analysis Section
Left Bank; RM 42.7 (Approximate)
Model Setup

Material Name	Color	KS (cm/s)	K2/K1
Levee Fill	🟨	1	1
Alluvium	🟫	1.4	1

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Levee Fill	🟨	125	Mohr-Coulomb	0	36
Alluvium	🟫	120	Mohr-Coulomb	0	34

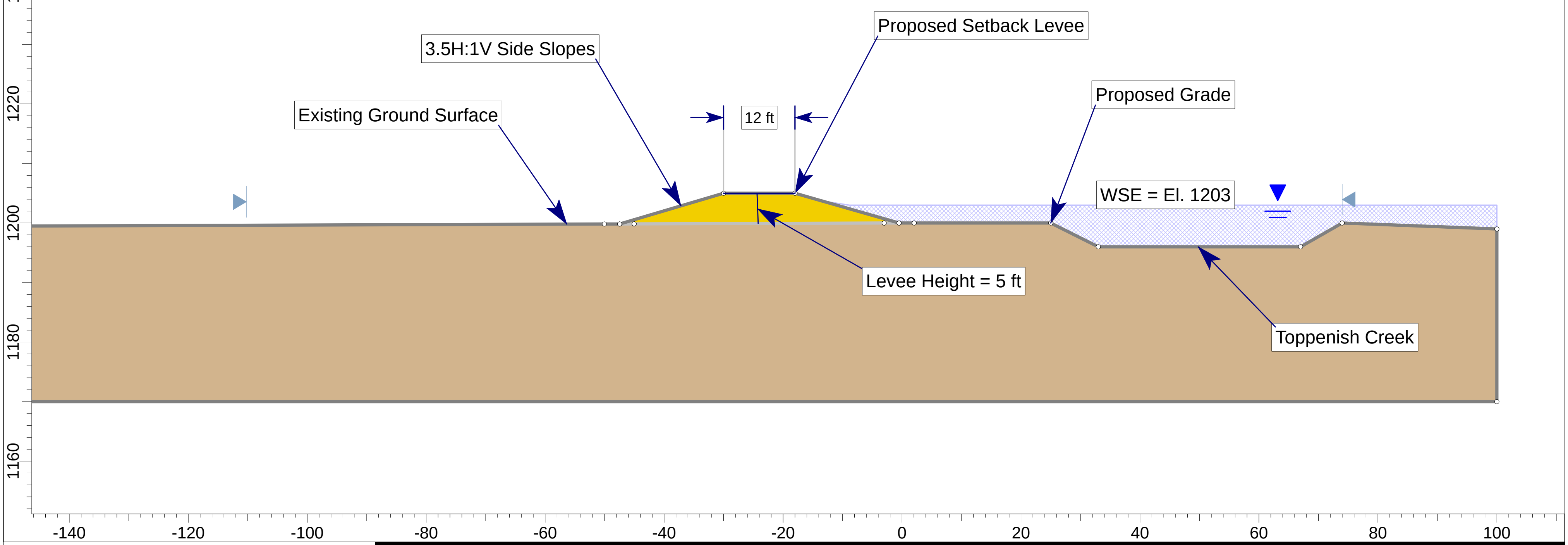
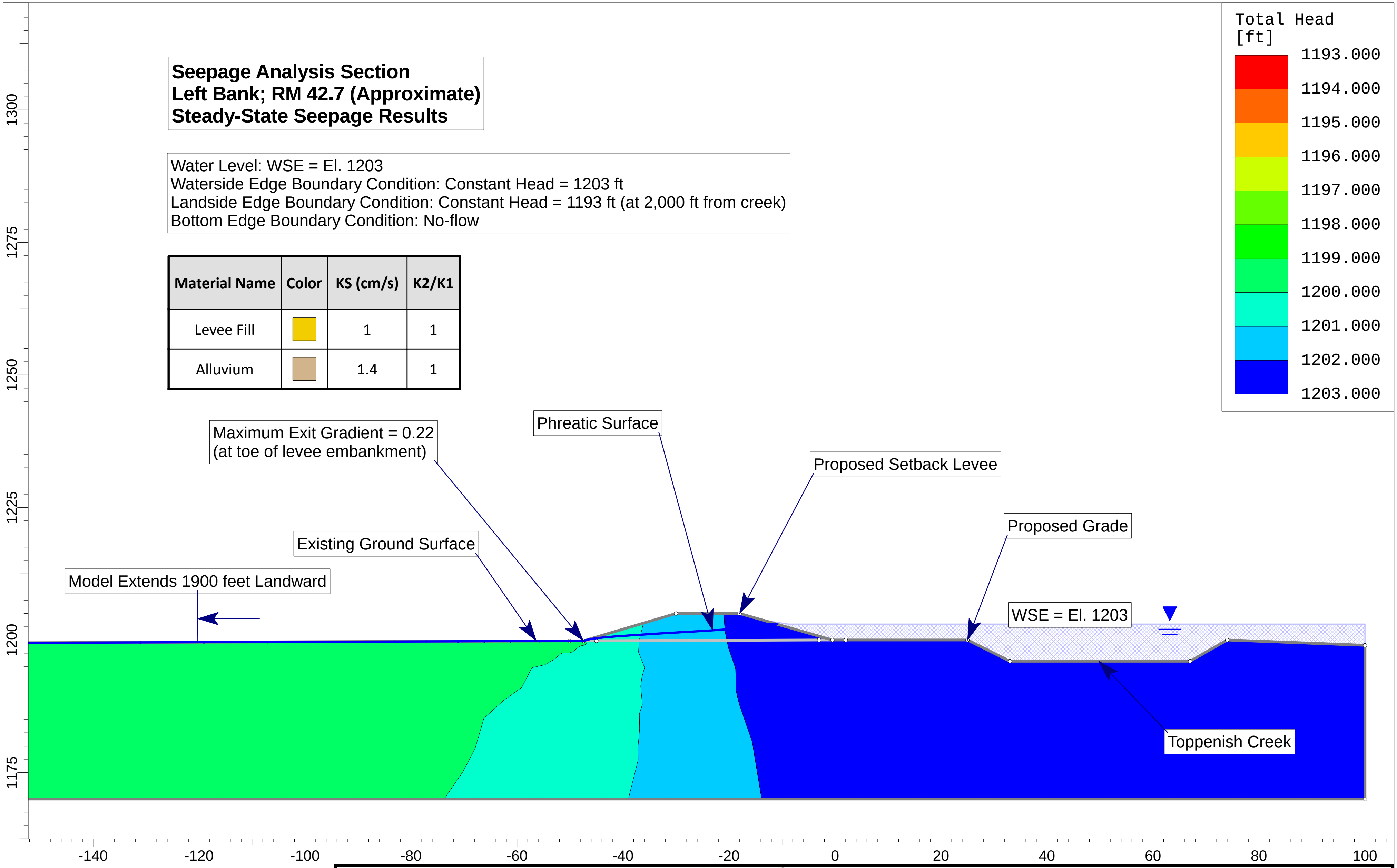


Figure C-1

Aspect CONSULTING

Toppenish Creek 3-Way Diversion
Levee Removal and Habitat Restoration
Aspect Project No. 160325
May, 2018



Seepage Analysis Section
Left Bank; RM 42.7 (Approximate)
Steady-State Seepage Results

Water Level: WSE = El. 1203
Waterside Edge Boundary Condition: Constant Head = 1203 ft
Landside Edge Boundary Condition: Constant Head = 1193 ft (at 2,000 ft from creek)
Bottom Edge Boundary Condition: No-flow

Material Name	Color	KS (cm/s)	K2/K1
Levee Fill	🟨	1	1
Alluvium	🟫	1.4	1

Figure C-2

Aspect CONSULTING

Toppenish Creek 3-Way Diversion
Levee Removal and Habitat Restoration
Aspect Project No. 160325
May, 2018

Stability Analysis Section
Left Bank; RM 42.7 (Approximate)
Landside Stability Results

Analysis Methods used:
Spencer

Surface Options
Surface Type: Circular
Search Method: Grid Search
Radius increment: 5
Composite Surfaces: Enabled
Reverse Curvature: Create Tension Crack
Minimum Depth: 3 ft

Water Level: WSE = El. 1203

Pore Water Pressure Conditions from Steady-State Seepage Analysis
Landside Stability

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Levee Fill	🟨	125	Mohr-Coulomb	0	36
Alluvium	🟫	120	Mohr-Coulomb	0	34

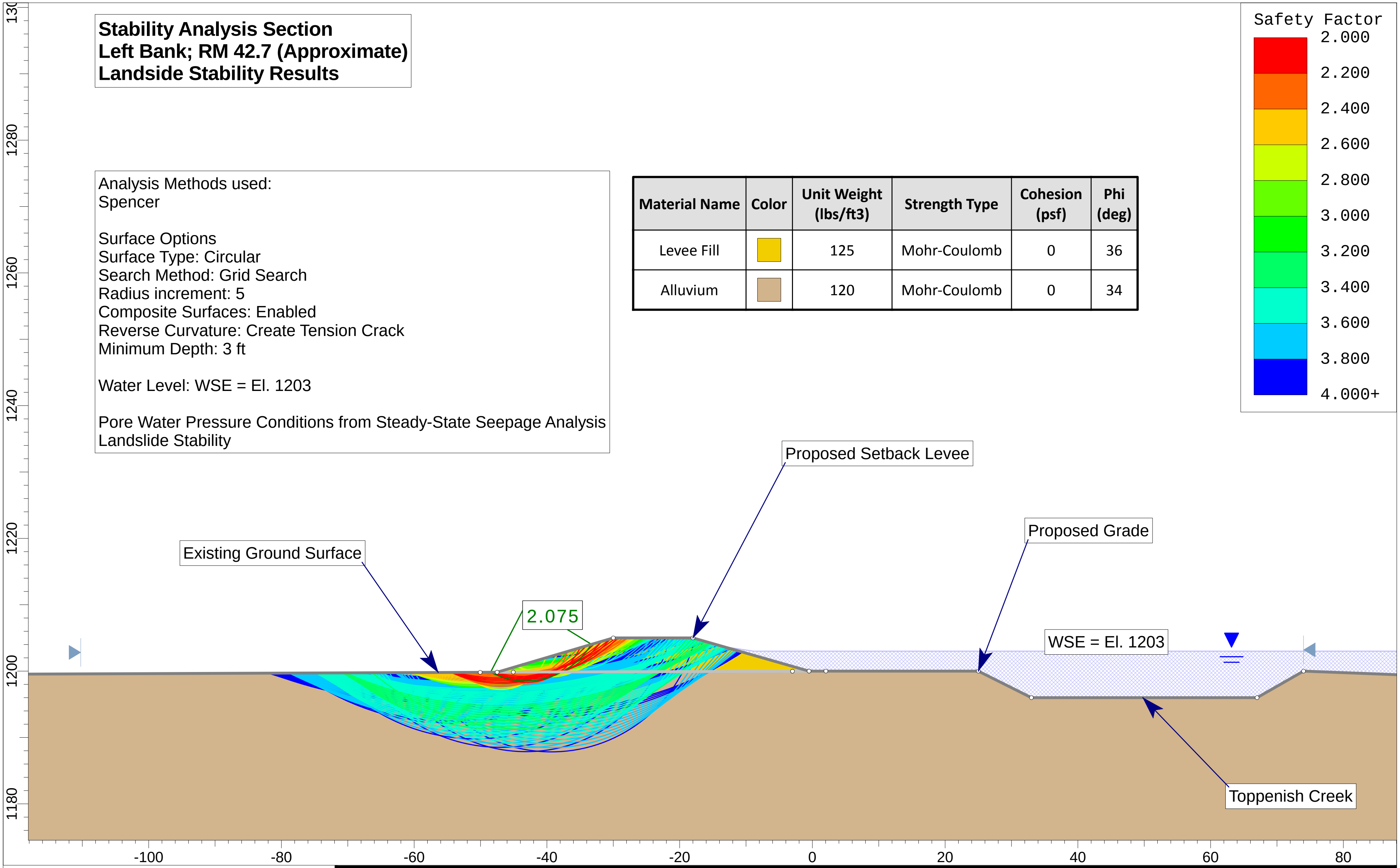
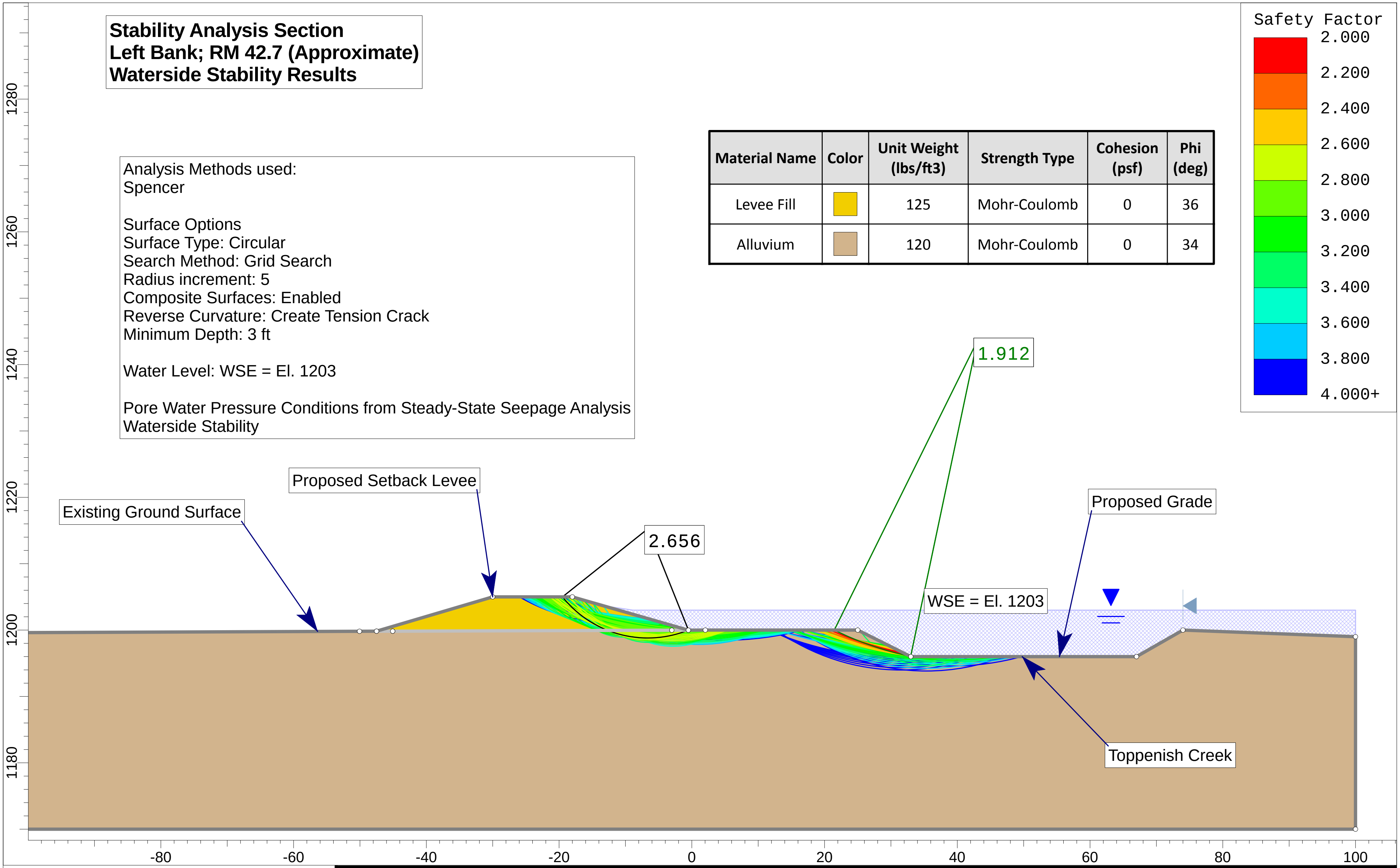


Figure C-2

Aspect CONSULTING

Toppenish Creek 3-Way Diversion
Levee Removal and Habitat Restoration
Aspect Project No. 160325
May, 2018



Stability Analysis Section
Left Bank; RM 42.7 (Approximate)
Waterside Stability Results

Analysis Methods used:
Spencer

Surface Options
Surface Type: Circular
Search Method: Grid Search
Radius increment: 5
Composite Surfaces: Enabled
Reverse Curvature: Create Tension Crack
Minimum Depth: 3 ft

Water Level: WSE = El. 1203

Pore Water Pressure Conditions from Steady-State Seepage Analysis
Waterside Stability

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Levee Fill	🟨	125	Mohr-Coulomb	0	36
Alluvium	🟫	120	Mohr-Coulomb	0	34

Figure C-4

Toppenish Creek 3-Way Diversion
Levee Removal and Habitat Restoration
Aspect Project No. 160325
May, 2018

APPENDIX D

Report Limitations and Guidelines for Use

REPORT LIMITATIONS AND GUIDELINES FOR USE

Geoscience is Not Exact

The geoscience practices (geotechnical engineering, geology, and environmental science) are far less exact than other engineering and natural science disciplines. It is important to recognize this limitation in evaluating the content of the report. If you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or property, you should contact Aspect Consulting, LLC (Aspect).

This Report and Project-Specific Factors

Aspect's services are designed to meet the specific needs of our clients. Aspect has performed the services in general accordance with our agreement (the Agreement) with the Client (defined under the Limitations section of this project's work product). This report has been prepared for the exclusive use of the Client. This report should not be applied for any purpose or project except the purpose described in the Agreement.

Aspect considered many unique, project-specific factors when establishing the Scope of Work for this project and report. You should not rely on this report if it was:

- Not prepared for you;
- Not prepared for the specific purpose identified in the Agreement;
- Not prepared for the specific subject property assessed; or
- Completed before important changes occurred concerning the subject property, project, or governmental regulatory actions.

If changes are made to the project or subject property after the date of this report, Aspect should be retained to assess the impact of the changes with respect to the conclusions contained in the report.

Reliance Conditions for Third Parties

This report was prepared for the exclusive use of the Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against liability claims by third parties with whom there would otherwise be no contractual limitations. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with our Agreement with the Client and recognized geoscience practices in the same locality and involving similar conditions at the time this report was prepared

Property Conditions Change Over Time

This report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by events such as a change in property use or occupancy, or by natural events, such as floods, earthquakes, slope instability, or groundwater fluctuations. If any of the described events may have occurred following the issuance of the report, you should contact Aspect so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Geotechnical, Geologic, and Environmental Reports Are Not Interchangeable

The equipment, techniques, and personnel used to perform a geotechnical or geologic study differ significantly from those used to perform an environmental study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually address any environmental findings, conclusions, or recommendations (e.g., about the likelihood of encountering underground storage tanks or regulated contaminants). Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding the subject property.

We appreciate the opportunity to perform these services. If you have any questions please contact the Aspect Project Manager for this project.