# Riley Pass Site Investigation and Data Collection Report

**Custer Gallatin National Forest**
**Sioux Ranger District**
**North Cave Hills Unit**

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***Custer Gallatin National Forest***
***Sioux Ranger District***
***North Cave Hills Unit***

February 21, 2017

*Prepared for:*
**U.S. Department of Agriculture**
**Forest Service – Custer Gallatin National Forest**

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# 1.0 Executive Summary

The Site Investigation and Data Collection report presented here is one of the deliverables associated with the Riley Pass Sediment Pond Cleanout Design project (Contract AD-0343-C-16-0031, Task Order AG-0343-D-16-0114). This report is an update to the Site Investigation and Data Collection Reports submitted to the USFS on December 20, 2016 and January 13, 2017. This report includes updated elements of the December 20 draft report, and information related to the conceptual design of the project has been removed.

The Riley Pass Sediment Pond Cleanout Design project is located in the North Cave Hills Unit of the Custer Gallatin National Forest in Harding County, South Dakota. Historic uranium mining operations in the area have caused significant erosion and sediment transport, which is affecting the downstream drainages. Sediment ponds were built to intercept sediment before it migrates down the drainages. However, after several years of sediment deposition, the ponds are nearly full of sediment. This project includes a site investigation and analysis of eight sediment ponds (Ponds 1 – 5, Upper Schleichart Draw Reservoir, Lower Schleichart Draw Reservoir, and Browns Pond). Other elements of the project involve a site investigation and analysis of sediment removal and transport potential, designing repairs of a sediment repository area, a section of Forest Service Road (FSR) #31232, and a landslide along FSR #3123. See Figure 1 for an overview of the project locations.

Listed below if a brief summary of our site investigation efforts. These topics are described in more detail later in the report.

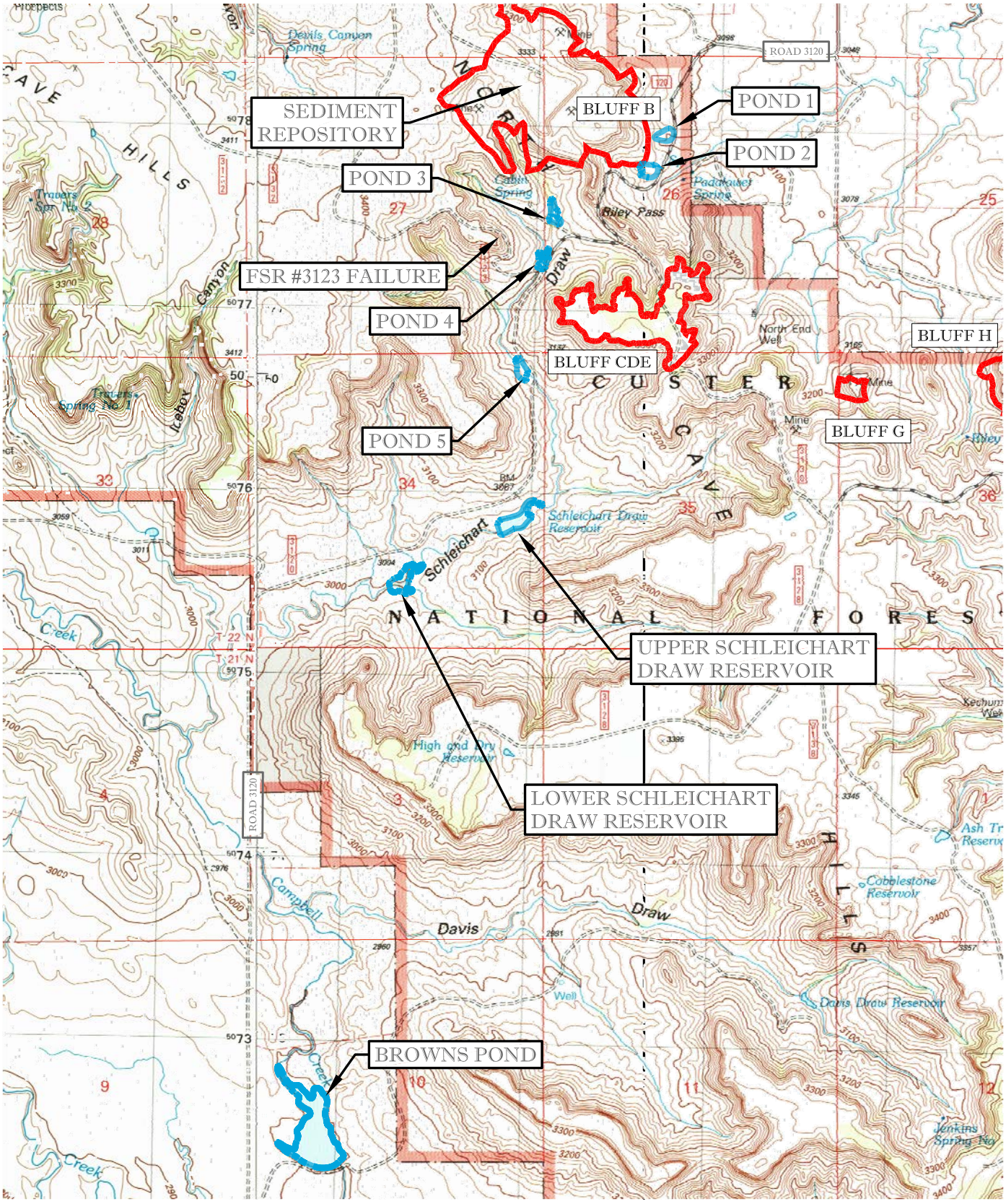
- Twenty (20) test pits were excavated throughout the project area. Test pits were dug with a CAT 315 excavator and ranged in depth from 4 to 12 feet. Appendix A1 provides the test pit exploration logs. Figure 3 provides an overview of the exploration locations.
- Thirteen (13) boreholes were drilled throughout the project area with a D-90 drill rig. Boreholes ranged in depth from 16 to 55 feet. Appendix A2 provides the borehole exploration logs.
- Seven (7) hand auger holes were conducted in the soft sediment accumulations of the sediment ponds. Hand auger holes ranged in depth from 2 to 11 feet. Appendix A3 provides hand auger exploration logs.
- Several dynamic cone penetrometer tests were taken in the vicinity of the sediment repository area. The dynamic cone penetrometer data is provided in Appendix A4.
- Generally one test pit was excavated within each pond and one borehole was drilled on the top of each pond embankment. Multiple test pit and borehole explorations were conducted at Browns Pond, the FSR #3123 landslide area, and other select locations.
- Soils were visually classified in the field during the site investigation. Select soil samples were sent to Terracon's laboratory for geotechnical testing and to Energy Labs for metals and agronomic testing. Appendix B provides the laboratory testing results.
- A sediment characterization and assessment was conducted using laboratory testing results and field information from the site investigation. Per an analysis of the laboratory testing results, the majority of pond sediment is re-usable as topsoil or subsoil either in its current state or with the addition of admixtures or soil mixing techniques.

- A field pickup survey was conducted by Allied Engineering to supplement existing LiDAR topographic data. The pickup survey measured pipe invert elevations, sediment boundaries, exploration locations, etc. The LiDAR survey and field pickup survey data will be used for future grading and design work.
- Using survey data and subsurface exploration information, approximate sediment volume estimates for each pond were calculated as provided later in this report.
- A general assessment of site conditions has been performed while considering consequences and implications related to future design work. Site assessments and interpretations are briefly described in this report with additional information and analysis provided in the Conceptual Design Report.

This document and attachments fulfills requirements for the Site Investigation and Data Collection Report (first version submitted on 12/20/16). Included below is the approved schedule for the project. Currently the project is behind schedule and submittal dates will be revised in cooperation with the Forest Service:

**Table 1 - Schedule**

| **Start Work** | **9/30/2016** |
|---|---|
| Site Investigation | 11/3/2016 |
| Site Investigation and Data Collection Report | 12/20/2016 |
| Conceptual Design Package | 1/8/2017 |
| 60% Complete Design Package | 1/27/2017 |
| 60% Plan-In-Hand Field Visit | 2/10/2017 |
| 95% Complete Design Package | 3/13/2017 |
| Construction Begins | 5/1/2017 |
| Contractor Demobilizes | 8/29/2017 |
| Draft Construction Report | 9/29/2017 |
| Final Construction Report | 30 days after review |

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# RILEY PASS
# PROJECT LOCATIONS MAP
## CUSTER GALLATIN NATIONAL FOREST


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**Land Surveying**

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| FIGURE 1 |
|---|
| DRAWN BY: GDF |
| DATE: 02/2017 |
| PROJECT #:16-050.05 |
| OVERVIEW SHEETS |

## 1.1 Project Location and Background

The project sites include eight ponds, a sediment repository, and a section of failed road located in the North Cave Hills Unit of the Custer Gallatin National Forest in Harding County, South Dakota (**Error! eference source not found.**). The project is located approximately 5 miles west of Ludlow, South Dakota. The project sites are spread out over approximately 8 square miles. A list of each of the site locations is provided in Table 2.

Each of the sites is affected by the Riley Pass Abandoned Uranium Mines. Unrestricted strip uranium mining occurred during the 1950s and 1960s on the bluff tops in the North Cave Hills area. The mining consisted stripping overburden down to uranium bearing lignite which created large land disturbances. The locations of the mining areas to be reclaimed are labeled Bluff A through Bluff H. The Bluff locations are also shown in Figure 1. The lack of vegetation and the erosive nature of the spoils from the excavations has resulted in substantial sediment erosion, transport and deposition in the nearby drainages. The Riley Pass Sediment Pond Cleanout Design project locations are shown on Figure 1.

According to the North Cave Hills Abandoned Uranium Mines Impact Investigation (Stone, 2007), the USFS installed ponds 1 through 5 in 1987 to control sediment runoff from the Riley Pass Mine. The Upper Schleichart Draw Reservoir was built in 1935 by the Civil Conservation Corps while the Lower Schleichart Draw Reservoir was built in 1987. Browns Pond is thought to have been built sometime between 1938 and 1958 (Stone, 2007). Ponds 3, 4, and 5 are noted as being cleaned out by the USFS in 1990 while several ponds were again cleaned out in 1997 and 2004 and then again in 2009. It is our understanding that sediment has never been cleaned out of either Schleichart Draw Reservoir or Browns Pond. A sediment repository area on top of Bluff B has previously been used to store sediment excavated out of the ponds.

**Table 2 - Project Sites**

| Site | Latitude° | Longitude° | Elevation (ft) |
|---|---|---|---|
| Pond 1 | 45.844736 | -103.471239 | 3097 |
| Pond 2 | 45.842991 | -103.472319 | 3108 |
| Pond 3 | 45.841036 | -103.479401 | 3142 |
| Pond 4 | 45.838687 | -103.480081 | 3116 |
| Pond 5 | 45.833223 | -103.481054 | 3074 |
| Upper Schleichart Draw | 45.825836 | -103.482458 | 3033 |
| Lower Schleichart Draw | 45.823374 | -103.489632 | 3009 |
| Browns Pond | 45.795662 | -103.495678 | 2899 |
| Sediment Repository | 45.846825 | -103.484353 | 3332 |
| FSR #3123 Failure | 45.840162 | -103.482955 | 3258 |
| FSR #31232 Design | 45.845756 | -103.485974 | 3347 |

## 1.2 Project Objectives

The primary objective of the project is to complete an engineering design for the rehabilitation of the sediment pond dams along with pond sediment removal and disposal, and reconstruction of about 0.6

miles of FSR #3123. The proposed sediment management is to remove sediment from eight existing ponds/reservoirs. The operating premise for this project is that the sediment ponds 1 through 5 are to capture sediment coming from Bluff B. Sediment will be removed from these ponds on a routine basis, estimated to be every two to four years.

## 1.3 Topography

The site area consists of upland flat-topped mesas (bluffs) at elevations around 3450 feet with sandstone cliffs defining the uplands and generally erosional timbered headland drainages dissecting the terrain around the bluff. The upland area is referred to as the North Cave Hills. Most of the project area drains southwest down Schleichart Draw to Middle Creek, which then flows east to Bull Creek and then in the South Fork of the Grand River toward the Missouri River 150 miles to the east. Two of the project ponds (Pond 1 and 2) are on the northeast side of Riley Pass along upper Pete's Creek, which drains northeast, then turns southward eventually joining the South Fork Grand River at Shade Hill Reservoir 70 miles to the east, and then continues east to the Missouri River at Mobridge.

## 1.4 Geology

Local geology is described in a report titled *Geology and Uranium Deposits in the Cave Hills Area, Harding County, South Dakota,* (Pipiringos, 1965). The rocks exposed in the project area are generally a part of the Ludlow Member and the overlying Tongue River Member of the Fort Union Formation from the early Tertiary Period (Paleocene Epoch). These rocks are characterized by nearly horizontal sedimentary rocks consisting of clay shale, siltstone, fine-grained sandstone, and beds of coal and coaly shale. The upland areas of the North Cave Hills include flat-topped rimmed mesas. The mesa cap rock is a sandstone unit that forms roughly 10 to 30 feet high sandstone cliffs in the area. Curtiss (1955) describes the sandstone as 39 to 100 feet thick, massive, slightly cemented with lime, and cross-bedded. The project site includes various abandoned lignite strip mines located on the relatively flat bluffs and the natural or erosional channels between the bluffs and the ponds. Spoils piles and mining disturbances expedite erosion and sediment transport into the Schleichart Draw drainage and upper Pete's Creek drainage. The Pipringos 1965 report describes certain features that are applicable to the sediment pond cleanout project including the following:

1. The bluffs are capped by thick sandstone deposits which create the steep cliffs and are subject to local weathering patterns which result in small caves and a honeycombed surface. This process is evident in the exposed sandstone wall on the northwest edge of the sediment repository area, where isolated caves (internally eroded "pipes") channelize infiltrated water into the repository area.
2. Numerous natural, mostly ephemeral springs are located in the Cave Hills area. These natural springs are evident between Bluff B and Ponds 1 – 5 and may be contributing to slope instability of FSR #3123 especially where weak carbonaceous coaly shale beds can become seasonally saturated. The principal aquifers of the area include sandstone and coal layers.
3. Rocks in the Cave Hills area generally dip mildly to the east and northeast at an average rate of about 0.4%. Local regional dipping is noted south of Bluff B. Figure 5 provides a conceptual geologic profile of FSR #3123.

4. Coaly shale layer thicknesses range from a few inches to about 21 feet. The ash content of the coaly shale averages about 40 percent. AESI's laboratory testing showed the organic content of carbonaceous shale layer to be between about 8% and 10%. During the subsurface explorations, organic bedrock layers ranging from shaley coal to carbonaceous shale were encountered at Pond 1, Pond 2, Pond 3, and at FSR #3123. This bedrock can weather into fat organic clay described in the exploration logs. Figure 2 in the Pipringos (1965) geology report provides a stratigraphic profile of the Cave Hills area which shows coaly shale at a depth of about 100 feet which generally corresponds to where it was encountered in TP-1 relative to the elevation of the top of Bluff B (Pipringos, 1965).

## 1.5 Morphology

Consideration of geomorphology is a basic element in reclamation success. Rapidly evolving morphologic conditions and processes should be analyzed during the design process. While our scope of work does not include landscape reclamation design, the design of the sediment retention ponds and the concept of reusing the retained pond sediments as topsoil or subsoil are considerations in this contract.

**Pertinent Morphology of Mesas and Coaly Shale Seams**: Nearly flat lying but fractured caprock formation exposed in the bluff tops result in high amounts of infiltration and then lateral movement of transient water tables through the more pervious sedimentary layers, in this case typically sandstone or organic seams. The result is fairly undefined surface drainages and springs with high exit gradients from outcrops of pervious layers below the cap rock formation. This condition results in piping and gradual removal of materials under the cap rock, with the effect most noticeable close to the cliffs where there is measureable subsidence or "drooping at the edge" of the mesa surface near the cliffs.

The subsurface flows from the pipes are not easily predicted since subsurface drainages are not as well defined or visible as surface drainages, plus the underground channels are likely unstable, subject to collapse or temporary blockage, and can result in widely seasonally fluctuating piezometric levels, which can reduce slope stability in bluffs below the cap rock and in the cliff itself.

These drainage and stability conditions weigh heavily on the design considerations for the proposed road building and the proposed sediment repositories. These conditions also need to be considered in the design of the sediment pond repair work.

**Pertinent Morphology of Sediment Ponds:** Sediment ponds are most effective close to the sediment source since the sediments are concentrated and flows from smaller basins can be more easily handled than larger flows from larger basins experienced further downstream. The most pertinent factor correlating to sedimentation efficiency of a pond is the retention time of the flow. From this perspective, the most effective ponds are Ponds 1, 2 and 3, which are high in the drainage from Bluff B which is contributing the sediment. However, Browns Pond, even with its 8,000 acre basin (roughly 85 times larger than the drainage area of Pond 3), has a longer retention time than Pond 3, such that it will accumulate fine grained sediments that pass through Pond 3. This should be evaluated more closely and remedied if feasible by increasing the size of Pond 3.

## 1.6 Sediment Pond Hydrology Overview

The spillway design event is an important consideration for rehabilitation of any of the ponds for the Riley Pass project. Depending upon the classification (dam or not a dam), the hazard classification, and the loss of life analysis, the spillway design event can range from a 25-year event to a probable maximum flood (PFM). The size of the event has implications for the magnitude and cost of spillway rehabilitation. A summary of existing information relative to dam classification and hazard analysis is provided in the two paragraphs below.

The 2015 report by Tetra Tech states, "*Based on the forgoing, and assuming that sediments in Browns Pond are not contaminated, results of this analysis indicated that Browns Pond ought to be classified as a small, Hazard Class 3 dam with a 50-year spillway design event according to DENR criteria (see Tables 1-1, 1-2 and 1-3). Using USFS ranking criteria (see Table 1-4); Browns Pond ought to be classified as a low hazard dam with a spillway design event of a 50 or 100-year runoff event"* (Tetra Tech, 2015). The sampling completed by AESI and subsequent testing by Energy Labs further collaborates that the sediments in Browns Pond are not contaminated.

Hydrometrics completed a hazard screening of Lower Schleichart Draw Reservoir in 2016 (Hydrometrics, 2016). The hazard screen recommendation was summarized as follows, "*Based on an assessment of a piping failure of Schleichart DU Dam, the peak breach flow of 574 cfs is unlikely to impact potential hazards as it is routed downstream. The dam breach flow is expected to be contained within the 100-year flood channel of Schleichert Draw by the time it reaches Campbell Creek. Therefore, a detailed hazard assessment is not recommended for Schleichert DU Dam.*"

The hazard assessments completed for Browns Pond and Lower Schleichart Draw Reservoir indicate that failure of these dams should not result in loss of life or significant property or environmental destruction. Therefore, a low hazard classification is appropriate for these reservoirs if they meet the requirements of a jurisdictional dam, which is discussed further in our Conceptual Design Report.

Calculation of recurrent interval flows, classification of the reservoirs/ponds, and the determination of the design spillway event will be undertaken during the conceptual design phase of the project. Table 3 provides approximate drainage basin sizes for each of the ponds. USGS Stream Stats and manual delineation in ArcGIS estimated the drainage basin size. The raw output data from Stream Stats is in Appendix C.

**Table 3- Drainage Basins**

| Pond | Drainage Basin Area (Square Miles) | Drainage Basin Area (Acres) | Approximate Disturbed Acreage in Drainage Basin | Percent of Drainage Basin which is Disturbed |
|---|---|---|---|---|
| Pond 1 | 0.03 | 19 | 5 | 26 |
| Pond 2 | 0.05 | 32 | 8 | 25 |
| Pond 3 | 0.15 | 96 | 35 | 36 |
| Pond 4 | 0.42 | 269 | 35 | 13 |
| Pond 5 | 0.79 | 506 | 50 | 10 |
| Upper Schleichart | 1.48 | 947 | 60 | 6 |
| Lower Schleichart | 2.95 | 1,888 | 60 | 3 |
| Browns Pond | 12.65 | 8,096 | 100 | 1 |

## 1.7 Vegetation

**Figure 2 – Well Vegetated Sediment Deposit in Channel**

The ecological setting in the area resembles woodland and savannah typical of the western Great Plains. Typical vegetation includes ponderosa pine with Rocky Mountain juniper (*Juniperus scopulorum*) or creeping Juniper (*Juniperus horizontalis*) as a common associate. Shrubs associated with ponderosa pine dominated forests include bearberry (*Arctostaphylos uva-ursi*), creeping Oregon grape (*Mahonia repens*), soapweed yucca (*Yucca glauca*), snowberry (*Symphoricarpos* species), chokecherry (*Prunus virginiana*), common juniper, serviceberry (*Amelanchier alnifolia*), skunkbush sumac (*Rhus trilobata*) and ninebark (*Physocarpus* species*)*. The herbaceous understory can range from a sparse to a dense layer of species typical of the surrounding prairie system. Mixed-grass species are usually common, such as big bluestem (*Andropogon gerardii*), sideoats grama (*Bouteloua curtipendula*), sun sedge (*Carex inops* ssp. *heliophila*), threadleaf sedge (*Carex filifolia*), poverty oatgrass (*Danthonia intermedia),* prairie junegrass (*Koeleria macrantha*), green needlegrass (*Nassella viridula*), roughleaf ricegrass (*Oryzopsis asperifolia*), and western wheatgrass (*Pascopyrum smithii*). Common herbaceous forbs include yarrow (*Achillea millefolium*), pussytoes (*Antennaria* species), boreal sagewort (*Artemisia frigida)*, arrowleaf balsamroot (*Balsamorhiza sagittata*), Indian blanket flower (*Gaillarida aristata*), silky lupine (*Lupinus argenteus*), crazyweed (*Oxytropis* species), alpine sweetvetch (*Hedysarum alpinum), penstemon (Penstemon* species), prairie cinquefoil (*Potentilla gracilis*), goldenrod (*Solidago* species) and smooth aster (*Symphyotrichum laeve*). The presence of beneficial vegetation to protect soil from erosion and to provide cover and feed for wildlife and livestock is the primary measure of successful

reclamation. Native vegetation is usually preferred, since it is typically better adapted to long term survival, and is not prone to displace or otherwise negatively affect native plants or wildlife.

# 2.0 Site Investigation and Data Collection

## 2.1 Initial Site Visit

The field investigation began with an initial site visit on August 17, 2016 with Doug Chandler of Allied Engineering (AESI) and Mary Beth Marks and Peter Werner, both of the United States Forest Service (USFS). The initial site visit included a general overview and analysis of each of the eight (8) ponds along with the sediment repository, FSR #3120, and the landslide failure along FSR #3120. The site visit included preliminary planning for borehole, test pit, and hand auger locations. Reclamation goals, project constraints, and design options were also discussed during the initial site visit.

## 2.2 Subsurface Explorations

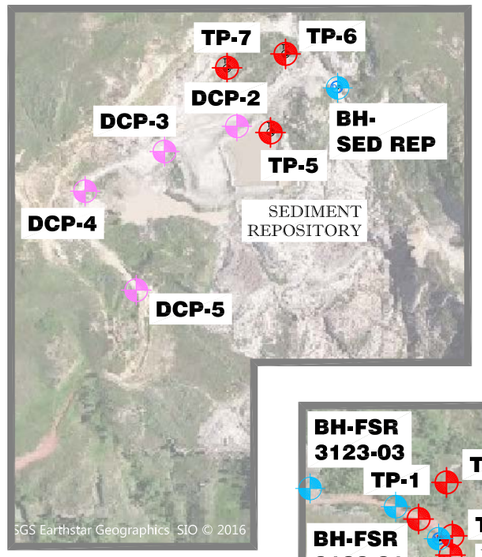
During the week of October 23, 2016 subsurface field explorations were conducted at the Riley Pass sites. Doug Chandler and Ron Orton of AESI oversaw the field exploration along with Peter Werner of the USFS. All on-site personnel were HAZWOPER (OSHA 40 hour Hazardous Waste Operations and Emergency Response) certified.

Twenty (20) test pits, thirteen (13) boreholes, and seven (7) hand auger holes were conducted during the site investigation. Figure 3 shows the approximate subsurface exploration locations. Site specific plan and profile drawings of the eight ponds provided in Attachment 1 show more specific exploration locations.

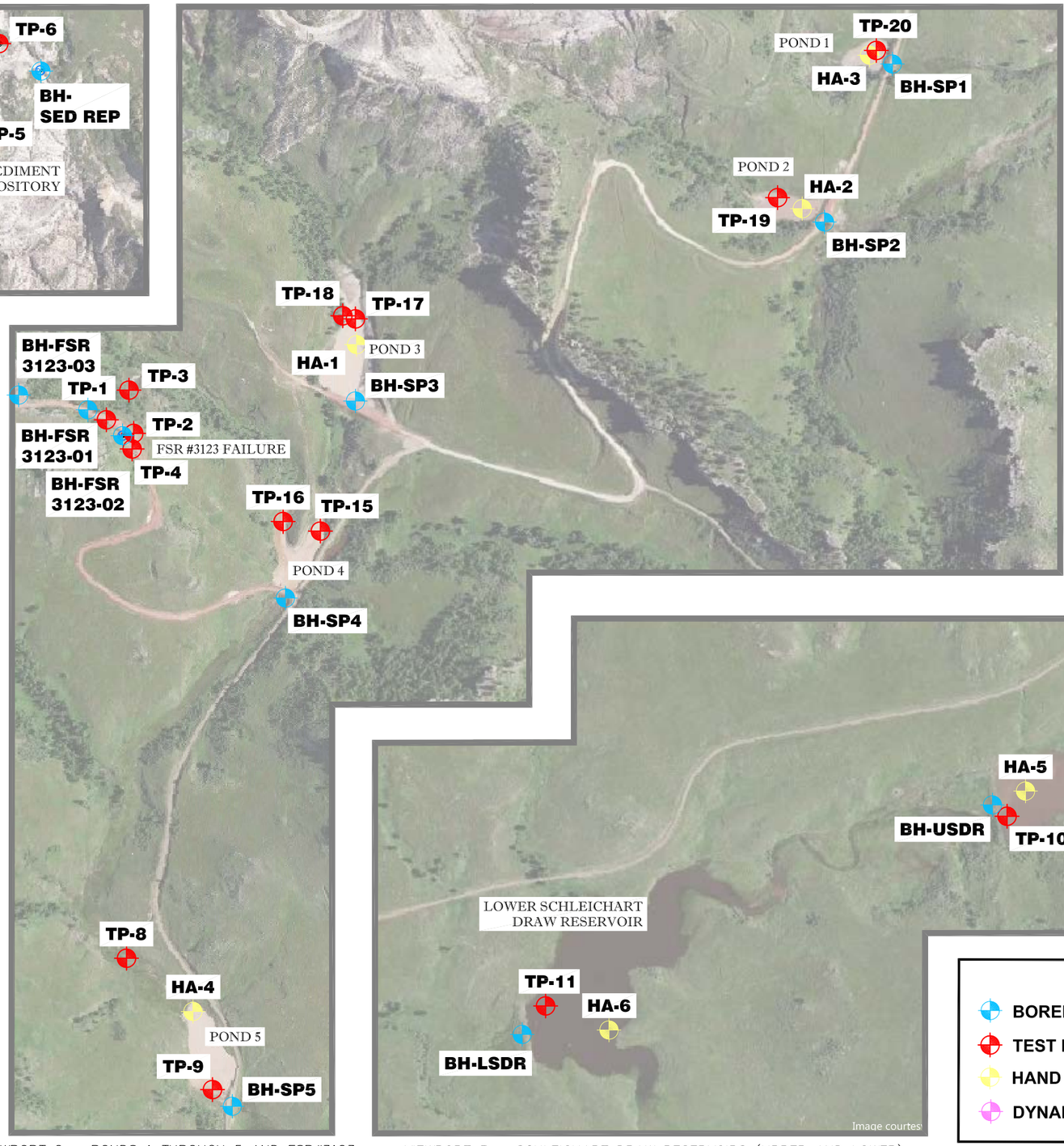
### 2.2.1 Borings

Boreholes were conducted by Terracon, Inc. between October 24 and October 26, 2016 under the direction of Matthew Hoffmann, PE, of Terracon, Inc. The D-90 drill rig was mobilized from Terracon's Bismarck office. The drilling was accomplished using 3.25-inch inside diameter hollow stem augers with standard penetration testing and split spoon sampling on 2.5 to 5.0 foot intervals along with intermittent Shelby tube samples (noted as "push" samples on the borehole logs). Standard penetration tests are conducted by driving a 2-inch diameter split spoon sampler 18 inches into the native ground below the hollow stem auger. The number of blows from a 140 pound weight dropping 30 inches required to drive the sampler each 6-inch increment of the test is recorded, and the blows required to drive the sampler the final 12 inches is termed the "standard blow count" or "N Value", which is correlated to many soil characteristics related to strength, density, consistency and others. The N Values, along with many other descriptors and information are recorded on the boring logs found in Appendix A2.

Thirteen (13) boreholes were conducted across the 10 sites. One borehole was drilled on the embankments at each of the eight ponds except Browns Pond where two boreholes were drilled. Three boreholes were drilled on FSR #3123 near the landslide failure and one borehole was drilled in the sediment repository area on Bluff B. Piezometers were installed in five of the borings. USFS staff will



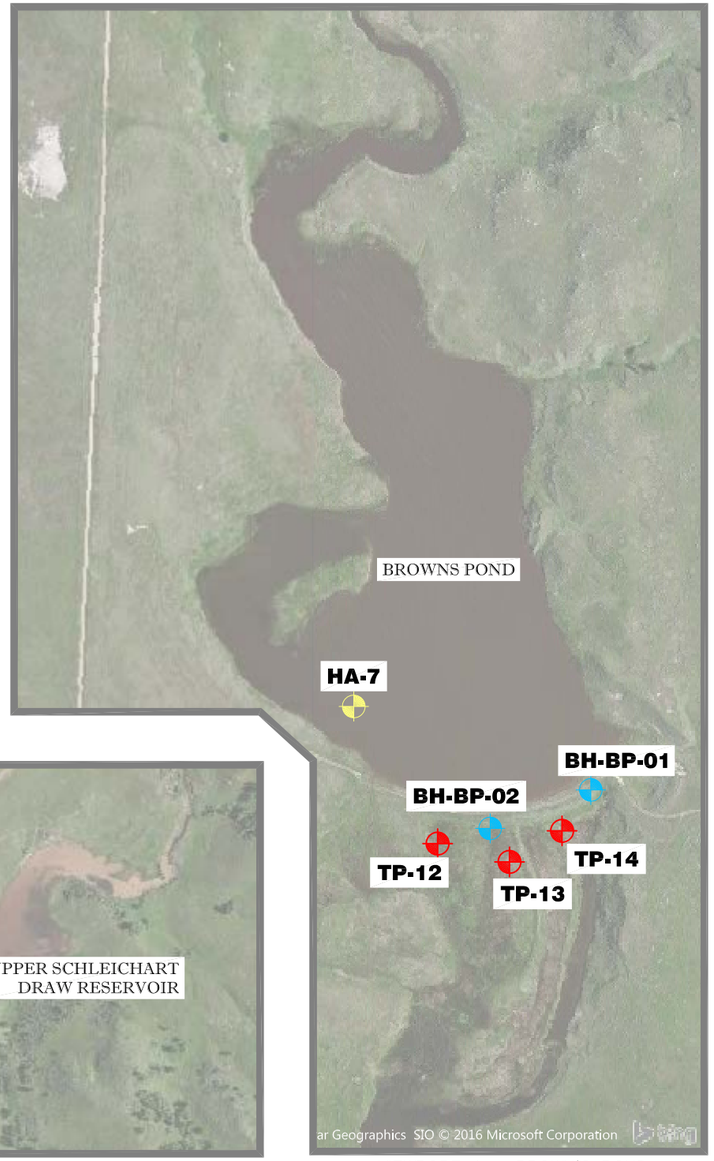

VIEWPORT 1 – SEDIMENT REPOSITORY AREA




VIEWPORT 2 – PONDS 1 THROUGH 5 AND FSR#3123




VIEWPORT 3 – SCHLEICHART DRAW RESERVOIRS (UPPER AND LOWER)




VIEWPORT 4 – BROWN'S POND

## LEGEND

- BOREHOLE LOCATION (APPROXIMATE)
- TEST PIT LOCATION (APPROXIMATE)
- HAND AUGER LOCATION (APPROXIMATE)
- DYNAMIC CONE PENETROMETER TEST (APPROXIMATE)

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| PROJECT ENGINEER: DSC/PJS | DRAWN BY: GDF |
| DESIGNED BY: DSC | REVIEWED BY: DSC/PJS |

# RILEY PASS SEDIMENT POND CLEANOUT
# EXPLORATION LOCATIONS OVERVIEW
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| OVERVIEW SHEETS | |

monitor the piezometers. Split spoon samples and standard penetration tests were generally taken at 5-foot intervals except at Pond 4 where samples were taken at 2.5-foot intervals due to the relative softness of the soils. Table 4 provides a summary of the borings.

**Table 4 - Summary of Boreholes**

| Boring Log Number | Site | Total Depth (ft) | Groundwater Depth (ft)[1] | Lat/Long |
|---|---|---|---|---|
| SP1 | Pond 1 | 26 | None | 45.84461,-103.4709 |
| SP2 | Pond 2 | 30.4 | 26 | 45.84287,-103.47186 |
| SP3 | Pond 3 | 36 | None | 45.84059,-103.47926 |
| SP4 | Pond 4 | 27 | 19 | 45.83045,-103.48022 |
| SP5 | Pond 5 | 21 | 18 | 45.83276,-103.48068 |
| Sed. Rep. | Repository | 16 | None | 45.8475,-103.48324 |
| 3123-01 | FSR #3123 | 41.5 | None | 45.84032,-103.48328 |
| 3123-02 (Piezometer) | FSR #3123 | 41.5 | None | 45.84014,-103.48293 |
| 3123-03 | FSR #3123 | 55 | None | 45.84055,-103.4846 |
| USDR (Piezometer) | Upper Sch | 31 | 17 | 45.82573,-103.48326 |
| LSDR (Piezometer) | Lower Sch | 41 | 17.5 | 45.82297,-103.49055 |
| BP-01 (Piezometer) | Browns | 46 | 42 | 45.79447,-103.49396 |
| BP-02 (Piezometer) | Browns | 41 | 23 | 45.7942,-103.4948 |

[1]Groundwater depths measured both during and after drilling. After drilling measurements listed here.

### 2.2.2 Test Pit Explorations

Test pits were excavated October 24 through October 26, 2016 with a CAT 315 excavator provided and operated by Terry Hafner, a local landowner and contractor who is familiar with the site conditions. Test pit explorations were directed and logged by Doug Chandler of Allied Engineering.

A total of 20 test pits were excavated across the site, focusing on areas that could not be accessed with the drill rig, including off-road locations and on and adjacent to the soft sediments within the ponds. Test pits ranged from about 4 feet to 20 feet in depth. Table 5 provides a summary of test pit locations and depths from the field investigation. Test pit logs can be found in Appendix A1.

**Table 5 - Test Pit Summary**

| Test Pit Number | Site | Total Depth (ft) | Groundwater Depth (ft)[1] | Lat/Long |
|---|---|---|---|---|
| TP-1 | FSR #3123 | 20 | None | 45.8402,-103.4830 |
| TP-2 | FSR #3123 | 13 | None | 45.8401,-103.4827 |
| TP-3 | FSR #3123 | 6 | None | 45.8406,-103.4828 |
| TP-4 | FSR #3123 | 12 | None | 45.8400,-103.4828 |
| TP-5 | FSR #3123 | 6 | None | 45.8471,-103.4841 |
| TP-6 | Repository | 6 | None | 45.8478,-103.4839 |
| TP-7 | Repository | 9 | None | 45.8476,-103.4847 |
| TP-8 | Pond 5 | 6 | 5.5 | 45.8343,-103.4825 |
| TP-9 | Pond 5 | 4 | None | 45.8329,-103.4810 |
| TP-10 | Upper Schleichart | 8 | 6 | 45.8256,-103.4830 |
| TP-11 | Lower Schleichart | 6 | 5 | 45.8232,-103.4902 |
| TP-12 | Browns Pond | 7.5 | 7.5 | 45.7941,-103.4952 |
| TP-13 | Browns Pond | 7.5 | 7.5 | 45.7941,-103.4947 |
| TP-14 | Browns Pond | 6 | 5.5 | 45.7941,-103.4944 |
| TP-15 | Pond 4 | 4.5 | 0 | 45.8392,-103.4797 |
| TP-16 | Pond 4 | 5 | 0 | 45.8392,-103.4803 |
| TP-17 | Pond 3 | 7 | None | 45.8416,-103.4792 |
| TP-18 | Pond 3 | 12 | 10 | 45.8415,-103.4793 |
| TP-19 | Pond 2 | 7.5 | 5 | 45.8431,-103.4726 |
| TP-20 | Pond 1 | 6 | 0 | 45.8448,-103.4711 |

[1]Groundwater depth generally measured at time of excavation.

### 2.2.3 Hand Auger Explorations

Five Hand Auger explorations were performed using a 3-inch diameter, hand operated, bucket auger in the pond sediments at locations that could not be accessed by either the drill or the excavator. Hand augering, sampling, and logging of the holes was performed by Ron Orton of Allied Engineering from October 24 through 26, 2016. Samples of the soft sediments were obtained in the process, and in HA-1 (in Pond 3) six dynamic cone penetration tests were performed at various depths. The blow counts from the dynamic cone penetrometer are calibrated to correlate directly with the N value of the Standard Penetration Test. The results of the dynamic cone penetrometer tests are provided on the log in Appendix A5. The hand auger logs are provided in Appendix A3.

## 2.3 Field Pickup Survey

During the week of November 16, 2016, a field pick-up survey was conducted by Ron Orton of Allied Engineering. The intention of this survey was to supplement existing LiDAR survey data which may have been outdated and/or was lacking specific information related to pipe invert elevations, sediment boundaries, test pit and borehole locations, etc. The field survey was conducted on NAD83 South Dakota State Plane, US Feet with survey checkpoints on several control points associated with the LiDAR survey. The LiDAR data is from a 2012 AeroMetric, Inc. flight published January 14, 2013. We understand the initial data was projected to UTM NAD83 Zone 13 in meters horizontally and in feet

vertically, which was not useable for design. Tetra Tech re-projected the data to South Dakota State Plane coordinates in US feet so that they could be used for design.

In general, the LiDAR data appears fairly accurate and has matched our field data collected with survey grade GPS in most areas. Some discrepancies between our survey grade GPS and the LiDAR surface have been noted and can be seen on the Plan and Profile drawings in Attachment 1. Those discrepancies are typically less than 6 inches vertically, and have so far been dealt with by showing both the LiDAR and the GPS data on the drawings in Attachment 1. The AESI field surveys of LiDAR control points 1 and 12 were both within 0.1 tenth vertically and 0.3 tenths for LiDAR control 5. We will remain cognizant of the likely presence of some discrepancies between actual topography and the LiDAR model, and deal with them as they arise and with the design of the project and project pay units and quantities.

## 2.4 Laboratory Testing

### 2.4.1 Analytical Laboratory Testing

Laboratory testing for metals and agronomic constituents was conducted on various sediment samples collected by Tetra Tech in 2013 as outlined in the *Tronox Bluff Waste Characterization Report Version 3.0* dated June 27, 2013 (Tetra Tech, 2013a). Since all of Tetra Tech's sampling was conducted within the top 8 inches of the pond sediments, additional sediment sampling at various depths was recommended. Consequently, this section presents Allied Engineering's laboratory testing results for sediment samples at various depths below 8 inches. These samples were delivered to Energy Laboratories in Billings, Montana for analytical testing of metals and agronomic characteristics in order to determine soil chemical characteristics at depth (between about 1 foot and 7 feet below the sediment surface). Table 6 and Table 7 summarize laboratory testing on select samples from the field investigation. These tables combine Tetra Tech's laboratory testing results from the 2013 Tronox Bluff report (Tetra Tech, 2013a) with AESI's results from 2016. The Energy Labs testing data can be found in Appendix B2. An interpretation and assessment of these results is presented in Section 3.6.

### 2.4.1 Geotechnical Laboratory Testing

Select soil samples were also sent to Terracon's laboratory in Great Falls, MT to be tested for geotechnical properties. Table 8 provides a summary of these results. Complete results can be found in Appendix B1. As will be discussed in the Conceptual Design Report, soil strength parameters for slope stability analyses will be based on typical correlations between soil strength and laboratory testing results and/or borehole SPT values. Interpretations and assessments of some of the lab testing results are provided in Section 3.5.1 and Section 3.5.5.1.

**Table 6 - Combined Metals Results (Tetra Tech, 2013a and AESI)**

| Total Metals (mg/kg) for Riley Pass: Tetra Tech (2013a) 8 inch Depth and AESI (2016) Variable Depths | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Location** | **Field ID** | **Arsenic** | **Cadmium** | **Copper** | **Lead** | **Molybdenum** | **Uranium** | **$^{226}RA^{1}$** | **$^{228}RA^{1}$** | **Zinc** |
| **Upper Schl.** | SED-DRAW-1 | 26 | 0.26 | 19 | 16 | 2 | 5.5 | | | 69 |
| | SED-DRAW-2 | 28 | 0.5 | 31 | 28 | 6.9 | 11 | | | 100 |
| | SED-DRAW-3 | 38 | 0.51 | 27 | 24 | 4.7 | 8.8 | | | 91 |
| | [2]HA-5 3.5'-4.0' | 23 | ND | 14 | 15 | 3 | 4 | | | 51 |
| | [2]HA-5 5.5'-6.0' | | | | | | | 0.03 | 0.009 | |
| **Browns Pond** | SED-BROWN-1 | 12 | 0.14 | 6.8 | 6.9 | 1 | 1.3 | | | 30 |
| | SED-BROWN-2 | 7.9 | 0.069 | 3.2 | 4.2 | 0.74 | 0.83 | | | 25 |
| | SED-BROWN-3 | 6.4 | 0.23 | 14 | 11 | 0.65 | 2.1 | | | 70 |
| | [2]HA-7 1.5'-2.0' | 24 | | | | | | 1.2 | 1.2 | |
| | [2]HA-7 4.2'-4.8' | 9 | | | | | | 0.8 | 1.1 | |
| **Lower Schl.** | SED-DUCK-1 | 48 | 0.29 | 14 | 13 | 1.3 | 2.7 | | | 65 |
| | SED-DUCK-2 | 54 | 0.57 | 38 | 31 | 6.2 | 16 | | | 160 |
| | SED-DUCK-3 | 43 | 0.41 | 25 | 24 | 4.3 | 8.7 | | | 130 |
| | [2]HA-6 3.0'-3.5' | 9 | | | | | | 2.2 | 2.1 | |
| **Pond 1** | SED-SP1-1 | 99 | 0.29 | 9.8 | 10 | 13 | 6.1 | | | 83 |
| | SED-SP1-2 | 43 | 0.2 | 9.2 | 10 | 8.9 | 3.2 | | | 58 |
| | SED-SP1-3 | 54 | 0.27 | 13 | 12 | 6.7 | 8.5 | | | 110 |
| | [2]HA-3 4.0'-4.5' | 47 | | | | | | 6.2 | 2.9 | |
| | [2]HA-3 5.5'-6.0' | 27 | ND | 9 | 10 | 7 | 9 | 0.3 | 1.9 | 37 |
| **Pond 2** | SED-SP2-1 | 77 | 0.36 | 18 | 15 | 15 | 13 | | | 100 |
| | SED-SP2-2 | 25 | 0.53 | 23 | 18 | 18 | 11 | | | 130 |
| | SED-SP2-3 | 69 | 0.2 | 14 | 11 | 25 | 14 | | | 78 |
| | [2]HA-2 3.0'-3.5' | 48 | | | | | | 6.2 | 2.9 | |
| | [2]HA-2 5.5'-6.0' | 40 | ND | 13 | 12 | 10 | 11 | 0.07 | 0.009 | 46 |
| | [2]TP-19 3.8'-4.0' | 45 | ND | 13 | 10 | 53 | 73 | | | 39 |
| | [2]TP-19 4.0' | | | | | | | 0.1 | 0.02 | |
| **Pond 3** | SED-SP3-1 | 26 | 0.3 | 13 | 13 | 2 | 5.2 | | | 81 |
| | SED-SP3-2 | 25 | 0.18 | 7.9 | 8.7 | 4 | 3.1 | | | 63 |
| | SED-SP3-3 | 31 | 0.58 | 8 | 8 | 2.4 | 4 | | | 56 |
| | [2]HA-1 7.0' | 21 | ND | 7 | 8 | 2 | 2 | 0.2 | 1.4 | 29 |
| **Pond 4** | SED-SP4-1 | 61 | 0.57 | 28 | 27 | 3.6 | 6.1 | | | 160 |
| | SED-SP4-2 | 58 | 0.55 | 27 | 26 | 4.8 | 11 | | | 99 |
| | SED-SP4-3 | 37 | 0.28 | 19 | 19 | 1.8 | 3.5 | | | 98 |
| | [2]TP-15 1.25' | 14 | | | | | | 0.5 | 3.1 | |
| | [2]TP-15 2.0'- | 14 | | | | | | 0.3 | 2.5 | |
| | [2]TP-16 2.0'- | 18 | ND | 9 | 9 | 1 | 2 | 2.4 | 2.8 | 37 |
| **Pond 5** | SED-SP5-1 | 60 | 0.48 | 31 | 26 | 2.9 | 5.5 | | | 110 |
| | SED-SP5-2 | 48 | 0.33 | 23 | 22 | 3.9 | 6.3 | | | 100 |
| | [2]HA-4 1.5'-2.0' | 18 | | | | | | 0.3 | 1.6 | |
| | [2]TP-8 1.0' | 29 | | | | | | 0.3 | 1.3 | |
| | [2]TP-8 3.0' | 19 | ND | 8 | 10 | 2 | 3 | 1.8 | 1.8 | 36 |
| MAX | | 99 | 0.58 | 38 | 31 | 53 | 73 | 6.2 | 3.1 | 160 |
| MIN | | 6.4 | 0.069 | 3.2 | 4.2 | 0.65 | 0.83 | 0.03 | 0.009 | 25 |
| AVG | | 35.4 | 0.35 | 16.5 | 15.26 | 7.3 | 8.7 | 1.43 | 1.665 | 78.0 |
| MED | | 29 | 0.3 | 14 | 12.5 | 3.95 | 5.8 | 0.4 | 1.7 | 74 |
| [1]Units = picocuries/liter | | | | | | | | | | |
| [2] Samples collected by AESI October 2016 | | | | | | | | | | |

## Table 7 – Combined Agronomic Testing Results (Tetra Tech, 2013a and AESI)

| Agronomic Testing Results (Saturation Paste Extract) for Riley Pass Sediment Samples (Tetra Tech, 2013a) 0- to 8-inch Depth) And AESI (2016) Depths Vary[1] | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Location** | **Field ID** | **pH** | **EC (dS/m[1])** | **Nitrate -N (mg/L[2])** | **Nitrate-N (mg/kg[3])** | **Phosp (mg/L)** | **Phosp (mg/kg)** | **Potass. (mg/L)** | **Potass. (mg/kg)** | **Calcium (me/L[4])** | **Magnesium (me/L)** | **Sodium (me/L)** | **SAR** | **ESP** | **Sulfate (mg/L)** | **CEC meq/100g** | **Gypsum (T/acre[5])** |
| **Upper Schl.** | SED DRAW-1 | **8.71** | 2.49 | 0.02 | | 0.13 | | 43.9 | | 1.47 | 5.37 | 32.6 | **1** | 2 | | | 9.75 |
| | SED DRAW-2 | 8.08 | 4.52 | 2.33 | | 0.58 | | 53.4 | | 1.89 | 9.84 | 55.1 | **2** | 3 | | | 9.68 |
| | SED DRAW-3 | 8.09 | 4.95 | 4.53 | | 1.11 | | 43.8 | | 2.32 | 10.6 | 63.8 | **2** | 3 | | | 15.8 |
| | [6]HA-5 3.5'-4.0' | 8.5 | 2.7 | | 1 | | 7 | | 490 | 0.88 | 0.68 | 26.2 | **2** | | 996 | 46.9 | |
| **Browns Pond** | SED BROWN-1 | 8.09 | 1.85 | 0.15 | | 0.01 | | 35.8 | | 1.11 | 11.1 | 43.8 | **1** | 2 | | | 10.6 |
| | SED BROWN-2 | 7.73 | 1.8 | 2.44 | | 0.03 | | 32.9 | | 2.93 | 8.03 | 38.6 | **1** | 2 | | | 8.8 |
| | SED BROWN-3 | 7.32 | 2.67 | 0.02 | | 0.02 | | 41.4 | | 6.72 | 10.5 | 42.8 | **1** | 2 | | | 11.6 |
| **Lower Schl.** | SED DUCK-1 | 8.26 | **7.02** | 0.02 | | 0.02 | | 51.9 | | 2.95 | 28.1 | 152 | **3** | 5 | | | 6.12 |
| | SED DUCK-2 | 8.14 | 4.77 | 1.81 | | 0.44 | | 33.9 | | 3.69 | 9.55 | 69.7 | **2** | 3 | | | 10.2 |
| | SED DUCK-3 | 7.98 | 8.19 | 0.04 | | 0.04 | | 86.2 | | 2.9 | 24.8 | 137 | **3** | 5 | | | 9.98 |
| **Pond 1** | SED SP1-1 | 7.41 | 1.76 | 5.46 | | 0.02 | | 27.5 | | 7.31 | 4.67 | 20.7 | 8. | 1 | | | 1.21 |
| | SED SP1-2 | 8.02 | 1.35 | 11.4 | | 0.01 | | 13.7 | | 2.33 | 1.41 | 16.3 | 1 | 1 | | | 1.47 |
| | SED SP1-3 | 7.57 | 1.87 | 0.01 | | 0.07 | | 24.6 | | 5.61 | 4.97 | 30.4 | **1** | 1 | | | 2.09 |
| | [6]HA-3 5.5'-6.0' | 7.9 | 3 | | ND | | 5 | | 161 | 1.51 | 1.69 | 30.8 | **2** | | 1150 | ND | |
| **Pond 2** | SED SP2-1 | 7.42 | 3.57 | 0.02 | | 0.22 | | 46. 7 | | 16.32 | 12.8 | 62 | **1** | 2 | | | 2.37 |
| | SED SP2-2 | 7.81 | 2.29 | 13.8 | | 0.13 | | 22.4 | | 7.37 | 6.41 | 54.1 | **2** | 2 | | | 2.29 |
| | SED SP2-3 | 7.64 | 2.89 | 0.55 | | 0.11 | | 26.2 | | 5.77 | 4.65 | 39.1 | **1** | 2 | | | 3.4 |
| | [6]HA-2 5.5'-6.0' | 7.4 | 2.4 | | ND | | 9 | | 298 | 1.89 | 1.51 | 22.1 | **1** | | 979 | 32.6 | |
| | [6]TP-19 3.8'-4.0' | 6.5 | 3.4 | | ND | | 7 | | 159 | 4.31 | 3.91 | 29.1 | **1** | | 1480 | 33.2 | |
| **Pond 3** | SED SP3-1 | 7.38 | 1.08 | 0.02 | | 0.14 | | 5.22 | | 0.86 | 0.39 | 10.9 | **1** | 1 | | | 1.92 |
| | SED SP3-2 | 7.82 | 1.22 | 1.23 | | 0.06 | | 8.42 | | 1.17 | 0.97 | 18.8 | **1** | 2 | | | 1.84 |
| | SED SP3-3 | 8.47 | 0.54 | 25.4 | | 0.47 | | 3.74 | | 0.32 | 0.01 | 9.8 | **2** | 3 | | | 1.65 |
| | [6]HA-1 7.0' | 8.6 | 1.2 | | 2 | | 4 | | 89 | 0.96 | 0.78 | 11.7 | **1** | | 176 | 15.2 | |
| **Pond 4** | SED SP4-1 | 7.93 | 3.95 | 1.58 | | 1.71 | | 17.9 | | 1.09 | 1.83 | 61.2 | **5** | 7 | | | 9.16 |
| | SED SP4-2 | 7.8 | 3.58 | 0.22 | | 0.08 | | 20.2 | | 2.22 | 3.04 | 40.8 | **2** | 3 | | | 9.13 |
| | SED SP4-3 | 7.71 | 3.43 | 0.57 | | 0.11 | | 18.1 | | 3.91 | 3.87 | 43.9 | **2** | 3 | | | 7.61 |
| | [6]TP-16 2.0'-3.0' | 8.4 | 6 | | 3 | | 8 | | 351 | 4.78 | 6.89 | 62.4 | **2** | | 3100 | 48.6 | |
| **Pond 5** | SED SP5-1 | 8.04 | 4.92 | 1.21 | | 0.29 | | 29.9 | | 3.03 | 4.62 | 65.1 | **3** | 4 | | | 30.3 |
| | SED SP5-2 | 7.59 | 5.75 | 0.03 | | 0.19 | | 44.8 | | 7.34 | 11.9 | 74.1 | **2** | 3 | | | 21.3 |
| | [6]TP-8 1.0' | 8.4 | 2.8 | | 2 | | 1 | | 83 | 1.63 | 2.19 | 26.4 | **1** | | 1130 | 16.3 | |
| | [6]TP-8 3.0' | 8.2 | 3 | | 1 | | 4 | | 128 | 1.19 | 2.73 | 29.4 | **2** | | 1170 | ND | |
| Max | | 8.71 | 8.19 | 25.4 | 3 | 1.71 | 9 | 86.2 | 490 | 16.32 | 28.1 | 152 | 5 | 7 | 3100 | 48.6 | 30.3 |
| Min | | 6.5 | 0.54 | 0.01 | 1 | 0.01 | 1 | 3.74 | 83 | 0.32 | 0.01 | 9.8 | 8. | 1 | 176 | 15.2 | 1.21 |
| AVG | | 7.90 | 3.26 | 3.17 | 1.80 | 0.26 | 5.63 | 31.18 | 219.88 | 3.48 | 6.45 | 45.83 | 2 | 3 | 1272.6 | 32.13 | 8.19 |
| Mean | | 7.93 | 2.89 | 0.57 | 2.00 | 0.11 | 6.00 | 28.70 | 160.00 | 2.33 | 4.65 | 39.10 | 2 | 2 | 1140.0 | 32.90 | 8.80 |

[1] Bold values exceed the topsoil suitability criteria provided by Tetra Tech (2013a) and Table 11

[2]mg/L =milligrams per liter, [3]mg/kg = milligrams per kilogram, [4]me/L = milliequivalent per liter, [5]T/acre = tons per acre, [6]Samples collected by AESI October 2016

## Table 8 - Geotechnical Lab Testing Summary[3][4][5]

| | Sample[1] | Depth (ft) | USCS Class. | Atterberg Limits | | | Grain Size Distribution | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | LL | PL | PI | % Fines | % Gravel | %Sand | %Silt | %Clay | MC% | Other[2] |
| **Pond 1** | TP-20 | 2 | SM | | | | 17.9 | 0.6 | 81.5 | | | 22.5 | |
| | TP-20 | 4 | CL | 42 | 17 | 25 | 69.5 | 0 | 30.5 | | | 61.2 | |
| | TP-20 | 6 | CL | | | | 56.3 | 0 | 43.7 | | | 22.8 | |
| | SP-1 | 19.5 - 21 | SC | 29 | 15 | 14 | 43.3 | 0 | 56.7 | | | 23.4 | |
| **Pond 2** | TP-19 | 2 | SW-SM | | | | 10.4 | 0.2 | 89.4 | | | 16.3 | |
| | TP-19 | 7 | SC | | | | 39.3 | 0 | 60.7 | | | 29.9 | |
| | SP-2 | 9.5 - 11 | CL | 33 | 14 | 19 | 52.3 | 0.5 | 47.2 | | | 17.7 | |
| | SP-2 | 19.5 - 21 | CL | 45 | 16 | 29 | 77.8 | 2.8 | 19.4 | | | 27.4 | |
| **Pond 3** | TP-18 | 6 | CL | | | | 90 | 0 | 10 | | | 44.5 | |
| | TP-18 | 10 | SM | | | | 21.1 | 0.2 | 89.4 | | | 22.2 | |
| | TP-17 | 0 | SP | | | | 4.4 | 3.4 | 92.2 | | | 21.2 | |
| | TP-17 | 6.5 | CL | 41 | 13 | 28 | 69.9 | 0 | 30.1 | | | 28.3 | |
| | SP-3 | 9.5 - 11 | CL | 31 | 15 | 16 | 63.3 | 0.9 | 35.8 | | | 17.1 | |
| | SP-3 | 14.5 - 16 | SM | 26 | 22 | 4 | 33.3 | 0.3 | 66.4 | | | 12.5 | |
| | SP-3 | 19.5 - 21 | SC-SM | 24 | 20 | 4 | 48.8 | 3.5 | 47.7 | | | 20.3 | |
| **Pond 4** | SP4 | 7.5 - 9 | CL | 35 | 14 | 21 | 62.2 | 0.6 | 37.2 | | | 25.8 | |
| | SP4 | 10 - 11.5 | CL | 36 | 13 | 23 | 61.8 | 0.1 | 38.1 | | | 26.8 | |
| **Pond 5** | - | 0 | CH | 120 | 23 | 97 | 99.6 | 0 | 0.4 | | | | 26.6 DD |
| | - | | | | | | | | | | | | 28.2 DD |
| **Upper Schl** | TP-10 | 2 | CH | 113 | 23 | 90 | 99.8 | 0 | 0.2 | 4.4 | 95.4 | 83.1 | |
| | BH- | 9.5 - 11.5 | SC | 31 | 14 | 17 | 48.2 | 0 | 51.8 | | | 20.9 | 1961 CS |
| | BH- | 9.5 - 11.5 | | | | | | | | | | 20.9 | 97.2 DD |
| **Lower Schl** | TP-11 | 3 | CL | 34 | 17 | 17 | 78.9 | 0 | 21.2 | 54.3 | 24.6 | 43.4 | |
| | BH- | 4.5 - 6.5 | CL | 30 | 18 | 12 | 58.7 | 0 | 41.3 | | | 14.7 | 107.8 DD |
| **Browns** | TP-12 | 4.5 | SM | | | | 16.9 | 2 | 81.1 | 11 | 5.9 | 22.1 | |
| | TP-12 | 7.5 | | | | | 21.1 | 21.2 | 57.7 | | | 23.7 | |
| | BP-01 | 9.5 - 11 | SC | 25 | 16 | 9 | 47.4 | 0.1 | 52.5 | | | 14.8 | |
| | BP-01 | 14.5 - 16 | CL | 29 | 12 | 17 | 56.1 | 0.1 | 43.8 | | | 24.6 | |
| | BP-01 | 19.5 - 21 | SC | 29 | 19 | 10 | 43.7 | 0.2 | 56.1 | | | 26.9 | |
| | BP-01 | 24.5 - 26 | CL | 47 | 14 | 33 | 56.4 | 0 | 43.6 | 27.2 | 29.2 | 31.1 | |
| | BP-02 | 19.5 - 21.5 | SC | 35 | 13 | 22 | 49 | 1.3 | 49.7 | | | 21.4 | 100.1 DD |
| **FSR# 3123[5]** | TP-1 | 1 - 2 | CH | 60 | 23 | 37 | | | | | | 26.6 | |
| | TP-1 | 4 - 8 | ML | 27 | 26 | 1 | 78.3 | 0 | 21.7 | | | | |
| | TP-2 | 23 | SC | 65 | 15 | 50 | 31.6 | 0 | 68.4 | | | 24 | |
| | TP-3 | 2 | CL | 45 | 22 | 23 | 84.8 | 0 | 15.2 | | | 18.5 | |
| | TP-4 | 3 | CH | 84 | 33 | 51 | 79.5 | 0.8 | 19.7 | | | 33.4 | |
| | 3123- | 20 - 21.5 | | 53 | 21 | 32 | | | | | | 26.7 | |
| | 3123- | 25 - 27 | | | | | 67.3 | 0 | 32.7 | | | 36 | 77 DD |
| | 3123- | 15 - 16.5 | CH | 84 | 19 | 65 | 74.6 | 0 | 25.4 | | | 32.9 | |
| | 3123- | 20 - 22 | SC | 117 | 20 | 97 | 43 | 0 | 57 | 15.5 | 27.5 | 25.5 | 98.2 DD |
| | 3123- | 25 - 26.5 | SC | 65 | 15 | 50 | 43.7 | 0 | 56.3 | | | 24.9 | |
| | 3123- | 30 - 31.5 | SC | 63 | 14 | 49 | 49.8 | 0 | 50.2 | | | 19.8 | |
| **Repository** | TP-5 | 3 | CL | 35 | 15 | 20 | 62.8 | 0 | 37.2 | | | 31.9 | |
| | TP-6 | 6 | SC | 26 | 14 | 12 | 42.1 | 0.4 | 57.5 | | | 18.7 | |
| | TP-7 | 5 | CL | 26 | 18 | 8 | 52.2 | 0 | 47.8 | 35.2 | 17 | 21.8 | |
| | DCP-2 | 1 | SC | | | | 60.7 | 0.8 | 38.5 | | | 8.5 | |
| | DCP-3 | 1 | SC | | | | 48.3 | 0 | 51.7 | | | 3.3 | |
| | DCP-4 | 1 | SC | | | | 63.4 | 0 | 36.6 | | | 12.9 | |
| | DCP-5 | 1 | SC | | | | 53.4 | 2.3 | 44.3 | | | 6.3 | |

[1]TP = Test Pit, BH = Borehole, DCP = Dynamic Cone Penetrometer, SP = Split Spoon Borehole Sample; [2]DD = Dry Density, CS = Compressive Strength; [3]See Appendix B1 for other moisture content test results; [4]Not all test pit and boreholes were tested; [5]Not all FSR #3123 testing shown in table. Refer to Appendix B for complete results.

## 2.5 Site Conditions

### 2.5.1 Ponds and Embankments Summary

The project consists of eight ponds in various states of repair and condition. Variables for each pond include hydraulic and hydrologic characteristics, sedimentation efficiency, and slope stability. Refer to the plan and profile drawings in Attachment 1 for existing conditions of each pond.

As shown on the plan and profile drawings in Attachment 1, the embankment slopes on the downstream face of the dams vary between approximately 1.9H:1V and 3.3H:1V. Upstream face slopes for the ponds vary between a maximum of 1.8H:1V for the wave eroded portion of Upper Schleichart to about 6H:1V for Browns Pond and Ponds 4 and 5. Several of the embankments including both Schleichart Draw Reservoirs have experienced significant erosion on the upstream face which has reduced the embankment top widths and created over-steepened slopes. Rip-rap armoring or other erosion control is needed and the type, amount, and availability of the rip-rap will need to be evaluated and sourced during conceptual design. In general, the native rock of the site vicinity does not meet hardness criteria for riprap. However, most of the existing riprap at Browns Pond and Upper Schleichart spillway is believed to be imported and suitable for reuse based on visual inspection. The relatively short wind fetch of these ponds may allow the use of synthetic erosion resisting revetments instead of rock. If the upper sediment ponds are designed to drain down between storms, rip-rap may not be needed on the upstream embankment slopes. Table 9 provides a summary of select existing conditions for the ponds and embankments.

Embankment soils were generally found to consist of loose to medium dense clayey sand with gravel fill overlying fat clay and/or coaly shale bedrock. Embankment soils appear to be homogeneous (not zoned). The clayey sand fill is generally a suitable embankment fill material when adequately compacted. However, low in-situ densities as indicated by blow counts indicate possible poor compaction during construction. Poorly compacted embankment materials likely contribute to seepage, sloughing, and erosion.

Foundation soils encountered at all dams except Sediment Pond 5 and Lower Schleichart Draw Reservoir included challenging soils including old topsoil layers, loose saturated sands, organic soils, fat clays, and coal layers. These conditions are discussed in more detail for each dam, but generally represent weak foundations that warrant some care to minimize potential for settlement, shear failures, and seepage issues. These soils are generally not suitable to reuse as backfill due to their high plasticity, low frictional resistance, often high organic and moisture contents, and poor workability. Since removal and replacement of these soils from under existing embankments is not practical, general approaches to addressing these poor foundation soils include flattening embankment slopes to reduce shear stresses and seepage gradients, and installing filtered drains to enhance stability and minimize piping potential.

**Table 9 - Summary of Existing Pond Conditions**

| | Pond 1 | Pond 2 | Pond 3 | Pond 4 | Pond 5 | Upper Schleichart | Lower Schleichart | Browns Pond |
|---|---|---|---|---|---|---|---|---|
| **Contributing Drainage Area, square miles** | 0.03 | 0.05 | 0.15 | 0.42 | 0.79 | 1.48 | 2.95 | 12.65 |
| **Storage at Minimum Dam Embankment, acre-feet** | 7.4 | 8.1 | 15.9 | 5.8 | 9.7 | 26.1 | 93.8 | 238.5 |
| **Embankment Length, feet** | 240 | 175 | 400 | 160 | 300 | 375 | 340 | 1370 |
| **Minimum Embankment Crest Elevation, feet** | 3106.5 | 3119.5 | 3136.2 | 3110.7 | 3072.3 | 3032 | 3012 | 2903 |
| **Elevation of Natural Streambed at Downstream Toe, feet** | 3091.2 | 3101 | 3115 | 3104 | 3062 | 3018 | 2996 | 2880 |
| **Height of Dam, feet** | 15.3 | 18.5 | 21.2 | 6.7 | 10.3 | 14 | 15 | 20 |
| **Outlet Works** | 36-inch CMP with standpipe | 36-inch CMP with standpipe | 30-inch CMP with standpipe | 40-inch CMP with standpipe | 65-inch CMP with standpipe | NA | 12 -inch CMP with standpipe | 10-inch PVC Culvert |
| **Outlet Works Upstream Invert Elevation, feet** | 3095.63 | 3105.92 | 3123.6 | 3104.84 | 3063.22 | NA | 2997.86 | 2895.8 |
| **Principal Spillway** | 36-inch Standpipe | 36-inch Standpipe | 48-inch Standpipe | 40-inch Standpipe | 96-inch Standpipe | Rip-Rap Channel | 18-inch Standpipe | 10-inch PVC Culvert |
| **Principal Spillway Elevation, feet** | 3099.7 | 3113.92 | 3132.8 | 3109.22 | 3069.92 | 3030.12 | 3007.27 | 2895.8 |
| **Emergency Spillway** | None | None | None | None | None | None | Natural Ground Channel | Natural Ground Channel |
| **Emergency Spillway Elevation, feet** | NA | NA | NA | NA | NA | NA | 3010 | 2898 |

#### *2.5.1.1 Pond 1*

Pond 1 is located on a tributary of upper Pete's Creek on the northeast side of the Riley Pass divide and was built in 1987 to control sediment runoff from the Riley Pass Mine. Sediment from Pond 1 was last removed in 2009. A significant portion of the sediment in Pond 1 appears to accumulate in a sandy delta along the north edge of the pond. Sediment near the outlet pipe appeared to be well vegetated during the site investigation. The 36-inch diameter CMP standpipe and outlet for the pond is corroded through and is therefore drained below the rim of the standpipe. Test Pit 20 (TP-20) was excavated near the north side of the pond and laboratory test results showed the sediment to be sand and sandy lean clay. The main access road (FSR #3120 also called Tufte Road) to the area crosses over the embankment of Pond 1. Borehole SP1 was drilled to 26 feet deep near the maximum section of the embankment and

encountered generally a loose to dense clayey sand fill embankment to 15 feet overlying medium stiff silty sand subgrade with lenses of organics from 15 to 23 feet, overlying a soft black coaly shale with some weathered sandstone lenses. Standard Penetration Testing revealed N values in the embankment between 5 and 15, with an N value of 5 in the silty sand subgrade and 63 in the coal bedrock.

Pond 1 is the smallest of the sediment ponds at approximately 0.3 acres and drains the smallest area at approximately 19 acres. Inflow into the pond is from unnaturally eroded channels created by sediment laden runoff from Bluff B. A relatively steep downstream dam face of about 1.9H:1V and a small muddy pond near the CMP outlet suggest the potential need for embankment rehab and replacement of outlet works.

#### *2.5.1.2 Pond 2*

Pond 2 was also built in 1987 and located on a tributary to upper Pete's Creek, however Pond 2 and Pond 1 are not affected by the same drainage area. Both ponds are fed by drainages influenced by abandoned mine activity located on Bluff B west of the ponds. A deep zig-zagging gully has eroded down the bluff and feeds sediment laden runoff to Pond 2. From the site investigation, TP-19 indicated sandy sediment deposits throughout the sediment profile near the inlet delta of the pond. The Pond 2 embankment was recently rehabilitated along with Pond 3 as described in Tetra Tech's as-built drawings and report dated December 20, 2010 (Tetra Tech 2010). Work generally included replacement of the existing CMP culverts and drop inlets along with installation of sand filters, flowable fill, and replacement of compacted embankment fill. The Pond 2 outlet consists of about 81.5 feet of 36-inch diameter CMP sloped at 4% with an 8-foot tall drop inlet. Like Pond 1, FSR #3120 crosses over the embankment of Pond 2.

Borehole SP2 was drilled to 30.4 feet near the maximum section of the embankment and encountered generally a loose to medium dense clayey sand fill embankment to 15.1 feet overlying an old topsoil layer and then overlying a dark gray to black, medium stiff to stiff, moist fat clay with a trace of organics down to 24.5 feet. From 24.5 to 25.8 feet, loose fine silty sand with some organics were encountered overlying soft black coal bedrock with some weathered sandstone lenses. Standard Penetration Testing revealed N values in the embankment between 4 and 11, with N values of 5 and 15 in the fat clay and silty sand subgrade and 50+ in the coal bedrock.

TP-19 was excavated within the inlet sediment delta and encountered about 4 feet of clean sand overlying a thin layer of silt/clay. The clean sand sediment deposits may be useful for sand filter or toe drain material for the project. This delta appears to contain the majority of the sediment in the pond. Some finer particles may settle out before reaching the outlet pipe while other suspended particles do not have adequate retention time to settle out in Pond 2. Lengthening retention time by raising the dam crest and/or reconfiguring the outlet works may be beneficial.

#### *2.5.1.3 Pond 3*

Pond 3, constructed in 1987, is located south of Riley Pass and first in line in the series of 5 ponds which drain the sediment repository area and adjacent Bluff B mining related disturbances. Based on explorations, a significant portion of the sediment is sandy with occasional layers of interbedded

silts/clays which may have been deposited during small flow events. The sandy sediment is a relatively clean sand and potentially useful as sand filter material or toe drain material. A significant amount of sediment is located on the delta near the pond inlet. The Pond 3 outlet consists of about 72 feet of 30-inch diameter CMP at 4% and an 8-foot tall, 48-inch diameter drop inlet. The Pond 3 embankment was recently rehabilitated along with Pond 2 as described in Tetra Tech's as-built drawings and report dated December 20, 2010 (Tetra Tech, 2010). Work generally included replacement of the existing CMP culverts and drop inlets along with installation of sand filters, flowable fill, and replacement of compacted embankment fill. The access road to the USFS field office crosses over the embankment of Pond 3.

Borehole SP3 was drilled to 36.0 feet near the maximum section of the embankment and encountered a generally loose to medium dense clayey sand fill embankment to 20.4 feet overlying a stiff brown, very moist, fat clay with a trace of silt down to 33.0 feet. From 33.0 to 36.0 feet, a soft black coal bedrock with some weathered sandstone lenses was encountered. Standard Penetration Testing revealed N values in the embankment between 6 and 11, with N values of 15 and 24 in the fat clay subgrade and refusal in the coal bedrock.

The fat clay subgrade found below the Pond 3 embankment (and several other dams) is a relatively low strength and low permeability soil that could form a failure surface during rapid drawdown on over-steepened embankment slopes. Repeated saturation and drying of the fat clay could cause shrinking/swelling/cracking of the embankment foundation which could also decrease stability. Filtered toe drains and chimney drains could be used to help control flow through the embankments.

At about 1.3 acres, Pond 3 is larger than both Pond 4 and Pond 5 (0.64 and 1.12 acres respectively) and with its smaller drainage area has a longer retention time. Therefore, sediment that does not have time to settle out in Pond 3 also likely does not have time to settle out in Pond 4 or Pond 5, leaving in question the value of Ponds 4 and 5 as sediment ponds. Increasing sedimentation efficiency by increasing the size and retention time of Pond 3 by raising the embankment and/or redesigning the outlet works may be an effective design measure.

#### *2.5.1.4 Pond 4*

Pond 4 was built in 1987 and is located just downstream of Pond 3. Pond 4 has two distinct arms, of which the east arm is fed by Pond 3 and the west arm is fed by a separate draw to the west which has substantially less disturbed area compared to the area that drains into Pond 3. Although the exact routing of flow into Pond 4 from the east is uncertain, it appears there is additional contributing drainage basin area to the east which also has substantially less disturbed area. Contributing drainage from the east basin should be confirmed during design. The effectiveness of this location as a sediment pond should be discussed. It may be more effective to enlarge Pond 3, or even move Pond 4 upstream to focus on drainage areas that are actually producing mining induced sediment.

Test pits in both the east and west arms showed similar sediment conditions being about 3 to 4 feet of very soft silt/clay sediment overlying native soils and alluvium. Based on visual comparison of sediments in Pond 3 and Pond 4, it appears that a significant amount of the sands and coarser materials settle out

in Pond 3 before getting to Pond 4. However, retention times and settlement velocities should be checked during the design process. About 5,000 cubic yards of sediment was removed from Pond 4 in 2009. The 40-inch diameter CMP standpipe and outlet for the pond is corroded. The FSR #3123 access road to the Bluff B and sediment repository area crosses over the embankment of Pond 4.

Borehole SP4 was drilled to 27 feet near the maximum section of the embankment and encountered generally a loose, light brown clayey sand and a soft, light brown lean clay embankment to 13.1 feet overlying a stiff lean and fat clay subgrade with some organics from 13 to 27 feet. Groundwater was encountered at between 10 and 18 feet deep during drilling.

Low standard penetration values (N values of between 2 and 5) in the top 15 feet of the embankment reveal poor compaction and the potential need for total reconstruction. The corroded standpipe leaks at its base acting as a partially uncontrolled low level outlet which may help to drain and consolidate sediments between storm events. Pond 4 could be a good place to test drying sediment in-place with the use of a low-level outlet orifice that empties the pond between events.

#### *2.5.1.5 Pond 5*

Pond 5 was built in 1987 downstream of Pond 4 and upstream of Upper Schleichart Draw Reservoir. While it no doubt varies with conditions and the season, the sediment that has been observed in Pond 5 resembles a wet soup of predominantly silts and clays, which is poorly drained, unconsolidated and has proven to be difficult to handle. A 2009 attempt to remove sediment from Pond 5 was postponed due to the sediment being too wet to handle. As can be seen from photos in Appendix D, the saturated sediment had no shear strength and generally flowed when our test pit was excavated. The 96-inch diameter CMP standpipe and 65 inch CMP outlet for the pond is rusted but still intact. The main road down Schleichart Draw (FSR #3120) crosses over the embankment of Pond 5. Borehole SP5 was drilled to 21 feet near the maximum section of the embankment and encountered generally clayey sand and a sandy silt embankment to the depth explored (21.0 feet). Groundwater was encountered at between 18 and 20.5 feet deep during drilling. Wet, soupy sediments within Pond 5 need to be dried/treated prior to removal and transport. A permanent or temporary low-level outlet, possibly an orifice installed at the base of the existing standpipe, could be used to drain the existing sediments for easier removal.

#### *2.5.1.6 Upper Schleichart Draw Reservoir*

Upper Schleichart Draw Reservoir was built in 1935 by the Civil Conservation Corps. It is located about one-half mile below Pond 5. The reservoir is nearly full of sediment and had minimal standing water during the site investigation. The sediment appeared to be relatively well consolidated compared to the upper ponds. The sediment surface could be easily walked upon during the site investigation, and the test pit walls stood relatively steeply overnight. As can be seen from Google imagery, the sediment top crust has a high concentration of salts. One hand auger hole (HA-5) was drilled near the center of the reservoir and encountered 6 feet of moist to wet silty clay and sand sediment. TP-10 was excavated in sediments near the center of the upstream face of the dam and encountered at least 7 feet of somewhat organic silt, clay, and sand sediment, some of which tested in the laboratory as a fat clay (CH) with almost 100% fines. This test pit was left open over the night and approximately 12 inches of standing water filled the hole during that time.

The reservoir embankment has heavy erosion on the upstream face due to wave action. There is an isolated slump on the left side of the embankment (looking downstream). Low standard penetration test values in loose, wet, silty sand foundation materials that overlie a fat clay were encountered during the exploratory boring (BH-USDR). A spring is located on the left downstream groin of the dam that is developed and includes a pipeline to a livestock tank. There is no apparent low-level outlet in the reservoir. The present outflow is over the riprapped, relatively well-vegetated, open channel spillway on the north (right) side of the embankment.

The embankment appears to be approximately 12 feet high based on topography, including a two foot deep undrained downstream depression that may be a result of the original embankment borrow or possibly a scour hole. One borehole (BH-USDR) was drilled on top of the embankment which encountered about 10 feet of clayey sand embankment fill overlying loose to medium dense clayey sand foundation materials overlying a very loose (N=3) layer of silty sand that was in turn underlain by weak fat clay and then shale. The observed seepage/spring on the left abutment/groin plus the very loose sand and fat clay at about 8 foot depth below the embankment toe represent a relatively poor foundation for the embankment. These conditions substantiate that a substantial reconfiguration of the embankment including upstream and downstream slopes, filtered drains, erosion protection, and placement of a low level outlet are likely necessary. Lower Schleichart Draw Reservoir

The Lower Schleichart Draw Reservoir was built in 1987, the same year as the Sediment Ponds. Lower Schleichart Draw Reservoir has a surface area of about 7 acres and is considered a dam by South Dakota Department of Environmental and Natural Resources standards. It is located located approximately 1000 feet downstream of the upper reservoir and is served by a 12-inch CMP outlet pipe with an 18-inch riser overflow standpipe and a broad grassed emergency spillway around the right abutment. The embankment is approximately 15 feet high with a 11.5 foot topwidth. The upstream embankment slope is approximately 2.5H:1V with some steeper portions from wave erosion. The downstream embankment slope is approximately 3.3H:1V, with some over steepening and scour around the low-level outlet plunge pool. The pond has a significant amount of sediment, the perimeter of which was relatively consolidated and crusted to the point that an excavator could be safely driven onto portions of the sediment (Figure 4).

A hand auger exploration (HA-6) was conducted on the east side of the reservoir which encountered at least 3.75 feet of sediment. TP-11 was excavated on the west side of the reservoir and encountered about 4.5 feet of lean clay with sand sediment overlying what appeared to be native soils.


**Figure 4 – Lower Schleichart Draw Reservoir Test Pit**

The downstream face of the embankment had a significant amount of sagebrush and woody vegetation, some of which may need to be removed. The upstream face will likely require

some reshaping and protection with erosion control.

A borehole drilled on top of the embankment (BH-LSDR) encountered about 12.5 feet of fill overlying lean clay and sand over sandstone and shale bedrock. The SPT blow counts in the embankment and foundation soils were y between 7 and 17, which is generally higher than SPT blow counts in the other ponds. The water table was encountered slightly below the downstream plunge pool water elevation.

There is currently no operating low-level outlet to drain the Lower Schleichart Draw Reservoir. However, removal of the standpipe or cutting a hole at the base of the standpipe in combination with some excavation to allow water to reach the present end of the 12" low-level outlet pipe is a possible means of draining the pond. This could be accomplished some time ahead of the proposed construction in order to facilitate internal drainage of the accumulated sediments prior to removal. Similar to all of the ponds, sediment type and quantity can be more accurately analyzed after the ponds are drained. Sediment excavations during the winter when the top crust is frozen could assist in access to and handling of sediment in Lower Schleichart Draw Reservoir and the upper ponds.

There is a roughly 100 foot wide grassy emergency spillway with a crest elevation of approximately 3010.0 feet on the north (right) abutment. The minimum dam crest elevation is approximately 3012.0, so the freeboard during a significant flow event is likely inadequate.

Generally speaking this embankment, foundation, and spillway configuration are in reasonably good shape and could likely be upgraded and improved with relatively straight forward modifications to the embankment and outlet works.

#### *2.5.1.7 Browns Pond*

Browns Pond is thought to have been built sometime between 1938 and 1958 (Stone, 2007) and it is our understanding that sediment has never been cleaned out of either Schleichart Draw Reservoir or Browns Pond. The embankment is approximately 24 feet high, with a roughly 20 foot wide topwidth. The downstream embankment slope is approximately 2.1H:1V plus an eight foot high by 12 foot wide toe berm along the southern (left) toe of the embankment. The upstream embankment slope is largely filled in by sediment, as is the upstream end of the existing CMP low level outlet pipe.

Browns Pond is below the two Schleichart Draw Reservoirs and receives inflow from a substantially larger drainage area than the Lower Schleichart Draw Reservoir (about 12 square miles compared to about 3 square miles). Only a small portion of the drainage basin area is within the mine disturbance extents. Browns Pond has a surface area of about 28 acres and is considered a dam by South Dakota Department of Environmental and Natural Resources standards.

Browns Pond has concentrated seepage on the left downstream abutment and also has a small PVC overflow pipe that discharges in the vicinity of the seepage area. An 18-inch diameter CMP low-level outlet is visible exiting near the center of the downslope dam face however, the inlet is buried by sediment and is therefore not functioning. Given the age, the buried CMP low-level outlet is also likely corroded and either way may be a hazard for future piping failures and should either be removed or properly abandoned in place.

All outflow from the reservoir (other than seepage) is therefore through the small PVC overflow pipe and over the emergency open channel spillway. The emergency spillway has a buried concrete wall/crest for erosion protection at approximate elevation 2898.0, which is approximately 5.0 feet below the minimum dam crest elevation. Tetra Tech (2015) estimated the capacity of the emergency spillway to be adequate to pass a 50 and 100 year event and generally indicated that the capacity of the PVC pipe principal spillway was less than a two year event and therefore expected that the emergency spillway may operate frequently. No detailed evaluation of the stability against downstream erosion was presented for the PVC overflow or emergency spillway, but some erosion in the in the vicinity of the PVC pipe is evident either from surface flow or internal piping. Some erosion protection for the spillway may be necessary, or there are numerous approaches to configuring the outlet works and spillway that could provide infrequent enough spillway flows to justify accepting some erosion damage during spill events.

Tetra Tech presented an evaluation of Browns Pond in 2015 that included multiple rehabilitation options (Tetra Tech, 2015). These options included enlarging the operating spillway pipe, slip lining the plugged and failing low-level outlet, removing and replacing the low-level outlet with a standpipe configured outlet, raising the embankment to increase freeboard, and grouting and abandoning the existing low-level outlet. Tetra Tech also evaluated the slope stability of the Browns Pond embankment and found it to be stable.

AESI completed two boreholes along the crest of the embankment and three test pits near the downstream toe of the embankment. The boreholes encountered about 20 feet of medium dense clayey sand and soft to medium sandy lean clay embankment fill overlying what appears to be a soft clayey/sandy organic topsoil or swamp deposit overlying silty sand and then fat organic clay and shale and groundwater between 23 and 40 feet below the surface in boring BP-01 and very loose to loose saturated sand (N=3) down to shale in Boring BP-02. SPT blow counts in the embankment and foundation were low, and especially low in loose saturated sand in BH-BP-02, which could be a source of possible instability or poorly compacted soil that could be addressed with a filtered toe drain. Three test pits, TP-12, TP-13, and TP-14, were then excavated along the toe of the downstream face. Those test pits encountered silt materials overlying loose to dense silty sand with the water table at five to seven feet depth. Piezometers were installed in all three test pits in order to evaluate the need and effectiveness of a filtered toe drain.

The borehole on the left side (looking downstream) of Browns Pond (BH-BP-01) had the lowest average standard penetration results compared to any of the other seven ponds. These conditions add to concern regarding piping through the Browns Pond embankment and abutment on the left side (looking downstream) of the dam and support the need for a filtered toe drain.

Borehole logs for Browns Pond did not indicate high water level through the embankment at the time of the drilling since the groundwater levels were found to be at or below the adjacent downstream channel grade (see borehole logs in Appendix A2). Consequently, the seepage that has been witnessed coming

out of the left side face of the dam may be due to isolated seepage paths through the embankment. Groundwater likely fluctuates during periods of higher reservoir surface and piezometers left in the boreholes should be monitored to determine water level fluctuations.

### 2.5.2 Sediment Volume Estimations

We have provided preliminary estimates of sediment volumes for each of the ponds (Table 10). The volume estimates are based on the following sources of information and methodology.

1. Allied Engineering's field survey of the visible or otherwise exposed sediment at the ponds. In general the perimeter of the sediment was surveyed along with points on top of the sediment where it was possible to safely walk out onto the pond. The biggest uncertainty with surveying the sediment perimeter was near the pond inlets where the line was relatively subjective and the difference between pond sediments and stream sediments had to be estimated. The field survey was conducted during a period of relatively low water.
2. Allied Engineering's subsurface explorations in and around the ponds where sediment thicknesses and depths to native soils were measured.
3. An interpolation of average channel slopes both above and below the ponds along with cross sections of the channel above and below the ponds. These simulated "natural channel" cross sections were superimposed into the pond to create a "natural" channel bottom through the reservoir. This natural channel bottom was then compared to the top of sediment elevations as found from field survey information.
4. Google imagery was used to supplement and check the sediment locations and the "natural" channel bottom geometry. LiDAR survey information was also referenced. However, the LiDAR survey data was from a period of relatively high water.
5. Information provided by the USFS in the Statement of Work regarding the amount of sediment removed in select ponds in 2004 and 2009 was referenced to check our calculated quantities.
6. For Browns Pond, Tetra Tech's 2014 bathymetric survey data was used to create a sediment surface which was compared to an estimation of the "natural" channel bottom found as described above (Tetra Tech 2015).

Due to the subjectivity of the "natural" channel bottom surface, there is considerable error associated with the volume of sediment in each of the ponds. We suspect that actual sediment volumes may be off by 30% or more.

Attachment 2 (Sheets S-1 through S-8) provides drawings showing plan and profiles of the estimated "natural" pond bottom surfaces as compared to field survey elevations and LiDAR survey elevations. Each drawing shows a "Pond Bottom Surface" which was used to calculate approximate sediment volumes. Each drawing also shows a "notch" surface or excavated channel through the sediment which will be discussed in more detail during the design phase but could be used to help drain and consolidate the existing sediments. Table 10 provides a summary of the sediment volume estimates for each of the ponds.

**Table 10 - Preliminary Estimated Sediment Volumes**

| Pond | Estimated Sediment Volume (CY) | Sediment Removed in 2004[1] (CY) | Sediment Removed in 2009[1] (CY) |
|---|---|---|---|
| Pond 1 | 1,900 | 1,341 | 2,074 |
| Pond 2 | 4,900 | 4,689 | 5,763 |
| Pond 3 | 11,500 | 11,724 | 13,039 |
| Pond 4 | 4,500 | 0 | 5,506 |
| Pond 5 | 8,500 | 0 | 570 |
| Upper Schleichart | 15,500 | 0 | 0 |
| Lower Schleichart | 13,800 | 0 | 0 |
| Browns Pond | 40,000 | 0 | 0 |

[1](USFS 2016) – Statement of Work 2016

### 2.5.3 Removal, Drying, and Disposal of Sediment

Allied Engineering has evaluated a number of alternatives to remove the significant accumulations of sediment in the existing eight ponds. Since sediment trapping and eventual removal is the primary intended function of the five sediment ponds until the upslope mining sites are stabilized, we have also evaluated alternatives to facilitate future sediment removal from these ponds. Lastly, we are evaluating the potential for reuse of the sediments for topsoil or subsoil in the eventual mine reclamation, and as construction materials (i.e. drainage sand) in the current design projects.

Two sediment repositories are located near the end of FSR #31232. AESI is developing recommendations and conceptual design alternatives for the repair and modification of the sediment disposal area(s) to improve facility layout, site function, and operation. Plan alternatives include typical design details such as road sections, regrading plans, inlet and outlet structures of dams, drainage control structures, and post reclamation erosion control. The need for the sediment repositories may be affected by other sediment management possibilities including re-use as topsoil or subsoil.

### 2.5.4 Pump Test in Pond 5

During the site investigation, a short pump test was completed in Pond 5 after the excavation of TP-9. TP-9 was excavated on October 25, 2016 and the pump test was conducted on October 26, 2016. Pond 5 did not encounter standing groundwater during the excavation. However groundwater accumulated in the test pit excavation overnight. An electric submersible pump with a maximum flow rate of 5-gallons per minute (gpm) was placed in the excavation in a constructed sump situated approximately 24-inches below the top of the sediment. A calibrated bucket and stopwatch was used to measure the flow rate over a 3.5-hour time interval. All water was purged from the sump at 1 hour and 44 minutes (following the initiation of pumping). The pumping rate fell quickly from 0.7 gpm and at the time of pump termination to a flow rate of 0.53 gpm. The pumping did not reach equilibrium during the test, but it took 1.5 hours for the pumping rate to drop from 0.57 gpm to 0.53 gpm. Based on observations of the sediment within the excavation during the pumping, water was seeping out of the upper 12-inches of the saturated “soupy” sediments. This data could be used to help estimate pumping requirements for Pond 5 sediment dewatering.

### 2.5.5 Road Repair and Reconstruction

Based on review of Google Earth historic images, the most recent landslide mass affecting the road is an earth and/or rock slump that initiated sometime between May 13, 2013 and October 11, 2013. Based on the historic images, the main presently active head scarp, which is up to about 10 feet in exposed height and about 220 feet long and forms the western boundary of the most recent slump block that has damaged FSR #3123. The active slump is also defined by a secondary transverse crack approximately 50 feet downslope of the main scarp that approximately defines the transition from the latest landslide zone of depletion to the zone of accumulation. A large lobate bulge defines the zone of accumulation and the downslope extents of the active movement, which encompasses approximately an acre of area downslope of the damaged and threatened FSR #3123.

Field reconnaissance including walking the slope and exploration test pits and borings near the site revealed the following additional information:

1. The headscarp of the most recent movement ruptures the ground surface in an area of slope wash deposits that have been previously displaced by landslide movements. In other words, this most recent movement occurred in a historic landslide.
2. Based on landforms and explorations, an area downslope of the existing FSR #3123 spanning approximately a 600 foot length of the road and extending approximately 200 feet below the road to the adjacent drainage bottom is a historic landslide area comprising over 5 acres. The characteristic landforms and soil types include uneven terrain formed from zones of depletion and accumulation and scarps of previous slumps.
3. No significant moisture or wet zones were identified by the explorations or field reconnaissance, although numerous heavily vegetated and green areas indicating significant moisture were observed at the site and can be observed in the aerial images of the site. In addition, the USFS reports seepage from the road cut in the immediate vicinity of the head scarp and our test pit TP-1 and Boring BH-FSR 3123-02, in which we installed a piezometer for potential future measurement.
4. TP-1 and BH-FSR 3123-02 in the above-described seepage area immediately above the head scarp both encountered nearly horizontally bedded (slight dip to the south), black, coaly shale or coaly claystone bedrock that was very moist. While we believe this bedrock was in-place (i.e. not presently part of the landslide at the exploration locations) it is a thinly bedded, weak, black, organic clay shale that weathers into a fat clay (i.e. plastic clay with liquid limits up to 117) with sand, with about 8% organic content. This organic layer is relatively pervious, and likely the offending layer that carried water to the landslide and contributed to the ultimate shear surface upon which the landslide moves. This layer was outcropping in the road cut at TP-1 and in TP-4 which is in the road cut 50 south of TP-1 (down the road) and it was also encountered in the boring BH-FSR 3123-01 at depths between 15.7 feet and 35.3 feet as seen on Figure 5. This approximately 18-foot thick layer of plastic organic coaly shale is likely a significant aquifer that collects infiltration that falls on the mesa top. This is a relatively common condition in organic (coal and lignite) layers in the local geology.

5. An erosional hole exists in the sandstone mesa caprock approximately 160 feet southwest of the landslide/road and approximately 35 feet back from the top edge of the sandstone mesa cliff. This erosional cave drains an unknown portion of the mesa top and likely provides a significant pathway for surface water to get into the above-mentioned organic (coaly shale) bedrock.

There are three primary concepts for repairing and stabilizing this landslide: 1) One concept is to unload the landslide by flattening the overlying slopes and removing the material from the site; 2) Another concept involves using reinforced earth structures to resist movements; and 3) The third concept is to alter the site drainage to minimize infiltration into the landslide area and to drain the subsurface accumulations of groundwater to enhance stability. Options 1 would involve a large excavation of the upslope areas above the existing landslide/road. We explored the subsurface in this area with three explorations: TP-1 and TP-4 which were excavated into the upslope road cut; and BH-FSR 3123-01 and BH-FSR 3123-03.

### 2.5.6 Reuse of Excavated Soils Generated for FSR 3123 Road Repair

In general, the non-organic Silt/Lean Clay soils found upslope of FSR #3123 (see units 2 and 3 of test pit log TP-1) would be a primary soil type generated by cut slope flattening described in concept 1 above anywhere higher in elevation (up road and upslope) from TP-1 and BH-FSR 3123-02. These sandy, silt/clay soils are suitable as select embankment fill (for dams or roads) and/or general site grading. The generally sandy, non-plastic character of these materials will also allow them to be used as subsoil, or in cases where the materials break into small enough clasts during placement, topsoil or topsoil mix. This material, is light brown and can be seen in the photo provided of TP-1 on the TP-1 log. This material has liquid and plastic limits ranging from about 20 to 26, and had moisture contents in the same range during our explorations. This material classifies as a silt with sand or a sandy lean clay and geologically would classify as slope wash or weathered bedrock derived from the local buried sandstone rock and exposed cliff.

The other type of materials that will be encountered the road cut upslope and up-road from TP-1 and BH-FSR 3123-01 is the less weathered, relatively intact soft sandstone rock visible in the area cliffs and explored by BH-FSR 3123-03, which was located on top of the cap rock west of the subject landslide. Although blow counts were relatively high (45 to 75 typ.) the fact that Boring BH-FSR 3123-03 could be fairly easily drilled with a hollowstem auger and sampled with the standard penetration test equipment indicates that the sandstone will be rippable and diggable with conventional excavators.

We believe this material will likely be suitable for use in unclassified fills or as temporary erosion protection along embankment slopes or as armoring for flow channels or temporary construction roads. However, the sandstone rock fragments weather relatively quickly making them poor choices for permanent erosion control. One specific use may potentially be as a temporary equipment road in the drained ponds during sediment removal. This use may require a considerable volume of rock that will support heavy equipment over a relatively soft and wet subgrade (the underlying natural soils, not the very soft sediments). We roughly estimate that two to three feet of this soft sandstone rock may hold up excavation equipment and trucks on a relatively soft wet subgrade. Lastly, we believe the generally

sandy, non-plastic character of these materials will also allow them to be used as subsoil, or in cases where the materials break into small enough clasts during placement, topsoil or topsoil mix.

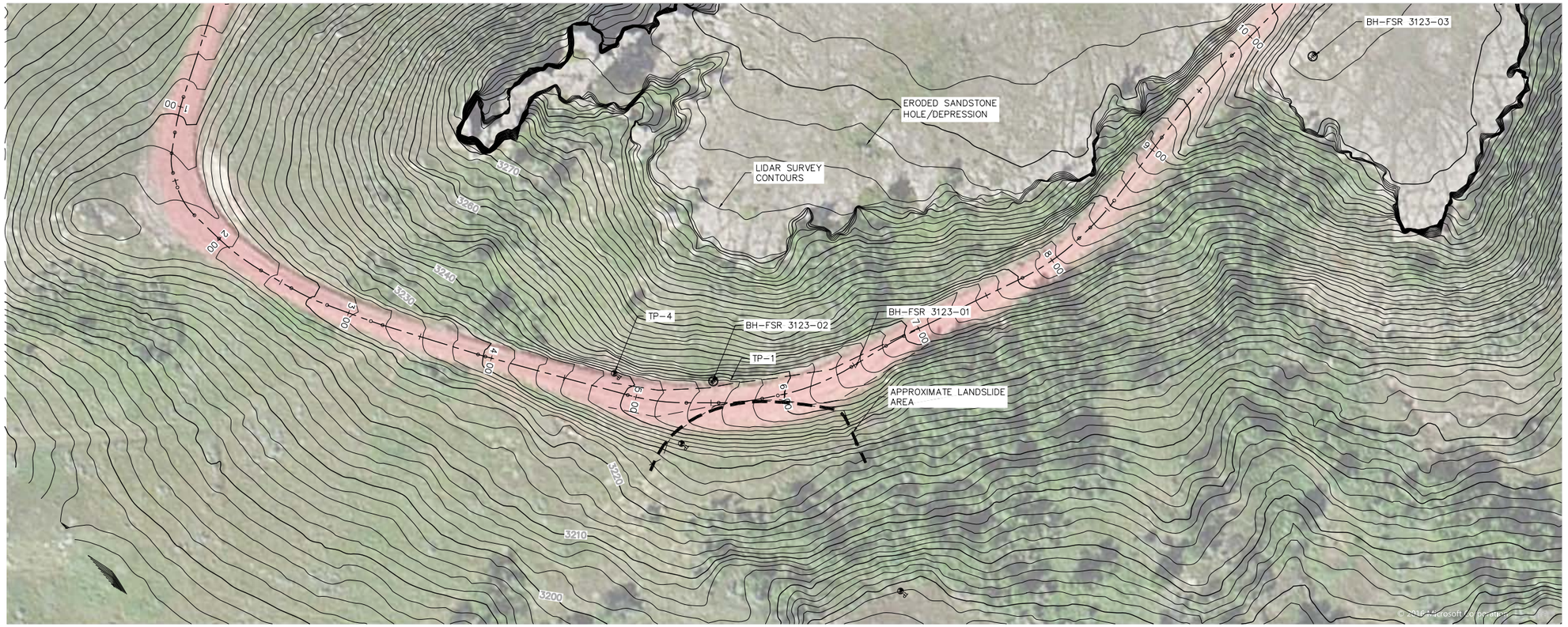
The other principal material expected to be encountered in the excavation/flattening of the cut slopes above the landslide and in the potential subdrain trenches is the organic clay/shale materials that weather into a fat clay. We believe these materials will generally be unsuitable for any structural use due to their high plasticity and potentially high organic content. However, they may make suitable low permeability cover or subsoil for contaminated mine tailings, or possibly, when mixed with other soils or amendments, subsoil or topsoil anywhere.

### 2.5.7 Sediment Repository

The sediment repository area is located on top of Bluff B and consists of two impoundments that have been previously used to store sediments removed from Ponds 1 – 5. The sediment repository is accessed from FSR #31232, which splits off from FSR #3123 and heads approximately 0.3 miles north along a serviceable existing road to a locked gate. After the locked gate, the road is not open to public use and has deteriorated since its last significant use, which was likely delivering sediment to the repository in 2009. The road is in passable condition for approximately 0.15 miles after the locked gate, where it enters the mining disturbed areas and there is a road washout shortly before reaching the sediment repositories. Similar to the road, one of the sediment repository containment berms has washed out/breached.

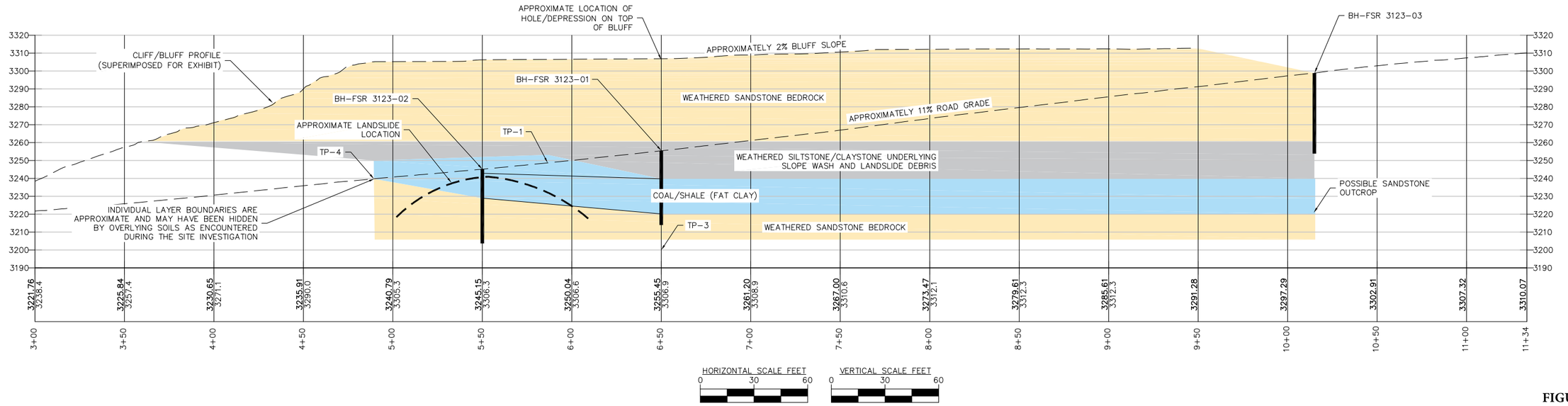
Based on our evaluation of the sediments in the repository, the sediment in the breached (north) repository (that drains) is consolidated, slightly moist, and well vegetated. Test pits 6 and 7 which were excavated in the north repository and encountered relatively stiff sandy lean clay and clayey sand with compressive strengths of 2 – 4 tons per square foot (as measured with a pocket penetrometer) indicating relatively stable, consolidated material as compared to the sediment ponds. This sediment appears ready to be handled and transported for use in bluff reclamation. While this material is easily handled and worked and suitable for light structural duty, its organic content is typically 4% to 8% and therefore not ideal for roads or structural embankments.

The sediment in the intact (non-breached, south) repository is saturated with evaporate salts on the soil surface and little vegetation. Test pit 5 (excavated in the south repository) consisted of very moist sandy lean clay with compressive strengths of only 0 to 0.5 tons per square foot. This material is generally not suitable for use until it can be dried and consolidated.




0 40 80 120

SCALE (FEET)




HORIZONTAL SCALE FEET 0 30 60

VERTICAL SCALE FEET 0 30 60

**FIGURE 5**

C:\cesi_w\Designs\2016\16-050.05 Riley Pass\09 CAD-Production\General\FSR 3120 Failure.dwg

| NO. | REVISIONS | DRAWN BY | DATE |
|---|---|---|---|
| | | | |

SCALES VARY. SEE ABOVE.

PROJECT ENGINEER: DSC | DRAWN BY: GDF

DESIGNED BY: | REVIEWED BY: DSC

# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## FSR #3123 GEOLOGIC PROFILE
### CUSTER NATIONAL FOREST, SOUTH DAKOTA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DATE: 12/27/2016

SHEET
P-FSR

## 2.6 Interpretation and Assessment

Provided below is an interpretation of the laboratory testing results for the sediment samples. A comparison between Tetra Tech's previous testing results and AESI's recent results is provided.

### 2.6.1 Characterization and Reuse of Sediment

Table 11 provides topsoil suitability criteria which were used during the review and assessment of sediment properties. The criteria presented is from Tetra Tech's Survey of Topsoil Borrow Resources report dated December, 2013 (Tetra Tech, 2013b).

**Table 11 - Preliminary Topsoil Suitability Chart (Tetra Tech, 2013b)**

| Property | Suitable | Unsuitable |
|---|---|---|
| Depth of Cover | 12 - 18 inches | < 12 inches |
| USDA Texture (thickest layer 0-40 in.) | All Others | > 45% Clay content and LS, S |
| Rock Fragments (% by volume) | < 45 (all fragments less than six inches diameter) | > 45 |
| Depth to High Water Table (feet) | --- | Perennial Wetness |
| Soil Acidity (pH 0 – 40 in.) | 6.5 to 8.5 | < 6.5 or > 8.5 |
| Arsenic | ≤ 142 ppm[2] | >142 ppm |
| Cadmium | ≤ 4 ppm | > 4 ppm |
| Copper | ≤ 100 ppm | > 100 ppm |
| Lead | ≤ 100 ppm | > 100 ppm |
| Zinc | ≤ 250 ppm | > 250 ppm |
| Specific Conductance/Electrical Conductivity, EC | ≤ 6 dS/m[1] | > 6 dS/m |
| Sodium Adsorption Ratio, SAR | ≤ 12 | > 12 |

[1]dS/m = deciSiemens per meter

[2]ppm = parts per million

Sampling and analysis of sediments in order to determine the potential for use as plant growth media was conducted by Tetra Tech in 2012 and results were presented in their *Tronox Bluff Waste Characterization Report Version 3.0* dated June 27, 2013. The sampling occurred within the top 8-inches of the soil surface in Ponds 1 - 5, Upper Schleichart Draw Reservoir, Lower Schleichart Draw Reservoir (Ducks Unlimited Pond) and Browns Pond. The sediment samples were analyzed for a suite of total metals (arsenic, cadmium, copper, lead, molybdenum, uranium, and zinc) and agronomic soil salinity parameters (pH, EC, SAR) in order to evaluate the sediments with respect to current reclamation criteria and removal action goals (Tetra Tech, 2013b). The sampling and analysis revealed that metals concentrations met suitability requirements for topsoil. Similarly, $^{226}$RA and arsenic levels were below the risk-based clean up criteria (30 pCi/g for $^{226}$RA and 142mg/kg for arsenic) in all ponds.

The agronomic soils testing performed by Tetra Tech resulted in generally unsuitable Sodium Absorption Ratios (SAR) for the majority of the samples that were collected for analytical testing. The report recommended additional sampling to verify the sediment characteristics at depth.

Allied Engineering Services, Inc. (AESI) completed soil sampling in order to further characterize sediment suitability for plant growth media at depth as recommended in the Tetra Tech Report. Samples were collected from at least one location from each pond on October 24-24, 2016. Sample depths ranged from 1 foot to 7 feet with an average depth of 3.7 feet. An excavator was used to dig test pits where possible. In addition, soil borings were advanced using a 3-inch diameter hand auger in order to obtain samples in locations that were inaccessible to the excavator.

Analytical results from the October 2016 samples indicate that Arsenic and $^{226}$RA levels within the sediments in all ponds are below the risk-based clean up criteria. However, analytical results indicate that deeper sediment SAR values were above the suitability criteria for plant growth media.

Exploratory test pits and boreholes were logged in the field for texture, moisture and consistency. Samples were selected for laboratory testing (completed by Terracon) of soils for physical properties including particle size distribution, consistency, organic content and moisture. Results indicate that sediments vary from clean sand to fat clay and include silt occurring in mixtures and stratified layers. Generally, Ponds 1 - 3 include higher amounts of sand with few silt layers. Downstream ponds including Ponds 4 - 5, Upper Schleichart, and Lower Schleichart include fine sediments with occasional sand lenses. Browns Pond includes sandy sediments and likely includes some silt/clay zones that were not revealed in the exploratory boreholes.

Based on grain size distribution analysis conducted by Terracon, sediments texture class related to the suitability criteria as outlined in Table 11 may not be suitable due to the clean sands that lack sufficient fines that occupy Ponds 1 - 3 and Browns Pond. Ponds 4 - 5, Upper Schleichart, and Lower Schleichart have higher silt and clay contents in the soil that may not meet the suitability requirements. Although sampling and analysis revealed areas of varying textural classes that may not meet the suitability requirements, mixing of predominately fine grained silts and clays with more coarse grained clean sand would likely meet the suitability requirements for growth media.

Predicting the suitability of using the pond sediments for topsoil or subsoil must consider the sediment characteristic including gradation, plasticity, organic content, and chemistry. The chemistry of the pond sediments complies with regulatory cleanup levels with regard to the tested analytes, particularly metals and radiation. Sediment suitability as topsoil is most compromised by its salinity, as measured by Sodium Absorption Ratio (SAR) as determined from analysis of water extracted from the soil. The primary problem caused by high SAR is to cause dispersion of soil particles impairing the soil's permeability and ability to grow vegetation. The permeability of soil is also greatly affected by its compaction level (density) and depositional history.

The overall limitation for the re-use of the majority of the sediments in their current condition is the Sodium Absorption Ration (SAR). These soils are generally sodic in nature and would require treatment in order for them to be suitable for re-use. Calcium sulfate (gypsum) is considered the best and least

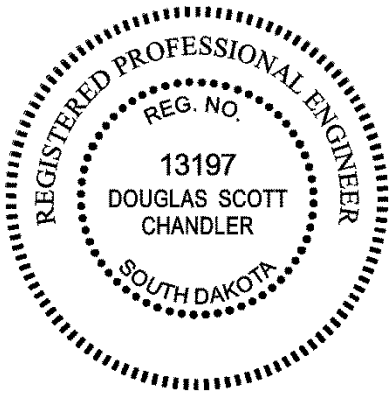
expensive alternative to remedy the sodic soil condition. Gypsum amendments are used to improve the soil structure by replacing sodium with calcium. The other component to treatment is leaching the sodium down through the soil profile and away from the plant root zone. The annual precipitation in the area of Riley Pass (15.4-inches annually at Ludlow) would likely be sufficient for the leaching of sodium. The use of sodic soil as sub-soil faces similar limitations as topsoil unless the sub-soil is used at depths greater than about 18-inches. The sodic soil used as subsoil (less than 18-inches below the soil surface) would have the inherent low permeability associated with high SAR values that could result in an undrained condition and potentially exacerbate the sodic condition.

There are several case studies that have successfully reclaimed sodic soils with the use of gypsum along with seed mixes that include drought and sodium tolerant species using precipitation (13-inches annual precipitation) as source water for sodium leaching (Fehringer 2016).

## 3.0 Limitations

This report provides results and data from our field investigation, testing, and analyses related to the proposed reconstruction of forest roads and sediment ponds in the North Cave Hills area of the Custer Gallatin National Forest in Harding County, South Dakota. It does not constitute a design or geotechnical report or provide recommendations, but rather, summarizes geotechnical, hydrologic, topographic, and other data gathered. The data was gathered in accordance with generally accepted engineering practices and is representative of both the conditions present and of the methods used to evaluate those conditions. The use of this data requires interpretation and judgment therefore no warrantee is expressed or implied regarding its use.

**Allied Engineering Services, Inc.**




cn=Douglas S. Chandler, o=Allied Engineering Services, Inc., ou, email=doug@allieden gineering.com, c=US
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Douglas S. Chandler, PhD, PE

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# LIST OF APPENDICES

# APPENDIX A

## EXPLORATION LOGS

- A1 - Test Pit Logs
- A2 - Bore Hole Logs
- A3 - Hand Auger Exploration Logs
- A4 - Dynamic Cone Penetrometer Tests

# A1 – TEST PIT LOGS

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Test Pit Designation: **TP-1**

Location: CUT SLOPE ABOVE LANDSLIDE

## DESCRIPTION OF MATERIALS

(1) Loose; Dark brown or brown; SILT with some Organics; moist; Typ. 1' to 2' thick; (Topsoil).

Notes:
- Fractured rock below Topsoil on South end of TP-1 .

(2) Stiff; Brown; SILT/CLAY; Moist; Thinly bedded; Dipping Steeply (≈45°); down slope (NE); Typ. 3' to 5' thick; (Weathered Siltsone).

Notes:
- Qp = 1.5 to 2.5 tsf in upper part of layer
- 3.0 tsf in lower part of layer

(3) Stiff to Hard; Gray and Brown; SILT/CLAY with Sand; moist; (Weathered Siltstone/Claystone bedrock).

Notes:
- Qp = 5+ tsf
- Can't distinguish dip

(4) Very Stiff; Black; ORGANIC CLAY/SILT; very moist; (Fractured Weathered, Clayey Coal Bedrock).

Notes:
- Horizontally Bedded

| % WATER CONTENT | SAMPLES | DEPTH (FT) |
|---|---|---|
| | S1-K @ 20' | 30 |
| | S1-J @ 15' | |
| | S1-I @ 10' | |
| | S1-H @ 8' | 20 |
| | S1-G @ 8' | |
| | S1-F @ 5-8' | |
| 8.5% | S1-E @ 4-8' | |
| | S1-D @ 2-3' | 10 |
| | S1-C @ 1-2' | |
| 26.6% | S1-B @ 0-2' | |
| | S1-A @ Coal | 0 |
| | | 10 |

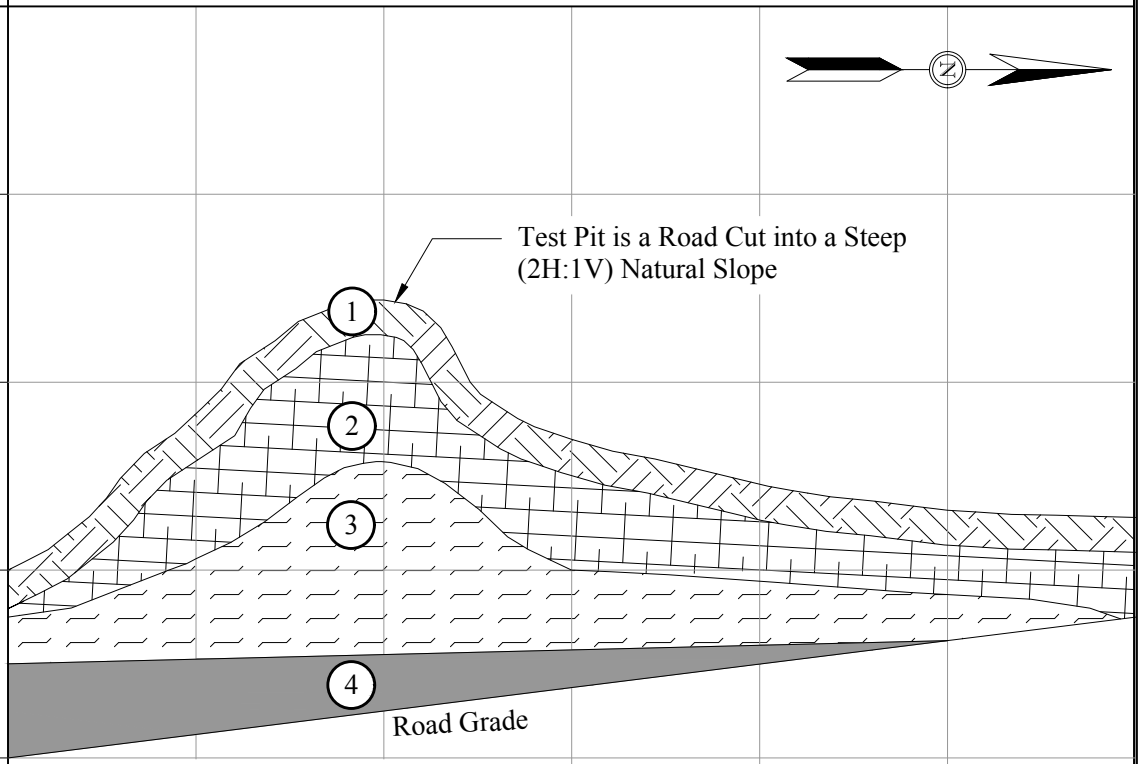


Fig 1 - Profile View Photo of Test Pit 1


Lab Testing:
- Sample S1-B
  - LL = 60, PL = 23, PI = 37
  - 9.19% Organics, 26.6% Water Content
- Sample S1-E
  - LL = 27, PL = 26, PI = 1
  - Classification = Silt with Sand (ML)
  - 0% Gravel, 21.7% Sand, 78.3% Fines
  - 8.5% Water Content
- CBR @ 1" = 5.80

SURFACE ELEVATION:
TOTAL DEPTH: 70' LONG x 20' HIGH
GROUNDWATER: DRY

BACKHOE TYPE: **CAT 315C**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 24, 2016**

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Test Pit Designation: **TP-2**

Location: BASE OF 10' SCARP BELOW ROAD

## DESCRIPTION OF MATERIALS

(1) Medium Dense; Brown with Black and Tan alternating layers; SILT/CLAY with layers of dark Organics; slightly moist to dry; 0' to 10' thick; (Exposed Scarp).

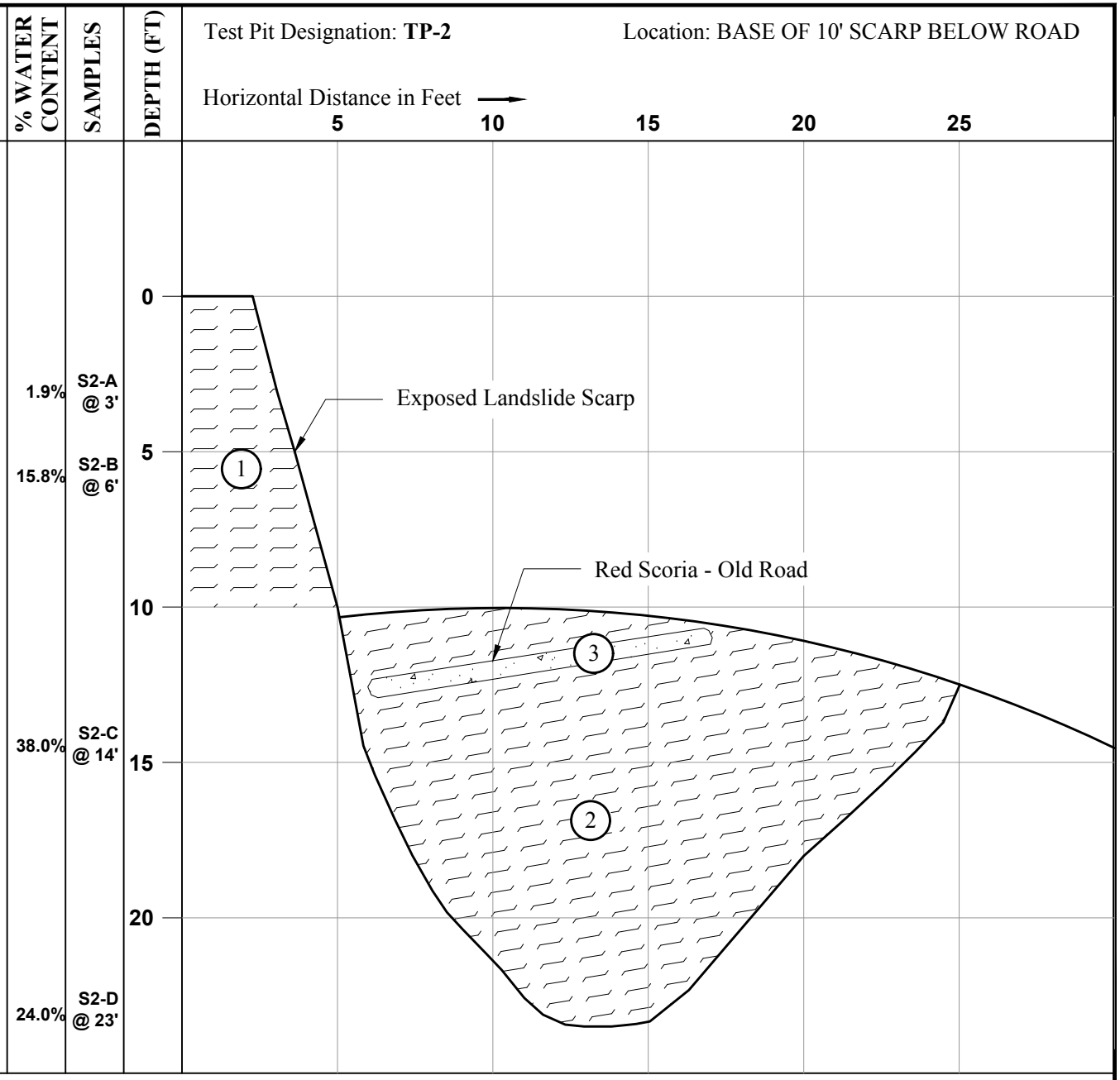
Notes:
- Originally deposited dipping with slope (old slope wash).
- Scarp is also displaced material

(2) Stiff; Brown with Black and Tan alternating layers; SILT/CLAY/SAND; Moist; (Slope Wash - Same as Scarp but rotated and displaced more).

(3) Loose; Red; SCORIA; Moist; (Scoria - Old Road).

Notes:
- Scoria Layer dips into slope

Lab Testing
- Sample S2-D
  - LL = 65, PL = 15, PI = 50
  - Classification = Clayey Sand (SC)
  - 0% Gravel, 68.4% Sand, 31.6% Fines
  - 24% Water Content




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **13' + 10' Scarp**
GROUNDWATER: **Dry**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 24, 2016**

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Test Pit Designation: **TP-3**

Location: MID SLOPE ZONE OF DEPLETION

Horizontal Distance in Feet →

## DESCRIPTION OF MATERIALS

(1) Soft; Brown; SILT with Organics; Moist to very Moist; (Topsoil).

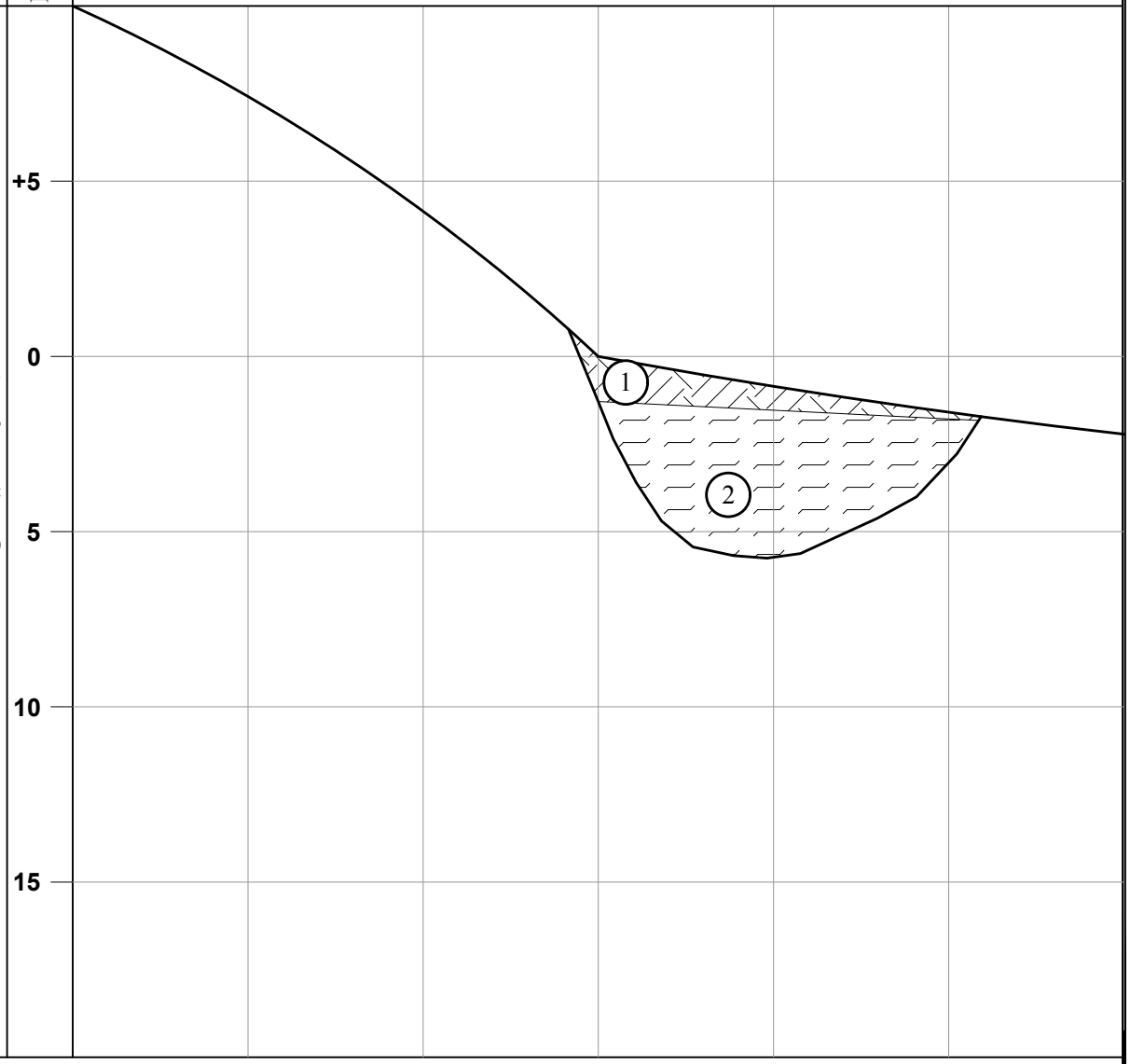
Notes:
- Roots visible in Topsoil

(2) Stiff; Dark Brown to Brown; CLAYSTONE; Moist; (Weathered Bedrock).

Notes:
- Layer was intact and Horizontally Bedded

Lab Testing
- Sample S3-B
  - LL = 45, PL = 22, PI = 23
  - Classification = Lean Clay w/ Sand (CL)
  - 0% Gravel, 15.2% Sand, 84.4% Fines
  - 18.5% Water Content

| % WATER CONTENT | SAMPLES |
|---|---|
| 31.3% | S3-A @ 1' |
| 18.5% | S3-B @ 2' |
| 25.5% | S3-C @ 4' |
| 23.8% | S3-D @ 6' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **6'**
GROUNDWATER: **Dry**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 24, 2016**

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Test Pit Designation: **TP-4**

Location: UPSLOPE ROAD CUT NEAR LANDSLIDE

## DESCRIPTION OF MATERIALS

1. Stiff; Brown/Tan; SILT/CLAY with angular rock; Slightly Moist; (Slope Wash).

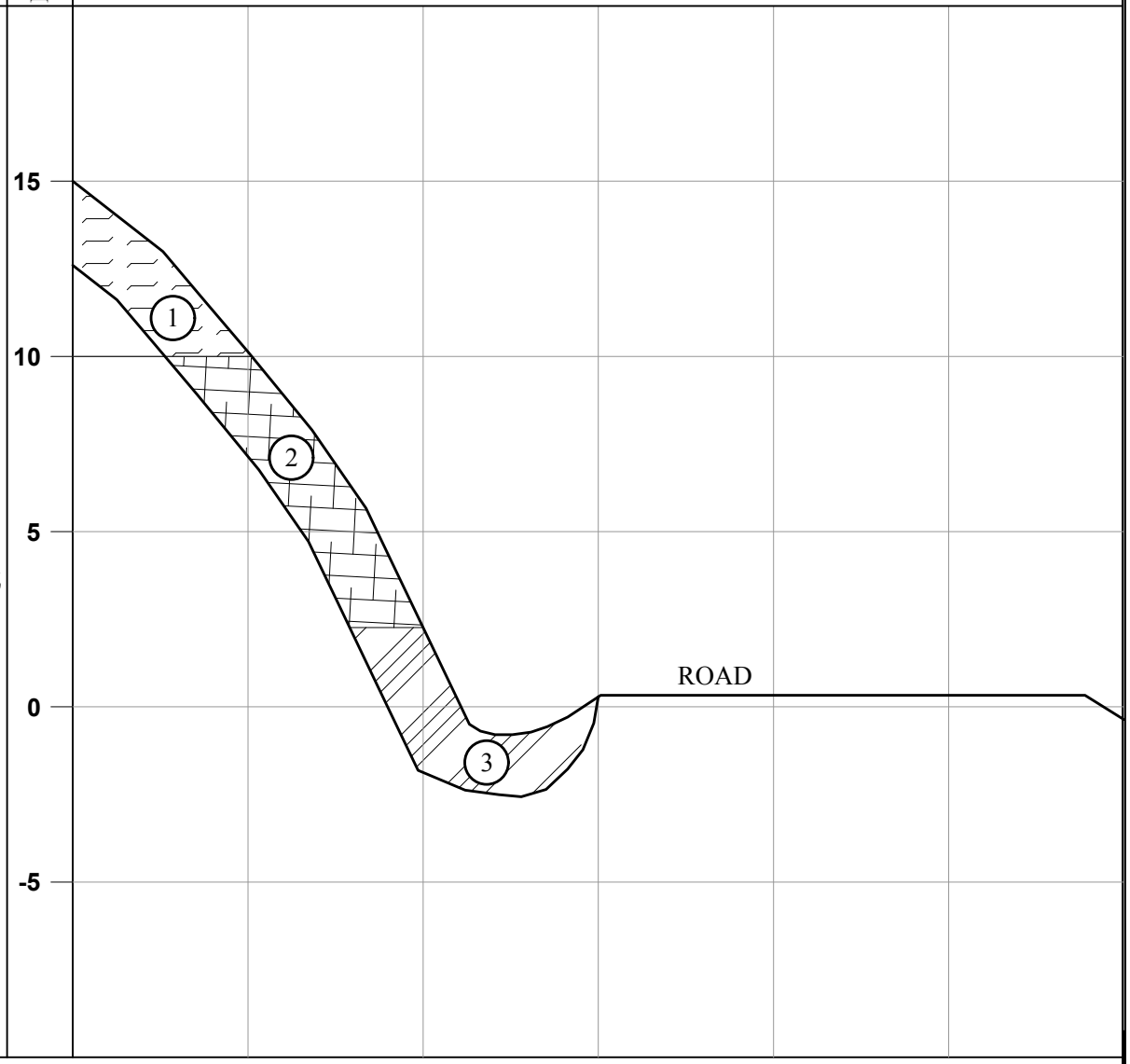
2. Stiff; Black; fractured organic CLAY/COAL; Slightly Moist; (Weathered Bedrock).

Notes:
- Thinly Bedded (1/8" flakes)
- Roughly Horizontal
- Dips slightly North (Based on contacts in borings)
- 8.08% Organics

3. Dense; Gray; SANDSTONE; Moist; (Weathered Sandstone Bedrock).

Lab Testing
- Sample S4-A
  - LL = 84, PL = 33, PI = 51
  - Classification = Fat Clay w/ Sand (CH)
  - 0.8% Gravel, 19.7% Sand, 79.5% Fines
  - 33.4% Water Content, 8.08% Organics

| % WATER CONTENT | SAMPLES |
|---|---|
| 33.4% | S4-A @ 3' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **12'**
GROUNDWATER: **Dry**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 25, 2016**

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Test Pit Designation: **TP-5**

Location: SOUTHERN SEDIMENT REPOSITORY POND - 15' FROM EDGE

## DESCRIPTION OF MATERIALS

(1) Stiff; Brown; SILT/CLAY with desiccation cracks; Slightly Moist to Moist; Typ. 0-1' thick; (Sediment).

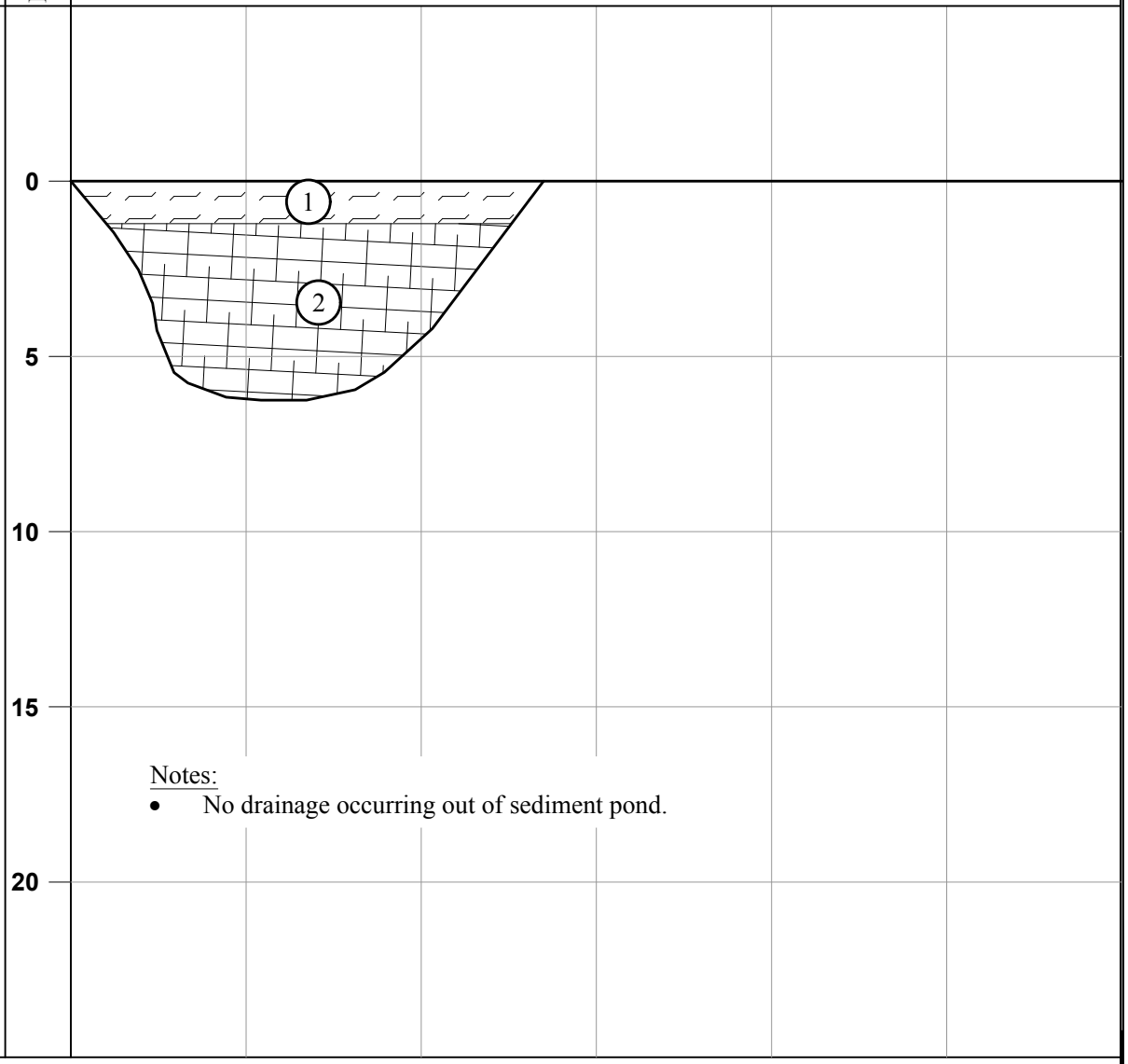
Notes:
- Qp = 1-1.5tsf

(2) Soft; Brown to Dark Brown; SANDY LEAN CLAY with ORGANICS; Very Moist; Sticky; (Sediment).

Notes:
- Qp = 0-0.5 tsf

Lab Testing
- Sample S5-A
  - LL = 35, PL = 15, PI = 20
  - Classification = Sandy Lean Clay (CL)
  - 0% Gravel, 37.2% Sand, 62.8% Fines
  - 31.9% Water Content, 5.38% Organics

| % WATER CONTENT | SAMPLES |
|---|---|
| 31.9% | S5-A @ 3-6' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **6'**
GROUNDWATER: **Dry**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 25, 2016**

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Test Pit Designation: **TP-6**

Location: EAST SIDE OF NORTH SEDIMENT REPOSITORY POND

## DESCRIPTION OF MATERIALS

(1) Stiff; Brown; Desiccated CLAY;
Slightly Moist to Moist; (Sediment).

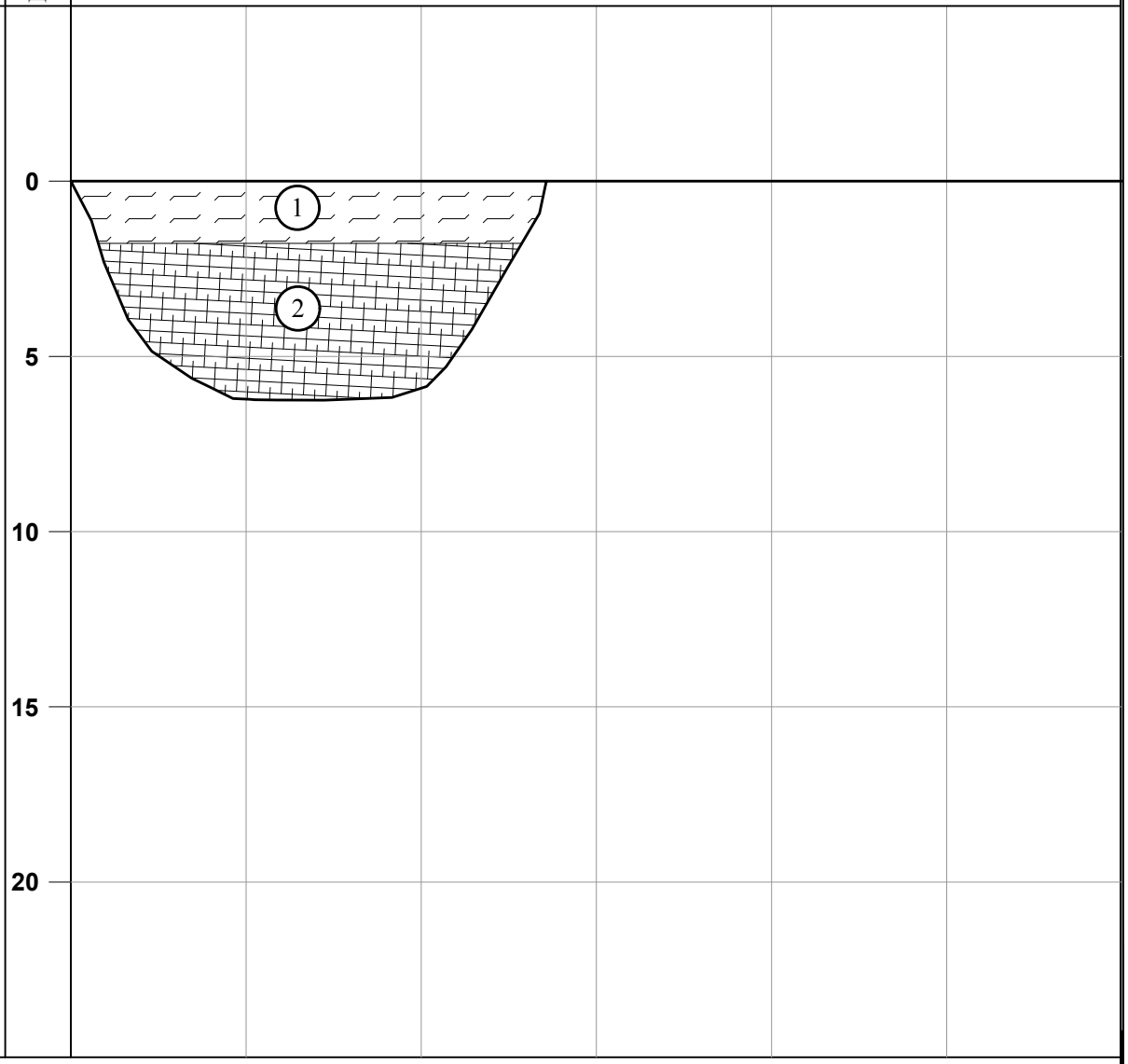
Notes:
- Qp = 0.5-1.5 tsf

(2) Stiff to Medium Dense; Brown;
CLAYEY/SILTY SAND; Moist; (Sediment).

Notes:
- Qp = 2.0-4.0 tsf

Lab Testing
- Sample S6-B
  - LL = 26, PL = 14, PI = 12
  - Classification = Clayey Sand (SC)
  - 0.4% Gravel, 57.5% Sand, 42.1% Fines
  - 18.7% Water Content, 4.18% Organics

| % WATER CONTENT | SAMPLES |
|---|---|
| 26.4% | S6-A @ 1.5' |
| 18.7% | S6-B @ 6' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **6'**
GROUNDWATER: **Dry**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 25, 2016**

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Test Pit Designation: **TP-7**

Location: WEST SIDE OF NORTH SEDIMENT REPOSITORY POND

## DESCRIPTION OF MATERIALS

(1) Stiff to Medium Dense; Brown to Gray; SILT/SAND/CLAY; Slightly Moist; (Sediment).

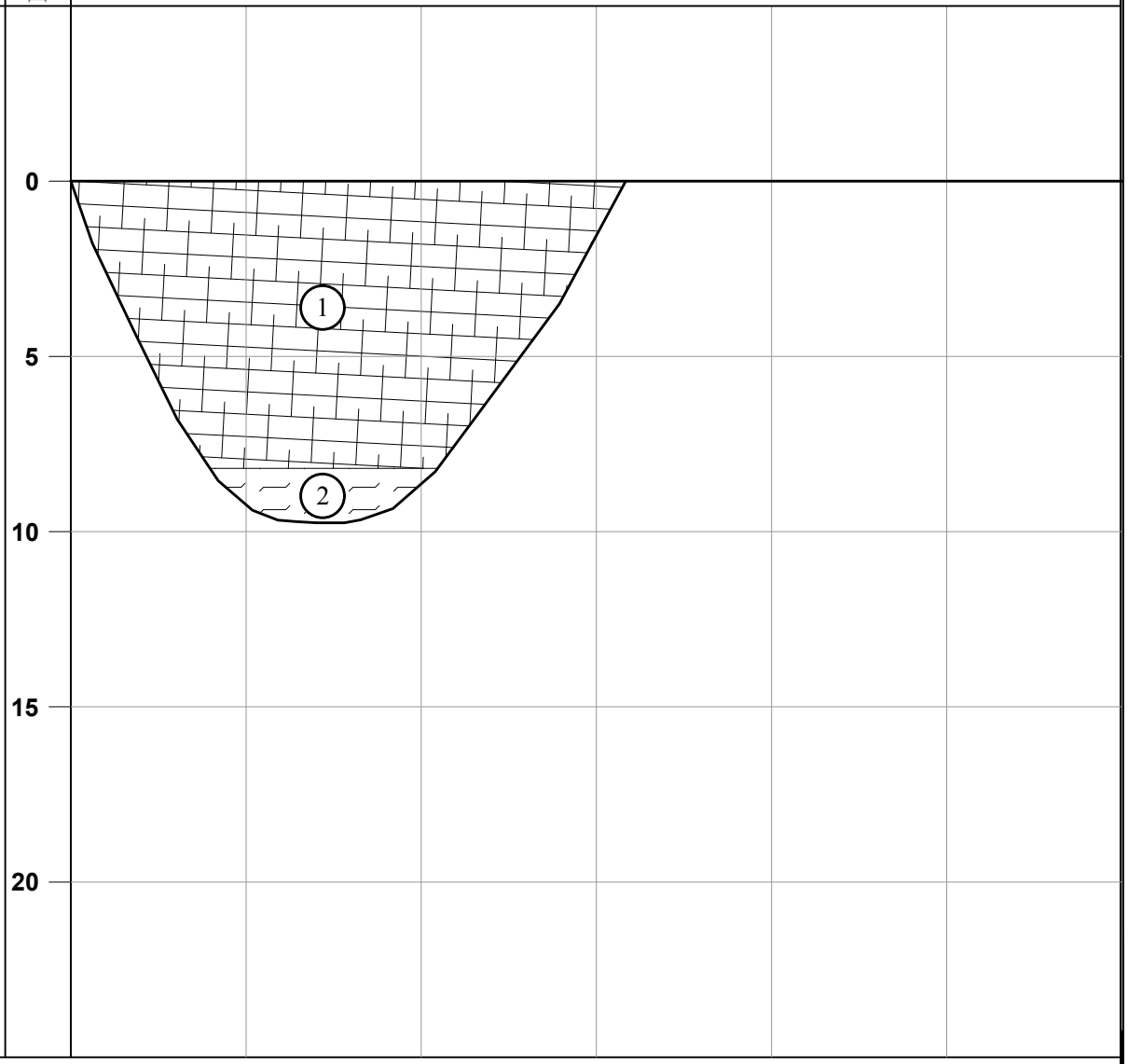
Notes:
- Qp = 1.0-2.0 tsf
- 6.12% Organics

(2) Very Stiff; Brown/Orange; SANDY LEAN CLAY; Moist.

Notes:
- Qp = 2.0-4.0 tsf

Lab Testing
- Sample S7-A
  - LL = 26, PL = 18, PI = 8
  - Classification = Sandy Lean Clay (CL)
  - 0% Gravel, 47.8% Sand, 52.2% Fines
  - 21.8% Water Content, 6.12% Organics

| % WATER CONTENT | SAMPLES |
|---|---|
| 21.8% | S7-A @ 5-7' |
| | S7-B @ 9' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **9'**
GROUNDWATER: **Dry**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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Test Pit Designation: **TP-8**

Location: 250' UPSTREAM FROM POND 5

Horizontal Distance in Feet →

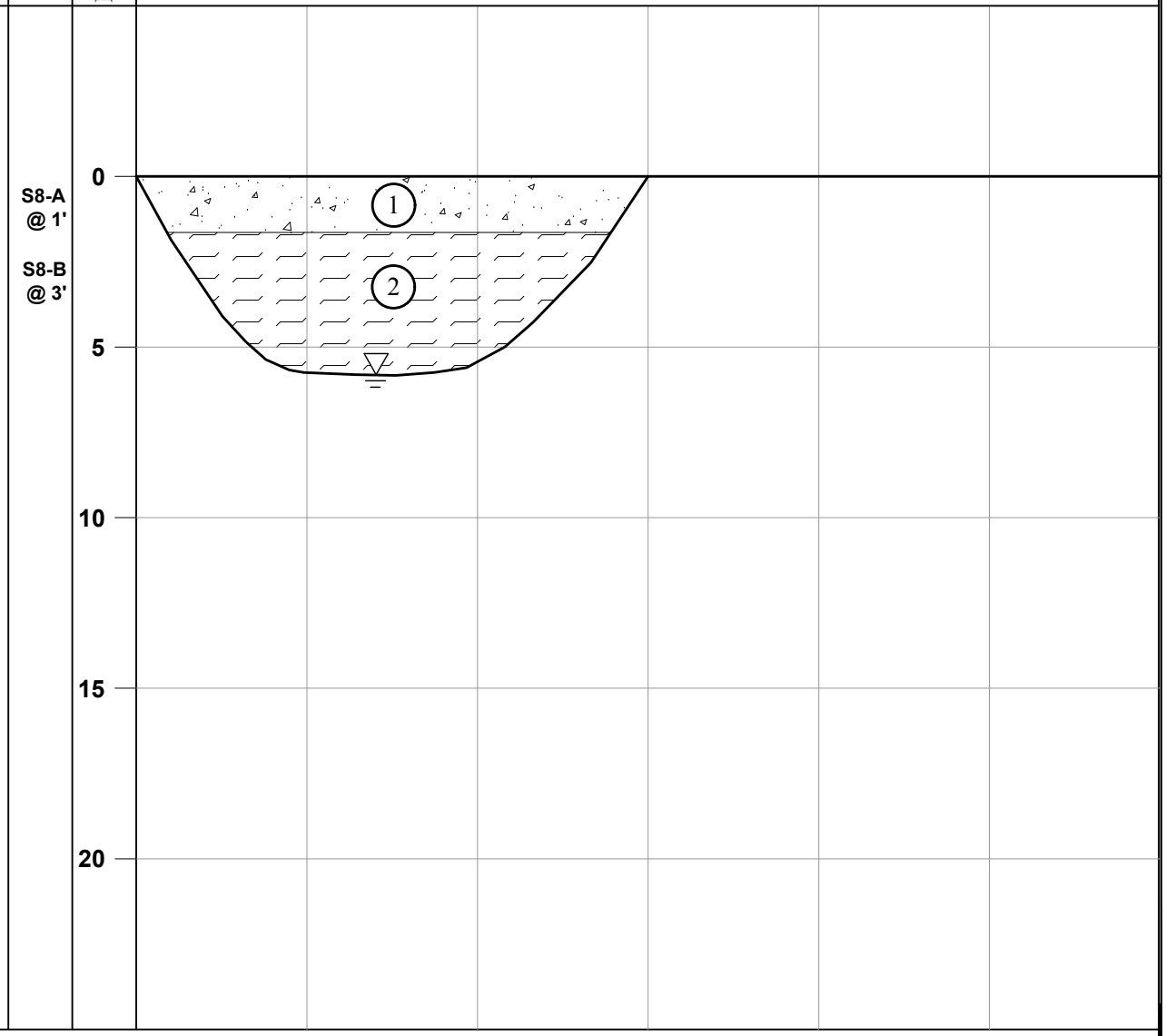
## DESCRIPTION OF MATERIALS

(1) Loose; Brown; SAND with Traces of Silt; Very Moist; (Sediment).

Notes:
- Material is Fairly Coarse and Clean

(2) Soft to Stiff; Brown; SILT/CLAY with Sandy Zones; Very Moist to Wet; (Sediment).

Notes:
- Qp = 2.0-3.0 tsf @ 3'-4'
- Qp = 0.5 tsf @ 4.5'
- Qp = 1.0 tsf @ 5'
- Groundwater was encountered at 5.5' with water coming in floor of hole at approximately 1 gpm.




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **6'**
GROUNDWATER: **5.5'**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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Test Pit Designation: **TP-9**

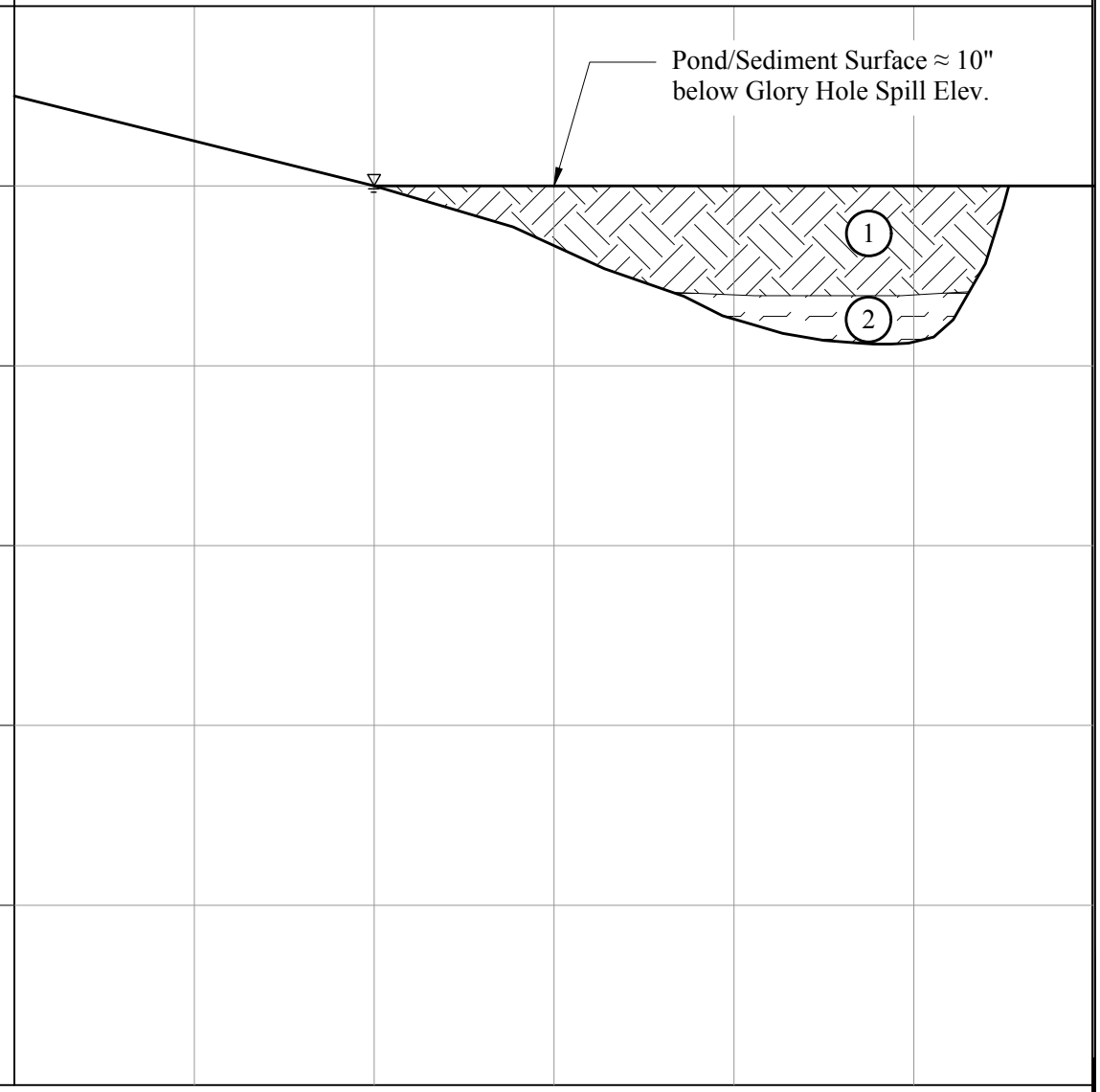
Location: WITHIN SOUTHERN BOUNDARY OF POND 5

## DESCRIPTION OF MATERIALS

(1) Very Loose; Brown; SILT with Clay Sediments; Wet ; (Sediment).

Notes:
- Silt was wet and Flowable

(2) Stiff; Brown; CLAY; Wet; (Subgrade).




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **4'**
GROUNDWATER: **At Surface**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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Test Pit Designation: **TP-10**

Location: UPSIDE OF MID DAM AT THE UPPER SCHLEICHART SEDIMENT POND

## DESCRIPTION OF MATERIALS

(1) Soft; Brown and Black; SILT and CLAY Sediment; Very Moist to Wet; (Sediment).

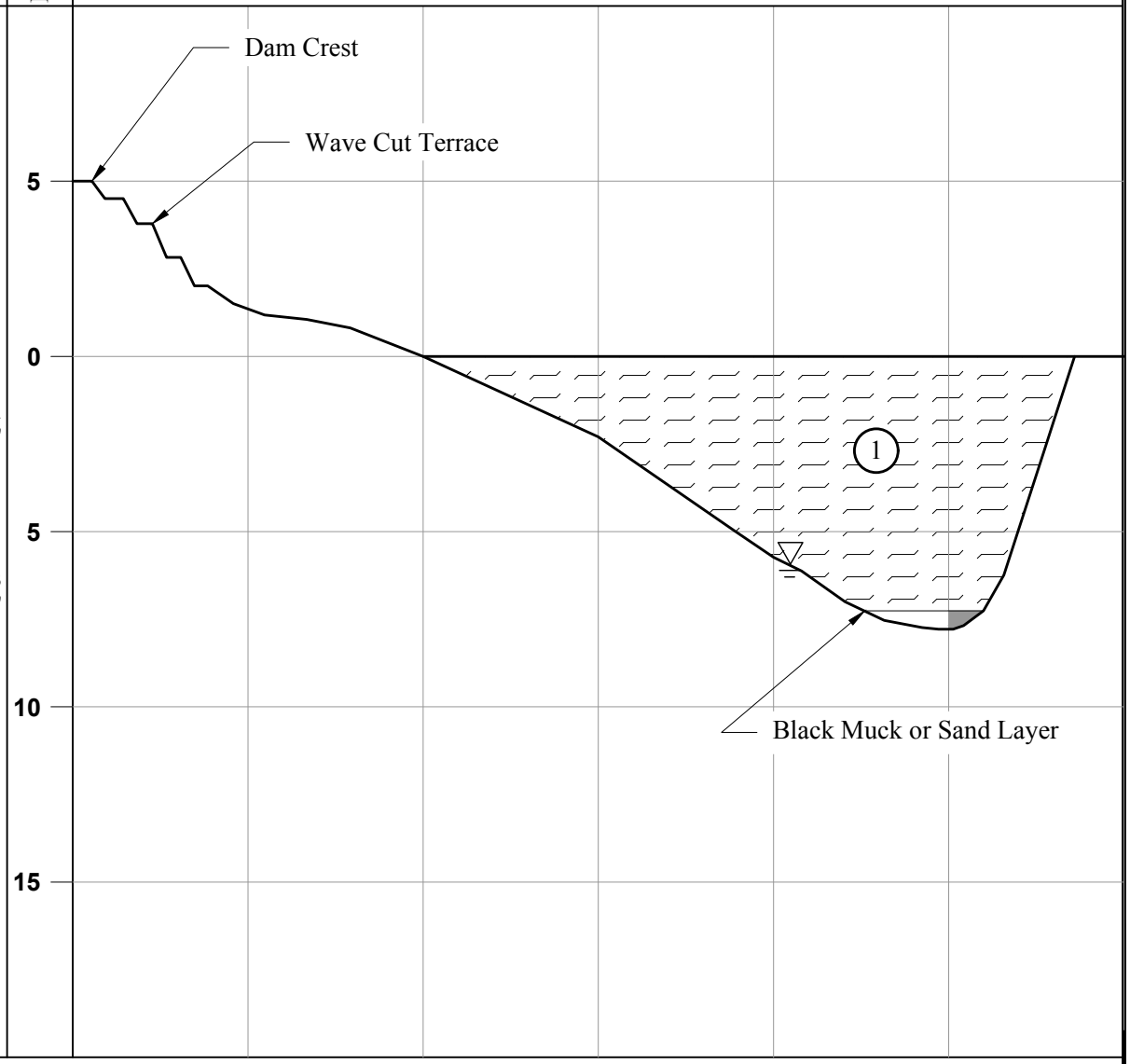
Notes:

- Would stand temporarily to ≈ 5' high wall
- No Visible Seepage into pit. However, 1' of standing water accumulated in pit over night

Lab Testing

- Sample S10-A
  - LL = 113, PL = 23, PI = 90
  - Classification = Fat Clay (CH)
  - 0% Gravel, 0.2% Sand, 99.8% Fines
  - 83.1% Water Content, 9.99% Organics

| % WATER CONTENT | SAMPLES |
|---|---|
| 83.1% | S10-A @ 2' |
| 127.8% | S10-B @ 8' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **8'**
GROUNDWATER: **6'**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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Test Pit Designation: **TP-11**

Location: ADJACENT TO WATER SURFACE EDGE AT THE LOWER SCHLEICHART POND

## DESCRIPTION OF MATERIALS

(1) Very Soft; Gray to Black; CLAY/SILT; Wet; Typ. 0'-1.5' BGS; (Sediment).

Notes:
- Layer has 3"-4" thick desiccated top layer that is moist to wet.

(2) Medium Dense to Loose; Brown, SAND; Very Moist; Typ. 1.5'-3' BGS; (Sediment).

Notes:
- Sand layer supports excavator

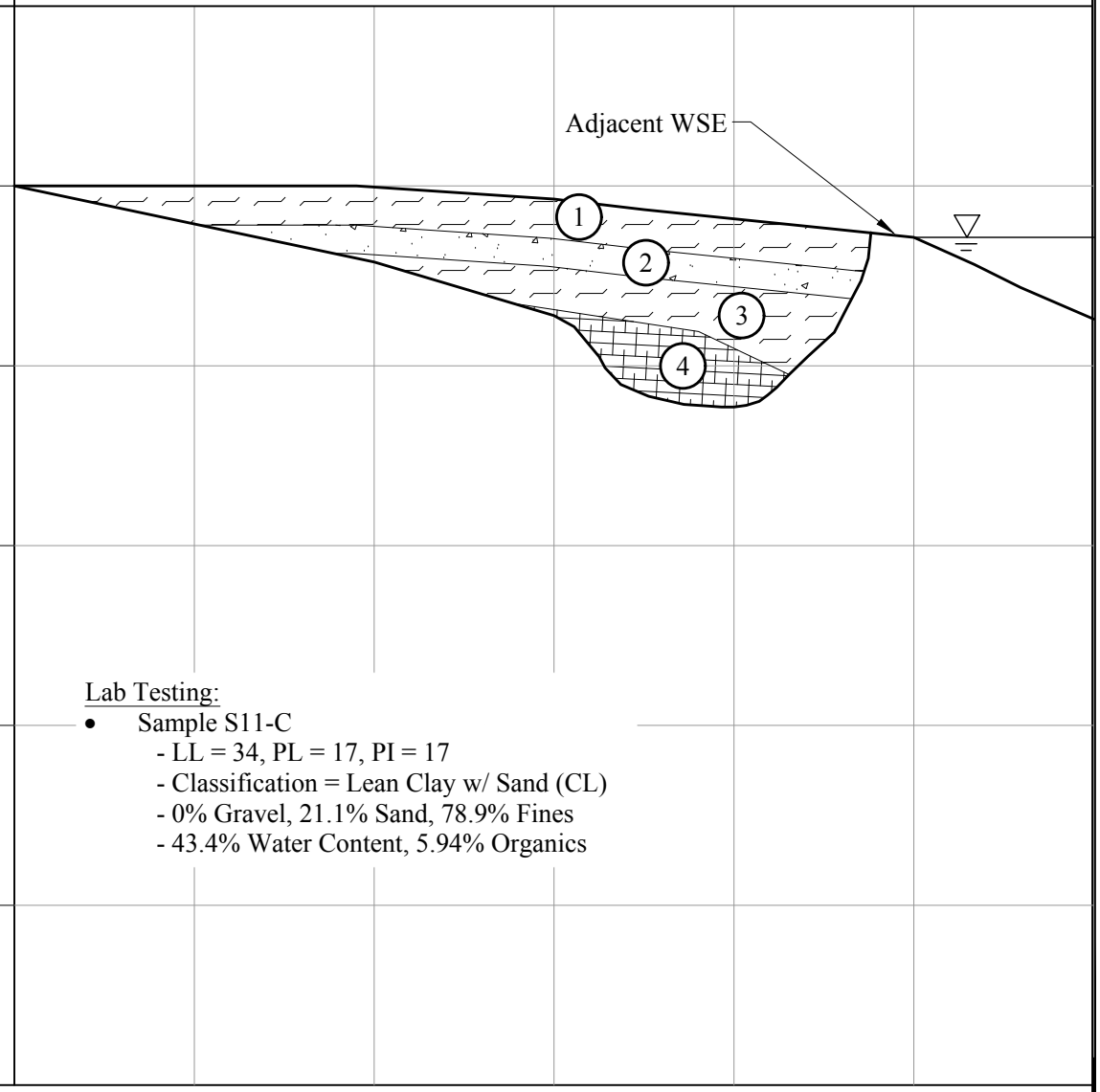
(3) Soft; Brown; SILT/CLAY; Wet; Typ. 3'-4' BGS; (Sediment).

Notes:
- Qp = 0.5 tsf or less
- 5.94% Organics

(4) Stiff; Brown; SANDY CLAY; Wet; Typ. 4.5' - Bottom of pit; (Native Bottom).

Notes:
- Seepage occurred into bottom of Test Pit
- Layer would support tracked equipment
- Qp = 1.5-2.0 tsf

| % WATER CONTENT | SAMPLES |
|---|---|
| 124.0% | S11-A @ 1.5' |
| 33.3% | S11-B @ 2' |
| 43.4% | S11-C @ 3' |
| 34.5% | S11-D @ 6' |




Lab Testing:
- Sample S11-C
  - LL = 34, PL = 17, PI = 17
  - Classification = Lean Clay w/ Sand (CL)
  - 0% Gravel, 21.1% Sand, 78.9% Fines
  - 43.4% Water Content, 5.94% Organics

SURFACE ELEVATION: **NA**
TOTAL DEPTH: **6'**
GROUNDWATER: **Seepage at 5'**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 25, 2016**

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Test Pit Designation: **TP-12**

Location: DOWN SLOPE TOE OF BROWNS POND DAM

## DESCRIPTION OF MATERIALS

(1) Soft; Dark Brown; Organic SILT with roots; Very Moist; (Topsoil).

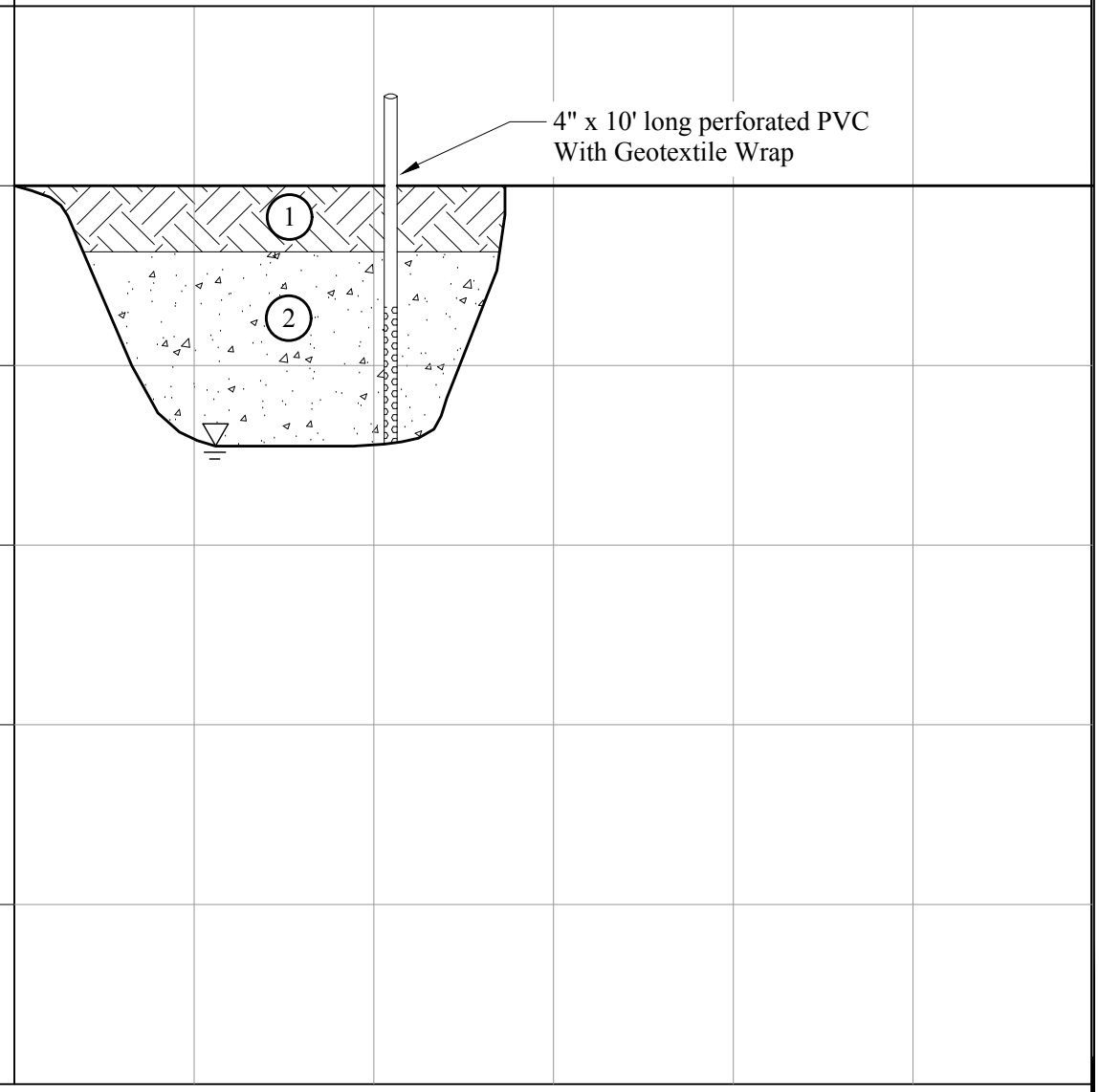
Notes:
- Heavy Grass Cover

(2) Medium Dense; Brown, SAND with Traces of Silt; Very Moist to Wet; (Sediment).

Notes:
- Scattered Gravel at 7.5'
- Seepage at 7.5'

Lab Testing
- Sample S12-A
  - Classification = Silty Sand (SM)
  - 2% Gravel, 81.1% Sand, 16.9% Fines
  - 22.1% Water Content

| % WATER CONTENT | SAMPLES |
|---|---|
| 22.1% | S12-A @ 4.5' |
| 23.7% | S12-B @ 7.5' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **7.5'**
GROUNDWATER: **7.5'**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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Test Pit Designation: **TP-13**

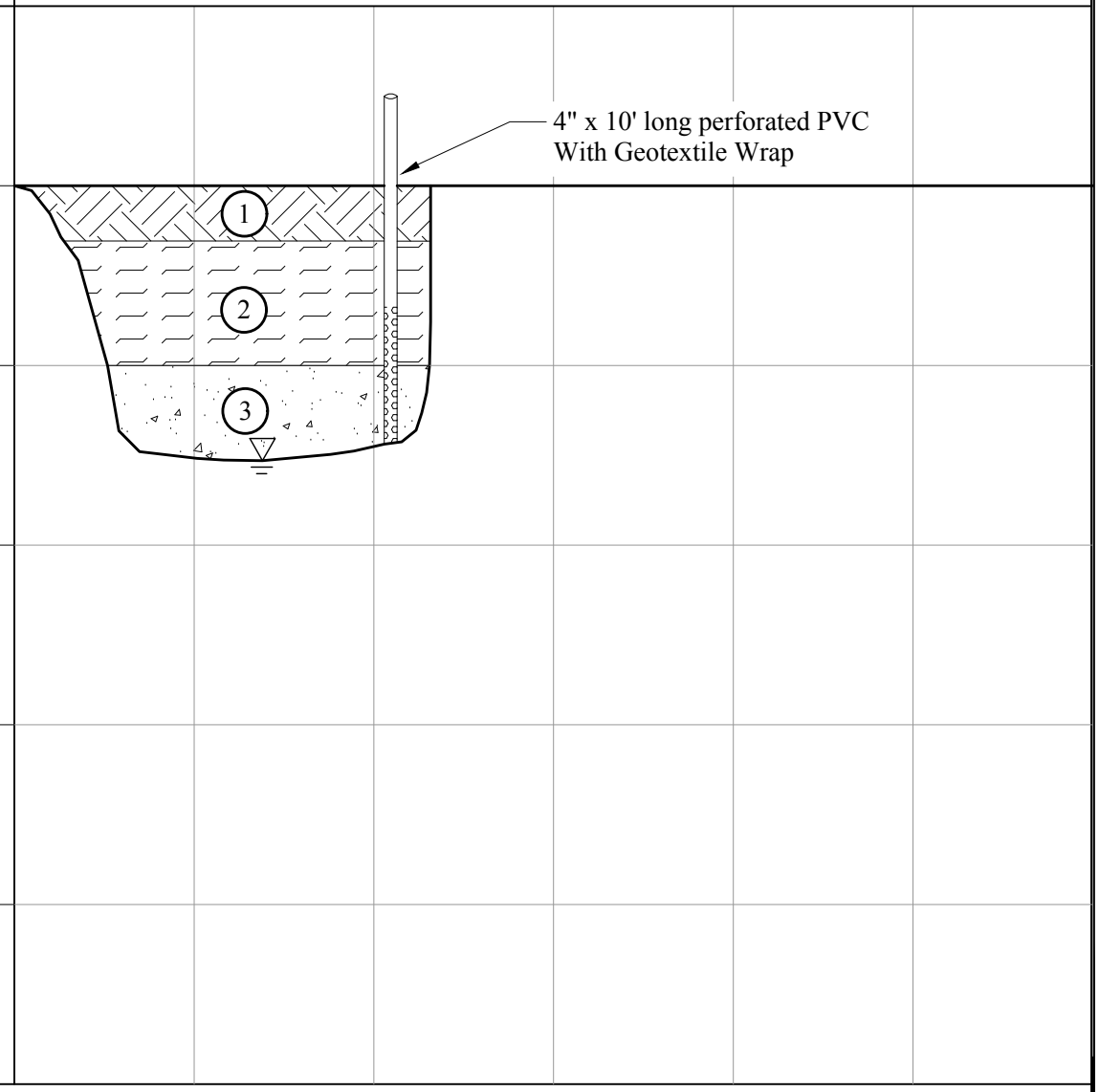
Location: DOWN SLOPE TOE OF DAM BELOW BH PIEZO

## DESCRIPTION OF MATERIALS

1. Soft; Dark Brown; Organic SILT; Very Moist; Typ. 0'-1.5' BGS (Topsoil).
2. Stiff; Brown, Sandy SILT; Very Moist; Typ. 1.5'-5' BGS; (Alluvium).
3. Loose, Brown, Silty Gravelly SAND; Very Moist to Wet; Typ. 5'-7.5' BGS; (Alluvium).

Notes:

- Gravel has max size of ≈ 3" rounded




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **7.5'**
GROUNDWATER: **7.5'**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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Test Pit Designation: **TP-14**

Location: DOWN SLOPE TOE OF DAM, EAST SIDE

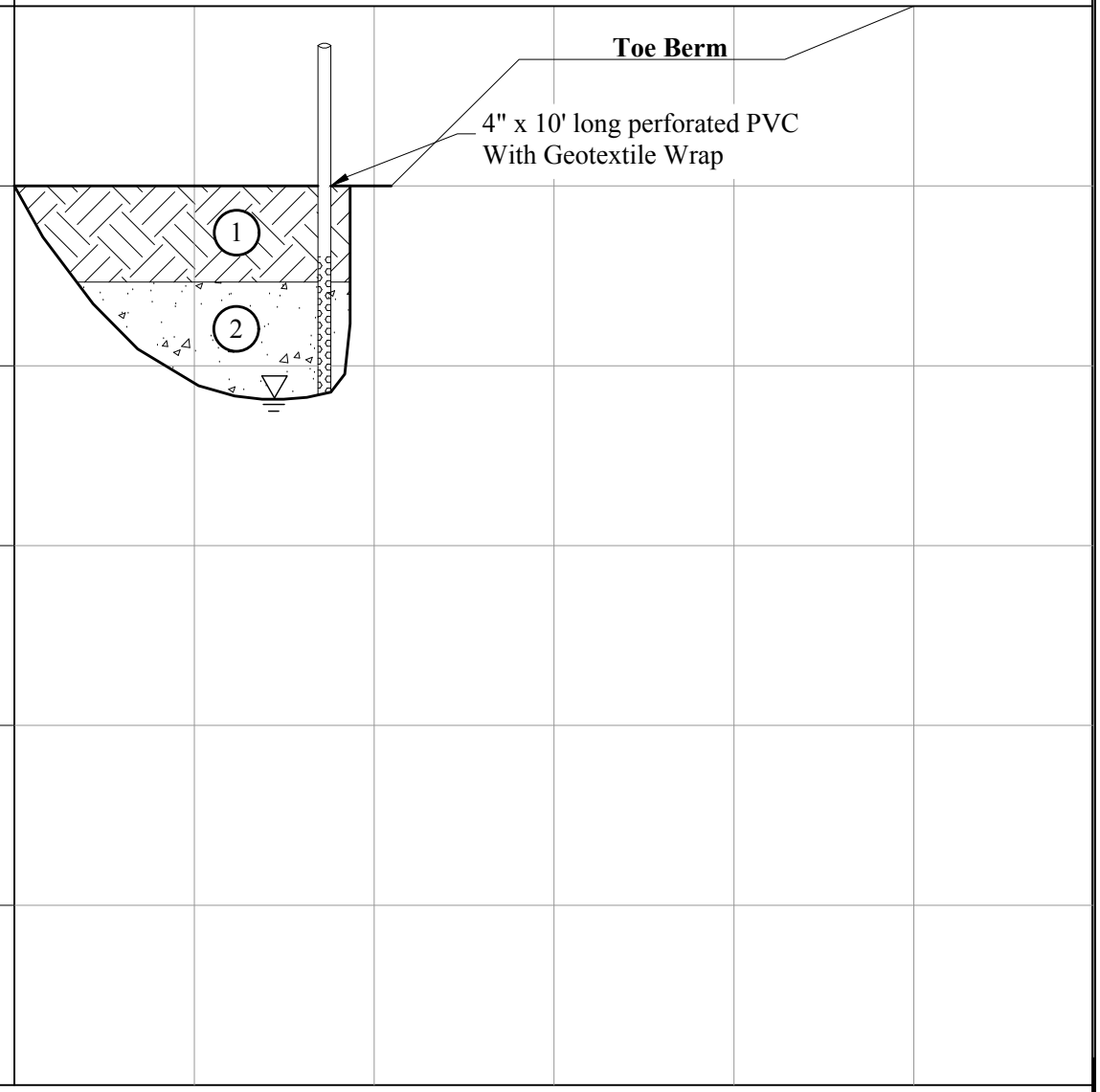
## DESCRIPTION OF MATERIALS

1. Stiff; Brown; SILT; Moist to very Moist; (Topsoil).
2. Medium to Loose; Gray, Sandy/Silty GRAVEL; Very Moist to Wet; (Gravel).

Notes:

- Gravel Max. Size ≈ 2" Rounded
- Test Pit was Wet at 5'

| % WATER CONTENT | SAMPLES |
|---|---|
| 31.9% | S14-A @ 5.5' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **6'**
GROUNDWATER: **5.5'**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 25, 2016**

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Test Pit Designation: **TP-15**

Location: EAST TRIBUTARY OF POND 4 - IN SEDIMENT

## DESCRIPTION OF MATERIALS

1. Very Soft; Gray; Smooth SILT/CLAY; Wet; Typ. 0'-1.25' BGS; (Sediment).

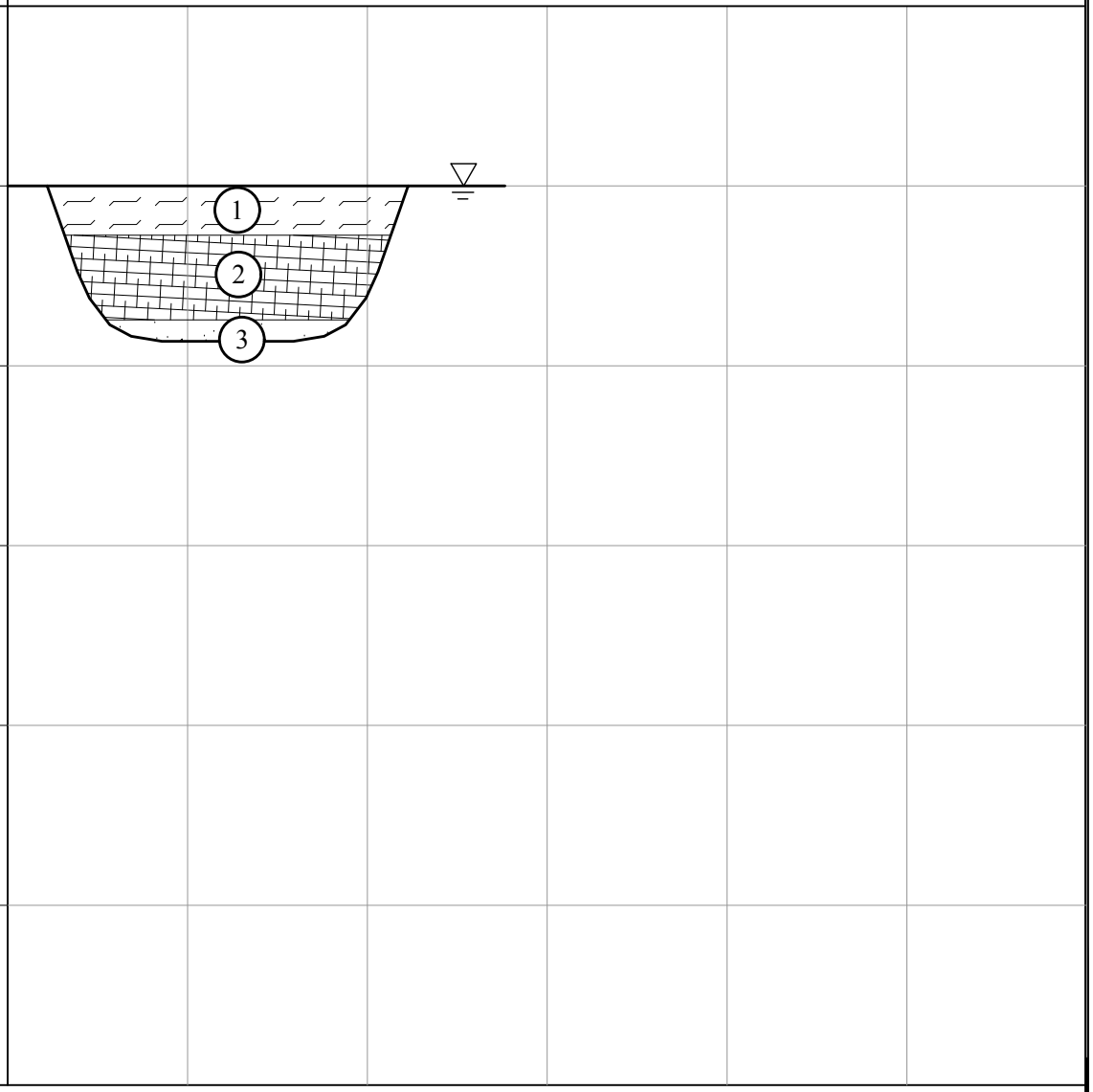
   Notes:
   - Qp = 0.0 - 0.1 tsf

2. Very Soft; Gray/Brown, SILT/CLAY; Wet; Typ. 1.25'-3.5' BGS; (Sediment).

   Notes:
   - Dark layer on top ≈ 2" thick

3. Medium Dense; Brown; Silty SAND; Wet; (Native Alluvium).

| % WATER CONTENT | SAMPLES |
|---|---|
| | S15-A @ 0-1.25' |
| | S15-B @ 2-3' |
| 21.7% | S15-C @ 4' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **4.5'**
GROUNDWATER: **At Surface**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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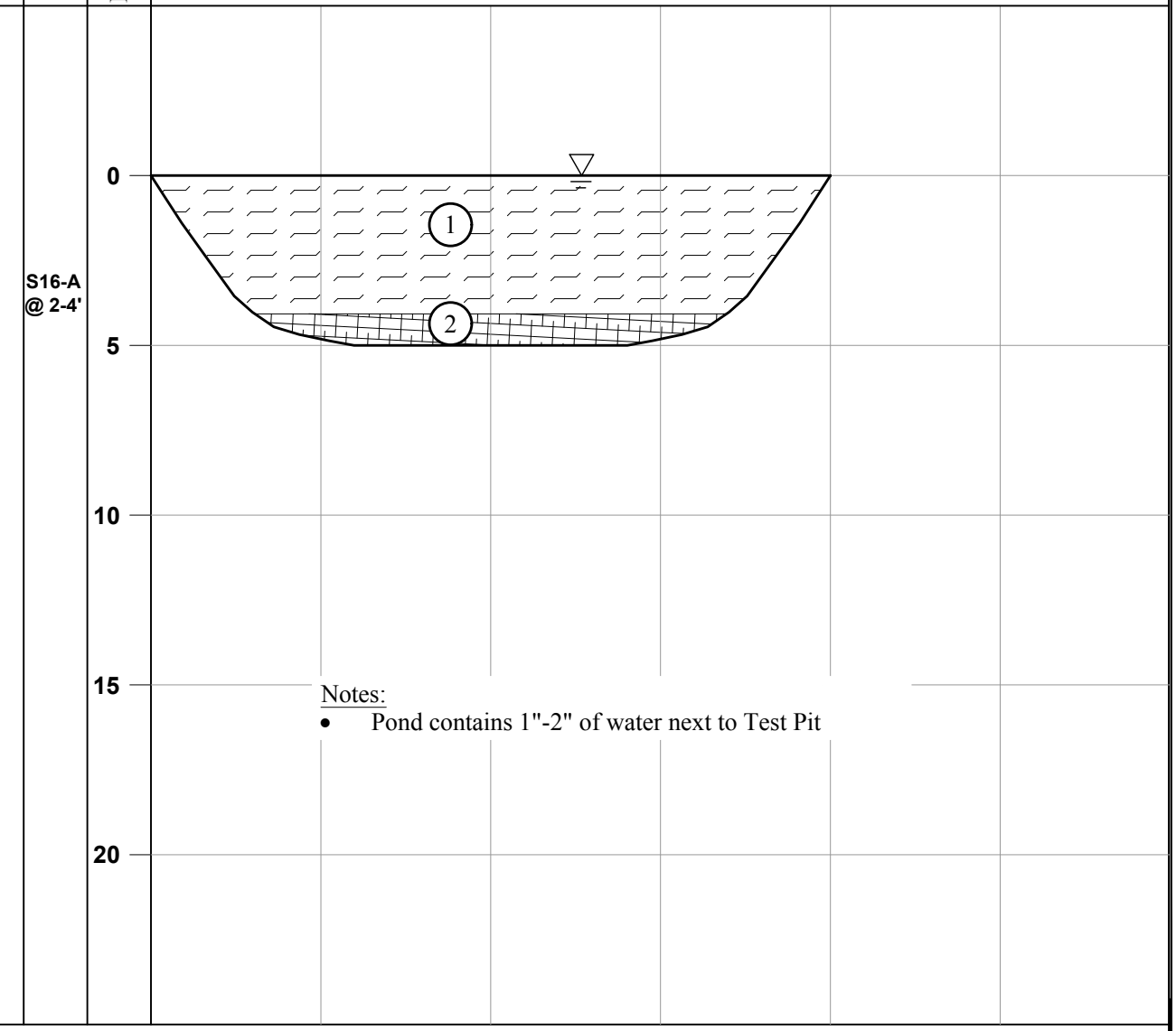
Test Pit Designation: **TP-16**

Location: WEST TRIBUTARY OF POND 4

## DESCRIPTION OF MATERIALS

1. Very Soft; Brown to Gray; SILT/CLAY; Wet; (Sediment).
2. Stiff; Brown, CLAY/SILT; Wet; (Natural Bottom).




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **5'**
GROUNDWATER: **At Surface**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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Test Pit Designation: **TP-17**

Location: EAST SIDE OF DELTA/INLET STREAM OF POND 3

Horizontal Distance in Feet →

## DESCRIPTION OF MATERIALS

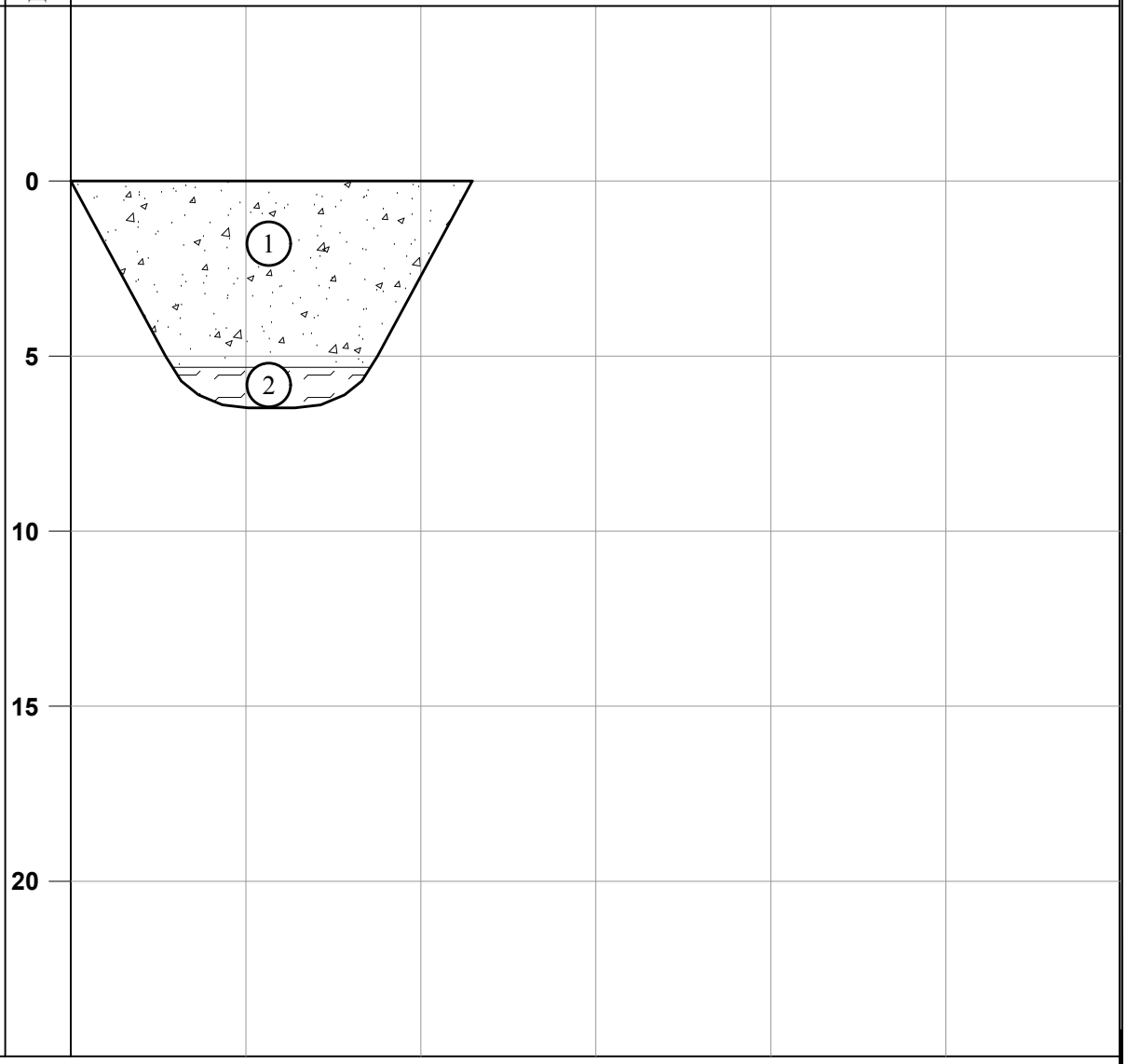
(1) Medium Dense; Brown; SAND; Very Moist to Moist; (Sand Sediment).

Notes:
- Sand is Medium Grained and Clean
- Occasional rounded Sandstone Gravel present; Typ. 1" with specimens up to 3".

(2) Stiff; Brown, Sandy Lean CLAY; Very Moist; (Natural Bottom).

Lab Testing
- Sample S17-A
  - Classification = Poorly Graded Sand (SP)
  - 3.4% Gravel, 92.2% Sand, 4.4% Fines
  - 21.2% Water Content
- Sample S17-B
  - LL = 41, PL = 13, PI = 28
  - Classification = Sandy Lean Clay (CL)
  - 0% Gravel, 30.1% Sand, 69.9% Fines
  - 28.3% Water Content

| % WATER CONTENT | SAMPLES |
|---|---|
| 21.2% | S17-A @ 0-5.5' |
| 28.3% | S17-B @ 6.5' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **7'**
GROUNDWATER: **Dry**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 25, 2016**

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Test Pit Designation: **TP-18**

Location: CENTER OF INLET DELTA OF POND 3

Horizontal Distance in Feet →

## DESCRIPTION OF MATERIALS

(1) Medium Dense; Brown; Stratified SAND; Very Moist; (Sand Sediment).

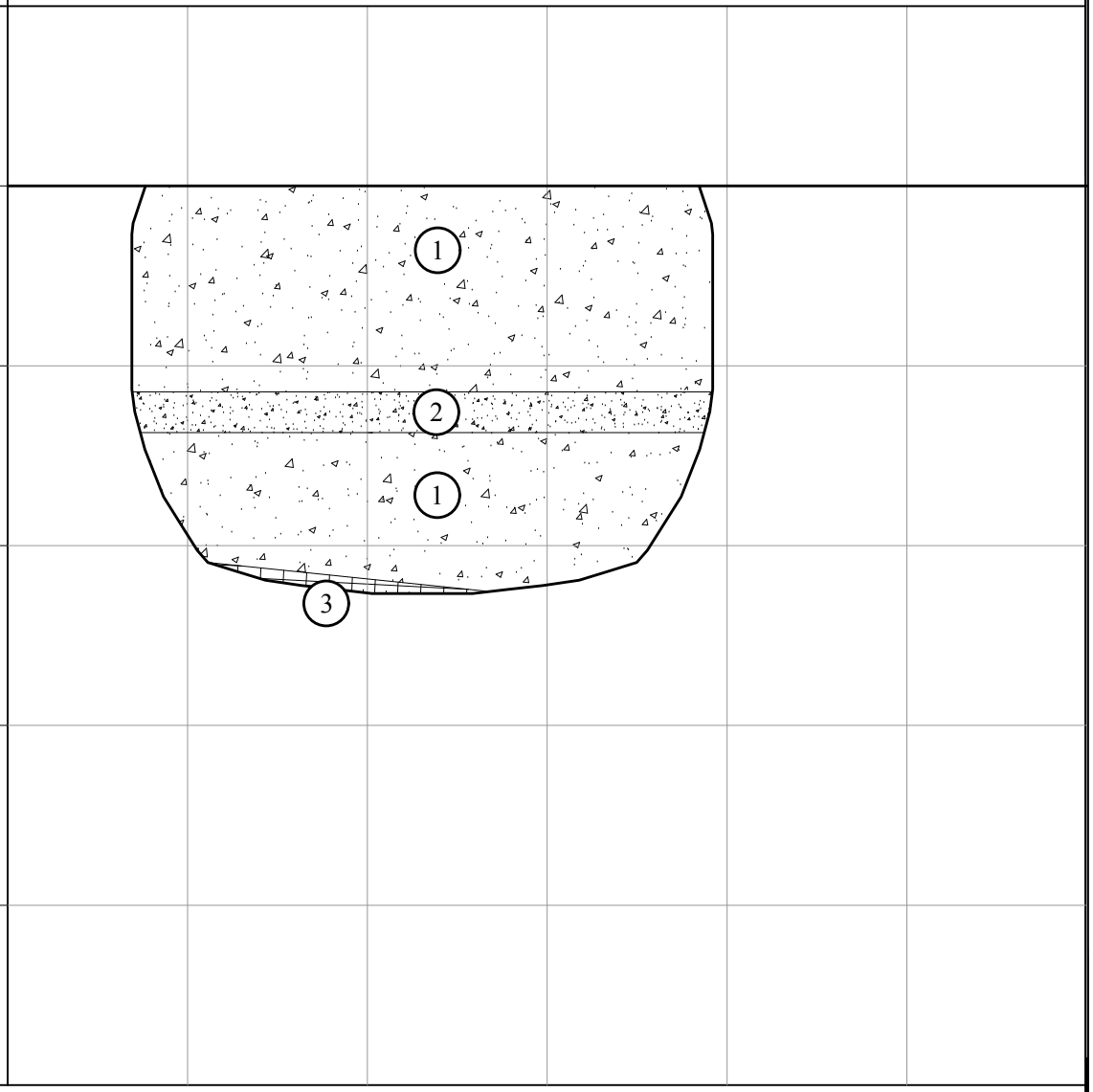
Notes:
- Sand has some finer lenses with Silt but is fairly coarse and clean.
- Occasional rounded Sandstone Gravel specimens present up to 2".

(2) Medium Dense; Brown, Sandy SILT/Silty SAND; Very Moist; (Sediment).

(3) Stiff; Brown; Sandy SILT; Very Moist to Wet; (Natural Bottom).

Lab Testing
- Sample S18-A
  - Classification = Lean Clay (CL)
  - 0% Gravel, 10.0% Sand, 90% Fines
  - 22.2% Water Content

| % WATER CONTENT | SAMPLES | DEPTH (FT) |
|---|---|---|
| 22.2% | S18-A @ 6-7' | 0 |
| | | 5 |
| 26.7% | S18-B @ 12' | 10 |
| | | 15 |
| | | 20 |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **12'**
GROUNDWATER: **10'**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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Test Pit Designation: **TP-19**

Location: INLET DELTA OF POND 2

Horizontal Distance in Feet →

## DESCRIPTION OF MATERIALS

(1) Medium Dense to Loose; Brown; SAND; Very Moist; (Sandstone Sediment).

Notes:
- Sand is generally clean with Silt layers

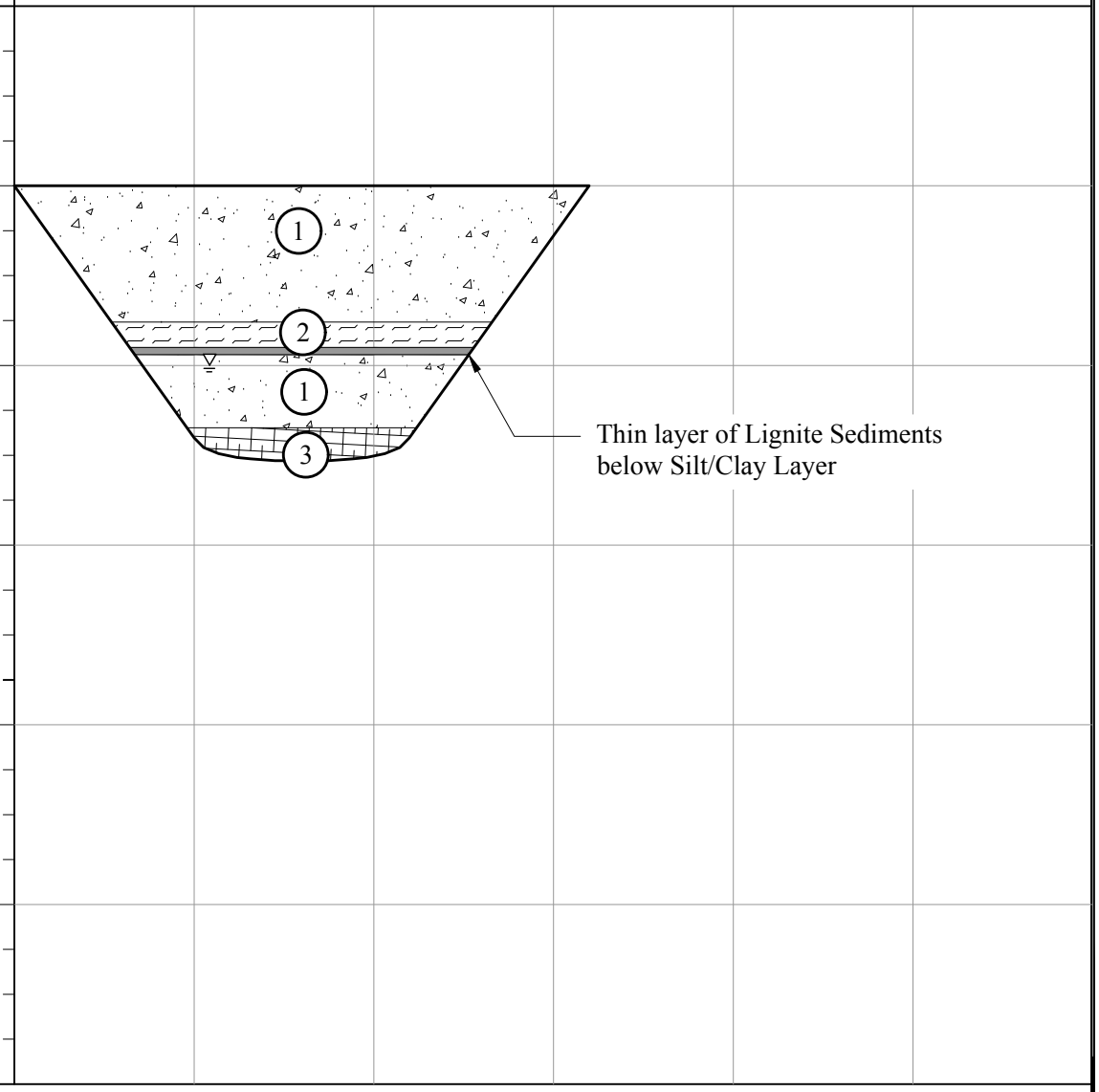
(2) Soft; Gray, SILT/CLAY; Very Moist to Wet; Typ. 3.8'-4.0' BGS; (Silt/Clay sediment over lignite layer).

Notes:
- Thin Lignite layer has up to 1" flakes

(3) Stiff; Tan; SILT with Sand; Wet; (Natural Bottom).

Lab Testing
- Sample S19-A
  - Classification = Well Graded Sand w/ Silt (SW-SM)
  - 0.2% Gravel, 89.4% Sand, 10.4% Fines
  - 16.3% Water Content
- Sample S19-D
  - Classification = Clayey Sand (SC)
  - 0% Gravel, 60.7% Sand, 39.3% Fines
  - 29.9% Water Content

| % WATER CONTENT | SAMPLES |
|---|---|
| 16.3% | S19-A @ 2' |
| | S19-B @ 3.8-4' |
| | S19-C @ 4' |
| 29.9% | S19-D @ 7' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **7.5'**
GROUNDWATER: **5'**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
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Test Pit Designation: **TP-20**

Location: DELTA OF SEDIMENT POND 1

## DESCRIPTION OF MATERIALS

1. Loose to Medium Dense; Brown; SAND; Wet; (Sediment).

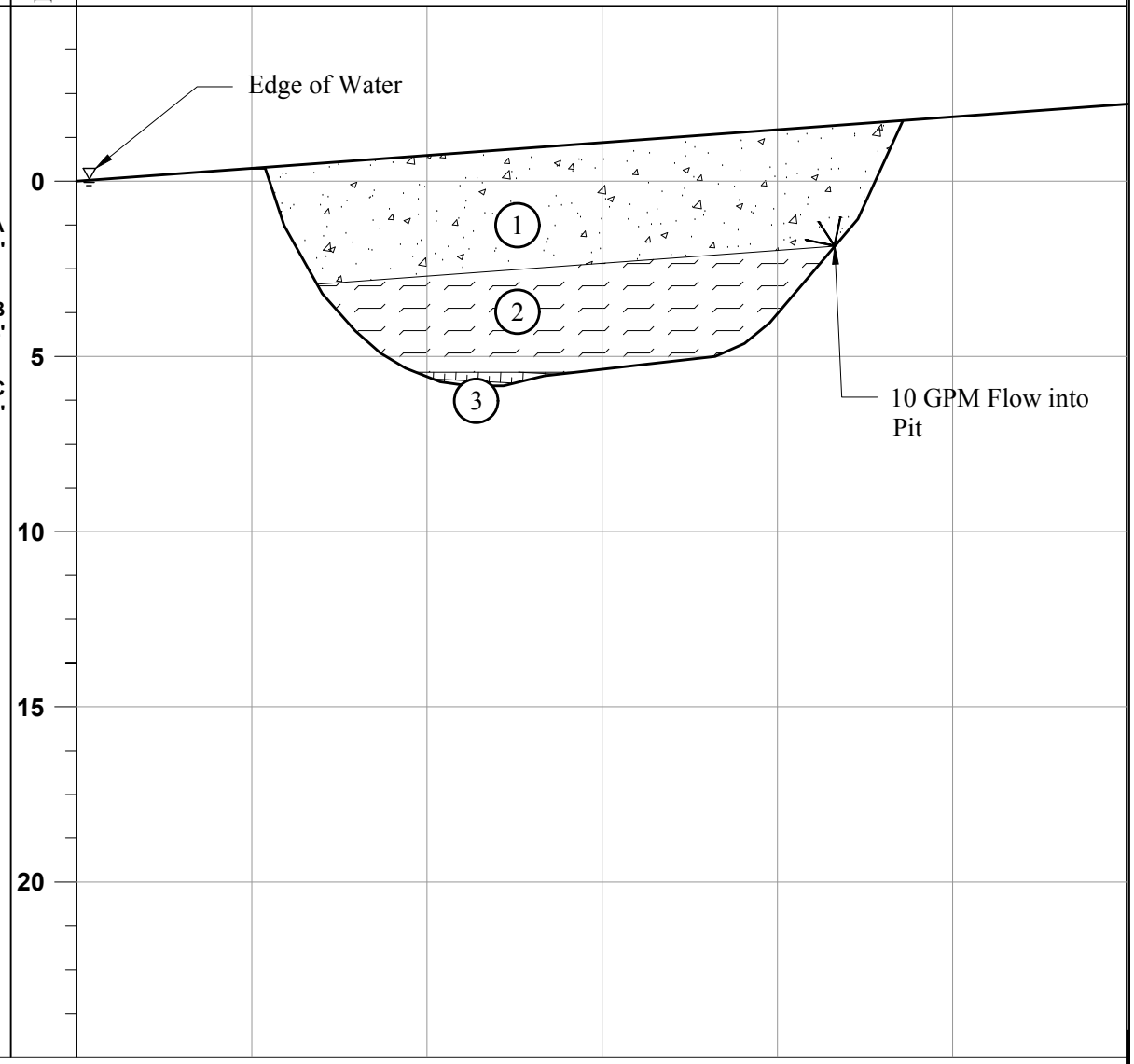
Notes:
- Sand is medium grained and clean

2. Soft; Brown, Sandy SILT/CLAY; Wet; (Sediment).

3. Stiff; Light Brown; Sandy SILT; Wet; (Natural Bottom).

Lab Testing
- Sample S20-A
  - Classification = Silty Sand (SM)
  - 0.6% Gravel, 81.5% Sand, 17.9% Fines
  - 22.5% Water Content
- Sample S20-B
  - LL = 42, PL = 17, PI = 25
  - Classification = Sandy Lean Clay (CL)
  - 0% Gravel, 30.5% Sand, 69.5% Fines
  - 61.2% Water Content
- Sample S20-C
  - Classification = Sandy Lean Clay (CL)
  - 0% Gravel, 43.7% Sand, 56.3% Fines
  - 22.8% Water Content

| % WATER CONTENT | SAMPLES |
|---|---|
| 22.5% | S20-A @ 2' |
| 61.2% | S20-B @ 4' |
| 22.8% | S20-C @ 6' |




SURFACE ELEVATION: **NA**
TOTAL DEPTH: **6'**
GROUNDWATER: **Immediate Adjacent to Pond**

BACKHOE TYPE: **CAT 315**
BACKHOE OPERATOR: **Terry Hafner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 26, 2016**

# A2 – BORE HOLE LOGS

# PIEZOMETER LOG NO. BP-01 (Browns)



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION:
Latitude: 45.79447° Longitude: -103.49396°
Approximate Surface Elev: 2906 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description | Installation Details |
|---|---|---|---|
| 0 | 2906+/- | **FILL - CLAYEY SAND WITH GRAVEL (SC)**, light brown, medium dense, slightly moist, some organics, subround to subangular gravels, trace silt<br>less gravels with depth | Solid 2" Riser backfilled with native soils<br>Solid 2" Riser packed in bentonite grout |
| 9.8 | 2896+/- | **FILL - SANDY LEAN CLAY (CL)**, brown, soft to medium stiff, moist | |
| 19.5 | 2886.5+/- | **CLAYEY SAND (SC)**, dark brown to black, soft, organic layer, muck, very moist to saturated | Solid 2" Riser packed in bentonite hole plug |
| 22.0 | 2884+/- | **SILTY SAND (SM)**, light gray to brown, medium dense, very moist to saturated, fine sand, some clay | Solid 2" Riser packed in sand<br>Slotted 2" Screen packed in sand |
| 25.3 | 2880.5+/- | **FAT CLAY (CH)**, mottled gray/orange/brown, very moist, faint bedding, trace sands and carbons/coal fragments, trace oxidation | |
| 34.5 | 2871.5+/- | **SHALE**, dark gray, very soft to soft rock, very severely weathered, poorly bonded, moist to very moist, interbedded sandstone, thin horizontal bedding, organic appearance, slighlty blocky, moderate to high plasticity matrix | Sandpoint cap |
| 46.0 | 2860+/- | bedded, more silty matrix with high plasticity/organic clay lenses | |
| | | ***Boring Terminated at 46 Feet*** | |

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI |
|---|---|---|---|---|---|---|---|
| 0 | | | 1.5 | 5-8-8<br>N=16 | 5 | | |
| 5 | | | 1.5 | 6-6-7<br>N=13 | 8 | | |
| 10 | | | 1.5 | 3-2-2<br>N=4 | 15 | | 25-16-9 |
| 15 | | | 1.5 | 1-2-2<br>N=4 | 25 | | 29-12-17 |
| 20 | | | 1.5 | 2-2-2<br>N=4 | 27 | | 29-19-10 |
| 25 | | | 1.5 | 3-6-7<br>N=13 | 31<br>36 | | 47-14-33 |
| 30 | | | 1.5 | 4-7-11<br>N=18 | 30 | | |
| 35 | | | 1.5 | 7-10-11<br>N=21 | 27 | | |
| 40 | ▽ 39.5' While Drilling<br>▽ 42.0' After Drilling | | 1.5 | 6-8-12<br>N=20 | 38 | | |
| 45 | | | 1.5 | 8-12-12<br>N=24 | 32 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.
Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Piezometer Installed

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

Piezometer constructed to depth of 40.0' below existing ground surface with approx. 3.0' stickup, capped with twist cap
8 bags of sand, 1 bag of 3/8" bentonite hole plug chips, and 1.5 bags of bentonite grout used during piezometer installatoin

**WATER LEVEL OBSERVATIONS**

▽ *39.5' While Drilling*
▽ *42.0' After Drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/25/2016 | Boring Completed: 10/25/2016
Drill Rig: D-90 | Driller: M. Roberts/Terracon
Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON_DATATEMPLATE.GDT 1/25/17

# PIEZOMETER LOG NO. BP-02 (Browns)



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION:
Latitude: 45.7942° Longitude: -103.4948°
Approximate Surface Elev: 2904 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 0.2 | 2904+/- | **TOPSOIL** |
| 8.1 | 2896+/- | **FILL - CLAYEY SAND WITH GRAVEL (SC)**, light brown, medium dense, slightly moist, some organics, subround to subangular gravels fewer gravels |
| 12.0 | 2892+/- | **FILL - POORLY GRADED GRAVEL WITH SAND (GP)**, light brown, medium dense, slightly moist, subround to subangular gravels, trace silt |
| 20.0 | 2884+/- | **FILL - LEAN CLAY (CL)**, brown, medium stiff, moist, scattered coarse sands and gravels, trace oxidation, moderate plasticity |
| 34.0 | 2870+/- | **POORLY GRADED SAND (SP)**, dark gray, very loose to loose, moist to very moist, coarse sand, trace silt very moist to saturated at 22.0', becoming more silty at 24.0' becoming more coarse grained |
| 41.0 | 2863+/- | **SHALE**, gray, very soft to soft rock, severely to moderately weathered, moderately bonded, moist to very moist, interbedded sandstone, thin horizontal bedding, trace carbons on bedding planes, moderate to high plasticity |
| | | ***Boring Terminated at 41 Feet*** |

INSTALLATION DETAILS: Solid 2" Riser backfilled with native soils; Solid 2" Riser packed in bentonite grout; Solid 2" Riser packed in bentonite hole plug; Solid 2" Riser packed in sand; Slotted 2" Screen packed in sand; Sandpoint cap

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | Torvane (psf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI |
|---|---|---|---|---|---|---|---|---|
| 5 | | | 1 | 7-6-6 N=12 | | 8 | | |
| 10 | | | 1.2 | 8-11-10 N=21 | | 5 | | |
| 15 | | | 1.5 | 2-3-4 N=7 | | 22 | | |
| 20 | | | 2 | PUSH | 6400 | 21 | 100 | 35-13-22 |
| | ▽ | | 1.5 | 2-3-3 N=6 | | 20 26 | | |
| 25 | | | 1.5 | 1-2-1 N=3 | | 31 | | |
| 30 | | | 1 | 2-4-6 N=10 | | 20 | | |
| 35 | | | 1.5 | 5-7-11 N=18 | | 33 | | |
| 40 | | | 1.5 | 7-11-12 N=23 | | 33 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.
Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Piezometer Installed

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

Piezometer constructed to depth of 37.0' below existing ground surface with approx. 3.0' stickup, capped with twist cap
11 bags of sand, 1 bag of 3/8" bentonite hole plug chips, and 1.5 bags of bentonite grout used during piezometer installatoin

**WATER LEVEL OBSERVATIONS**

▽ *22.7' While Drilling*

▽ *23.0' After Drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/25/2016 | Boring Completed: 10/25/2016

Drill Rig: D-90 | Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON_DATATEMPLATE.GDT 1/25/17

# BORING LOG NO. FSR 3123-01



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION

Latitude: 45.84032° Longitude: -103.48328°

Approximate Surface Elev: 3261 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 2.0 | 3259+/- | **FILL - WELL GRADED GRAVEL WITH SAND (GW)**, red, medium dense to dense, Scoria Road Surfacing (-1 1/2") Gravels, damp to slightly moist, subangular to subround gravels, coarse sand |
| 7.5 | 3253.5+/- | **SILTY SAND (SM)**, brown, loose to medium dense, moist, trace organics<br>color change to mottled light brown/orange/gray |
| 15.7 | 3245.5+/- | **SANDY SILT (ML)**, mottled orange/gray, medium stiff, moist, trace sand, trace oxidation, friable<br>becoming very stiff |
| 35.3 | 3225.5+/- | **FAT CLAY (CH)**, black, very stiff to hard, slightly moist, very thin horizontal bedding, very organic, some oxidation staining, trace salts |
| 41.5 | 3219.5+/- | **SANDSTONE**, mottled olive/gray/brown, no cementation to very weak cementation, very soft rock, completely weathered (sandy lean clay matrix, moderate plasticity), trace oxidation, thin horizontal bedding, |
| | | ***Boring Terminated at 41.5 Feet*** |

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | STRENGTH TEST: TEST TYPE | STRENGTH TEST: COMPRESSIVE STRENGTH (psf) | STRENGTH TEST: STRAIN (%) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS: LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1.5 | 7-9-7<br>N=16 | | | | 8<br>8 | | |
| 5 | | | 1.2 | 6-5-4<br>N=9 | | | | 7 | | |
| | | | 1.1 | 4-3-3<br>N=6 | | | | 25 | | |
| 10 | | | 1.2 | 5-10-11<br>N=21 | | | | 22 | | |
| 15 | | | 1.5 | 11-13-17<br>N=30 | | | | 29 | | 59-24-35 |
| 20 | | | 1.5 | 8-13-17<br>N=30 | | | | 27 | | 53-21-32 |
| 25 | | | 1 | PUSH | | | | 36 | 77 | 49-19-30 |
| | | | 1.5 | 6-11-17<br>N=28 | | | | 29 | | 52-21-31 |
| 30 | | | 1.5 | 7-10-13<br>N=23 | | | | 31 | | 59-22-37 |
| 35 | | | 1.5 | 9-11-13<br>N=24 | | | | 23 | | 83-13-70 |
| 40 | | | 1.5 | 8-12-15<br>N=27 | | | | 23 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

**WATER LEVEL OBSERVATIONS**

*None Encountered While drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/24/2016 Boring Completed: 10/24/2016

Drill Rig: D-90 Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# PIEZOMETER LOG NO. FSR 3123-02



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION: Latitude: 45.84014° Longitude: -103.48293°

Approximate Surface Elev: 3246 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 2.3 | 3243.5+/- | **FILL - SILTY CLAYEY SAND (SC-SM)**, olive to light brown, loose, moist, fine to medium grained sand (filled from slope inboard of ditch to level road for drill access) |
| | | **FAT CLAY (CH)**, black, very stiff to hard, slightly moist, blocky, some thin bedding, organic, some oxidation staining, trace salts |
| 16.2 | 3230+/- | organics found on bedding planes at 15.5' (leaf imprint) |
| | | **SANDSTONE**, mottled olive/gray/orange, no cementation to very weak cementation, very soft rock, completely weathered (sandy lean clay matrix, moderate plasticity), trace oxidation on apparent high angle fractures, thin horizontal bedding, some apparent cohesion/plasticity trace carbons, color changing to gray at 25.0' interbedded claystone, organic content, dark gray/black at 30.0' |
| | | heavily oxidized seam at 36.3' |
| 41.5 | 3204.5+/- | |

***Boring Terminated at 41.5 Feet***

INSTALLATION DETAILS: Solid 2" Riser backfilled with native soils; Solid 2" Riser packed in bentonite grout; Solid 2" Riser packed in bentonite hole plug; Solid 2" Riser packed in sand; Slotted 2" Screen packed in sand; Sandpoint cap

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | Torvane (psf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI |
|---|---|---|---|---|---|---|---|---|
| 5 | | | 1.5 | 8-10-13 N=23 | | 33 | | |
| | | | 1.5 | 9-12-15 N=27 | | 29 | | 55-23-32 |
| | | | 1.5 | 6-8-9 N=17 | | 32 | | 55-21-34 |
| 10 | | | 1.5 | 5-6-10 N=16 | | 36 | | 62-23-39 |
| 15 | | | 1.5 | 6-8-12 N=20 | | 33 24 | | 84-19-65 |
| 20 | | | 2 | PUSH | 10000 | 26 | 98 | 117-20-97 |
| | | | 1.5 | 7-9-10 N=19 | | 25 | | |
| 25 | | | 1.5 | 7-11-14 N=25 | | 25 | | 65-15-50 |
| 30 | | | 1.5 | 9-14-15 N=29 | | 20 | | 63-14-49 |
| 35 | | | 1.5 | 10-14-16 N=30 | | 22 | | 49-17-32 |
| 40 | | | 1.5 | 8-13-16 N=29 | | 22 | | 44-13-31 |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method: 3 1/4" Hollow Stem Auger

Abandonment Method: Piezometer Installed

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes: Piezometer constructed to depth of 40' below existing ground surface with approx. 3' stickup, capped with twist cap 15 bags of sand, 1 bag of 3/8" bentonite hole plug chips, and 1.5 bags of bentonite grout used during piezometer installatoin

**WATER LEVEL OBSERVATIONS**

*None Encountered While drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/24/2016 | Boring Completed: 10/24/2016

Drill Rig: D-90 | Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON_DATATEMPLATE.GDT 1/25/17

# BORING LOG NO. FSR 3123-03



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION

Latitude: 45.84055° Longitude: -103.4846°

Approximate Surface Elev: 3311 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | DESCRIPTION |
|---|---|---|
| 0 | 3311+/- | **SANDSTONE**, light brown to rusty brown, poor to very weak cementation, soft rock, very severely to completely weathered, some interbedded siltstone layers, faint horizontal bedding |
| | | auger advancing with little resistance, color changing in cuttings from 7.5' to 8.5' to light brown from very light brown |
| | | oxidation staining visible, color becoming rusty brown at 13.5' |
| | | some calcination on seams |
| | | finer grained with some silt lenses at 38.5' |
| | | becoming moist to very moist at 45.5' |
| 48.0 | 3263+/- | **SHALE**, medium hard to hard rock, moderately weathered, poorly bonded, thin horizontal bedding, interbeds of sandstone, trace oxidation, moderate plasticity |
| 55.0 | 3256+/- | ***Boring Terminated at 55 Feet*** |

| DEPTH (Ft.) | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | STRENGTH TEST: TEST TYPE | STRENGTH TEST: COMPRESSIVE STRENGTH (psf) | STRENGTH TEST: STRAIN (%) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS: LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|
| 5 | X | 1.4 | 33-51-49/5" | | | | 6 | | |
| 10 | X | 1.5 | 27-29-37 N=66 | | | | 9 | | |
| 15 | X | 1.5 | 27-37-39 N=76 | | | | 12 | | |
| 20 | X | 1.5 | 23-36-48 N=84 | | | | 5 | | |
| 25 | X | 1.5 | 24-35-43 N=78 | | | | 6 | | |
| 30 | X | 1.5 | 23-31-42 N=73 | | | | 13 | | |
| 35 | X | 1.4 | 24-44-56/5" | | | | 14 | | |
| 40 | X | 1.5 | 17-17-17 N=34 | | | | 17 | | NP |
| 45 | X | 1.5 | 24-31-33 N=64 | | | | 22 | | |
| 50 | X | 1.5 | 13-21-31 N=52 | | | | 21 | | 36-22-14 |
| 55 | X | 1.5 | 17-21-24 N=45 | | | | 16 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

**WATER LEVEL OBSERVATIONS**

*None Encountered While drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/25/2016 Boring Completed: 10/25/2016

Drill Rig: D-90 Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# PIEZOMETER LOG NO. Lower Schleichart (LSDR)



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION: Latitude: 45.82297° Longitude: -103.49055°

Approximate Surface Elev: 3011 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 0.2 | 3011+/- | **TOPSOIL** |
| | | **FILL - SANDY LEAN CLAY (CL)**, brown, medium dense, slightly moist to moist, some organics, scattered high plasticity inclusions |
| 12.5 | 2998.5+/- | |
| | | **LEAN CLAY WITH SAND (CL)**, brown to dark brown, medium stiff, moist, fine sand, moderate to high plasticity, trace coal fragments |
| 19.0 | 2992+/- | |
| | | **POORLY GRADED SAND WITH CLAY (SP-SC)**, brown, medium dense to loose, very moist to saturated, coarse sand, scattered gravels, trace oxidation, trace silt coarser with depth |
| 29.5 | 2981.5+/- | |
| | | **SANDSTONE**, light gray, weak cementation, very soft to soft rock (residual clayey sand soil matrix, low plasticity), very severely to completely weathered, moist to very moist, interbedded siltstone, thin horizontal bedding |
| 38.0 | 2973+/- | |
| 41.0 | 2970+/- | **SHALE**, very soft rock, severely weathered, very poorly bonded, organic, high plasticity soil matrix interbeds of lignite/claystone encountered with trace salts, dark brown/black |
| | | ***Boring Terminated at 41 Feet*** |

INSTALLATION DETAILS: Solid 2" Riser backfilled with native soils; Solid 2" Riser packed in bentonite grout; Solid 2" Riser packed in bentonite hole plug; Solid 2" Riser packed in sand; Slotted 2" Screen packed in sand; Sandpoint cap

| DEPTH (Ft.) | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | Torvane (psf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI |
|---|---|---|---|---|---|---|---|
| | | 1.2 | 6-8-8 N=16 | | 12 | | |
| 5 | | 2 | PUSH | 8400 16800 | 15 | 108 | 30-18-12 |
| 10 | | 1 | 4-5-8 N=13 | | 20 | | |
| | | 1.8 | PUSH | | | | |
| 15 | | 1.5 | 4-5-6 N=11 | | 19 | | |
| 20 | | 1.5 | 2-4-7 N=11 | | 24 | | |
| 25 | | 1.5 | 4-2-5 N=7 | | 21 | | |
| 30 | | 1.5 | 4-7-10 N=17 | | 32 | | |
| 35 | | 1.5 | 10-14-21 N=35 | | 25 | | |
| 40 | | 1.5 | 8-12-16 N=28 | | 25 | | |

WATER LEVEL OBSERVATIONS: 19.0' While Drilling; 17.5' After Drilling

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method: 3 1/4" Hollow Stem Auger

Abandonment Method: Piezometer Installed

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes: Piezometer constructed to depth of 32.0' below existing ground surface with approx. 3.0' stickup, capped with twist cap
10 bags of sand and 1 bag of 3/8" bentonite hole plug chips, and 1 bag of bentonite grout

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/25/2016 | Boring Completed: 10/25/2016

Drill Rig: D-90 | Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON_DATATEMPLATE.GDT 1/25/17

# BORING LOG NO. Sed. Rep.



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION

Latitude: 45.8475° Longitude: -103.48324°

Approximate Surface Elev: 3333 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | DESCRIPTION |
|---|---|---|
| 0.8 | 3332+/- | **FILL - SILTY SAND WITH GRAVEL (SM)**, light gray and light brown, loose to medium dense, (sediment repository sand matrix includes larger gravels and cobbles) |
| 9.5 | 3323.5+/- | **SHALE**, gray to brown, Clay Shale, very soft rock, severely to completely weathered, bedded, some silt lenses, blocky |
| 16.0 | 3317+/- | **SANDSTONE**, light gray, weak cementation, medium hard, completely weathered sandy lean clay matrix, moderate plasticity, less plastic with depth, trace oxidation |
| | | ***Boring Terminated at 16 Feet*** |

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | STRENGTH TEST: TEST TYPE | STRENGTH TEST: COMPRESSIVE STRENGTH (psf) | STRENGTH TEST: STRAIN (%) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS: LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 | 2-3-7-5/0" N=10 | | | | 19 18 | | |
| 5 | | | 1.5 | 4-8-10 N=18 | | | | 21 | | |
| 10 | | | 1.5 | 11-22-29 N=51 | | | | 7 | | |
| 15 | | | 1.5 | 29-27-41 N=68 | | | | 17 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

**WATER LEVEL OBSERVATIONS**

*None Encountered While drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/26/2016 | Boring Completed: 10/26/2016

Drill Rig: D-90 | Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# BORING LOG NO. SP1 (Pond 1)



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION

Latitude: 45.84461° Longitude: -103.4709°

Approximate Surface Elev: 3107 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 0.4 | 3106.5+/- | **FILL - WELL GRADED GRAVEL WITH SAND (GW)**, brown, dense, Crushed Road Surfacing (-1 1/2") Gravels, damp, angular to subangular gravels, trace silt |
| 0.9 | 3106+/- | **FILL - WELL GRADED GRAVEL WITH SAND (GW)**, red, medium dense to dense, Scoria Base Course (-1 1/2") Gravels, damp to slightly moist, subangular to subround gravels, coarse sand |
| | | **FILL - CLAYEY SAND (SC)**, brown, loose to medium dense, moist, trace gravels |
| 15.0 | 3092+/- | |
| | | **SILTY SAND (SM)**, dark gray, medium stiff, moist, trace organics, more clayey with depth, bedded with lenses of organics |
| 23.0 | 3084+/- | |
| | | **COAL**, black, very soft to soft rock, fissile, bedded, poorly to moderately bonded, very |
| 26.0 | 3081+/- | organic, some weathered sandstone lenses |
| | | ***Boring Terminated at 26 Feet*** |

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | STRENGTH TEST: TEST TYPE | STRENGTH TEST: COMPRESSIVE STRENGTH (psf) | STRENGTH TEST: STRAIN (%) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS: LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | X | 1.1 | 3-3-2 N=5 | | | | 16 | | |
| 10 | | X | 1.2 | 4-7-8 N=15 | | | | 19 | | |
| 15 | | X | 1.5 | 4-6-5 N=11 | | | | 16 | | |
| 20 | | X | 1.5 | 2-2-3 N=5 | | | | 23 | | 29-15-14 |
| 25 | | X | 1.5 | 15-30-33 N=63 | | | | 56 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

**WATER LEVEL OBSERVATIONS**

*None Encountered While drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/26/2016 | Boring Completed: 10/26/2016

Drill Rig: D-90 | Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# BORING LOG NO. SP2 (Pond 2)



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION

Latitude: 45.84287° Longitude: -103.47186°

Approximate Surface Elev: 3120 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 0.3 | 3119.5+/- | **FILL - WELL GRADED GRAVEL WITH SAND (GW)**, brown, dense, Crushed Road Surfacing (-1 1/2") Gravels, damp, angular to subangular gravels, trace silt |
| 0.8 | 3119+/- | **FILL - WELL GRADED GRAVEL WITH SAND (GW)**, red, medium dense to dense, Scoria Base Course (-1 1/2") Gravels, damp to slightly moist, subangular to subround gravels, coarse sand |
| | | **FILL - CLAYEY SAND (SC)**, brown, loose to medium dense, moist, coarse sand, scattered subangular to subround gravels; moist to very moist at 9.5' |
| 15.1 | 3105+/- | |
| 15.8 | 3104+/- | **OLD TOPSOIL**, mottled brown/black, roots, organics, some sand |
| | | **FAT CLAY (CH)**, dark gray to black, medium stiff to stiff, moist, faint bedding, trace organics, trace coarse sand, trace oxidation |
| 24.5 | 3095.5+/- | |
| 25.8 | 3094+/- | **SILTY SAND (SM)**, gray and brown, loose, very fine sand, bedded, some organics |
| | | **COAL**, rusty and black, very soft to soft rock, fissile, bedded, poorly to moderately bonded, very |
| 30.4 | 3089.5+/- | organic, some weathered sandstone lenses |
| | | ***Boring Terminated at 30.4 Feet*** |

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | STRENGTH TEST: TEST TYPE | STRENGTH TEST: COMPRESSIVE STRENGTH (psf) | STRENGTH TEST: STRAIN (%) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS: LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | | 1.5 | 3-3-4 N=7 | | | | 12 | | |
| 10 | | | 1 | 2-2-2 N=4 | | | | 18 | | 33-14-19 |
| 15 | | | 1.5 | 4-5-6 N=11 | | | | 19 20 | | |
| 20 | | | 1.5 | 2-2-3 N=5 | | | | 27 | | 45-16-29 |
| 25 | ▽ | | 1.5 | 4-6-9 N=15 | | | | 25 31 | | |
| 30 | | | 1.5 | 41-100/5" | | | | 72 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

**WATER LEVEL OBSERVATIONS**

▽ *26.0' After Drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/26/2016 | Boring Completed: 10/26/2016

Drill Rig: D-90 | Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# BORING LOG NO. SP3 (Pond 3)



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION

Latitude: 45.84059° Longitude: -103.47926°

Approximate Surface Elev: 3136 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 0.4 | 3135.5+/- | **FILL - WELL GRADED GRAVEL WITH SAND (GW)**, brown, dense, Crushed Road Surfacing (-1 1/2") Gravels, damp, angular to subangular gravels, trace silt |
| 0.9 | 3135+/- | **FILL - POORLY GRADED GRAVEL WITH CLAY AND SAND (GW)**, red, medium dense to dense, Scoria Base Course (-1 1/2") Gravels, damp to slightly moist, subangular to subround gravels, coarse sand |
| | | **FILL - CLAYEY SAND (SC)**, brown and red, loose to medium dense, moist, coarse scoria sand inclusions, scattered subangular to subround gravels, trace oxidation, some carbons, trace organics |
| | | more sand at 14.5' grading to silty sand |
| 20.4 | 3115.5+/- | |
| | | **FAT CLAY (CH)**, brown, stiff to very stiff, very moist, faint bedding, trace silt |
| | | less plastic, very silty, bedded, with organic/coal lenses, gray |
| 33.0 | 3103+/- | |
| | | **COAL**, rusty and black, very soft to soft rock, fissile, bedded, poorly to moderately bonded, very organic, some weathered sandstone lenses |
| 36.0 | 3100+/- | ***Boring Terminated at 36 Feet*** |

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | STRENGTH TEST: TEST TYPE | STRENGTH TEST: COMPRESSIVE STRENGTH (psf) | STRENGTH TEST: STRAIN (%) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS: LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1.5 | 9-7-8 N=15 | | | | 17 6 2 | | |
| 5 | | | 1.5 | 3-5-6 N=11 | | | | 14 | | |
| 10 | | | 1.5 | 2-3-3 N=6 | | | | 17 | | 31-15-16 |
| 15 | | | 1.5 | 3-3-4 N=7 | | | | 13 | | 26-22-4 |
| 20 | | | 1.5 | 2-4-4 N=8 | | | | 20 | | 24-20-4 |
| 25 | | | 1.5 | 4-7-8 N=15 | | | | 21 | | |
| 30 | | | 1.5 | 7-11-13 N=24 | | | | 27 | | |
| 35 | | | 0.6 | 78-22/1" | | | | 78 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

**WATER LEVEL OBSERVATIONS**

*None Encountered While drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/26/2016 Boring Completed: 10/26/2016

Drill Rig: D-90 Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# BORING LOG NO. SP4 (Pond 4)



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION

Latitude: 45.838459° Longitude: -103.480275°

Approximate Surface Elev: 3110 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 1.2 | 3109+/- | **FILL - WELL GRADED GRAVEL WITH SAND (GW)**, brown, dense, Crushed Road Surfacing (-1 1/2") Gravels, damp, angular to subangular gravels, trace silt |
| 7.5 | 3102.5+/- | **FILL - CLAYEY SAND (SC)**, light brown, loose, moist, coarse sand, scattered subangular to subround gravels<br>scattered red sand and gravels at 4.0 to 6.5'<br>very moist to saturated sand seams between 5.0 to 7.5' |
| 13.1 | 3097+/- | **FILL - LEAN CLAY (CL)**, light brown, soft, very moist to saturated, trace organics, scattered gravels, some sand |
| 20.0 | 3090+/- | **LEAN CLAY (CL)**, dark brown, very stiff, very moist, trace organics, some ped structure, moderate plasticity<br>very moist to saturated at 16.5'<br>faint horizontal bedding, some oxidation |
| 27.0 | 3083+/- | **FAT CLAY (CH)**, dark gray to black, very stiff, bedded, organic |
| | | ***Boring Terminated at 27 Feet*** |

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | STRENGTH TEST: TEST TYPE | STRENGTH TEST: COMPRESSIVE STRENGTH (psf) | STRENGTH TEST: STRAIN (%) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS: LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1.5 | 2-3-2 N=5 | | | | 18 | | |
| 5 | | | 0.6 | 2-1-2 N=3 | | | | 24 | | |
| | | | 1.5 | 1-1-1 N=2 | | | | 26 | | 35-14-21 |
| 10 | ▽ | | 1.5 | 1-2-2 N=4 | | | | 27 | | 36-13-23 |
| | | | 1.5 | 2-3-3 N=6 | | | | 31<br>25 | | 39-13-26 |
| 15 | ▽ | | 1.5 | 2-3-14 N=17 | | | | 36 | | |
| | ▼ | | | | | | | | | |
| 20 | | | 1.5 | 4-8-12 N=20 | | | | 31 | | |
| | | | 1.5 | 5-9-13 N=22 | | | | | | |
| 25 | | | 2 | PUSH | | | | | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

**WATER LEVEL OBSERVATIONS**

▽ *16.5' While Drilling*

▽ *10.0' While drilling to 20' depth*

▼ *After Drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/24/2016 Boring Completed: 10/24/2016

Drill Rig: D-90 Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# BORING LOG NO. SP5 (Pond 5)



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION

Latitude: 45.83276° Longitude: -103.48068°

Approximate Surface Elev: 3074 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 0.6 | 3073.5+/- | **FILL - WELL GRADED GRAVEL WITH SAND (GW)**, red, dense, Scoria Crushed Road Surfacing (-1 1/2") Gravels, damp, angular to subangular gravels, trace silt |
| | | **FILL - CLAYEY SAND (SC)**, brown, loose to medium dense, slightly moist, coarse sand, scattered subangular to subround gravels becoming moist at 5.0' |
| 11.0 | 3063+/- | grading to sandy lean clay with roots |
| | | **FILL - SANDY SILT (ML)**, light gray, stiff to very stiff, moist, bedded, very fine sand becoming coarser with depth |
| | | grading to silty sand |
| 21.0 | 3053+/- | saturated sand seam at 20.6' |
| | | ***Boring Terminated at 21 Feet*** |

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | STRENGTH TEST: TEST TYPE | STRENGTH TEST: COMPRESSIVE STRENGTH (psf) | STRENGTH TEST: STRAIN (%) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS: LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1.5 | 10-6-5 N=11 | | | | 15 6 | | |
| 5 | | | 1.5 | 3-2-3 N=5 | | | | 12 | | |
| 10 | | | 1.5 | 4-5-8 N=13 | | | | 19 | | |
| 15 | | | 1.5 | 5-8-10 N=18 | | | | 24 | | |
| 20 | | | 1.5 | 8-11-14 N=25 | | | | 26 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method:
3 1/4" Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes:

**WATER LEVEL OBSERVATIONS**

*20.5' While Drilling*

*18.0' After Drilling*

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/26/2016 Boring Completed: 10/26/2016

Drill Rig: D-90 Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# PIEZOMETER LOG NO. Upper Schleichart (USDR)



**PROJECT:** Riley Pass Sediment Pond Cleanout - Site Characterization

**CLIENT:** Allied Engineering Services, Inc. Bozeman, Montana

**SITE:** Custer Gallatin National Forest Near Ludlow, South Dakota

**Mr. Doug Chandler, PhD, PE**

LOCATION: Latitude: 45.82573° Longitude: -103.48326°

Approximate Surface Elev: 3031 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description |
|---|---|---|
| 0.2 | 3031+/- | **TOPSOIL** |
| | | **FILL - SILTY CLAYEY SAND (SC-SM)**, brown, loose, moist, fine to medium grained sand, some organics and roots |
| 10.0 | 3021+/- | |
| | | **SILTY CLAYEY SAND (SC-SM)**, brown, loose to medium dense, moist, trace carbons, trace oxidation less plastic, numerous sandstone fragments |
| 19.5 | 3011.5+/- | |
| | | **SILTY SAND (SM)**, brown, very loose, saturated, fine to medium sand, bedded, trace oxidation |
| 24.0 | 3007+/- | |
| | | **FAT CLAY (CH)**, gray, very stiff, moist, bedded, high plasticity, some sand |
| 29.2 | 3002+/- | |
| 31.0 | 3000+/- | **SHALE**, mottled olive/gray/orange, no cementation to very weak cementation, very soft rock, severely weathered, very poorly bonded, organic, high plasticity soil matrix |
| | | ***Boring Terminated at 31 Feet*** |

INSTALLATION DETAILS: Solid 2" Riser backfilled with native soils; Solid 2" Riser packed in bentonite hole plug; Solid 2" Riser packed in sand; Slotted 2" Screen packed in sand; Sandpoint cap

| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | Torvane (psf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 3-3-3 N=6 | | 8 | | |
| 5 | | | 1.5 | 3-2-1 N=3 | | 13 | | |
| 10 | | | 2 | PUSH | 7800 | 21 | 97 | 31-14-17 |
| | | | 1.5 | 3-4-5 N=9 | | 20 | | |
| 15 | | | 1.5 | 5-7-10 N=17 | | 12 | | |
| 20 | | | 1.5 | 2-1-2 N=3 | | 30 | | |
| 25 | | | 1.5 | 4-9-12 N=21 | | 24 | | |
| 30 | | | 1.5 | 7-10-16 N=26 | | 38 21 | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Logged by M. Hoffmann (Terracon)

Hammer Type: Automatic

Advancement Method: 3 1/4" Hollow Stem Auger

Abandonment Method: Piezometer Installed

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations interpolated from LIDAR Topographic Survey provided by AESI

Notes: Piezometer constructed to depth of 28.5' below existing ground surface with approx. 1.5' stickup, capped with twist cap
8 bags of sand and 3 bags of 3/8" bentonite hole plug chips

**WATER LEVEL OBSERVATIONS**

18.0' While Drilling

17.0' After Drilling

Terracon
1392 13th Ave SW
Great Falls, MT

Boring Started: 10/26/2016 | Boring Completed: 10/26/2016

Drill Rig: D-90 | Driller: M. Roberts/Terracon

Project No.: C4165045

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-WELL C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON_DATATEMPLATE.GDT 1/25/17

# A3 – HAND AUGER EXPLORATION LOGS

Civil Engineering
Land Surveying
Geotechnical Engineering
Structural Engineering

32 DISCOVERY DRIVE
BOZEMAN, MT 59718
PHONE (406) 582-0221
FAX (406) 582-5770

# HAND AUGER LOG

PROJECT: **Riley Pass** JOB #: **16-050.05** DATE: **10/24/2016** BORING: **HA-1** PAGE: **1 of 1**

LOCATION: **Sediment Pond 3** ELEVATION: **NA** TOTAL DEPTH: **10.9'** DEPTH TO GW: **0.4'**

DRILL TYPE: **Hand Auger** CASING/HAMMER/SAMPLER: **3" Hand Auger/DCPT/NA**

DRILLER: **Ron Orton - AESI** FIELD ENGINEER: **Ron Orton, AESI (Bozeman, MT)**

| DEPTH (FT) | GEOLOGIC LOG | DESCRIPTION OF MATERIALS | SAMPLES | N(UNCOR) BLOWS/FT. | MOISTURE CONTENT | OTHER FIELD OR SAMPLE INFORMATION |
|---|---|---|---|---|---|---|
| | | **{0.0' - 0.4'}: SEDIMENT**<br>Loose; Gray; Medium SAND; Moist. | | 10<br>7 | | |
| | | **{0.4' - 7.0'}: SEDIMENT**<br>Very Loose; Gray; Medium SAND; Moist. | | | | |
| 5.0 | | | H1-A @ 6.0' - 6.5' | | | |
| | | | | 7<br>5 | | |
| | | **{7.0' - 10.9'}: SPT TEST** | | 9<br>0 | | |
| 10.0 | | **End of Boring** | | | | |
| 15.0 | | | | | | |

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# HAND AUGER LOG

PROJECT: **Riley Pass** JOB #: **16-050.05** DATE: **10/25/2016** BORING: **HA-2** PAGE: **1 of 1**

LOCATION: **Sediment Pond 2** ELEVATION: **NA** TOTAL DEPTH: **6.0'** DEPTH TO GW: **NA**

DRILL TYPE: **Hand Auger** CASING/HAMMER/SAMPLER: **3" Hand Auger/NA/NA**

DRILLER: **Ron Orton - AESI** FIELD ENGINEER: **Ron Orton, AESI (Bozeman, MT)**

| DEPTH (FT) | GEOLOGIC LOG | DESCRIPTION OF MATERIALS | SAMPLES | N(UNCOR) BLOWS/FT. | MOISTURE CONTENT | OTHER FIELD OR SAMPLE INFORMATION |
|---|---|---|---|---|---|---|
| 5.0 | | **{0.0' - 6.0'}: SEDIMENT**<br>Soft; Gray; SILT/CLAY; Moist. | H2-A @ 3.0' - 3.5'<br>H2-B @ 5.5' - 6.0' | | | **General Notes:**<br>1. Materials became very soft at 3.0' below ground surface.<br>2. Delta Portion of Pond included a visible deposit of clean sand with Lignite Clusters (dark in color). |
| | | **End of Boring** | | | | |
| 10.0 | | | | | | |
| 15.0 | | | | | | |

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# HAND AUGER LOG

PROJECT: **Riley Pass** JOB #: **16-050.05** DATE: **10/25/2016** BORING: **HA-3** PAGE: **1 of 1**

LOCATION: **Sediment Pond 1** ELEVATION: **NA** TOTAL DEPTH: **6.0'** DEPTH TO GW: **0.25'**

DRILL TYPE: **Hand Auger** CASING/HAMMER/SAMPLER: **3" Hand Auger/NA/NA**

DRILLER: **Ron Orton - AESI** FIELD ENGINEER: **Ron Orton, AESI (Bozeman, MT)**

| DEPTH (FT) | GEOLOGIC LOG | DESCRIPTION OF MATERIALS | SAMPLES | N(UNCOR) BLOWS/FT. | MOISTURE CONTENT | OTHER FIELD OR SAMPLE INFORMATION |
|---|---|---|---|---|---|---|
| | | **{0.0' - 3.0'}: SEDIMENT**<br>Medium Dense; Dark Brown; SAND; Wet. | | | | |
| | | **{3.0' - 4.5'}: SEDIMENT**<br>Soft; Gray; SILT/CLAY; Very Wet. | | | | |
| 5.0 | | **{4.5' - 6.0'}: SEDIMENT**<br>Medium Stiff; Olive/Gray; CLAY/SILT; Moist. | | | | |
| | | **End of Boring** | | | | |
| 10.0 | | | | | | |
| 15.0 | | | | | | |

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# HAND AUGER LOG

PROJECT: **Riley Pass** JOB #: **16-050.05** DATE: **10/25/2016** BORING: **HA-4** PAGE: **1 of 1**

LOCATION: **Sediment Pond 5** ELEVATION: **NA** TOTAL DEPTH: **2.0'** DEPTH TO GW: **0.25'**

DRILL TYPE: **Hand Auger** CASING/HAMMER/SAMPLER: **3" Hand Auger/NA/NA**

DRILLER: **Ron Orton - AESI** FIELD ENGINEER: **Ron Orton, AESI (Bozeman, MT)**

| DEPTH (FT) | GEOLOGIC LOG | DESCRIPTION OF MATERIALS | SAMPLES | N(UNCOR) BLOWS/FT. | MOISTURE CONTENT | OTHER FIELD OR SAMPLE INFORMATION |
|---|---|---|---|---|---|---|
| | | **{0.0' - 0.2'}: TOP CRUST**<br>Soft; Gray; Silty CLAY; Moist. | | | | |
| | | **{0.2' - 1.5'}: SEDIMENT**<br>Soft; Gray; Silty CLAY; Wet; Sticky. | | | | |
| | | **{1.5' - 1.8'}: SEDIMENT**<br>Loose; Dark Gray; SAND; Wet. | | | | |
| | | **{1.8' - 2.0'}: SEDIMENT**<br>Medium Stiff; Gray; CLAY; Wet; Sticky. | | | | |
| 5.0 | | **End of Boring**<br>**(Poor Drilling Conditions)** | | | | |
| 10.0 | | | | | | |
| 15.0 | | | | | | |

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# HAND AUGER LOG

PROJECT: **Riley Pass** JOB #: **16-050.05** DATE: **10/25/2016** BORING: **HA-5** PAGE: **1 of 1**

LOCATION: **Upper Schleichart** ELEVATION: **NA** TOTAL DEPTH: **6.0'** DEPTH TO GW: **NA**

DRILL TYPE: **Hand Auger** CASING/HAMMER/SAMPLER: **3" Hand Auger/NA/NA**

DRILLER: **Ron Orton - AESI** FIELD ENGINEER: **Ron Orton, AESI (Bozeman, MT)**

| DEPTH (FT) | GEOLOGIC LOG | DESCRIPTION OF MATERIALS | SAMPLES | N(UNCOR) BLOWS/FT. | MOISTURE CONTENT | OTHER FIELD OR SAMPLE INFORMATION |
|---|---|---|---|---|---|---|
| | | **{0.0' - 0.25'}: TOP CRUST**<br>Medium Dense; Dark Brown; SAND; Wet. | | | | |
| | | **{0.25' - 3.75'}: SEDIMENT**<br>Soft; Gray; Silty CLAY; Moist. | H5-A @ 3.0' - 3.5' | | | |
| 5.0 | | **{3.75' - 6.0'}: SEDIMENT**<br>Soft; Gray; Silty CLAY; Wet. | H5-B @ 5.5' - 6.0' | | | |
| | | **End of Boring** | | | | |
| 10.0 | | | | | | |
| 15.0 | | | | | | |

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# HAND AUGER LOG

PROJECT: **Riley Pass** JOB #: **16-050.05** DATE: **10/25/2016** BORING: **HA-6** PAGE: **1 of 1**

LOCATION: **Lower Schleichart** ELEVATION: **NA** TOTAL DEPTH: **3.75'** DEPTH TO GW: **NA**

DRILL TYPE: **Hand Auger** CASING/HAMMER/SAMPLER: **3" Hand Auger/NA/NA**

DRILLER: **Ron Orton - AESI** FIELD ENGINEER: **Ron Orton, AESI (Bozeman, MT)**

| DEPTH (FT) | GEOLOGIC LOG | DESCRIPTION OF MATERIALS | SAMPLES | N(UNCOR) BLOWS/FT. | MOISTURE CONTENT | OTHER FIELD OR SAMPLE INFORMATION |
|---|---|---|---|---|---|---|
| | | **{0.0' - 1.0'}: SEDIMENT**<br>Soft; Black; SILT; Moist. | | | | **General Notes:**<br>1. **Stiffness changed at 3.5' from Medium Stiff to Stiff.**<br>2. **Stiffness increasing with depth.** |
| | | **{1.0' - 1.5'}: SEDIMENT**<br>Soft; Brown; CLAY; Moist. | | | | |
| | | **{1.5' - 3.75'}: SEDIMENT**<br>Medium Stiff to Stiff; Brown; CLAY; Moist. | | | | |
| | | **End of Boring** | | | | |
| 5.0 | | | | | | |
| 10.0 | | | | | | |
| 15.0 | | | | | | |

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# HAND AUGER LOG

PROJECT: **Riley Pass** JOB #: **16-050.05** DATE: **10/25/2016** BORING: **HA-7** PAGE: **1 of 1**

LOCATION: **Browns Pond** ELEVATION: **NA** TOTAL DEPTH: **4.8'** DEPTH TO GW: **2.3'**

DRILL TYPE: **Hand Auger** CASING/HAMMER/SAMPLER: **3" Hand Auger/NA/NA**

DRILLER: **Ron Orton - AESI** FIELD ENGINEER: **Ron Orton, AESI (Bozeman, MT)**

| DEPTH (FT) | GEOLOGIC LOG | DESCRIPTION OF MATERIALS | SAMPLES | N(UNCOR) BLOWS/FT. | MOISTURE CONTENT | OTHER FIELD OR SAMPLE INFORMATION |
|---|---|---|---|---|---|---|
| | | **{0.0' - 0.7'}: SEDIMENT** Medium Dense; Dark Brown/Black; Silty SAND; Moist. | | | | |
| | | **{0.7' - 2.5'}: SEDIMENT** Dense; Olive Brown; Gravelly SAND; Moist. | | | | |
| | | **{2.5' - 4.6'}: SEDIMENT** Dense; Olive Brown; Medium-Fine SAND; Wet. | | | | |
| 5.0 | | **{4.6' - 4.8'}: SEDIMENT** Dense; Olive Brown; Gravelly SAND; Wet. | | | | |
| | | **End of Boring** | | | | |
| 10.0 | | | | | | |
| 15.0 | | | | | | |

# A4 – DYNAMIC CONE PENETROMETER TESTS

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## DYNAMIC CONE PENETROMETER TEST

The Dynamic Cone Penetrometer (DCP) is a device for measuring the in situ strength of paving materials and subgrade soils. The DCP penetration rate can be used to identify pavement layer boundaries and subgrade strata and to estimate the California Bearing Ratio (CBR) values of those layers.

The DCP consists of a 16-mm diameter steel rod with a steel cone attached to one end which is driven into the pavement or subgrade by means of a sliding hammer. The angle of the cone is 60° and the diameter of the base of the cone is 20mm. The diameter of the cone is 4 mm larger than that of the rod to ensure that the resistance to penetration is only exerted on the cone. The DCP is driven into the soil with an 80kg drop hammer, which slides on a 16-mm diameter steel rod, and strikes an anvil. The hammer has a fall height of 575 mm. The steel rod is scored at 20-mm and 100-mm intervals so the depth of penetration can be measured.

Source: DCP Field Manual, USDA - Forest Service, December 1993.

## DYNAMIC CONE PENETROMER TESTS 1-5

Location: See Map

4" Increment CBR

| DEPTH (FT) | DEPTH (IN) | DCP - 1 (BLOWS / 4") | DCP - 2 (BLOWS / 4") | DCP - 3 (BLOWS / 4") | DCP - 4 (BLOWS / 4") | DCP - 5 (BLOWS / 4") |
|---|---|---|---|---|---|---|
| 0 | 0 | 7 | 10 | 16 | 18 | 6 |
| | 4 | 5 | 6 | 14 | 7 | 7 |
| | 8 | 8 | 2 | 14 | 9 | 9 |
| 1 | 12 | | 4 | 16 | 21 | 13 |
| | 16 | | 7 | 28 | 13 | 18 |
| | 20 | | 6 | 21 | 8 | 22 |
| 2 | 24 | | | | | |
| 3 | 36 | | | | | |
| 4 | 48 | | | | | |

SURFACE ELEVATION: **NA**
TOTAL DEPTH: **1' To 2'**
GROUNDWATER: **DRY**

CONE TYPE: **CBR DCP**
DCP TEST CONE OPERATOR: **Peter Werner**
LOGGED BY: **DSC (AESI)**

JOB NUMBER: **16-050.05**
PROJECT: **Riley Pass**
DATE: **October 25, 2016**

# APPENDIX B

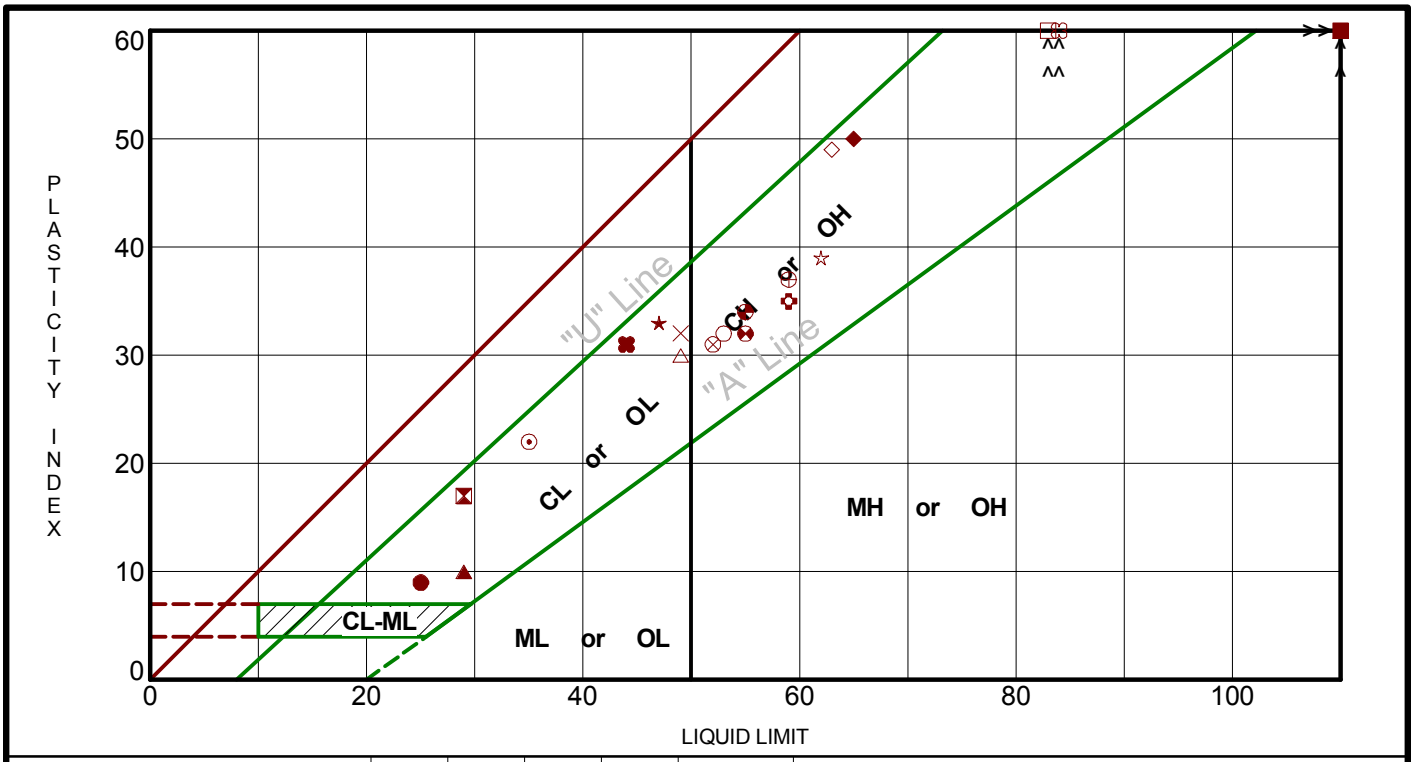
## LABORATORY TESTING RESULTS

- B1 - Geotechnical Testing from Terracon, Inc.
- B2 - Analytical Testing from Energy Laboratories

# B1 – GEOTECHNICAL TESTING FROM TERRACON, INC.

# ATTERBERG LIMITS RESULTS

**ASTM D4318**




| Boring ID | Depth | LL | PL | PI | Fines | USCS | Description |
|---|---|---|---|---|---|---|---|
| BP-01 (Pond 1) | 9.5 - 11 | 25 | 16 | 9 | 47 | SC | CLAYEY SAND |
| BP-01 (Pond 1) | 14.5 - 16 | 29 | 12 | 17 | 56 | CL | SANDY LEAN CLAY |
| BP-01 (Pond 1) | 19.5 - 21 | 29 | 19 | 10 | 44 | SC | CLAYEY SAND |
| BP-01 (Pond 1) | 24.5 - 26 | 47 | 14 | 33 | 56 | CL | SANDY LEAN CLAY |
| BP-02 (Pond 2) | 19.5 - 21.5 | 35 | 13 | 22 | 49 | SC | CLAYEY SAND |
| FSR 3123-01 | 15 - 16.5 | 59 | 24 | 35 | | | FAT CLAY |
| FSR 3123-01 | 20 - 21.5 | 53 | 21 | 32 | | | FAT CLAY |
| FSR 3123-01 | 25 - 27 | 49 | 19 | 30 | 67 | CL | SANDY LEAN CLAY |
| FSR 3123-01 | 27 - 28.5 | 52 | 21 | 31 | | | FAT CLAY |
| FSR 3123-01 | 30 - 31.5 | 59 | 22 | 37 | | | FAT CLAY |
| FSR 3123-01 | 35.3 | 83 | 13 | 70 | | | FAT CLAY |
| FSR 3123-02 | 5 - 6.5 | 55 | 23 | 32 | 73 | CH | FAT CLAY with SAND |
| FSR 3123-02 | 7.5 - 9 | 55 | 21 | 34 | | | FAT CLAY |
| FSR 3123-02 | 10 - 11.5 | 62 | 23 | 39 | | | FAT CLAY |
| FSR 3123-02 | 15 - 16.5 | 84 | 19 | 65 | 75 | CH | FAT CLAY with SAND |
| FSR 3123-02 | 20 - 22 | 117 | 20 | 97 | 43 | SC | CLAYEY SAND |
| FSR 3123-02 | 25 - 26.5 | 65 | 15 | 50 | 44 | SC | CLAYEY SAND |
| FSR 3123-02 | 30 - 31.5 | 63 | 14 | 49 | 50 | SC | CLAYEY SAND |
| FSR 3123-02 | 35 - 36.5 | 49 | 17 | 32 | 53 | CL | SANDY LEAN CLAY |
| FSR 3123-02 | 40 - 41.5 | 44 | 13 | 31 | 68 | CL | SANDY LEAN CLAY |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

SITE: Custer Gallatin National Forest
Near Ludlow, South Dakota

Terracon
1392 13th Ave SW
Great Falls, MT

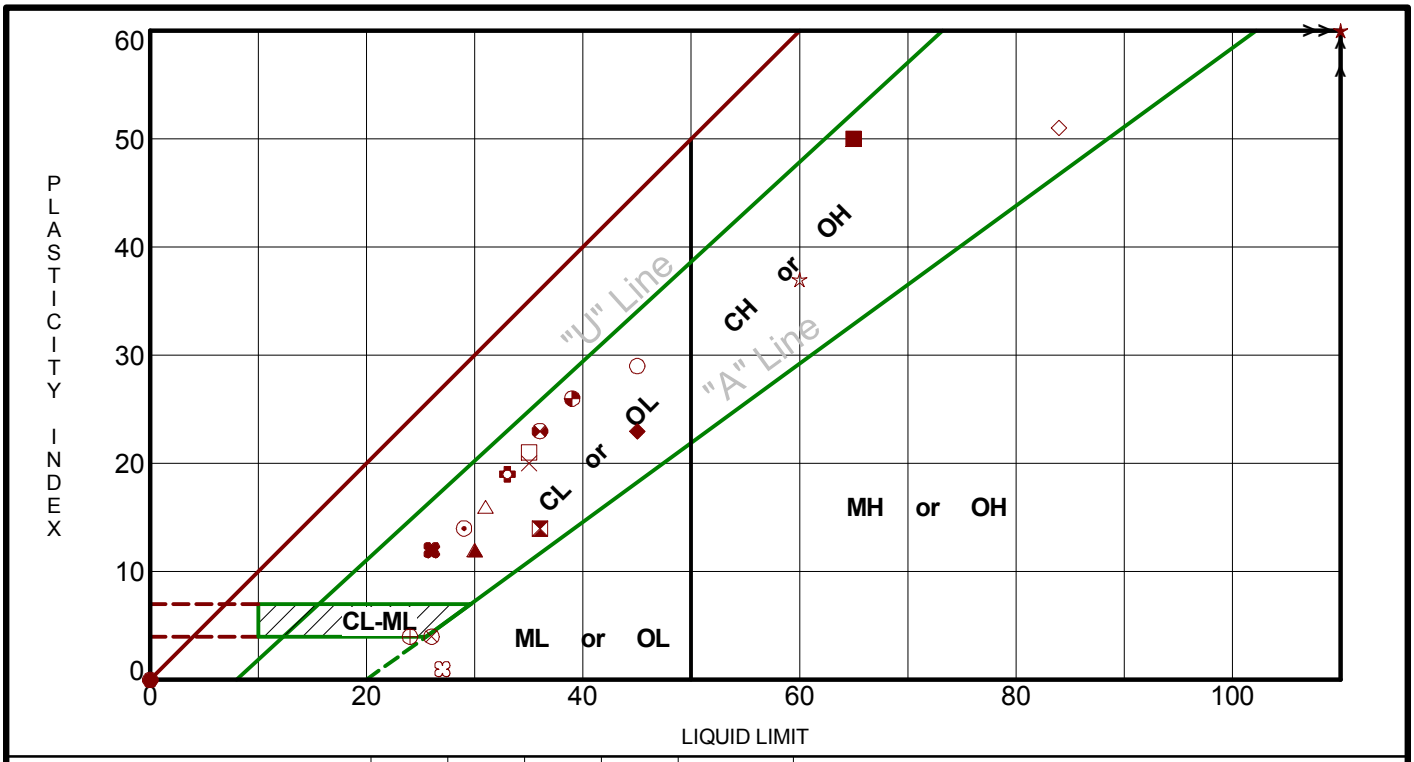
PROJECT NUMBER: C4165045

CLIENT: Allied Engineering Services, Inc.
Bozeman, Montana

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# ATTERBERG LIMITS RESULTS

**ASTM D4318**




| Boring ID | Depth | LL | PL | PI | Fines | USCS | Description |
|---|---|---|---|---|---|---|---|
| FSR 3123-03 | 38.5 - 40 | NP | NP | NP | 74 | ML | SILT with SAND |
| FSR 3123-03 | 48.5 - 50 | 36 | 22 | 14 | 89 | CL | LEAN CLAY |
| LSDR | 4.5 - 6.5 | 30 | 18 | 12 | 59 | CL | SANDY LEAN CLAY |
| POND 5 | 0 | 120 | 23 | 97 | 100 | CH | FAT CLAY |
| SP1 (Pond 1) | 19.5 - 21 | 29 | 15 | 14 | 43 | SC | CLAYEY SAND |
| SP2 (Pond 2) | 9.5 - 11 | 33 | 14 | 19 | 52 | CL | SANDY LEAN CLAY |
| SP2 (Pond 2) | 19.5 - 21 | 45 | 16 | 29 | 78 | CL | LEAN CLAY with SAND |
| SP3 (Pond 3) | 9.5 - 11 | 31 | 15 | 16 | 63 | CL | SANDY LEAN CLAY |
| SP3 (Pond 3) | 14.5 - 16 | 26 | 22 | 4 | 33 | SM | SILTY SAND |
| SP3 (Pond 3) | 19.5 - 21 | 24 | 20 | 4 | 49 | SC-SM | SILTY, CLAYEY SAND |
| SP4 (Pond 4) | 7.5 - 9 | 35 | 14 | 21 | 62 | CL | SANDY LEAN CLAY |
| SP4 (Pond 4) | 10 - 11.5 | 36 | 13 | 23 | 62 | CL | SANDY LEAN CLAY |
| SP4 (Pond 4) | 13.1 | 39 | 13 | 26 | 77 | CL | LEAN CLAY with SAND |
| TP- 1 | 1 - 2 | 60 | 23 | 37 | | | FAT CLAY |
| TP- 1 | 4 - 8 | 27 | 26 | 1 | 78 | ML | SILT with SAND |
| TP- 2 | 23 | 65 | 15 | 50 | 32 | SC | CLAYEY SAND |
| TP- 3 | 2 | 45 | 22 | 23 | 85 | CL | LEAN CLAY with SAND |
| TP- 4 | 3 | 84 | 33 | 51 | 80 | CH | FAT CLAY with SAND |
| TP- 5 | 3 | 35 | 15 | 20 | 63 | CL | SANDY LEAN CLAY |
| TP- 6 | 6 | 26 | 14 | 12 | 42 | SC | CLAYEY SAND |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

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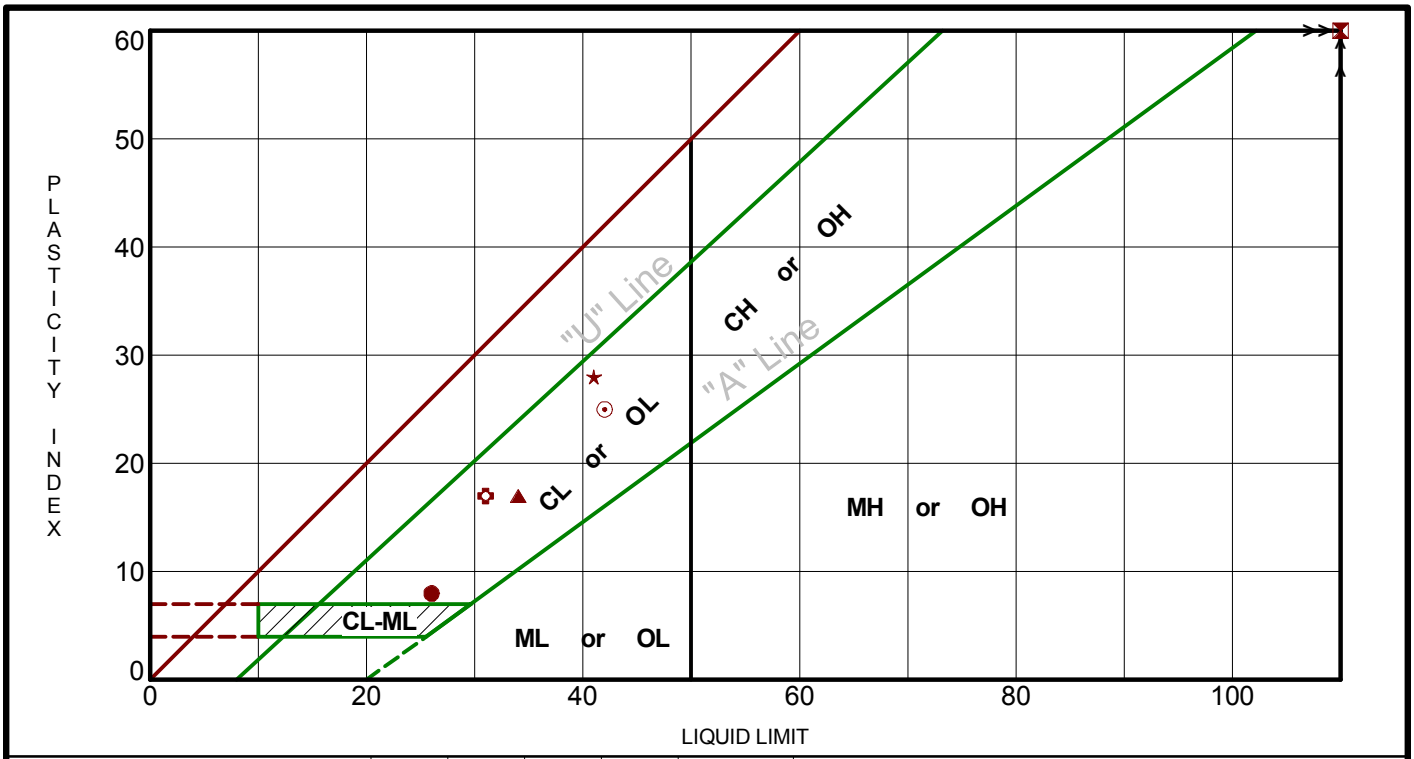
# ATTERBERG LIMITS RESULTS

**ASTM D4318**




| Boring ID | Depth | LL | PL | PI | Fines | USCS | Description |
|---|---|---|---|---|---|---|---|
| TP- 7 | 5 | 26 | 18 | 8 | 52 | CL | SANDY LEAN CLAY |
| TP-10 | 2 | 113 | 23 | 90 | 100 | CH | FAT CLAY |
| TP-11 | 3 | 34 | 17 | 17 | 79 | CL | LEAN CLAY with SAND |
| TP-17 | 6.5 | 41 | 13 | 28 | 70 | CL | SANDY LEAN CLAY |
| TP-20 | 4 | 42 | 17 | 25 | 70 | CL | SANDY LEAN CLAY |
| USDR | 9.5 - 11.5 | 31 | 14 | 17 | 48 | SC | CLAYEY SAND |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

SITE: Custer Gallatin National Forest
Near Ludlow, South Dakota

Terracon
1392 13th Ave SW
Great Falls, MT

PROJECT NUMBER: C4165045

CLIENT: Allied Engineering Services, Inc.
Bozeman, Montana

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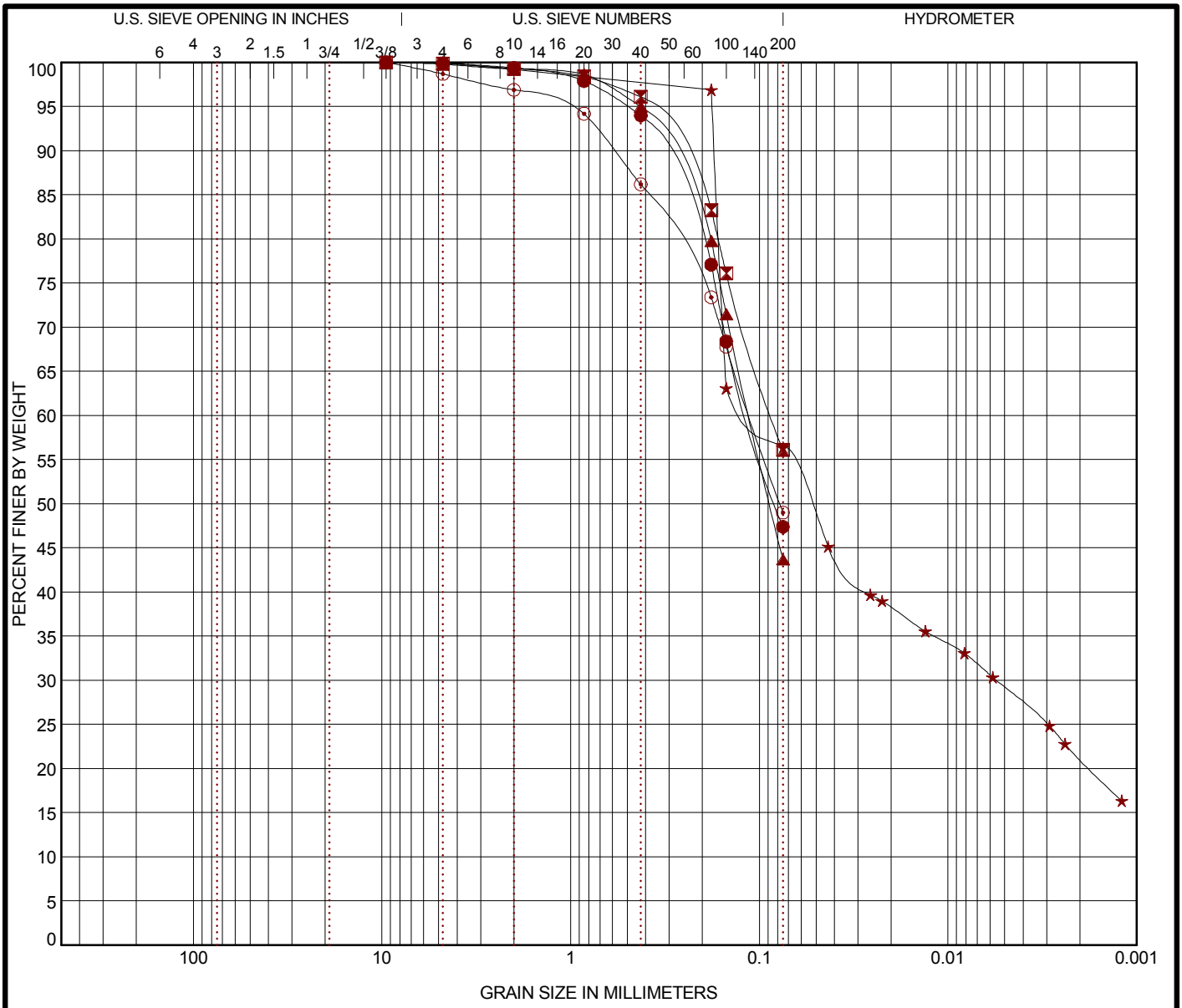
# GRAIN SIZE DISTRIBUTION

**ASTM D422 / ASTM C136**




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| BP-01 (Pond 1) | 9.5 - 11 | CLAYEY SAND (SC) | 15 | 25 | 16 | 9 | | |
| BP-01 (Pond 1) | 14.5 - 16 | SANDY LEAN CLAY (CL) | 25 | 29 | 12 | 17 | | |
| BP-01 (Pond 1) | 19.5 - 21 | CLAYEY SAND (SC) | 27 | 29 | 19 | 10 | | |
| BP-01 (Pond 1) | 24.5 - 26 | SANDY LEAN CLAY (CL) | 31 | 47 | 14 | 33 | | |
| BP-02 (Pond 2) | 19.5 - 21.5 | CLAYEY SAND (SC) | 21 | 35 | 13 | 22 | | |

| Boring ID | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| BP-01 (Pond 1) | 9.5 - 11 | 9.5 | 0.114 | | | 0.1 | 52.5 | | 47.4 | |
| BP-01 (Pond 1) | 14.5 - 16 | 9.5 | 0.086 | | | 0.1 | 43.8 | | 56.1 | |
| BP-01 (Pond 1) | 19.5 - 21 | 9.5 | 0.113 | | | 0.2 | 56.1 | | 43.7 | |
| BP-01 (Pond 1) | 24.5 - 26 | 4.75 | 0.109 | 0.006 | | 0.0 | 43.6 | 27.2 | | 29.2 |
| BP-02 (Pond 2) | 19.5 - 21.5 | 9.5 | 0.113 | | | 1.3 | 49.7 | | 49.0 | |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

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Near Ludlow, South Dakota

Terracon
1392 13th Ave SW
Great Falls, MT

PROJECT NUMBER: C4165045

CLIENT: Allied Engineering Services, Inc.
Bozeman, Montana

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# GRAIN SIZE DISTRIBUTION

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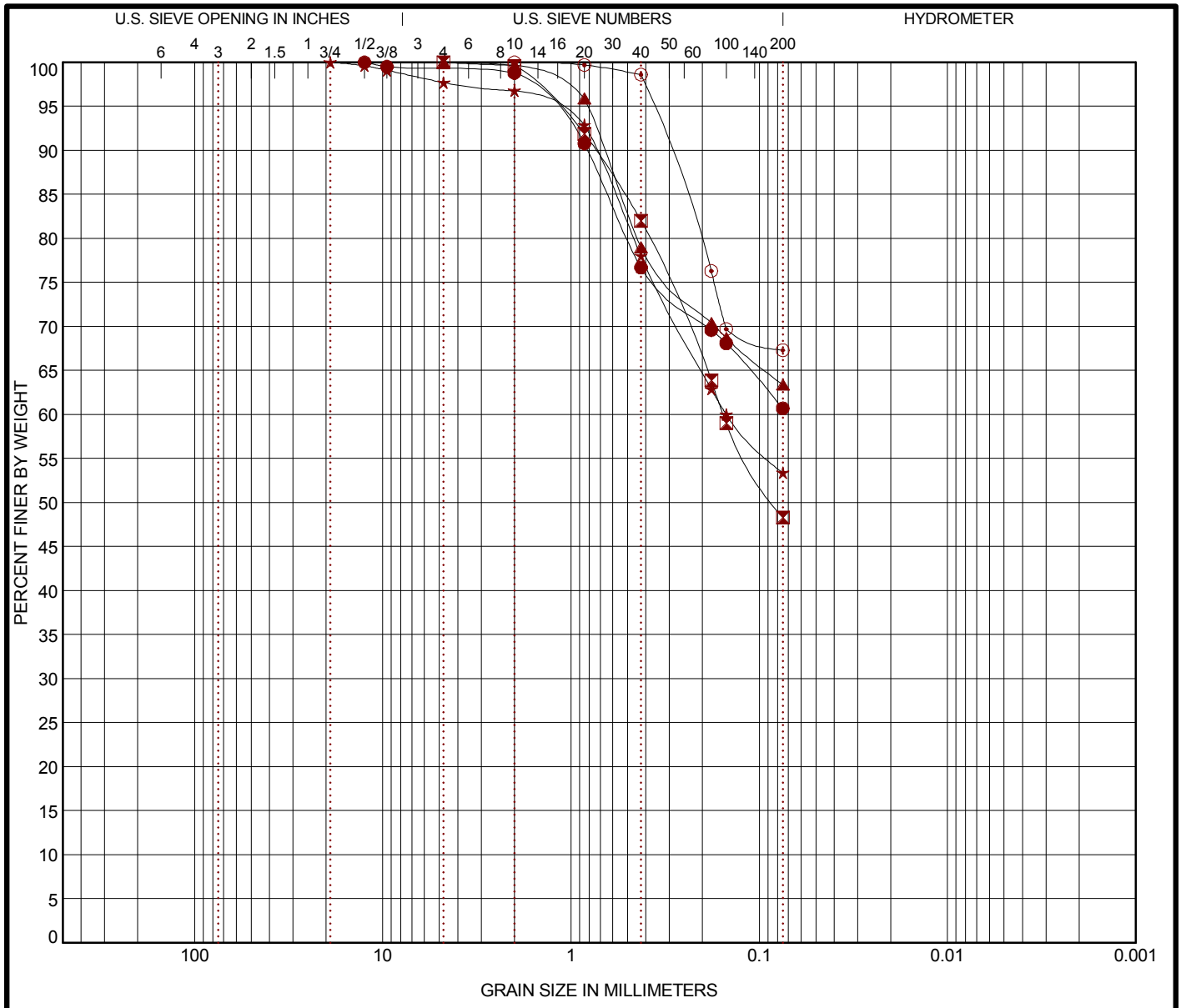


| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|
| ● | DCP 2 | 1 | SANDY LEAN CLAY (SC) | 9 | | | | | |
| ⊠ | DCP 3 | 1 | CLAYEY SAND (SC) | 3 | | | | | |
| ▲ | DCP 4 | 1 | SANDY LEAN CLAY (SC) | 13 | | | | | |
| ★ | DCP 5 | 1 | SANDY LEAN CLAY (SC) | 6 | | | | | |
| ⊙ | FSR 3123-01 | 25 - 27 | SANDY LEAN CLAY (CL) | 36 | 49 | 19 | 30 | | |

| Boring ID | | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | DCP 2 | 1 | 12.5 | | | | 0.8 | 38.5 | 60.7 | | |
| ⊠ | DCP 3 | 1 | 4.75 | 0.156 | | | 0.0 | 51.7 | 48.3 | | |
| ▲ | DCP 4 | 1 | 4.75 | | | | 0.0 | 36.6 | 63.4 | | |
| ★ | DCP 5 | 1 | 19 | 0.15 | | | 2.3 | 44.3 | 53.4 | | |
| ⊙ | FSR 3123-01 | 25 - 27 | 2 | | | | 0.0 | 32.7 | 67.3 | | |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

SITE: Custer Gallatin National Forest
Near Ludlow, South Dakota

Terracon
1392 13th Ave SW
Great Falls, MT

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CLIENT: Allied Engineering Services, Inc.
Bozeman, Montana

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# GRAIN SIZE DISTRIBUTION

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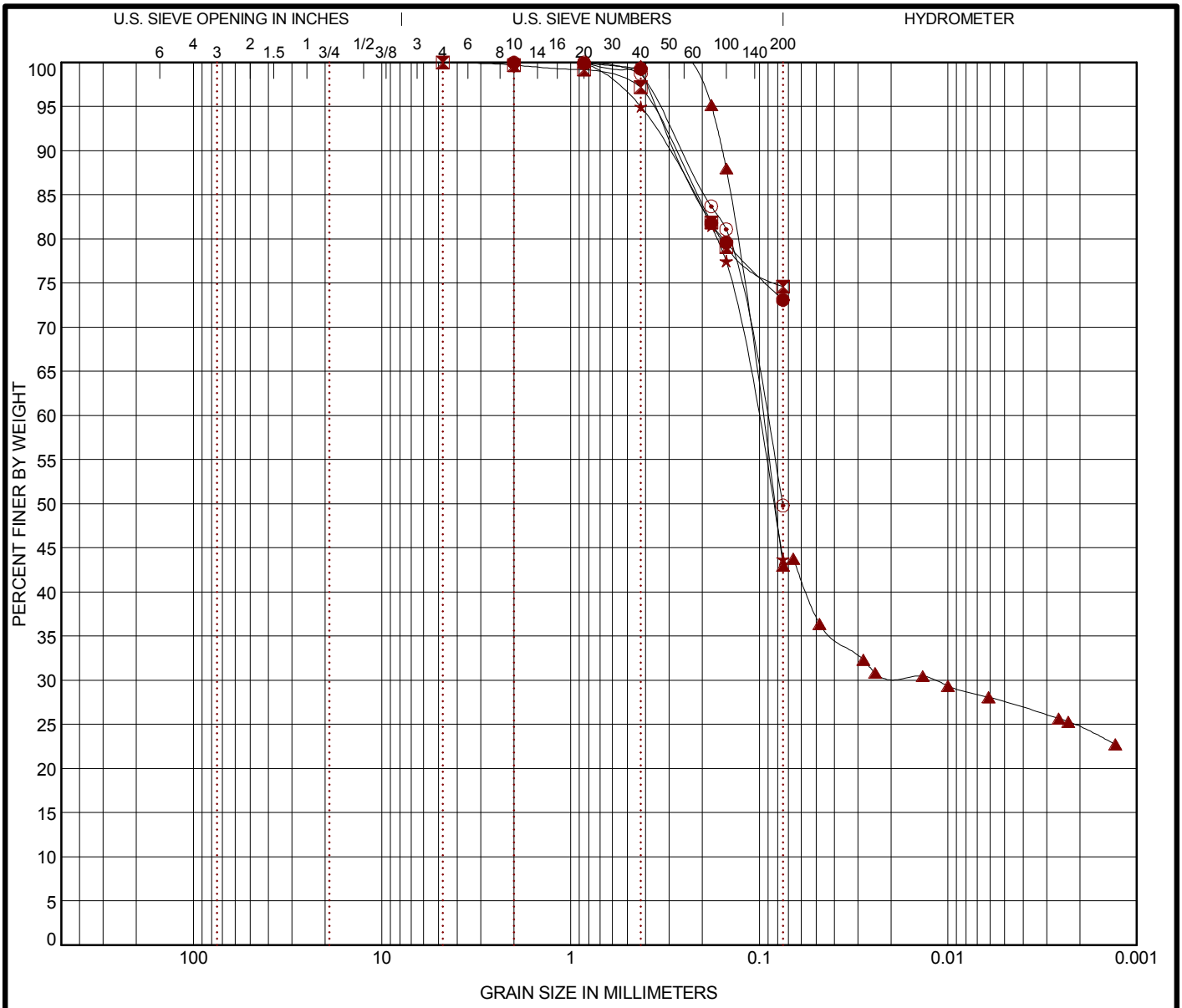


| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|
| ● | FSR 3123-02 | 5 - 6.5 | FAT CLAY with SAND (CH) | 29 | 55 | 23 | 32 | | |
| ⊠ | FSR 3123-02 | 15 - 16.5 | FAT CLAY with SAND (CH) | 33 | 84 | 19 | 65 | | |
| ▲ | FSR 3123-02 | 20 - 22 | CLAYEY SAND (SC) | 26 | 117 | 20 | 97 | | |
| ★ | FSR 3123-02 | 25 - 26.5 | CLAYEY SAND (SC) | 25 | 65 | 15 | 50 | | |
| ⊙ | FSR 3123-02 | 30 - 31.5 | CLAYEY SAND (SC) | 20 | 63 | 14 | 49 | | |

| Boring ID | | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | FSR 3123-02 | 5 - 6.5 | 2 | | | | 0.0 | 26.9 | | 73.1 | |
| ⊠ | FSR 3123-02 | 15 - 16.5 | 4.75 | | | | 0.0 | 25.4 | | 74.6 | |
| ▲ | FSR 3123-02 | 20 - 22 | 0.85 | 0.089 | 0.012 | | 0.0 | 57.0 | 15.5 | | 27.5 |
| ★ | FSR 3123-02 | 25 - 26.5 | 2 | 0.105 | | | 0.0 | 56.3 | | 43.7 | |
| ⊙ | FSR 3123-02 | 30 - 31.5 | 0.85 | 0.094 | | | 0.0 | 50.2 | | 49.8 | |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

SITE: Custer Gallatin National Forest
Near Ludlow, South Dakota

Terracon
1392 13th Ave SW
Great Falls, MT

PROJECT NUMBER: C4165045

CLIENT: Allied Engineering Services, Inc.
Bozeman, Montana

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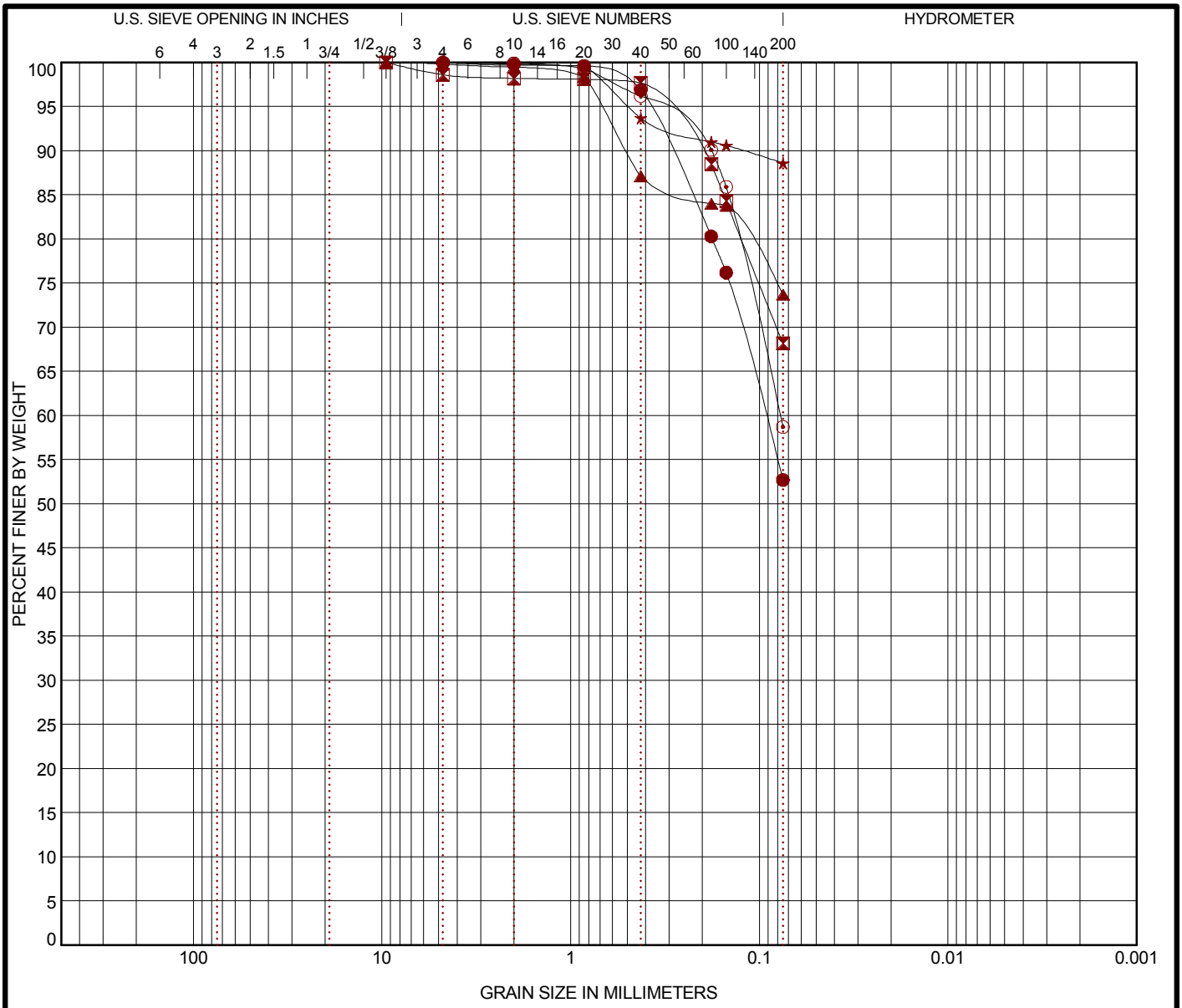
# GRAIN SIZE DISTRIBUTION

**ASTM D422 / ASTM C136**




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|
| ● | FSR 3123-02 | 35 - 36.5 | SANDY LEAN CLAY (CL) | 22 | 49 | 17 | 32 | | |
| ⊠ | FSR 3123-02 | 40 - 41.5 | SANDY LEAN CLAY (CL) | 22 | 44 | 13 | 31 | | |
| ▲ | FSR 3123-03 | 38.5 - 40 | SILT with SAND (ML) | 17 | NP | NP | NP | | |
| ★ | FSR 3123-03 | 48.5 - 50 | LEAN CLAY (CL) | 21 | 36 | 22 | 14 | | |
| ⊙ | LSDR | 4.5 - 6.5 | SANDY LEAN CLAY (CL) | 15 | 30 | 18 | 12 | | |

| Boring ID | | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | FSR 3123-02 | 35 - 36.5 | 4.75 | 0.093 | | | 0.0 | 47.3 | 52.7 | | |
| ⊠ | FSR 3123-02 | 40 - 41.5 | 9.5 | | | | 1.4 | 30.4 | 68.2 | | |
| ▲ | FSR 3123-03 | 38.5 - 40 | 9.5 | | | | 0.2 | 26.1 | 73.7 | | |
| ★ | FSR 3123-03 | 48.5 - 50 | 4.75 | | | | 0.0 | 11.4 | 88.6 | | |
| ⊙ | LSDR | 4.5 - 6.5 | 4.75 | 0.078 | | | 0.0 | 41.3 | 58.7 | | |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

SITE: Custer Gallatin National Forest
Near Ludlow, South Dakota

Terracon
1392 13th Ave SW
Great Falls, MT

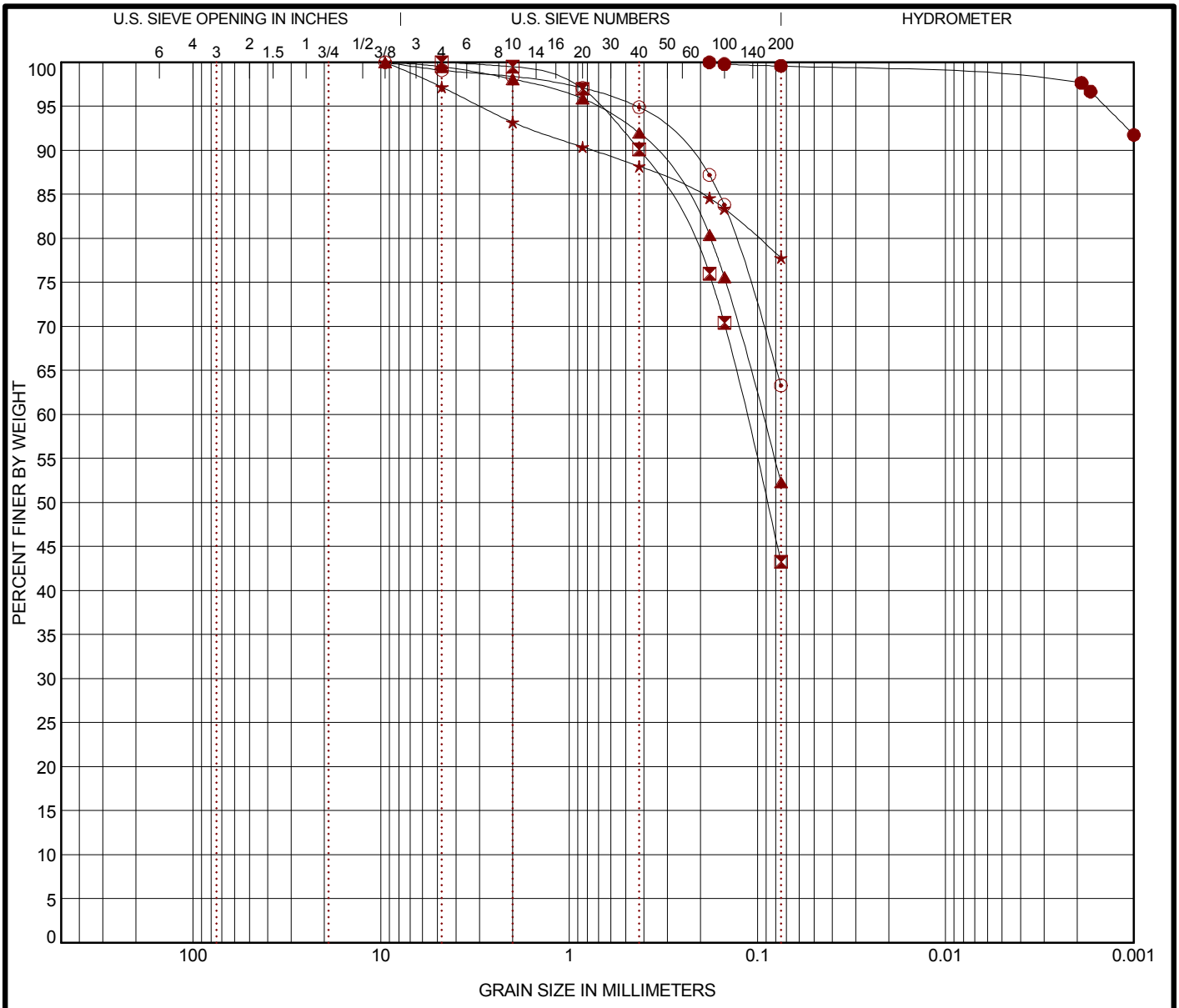
PROJECT NUMBER: C4165045

CLIENT: Allied Engineering Services, Inc.
Bozeman, Montana

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2015.GDT 1/25/17

# GRAIN SIZE DISTRIBUTION

**ASTM D422 / ASTM C136**




| Boring ID | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● POND 5 | 0 | FAT CLAY (CH) | 191 | 120 | 23 | 97 | | |
| ⊠ SP1 (Pond 1) | 19.5 - 21 | CLAYEY SAND (SC) | 23 | 29 | 15 | 14 | | |
| ▲ SP2 (Pond 2) | 9.5 - 11 | SANDY LEAN CLAY (CL) | 18 | 33 | 14 | 19 | | |
| ★ SP2 (Pond 2) | 19.5 - 21 | LEAN CLAY with SAND (CL) | 27 | 45 | 16 | 29 | | |
| ⊙ SP3 (Pond 3) | 9.5 - 11 | SANDY LEAN CLAY (CL) | 17 | 31 | 15 | 16 | | |

| Boring ID | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● POND 5 | 0 | 0.18 | | | | 0.0 | 0.4 | 99.6 | | |
| ⊠ SP1 (Pond 1) | 19.5 - 21 | 4.75 | 0.115 | | | 0.0 | 56.7 | 43.3 | | |
| ▲ SP2 (Pond 2) | 9.5 - 11 | 9.5 | 0.094 | | | 0.5 | 47.2 | 52.3 | | |
| ★ SP2 (Pond 2) | 19.5 - 21 | 9.5 | | | | 2.8 | 19.4 | 77.8 | | |
| ⊙ SP3 (Pond 3) | 9.5 - 11 | 9.5 | | | | 0.9 | 35.8 | 63.3 | | |

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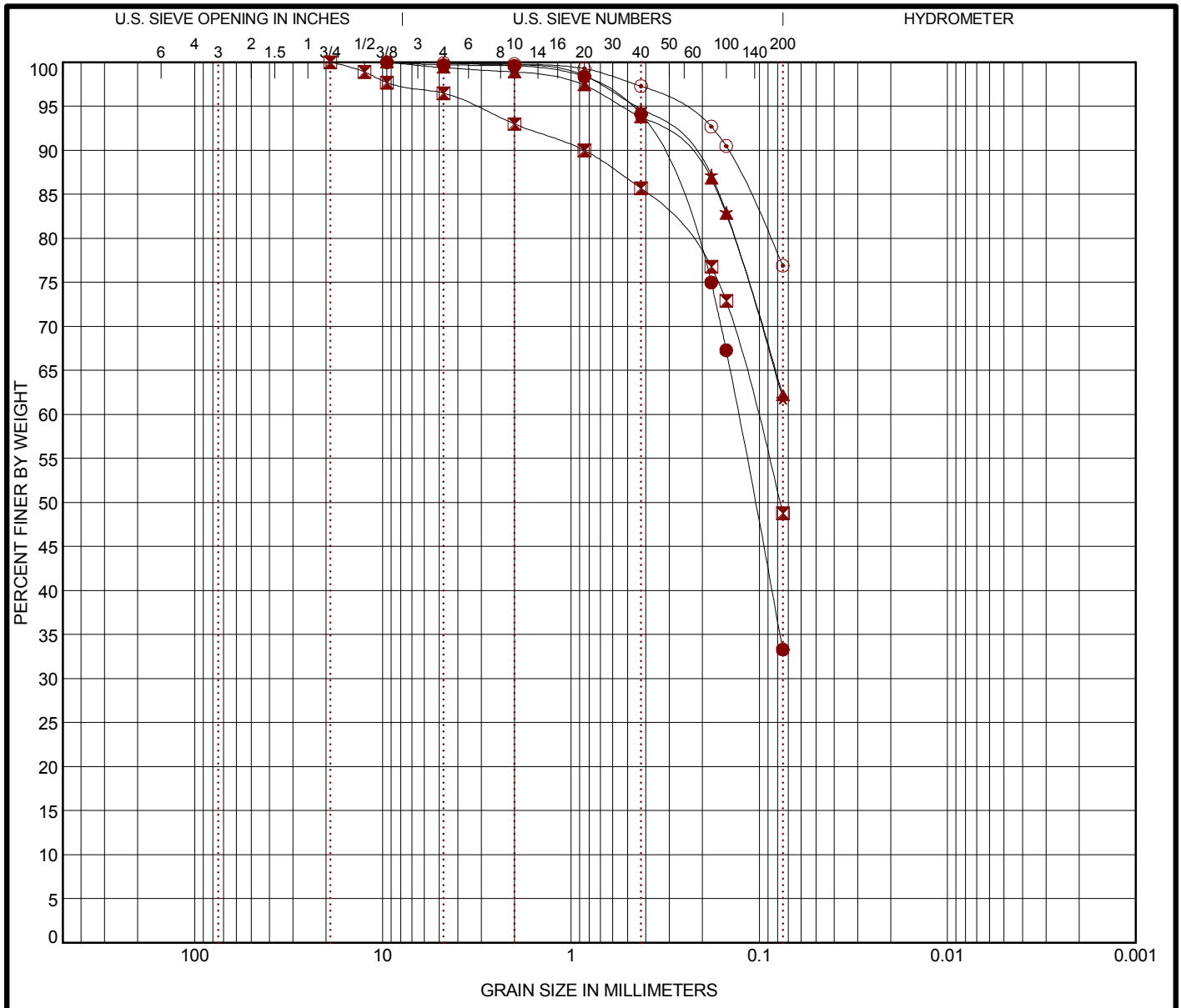


| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|
| ● | SP3 (Pond 3) | 14.5 - 16 | SILTY SAND (SM) | 13 | 26 | 22 | 4 | | |
| ⊠ | SP3 (Pond 3) | 19.5 - 21 | SILTY, CLAYEY SAND (SC-SM) | 20 | 24 | 20 | 4 | | |
| ▲ | SP4 (Pond 4) | 7.5 - 9 | SANDY LEAN CLAY (CL) | 26 | 35 | 14 | 21 | | |
| ★ | SP4 (Pond 4) | 10 - 11.5 | SANDY LEAN CLAY (CL) | 27 | 36 | 13 | 23 | | |
| ⊙ | SP4 (Pond 4) | 13.1 | LEAN CLAY with SAND (CL) | 31 | 39 | 13 | 26 | | |

| Boring ID | | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | SP3 (Pond 3) | 14.5 - 16 | 9.5 | 0.129 | | | 0.3 | 66.4 | | 33.3 | |
| ⊠ | SP3 (Pond 3) | 19.5 - 21 | 19 | 0.104 | | | 3.5 | 47.7 | | 48.8 | |
| ▲ | SP4 (Pond 4) | 7.5 - 9 | 9.5 | | | | 0.6 | 37.2 | | 62.2 | |
| ★ | SP4 (Pond 4) | 10 - 11.5 | 9.5 | | | | 0.1 | 38.1 | | 61.8 | |
| ⊙ | SP4 (Pond 4) | 13.1 | 9.5 | | | | 0.1 | 23.0 | | 76.9 | |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

SITE: Custer Gallatin National Forest
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Terracon
1392 13th Ave SW
Great Falls, MT

PROJECT NUMBER: C4165045

CLIENT: Allied Engineering Services, Inc.
Bozeman, Montana

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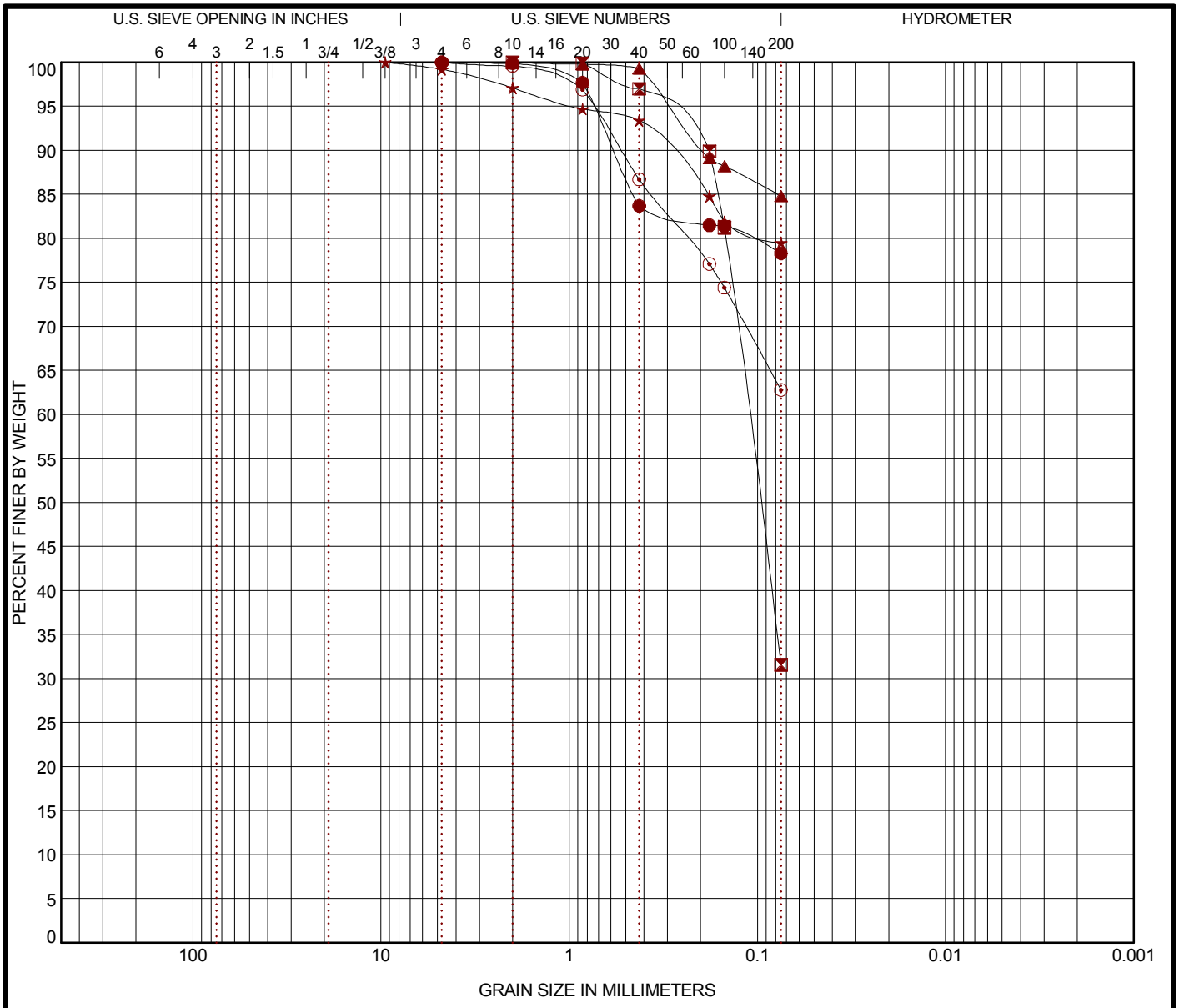
# GRAIN SIZE DISTRIBUTION

**ASTM D422 / ASTM C136**




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|
| ● | TP- 1 | 4 - 8 | SILT with SAND (ML) | | 27 | 26 | 1 | | |
| ⊠ | TP- 2 | 23 | CLAYEY SAND (SC) | 24 | 65 | 15 | 50 | | |
| ▲ | TP- 3 | 2 | LEAN CLAY with SAND (CL) | 18 | 45 | 22 | 23 | | |
| ★ | TP- 4 | 3 | FAT CLAY with SAND (CH) | 33 | 84 | 33 | 51 | | |
| ⊙ | TP- 5 | 3 | SANDY LEAN CLAY (CL) | 32 | 35 | 15 | 20 | | |

| Boring ID | | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | TP- 1 | 4 - 8 | 4.75 | | | | 0.0 | 21.7 | 78.3 | | |
| ⊠ | TP- 2 | 23 | 2 | 0.112 | | | 0.0 | 68.4 | 31.6 | | |
| ▲ | TP- 3 | 2 | 2 | | | | 0.0 | 15.2 | 84.8 | | |
| ★ | TP- 4 | 3 | 9.5 | | | | 0.8 | 19.7 | 79.5 | | |
| ⊙ | TP- 5 | 3 | 4.75 | | | | 0.0 | 37.2 | 62.8 | | |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

SITE: Custer Gallatin National Forest
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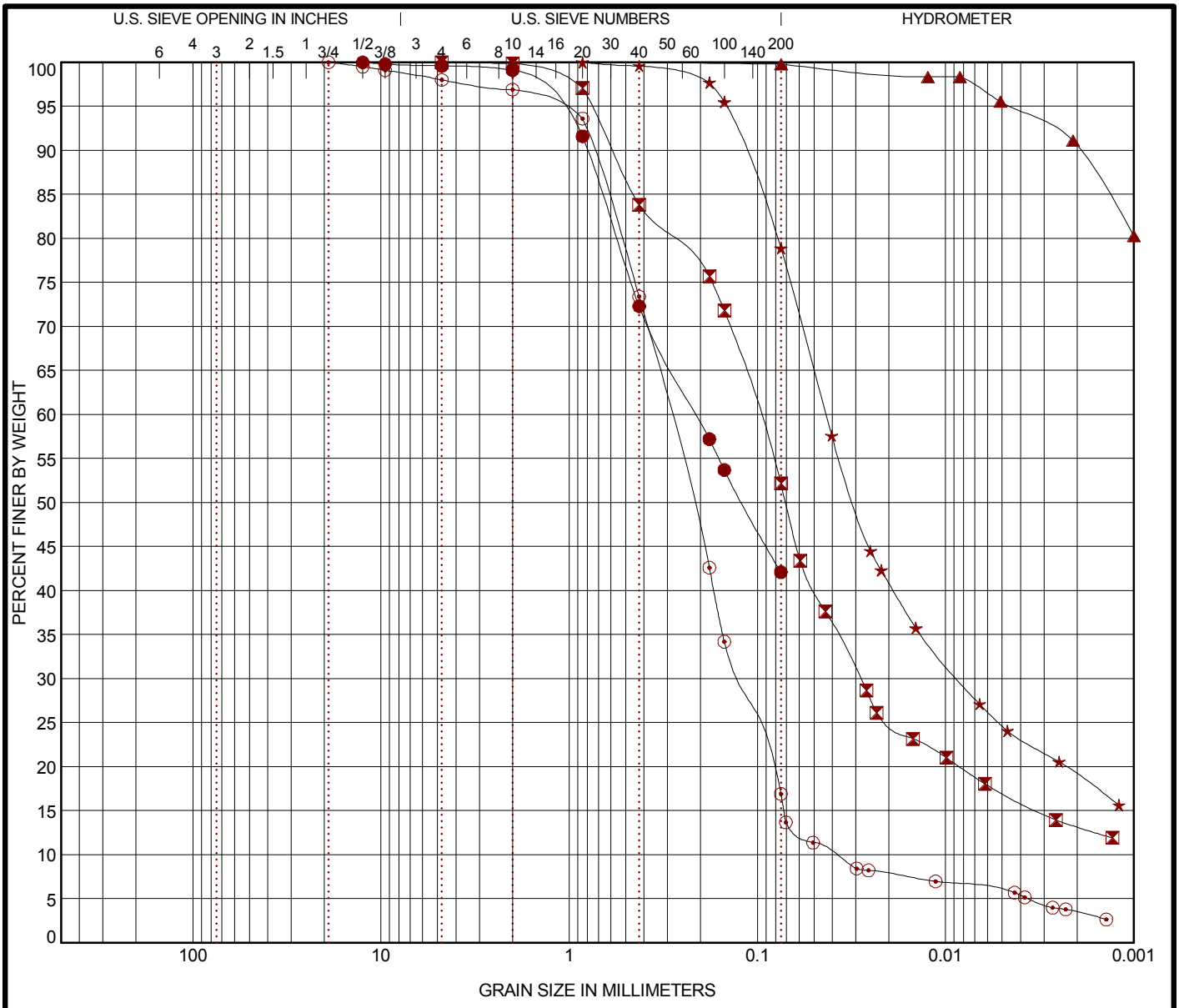


| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|
| ● | TP- 6 | 6 | CLAYEY SAND (SC) | 19 | 26 | 14 | 12 | | |
| ⊠ | TP- 7 | 5 | SANDY LEAN CLAY (CL) | 22 | 26 | 18 | 8 | | |
| ▲ | TP-10 | 2 | FAT CLAY (CH) | 83 | 113 | 23 | 90 | | |
| ★ | TP-11 | 3 | LEAN CLAY with SAND (CL) | 43 | 34 | 17 | 17 | | |
| ⊙ | TP-12 | 4.5 | SILTY SAND (SM) | 22 | | | | 1.39 | 7.41 |

| Boring ID | | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | TP- 6 | 6 | 12.5 | 0.211 | | | 0.4 | 57.5 | | 42.1 | |
| ⊠ | TP- 7 | 5 | 4.75 | 0.099 | 0.028 | | 0.0 | 47.8 | 35.2 | | 17.0 |
| ▲ | TP-10 | 2 | 2 | | | | 0.0 | 0.2 | 4.4 | | 95.4 |
| ★ | TP-11 | 3 | 0.85 | 0.043 | 0.009 | | 0.0 | 21.1 | 54.3 | | 24.6 |
| ⊙ | TP-12 | 4.5 | 19 | 0.292 | 0.127 | 0.039 | 2.0 | 81.1 | 11.0 | | 5.9 |

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Terracon
1392 13th Ave SW
Great Falls, MT

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Bozeman, Montana

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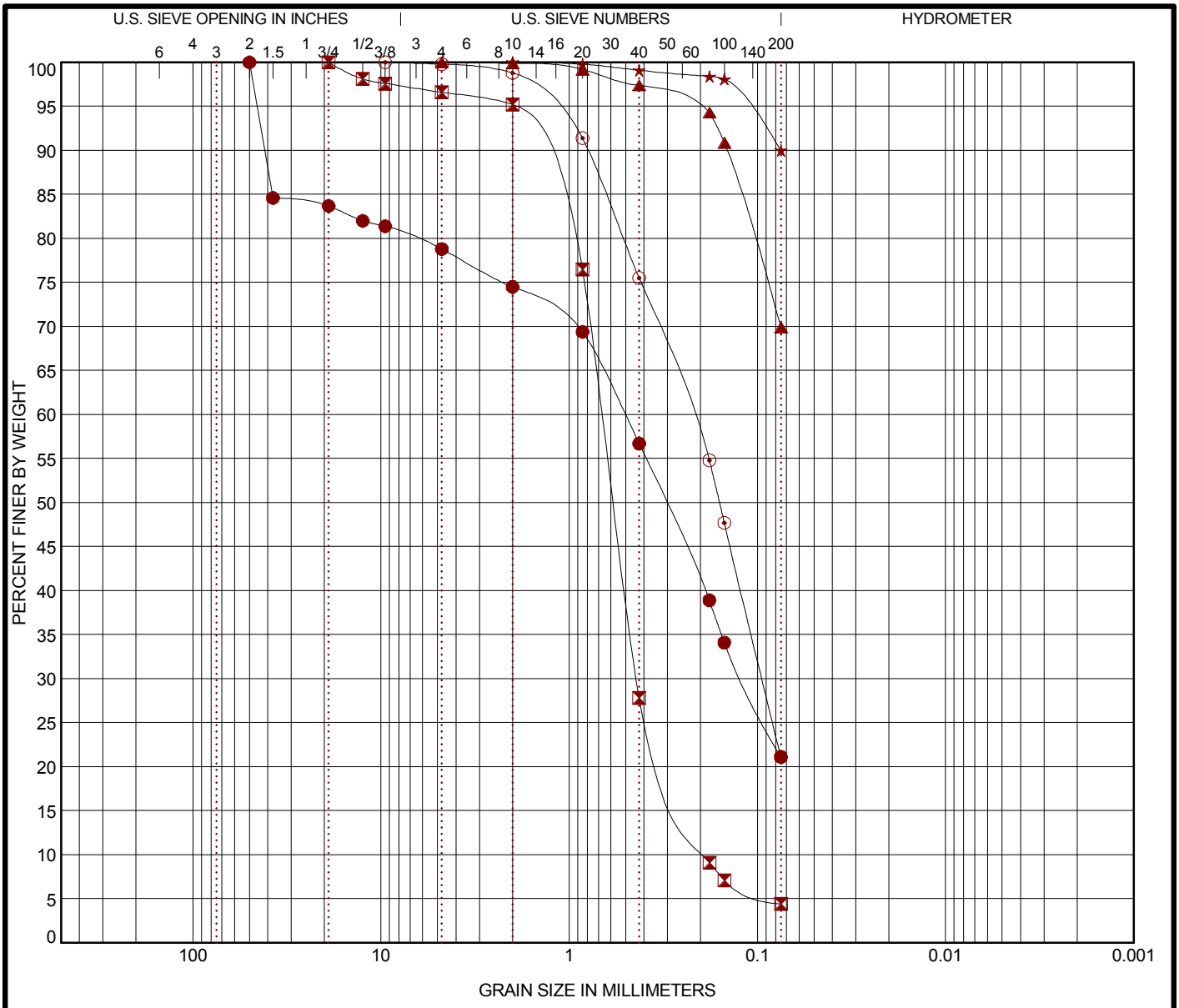
# GRAIN SIZE DISTRIBUTION

**ASTM D422 / ASTM C136**




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|
| ● | TP-12 | 7.5 | | 24 | | | | | |
| ⊠ | TP-17 | 0 | POORLY GRADED SAND (SP) | 21 | | | | 1.53 | 3.58 |
| ▲ | TP-17 | 6.5 | SANDY LEAN CLAY (CL) | 28 | 41 | 13 | 28 | | |
| ★ | TP-18 | 6 | LEAN CLAY (CL) | 45 | | | | | |
| ⊙ | TP-18 | 10 | SILTY SAND (SM) | 22 | | | | | |

| Boring ID | | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | TP-12 | 7.5 | 50 | 0.509 | 0.121 | | 21.2 | 57.7 | 21.1 | | |
| ⊠ | TP-17 | 0 | 19 | 0.672 | 0.439 | 0.188 | 3.4 | 92.2 | 4.4 | | |
| ▲ | TP-17 | 6.5 | 4.75 | | | | 0.0 | 30.1 | 69.9 | | |
| ★ | TP-18 | 6 | 2 | | | | 0.0 | 10.0 | 90.0 | | |
| ⊙ | TP-18 | 10 | 9.5 | 0.223 | 0.095 | | 0.2 | 78.7 | 21.1 | | |

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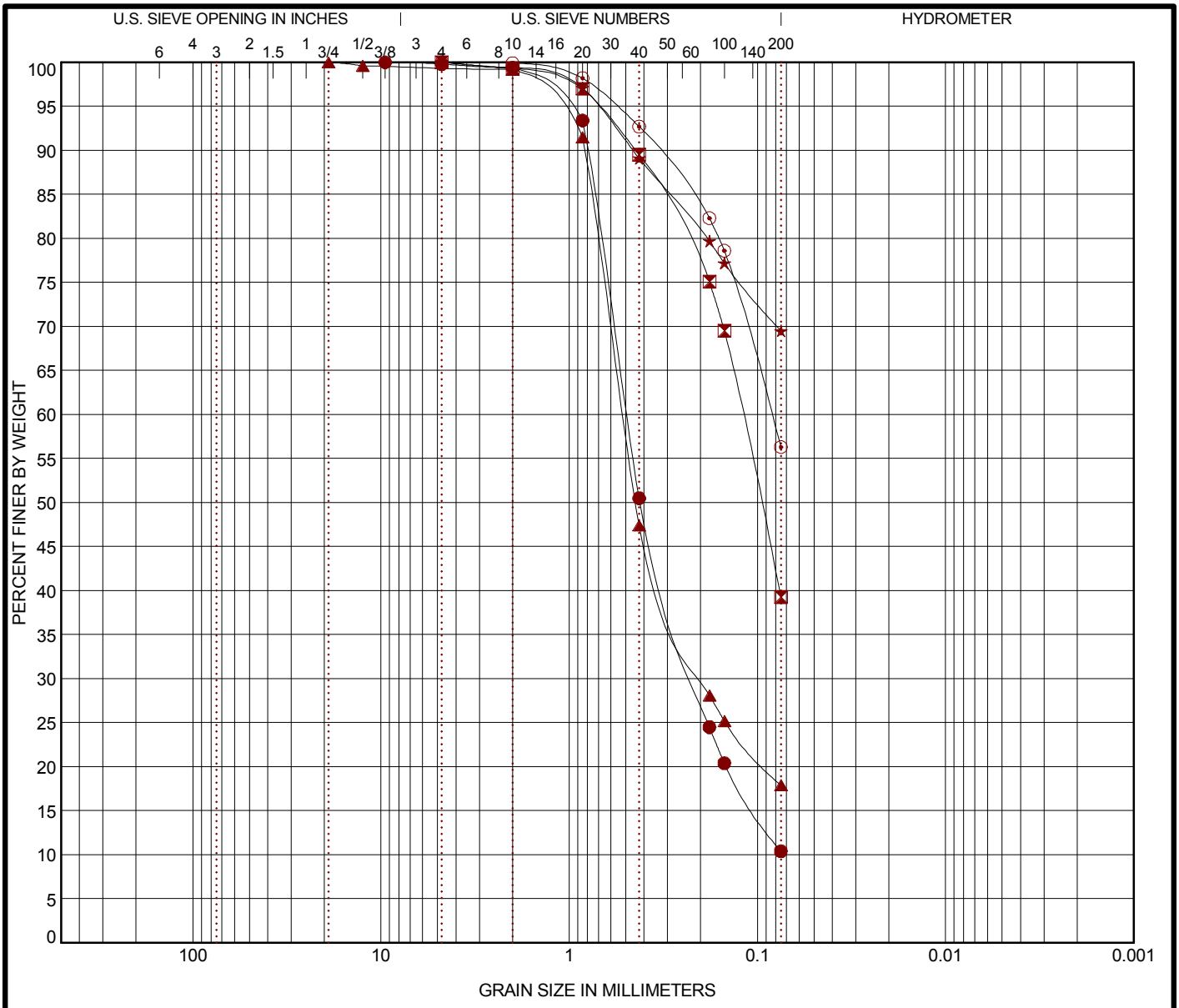
# GRAIN SIZE DISTRIBUTION

**ASTM D422 / ASTM C136**




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|
| ● | TP-19 | 2 | WELL GRADED SAND WITH SILT (SW-SM) | 16 | | | | 1.29 | 6.79 |
| ⊠ | TP-19 | 7 | CLAYEY SAND (SC) | 30 | | | | | |
| ▲ | TP-20 | 2 | SILTY SAND (SM) | 23 | | | | | |
| ★ | TP-20 | 4 | SANDY LEAN CLAY (CL) | 61 | 42 | 17 | 25 | | |
| ⊙ | TP-20 | 6 | SANDY LEAN CLAY (CL) | 23 | | | | | |

| Boring ID | | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | TP-19 | 2 | 9.5 | 0.496 | 0.216 | | 0.2 | 89.4 | 10.4 | | |
| ⊠ | TP-19 | 7 | 4.75 | 0.121 | | | 0.0 | 60.7 | 39.3 | | |
| ▲ | TP-20 | 2 | 19 | 0.518 | 0.196 | | 0.6 | 81.5 | 17.9 | | |
| ★ | TP-20 | 4 | 4.75 | | | | 0.0 | 30.5 | 69.5 | | |
| ⊙ | TP-20 | 6 | 4.75 | 0.084 | | | 0.0 | 43.7 | 56.3 | | |

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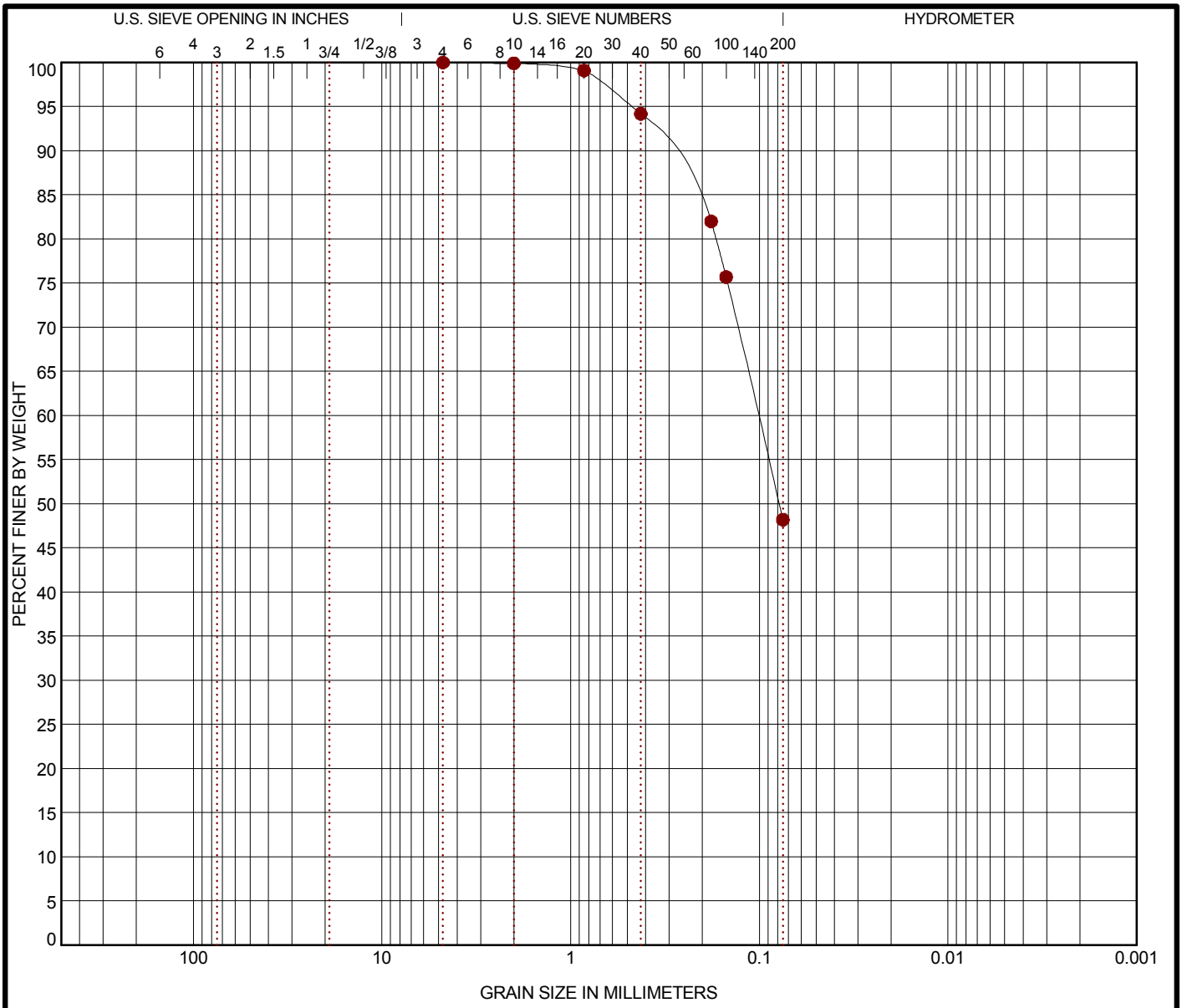
# GRAIN SIZE DISTRIBUTION

**ASTM D422 / ASTM C136**




| Boring ID | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| USDR | 9.5 - 11.5 | CLAYEY SAND (SC) | 21 | 31 | 14 | 17 | | |

| Boring ID | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| USDR | 9.5 - 11.5 | 4.75 | 0.101 | | | 0.0 | 51.8 | 48.2 | | |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

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Near Ludlow, South Dakota

Terracon
1392 13th Ave SW
Great Falls, MT

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Bozeman, Montana

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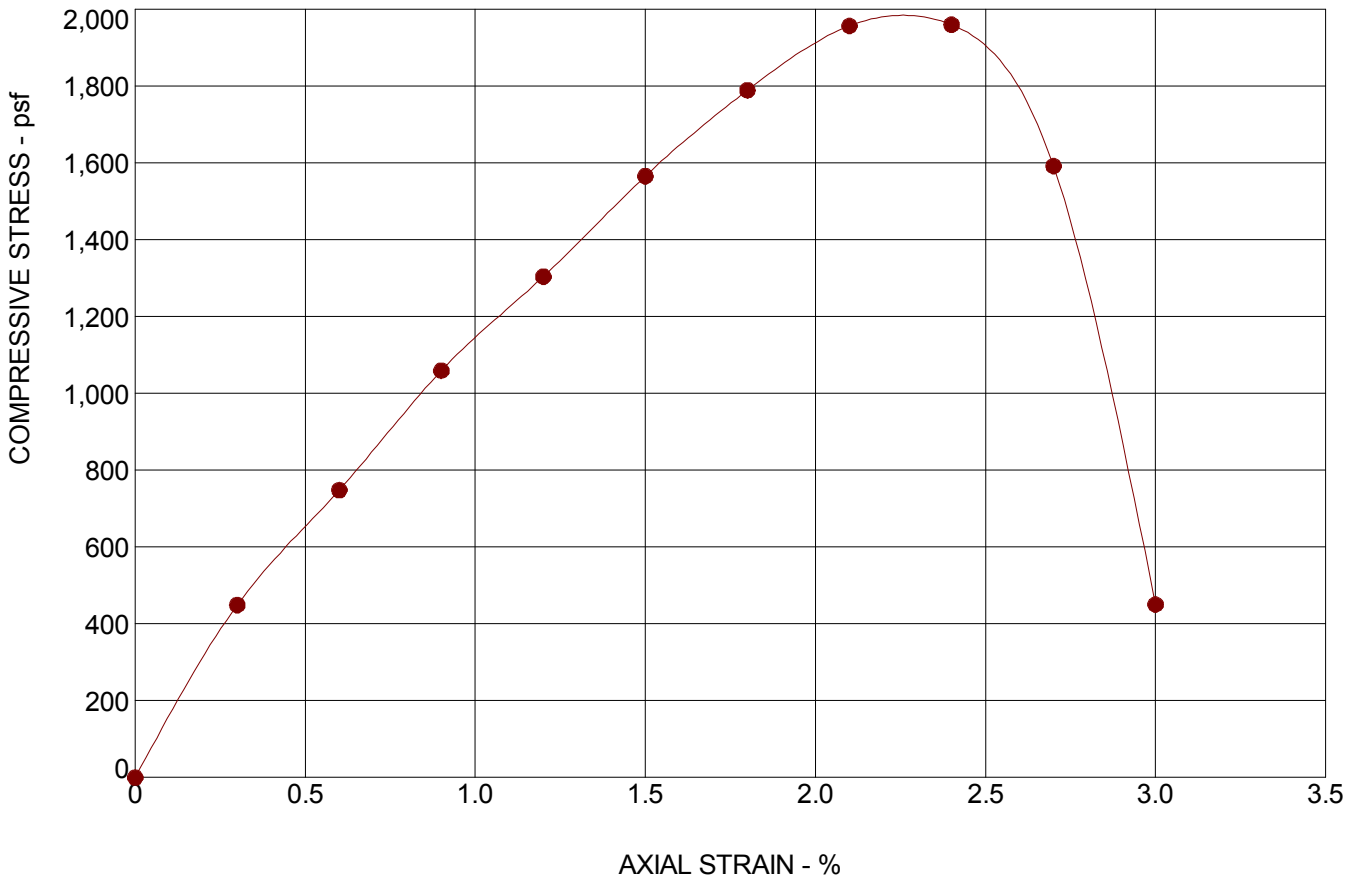
# UNCONFINED COMPRESSION TEST

**ASTM D2166**




## SPECIMEN FAILURE PHOTOGRAPH

## SPECIMEN TEST DATA

| | | |
|---|---|---|
| Moisture Content: | % | 13 |
| Dry Density: | pcf | 102 |
| Diameter: | in. | |
| Height: | in. | |
| Height / Diameter Ratio: | | |
| Calculated Saturation: | % | |
| Calculated Void Ratio: | | |
| Assumed Specific Gravity: | | |
| Failure Strain: | % | 2.40 |
| Unconfined Compressive Strength | (psf) | 1961 |
| Undrained Shear Strength: | (psf) | 980 |
| Strain Rate: | in/min | |
| Remarks: | | |

SAMPLE TYPE: Shelby Tube

SAMPLE LOCATION: USDR @ 9.5 - 11.5 feet

SAMPLE DESCRIPTION: CLAYEY SAND(SC)

| LL | PL | PI | Percent < #200 Sieve |
|---|---|---|---|
| 31 | 14 | 17 | 48 |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

SITE: Custer Gallatin National Forest
Near Ludlow, South Dakota

Terracon
1392 13th Ave SW
Great Falls, MT

PROJECT NUMBER: C4165045

CLIENT: Allied Engineering Services, Inc.
Bozeman, Montana

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. UNCONFINED WITH PHOTOS C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2012.GDT 1/26/17

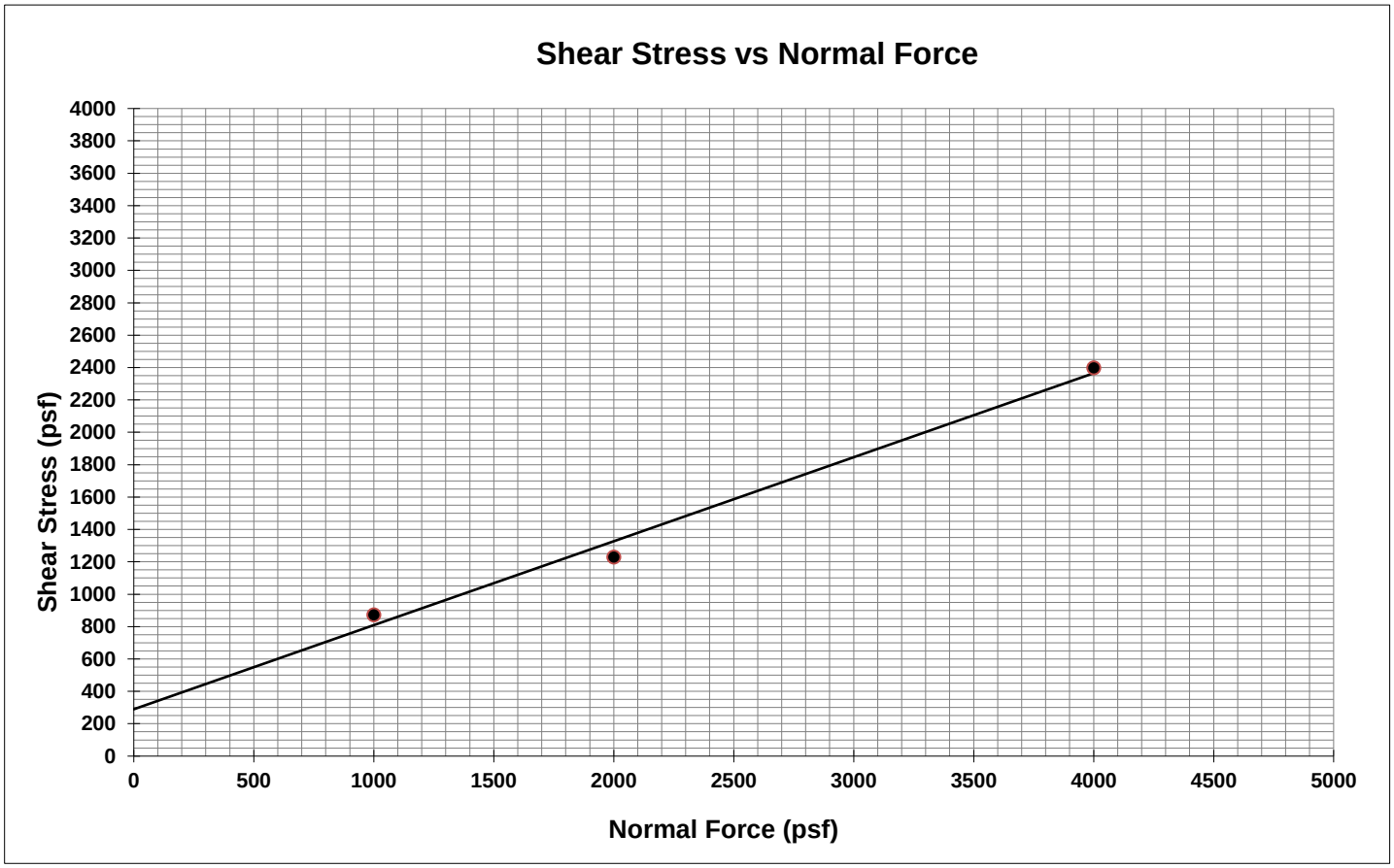
**Direct Shear Test**
Consolidated Drained
ASTM D3080

**Drill Hole:** FSR-3123-02 Sample Depth: 20.0-22.0' Tested By: BE
**Classification:** Clayey Sand (SC) - Weathered Sandstone Reviewed By: BE

***Test Data***

| Load | Wet Unit Wt. (pcf) | Dry Unit Wt. (pcf) | Test MC% | After Test MC% | Shear Strength (psf) |
|---|---|---|---|---|---|
| 1000 | 125.25 | 101.08 | 23.9 | 29.0 | 873.15 |
| 2000 | 119.69 | 98.01 | 22.1 | 28.4 | 1229.90 |
| 4000 | 121.34 | 99.23 | 22.3 | 27.0 | 2397.45 |

**Shear Rate (inches/min):** 0.00047




***Cohesion:*** 289.37 ***Angle Phi:*** 27.4

| | | |
|---|---|---|
| PROJECT: Riley Pass Sediment Pond Cleanout | Terracon | PROJECT NUMBER: C4165045 |
| SITE: Near Ludlow South Dakpta | 1392 13th Ave. SW Great Falls, MT | CLIENT: Allied Engineering Services Inc. |

# LABORATORY COMPACTION CHARACTERISTICS OF SOIL

| | |
|---|---|
| **CLIENT NAME:** | Allied Engineering |
| **PROJECT NAME & LOCATION** | Riley Pass Sediment Pond Cleanout<br>Custer Gallatin National Forest<br>Near Ludlow,South Dakota |
| **PROJECT NO.:** | C4165045 |
| **SOURCE MATERIAL:** | Composite TP-1 |
| **SAMPLE DESCRIPTION:** | SILT with SAND |
| **MATERIAL DESIGNATION:** | Existing Subgrade |
| **TEST METHOD:** | Method A |
| **TEST PROCEDURE:** | ASTM D698 |
| **SAMPLE PREPARATION:** | Moist |

**DATE:** 26-Jan-17 **CURVE NO.:** N/A
**Sampled:**

## TEST RESULTS

| | |
|---|---|
| % OVERSIZED (ROCK CORRECTION): | NA |
| UN-CORRECTED MAXIMUM DENSITY, PCF | **100.5** |
| UN-CORRECTED OPTIMUM WATER CONTENT | **16.6** |

**RAMMER:** MECHANICAL X MANUAL

## OVERSIZE ROCK CORRECTION

| | |
|---|---|
| ASSUMED SPECIFIC GRAVITY | 2.70 |
| ASSUMED ABSORPTION, % | 1 |
| CORRECTED MAXIMUM DENSITY, PCF | **na** |
| CORRECTED OPTIMUM WATER CONTENT, % | na |

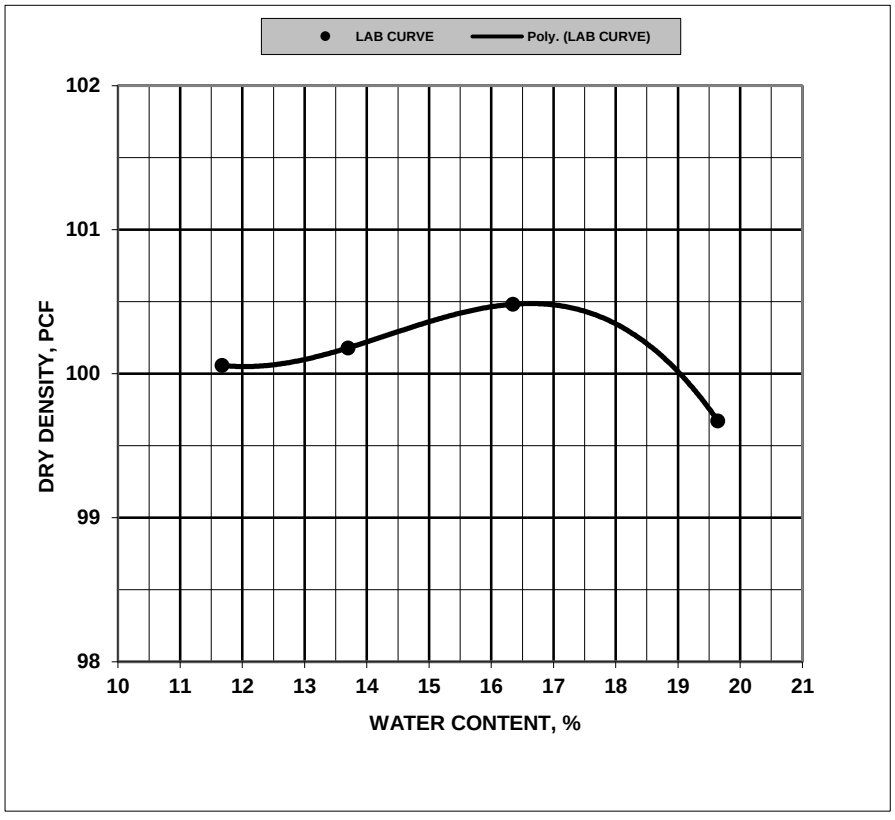
**REVIEWED BY:** Brian Evans

## SIEVE ANALYSIS

| Sieve Size | % Passing |
|---|---|
| 6" | |
| 5" | |
| 4" | |
| 3" | |
| 2" | |
| 1-1/2" | |
| 1" | |
| 3/4" | |
| 1/2" | |
| 3/8" | |
| No. 4 | 100 |
| No. 10 | 100 |
| No. 20 | 98 |
| No. 40 | 84 |
| No. 80 | 82 |
| No. 100 | 81 |
| No. 200 | 78 |

## ATTERBERG LIMITS

| | |
|---|---|
| LL | 27 |
| PI | 1 |



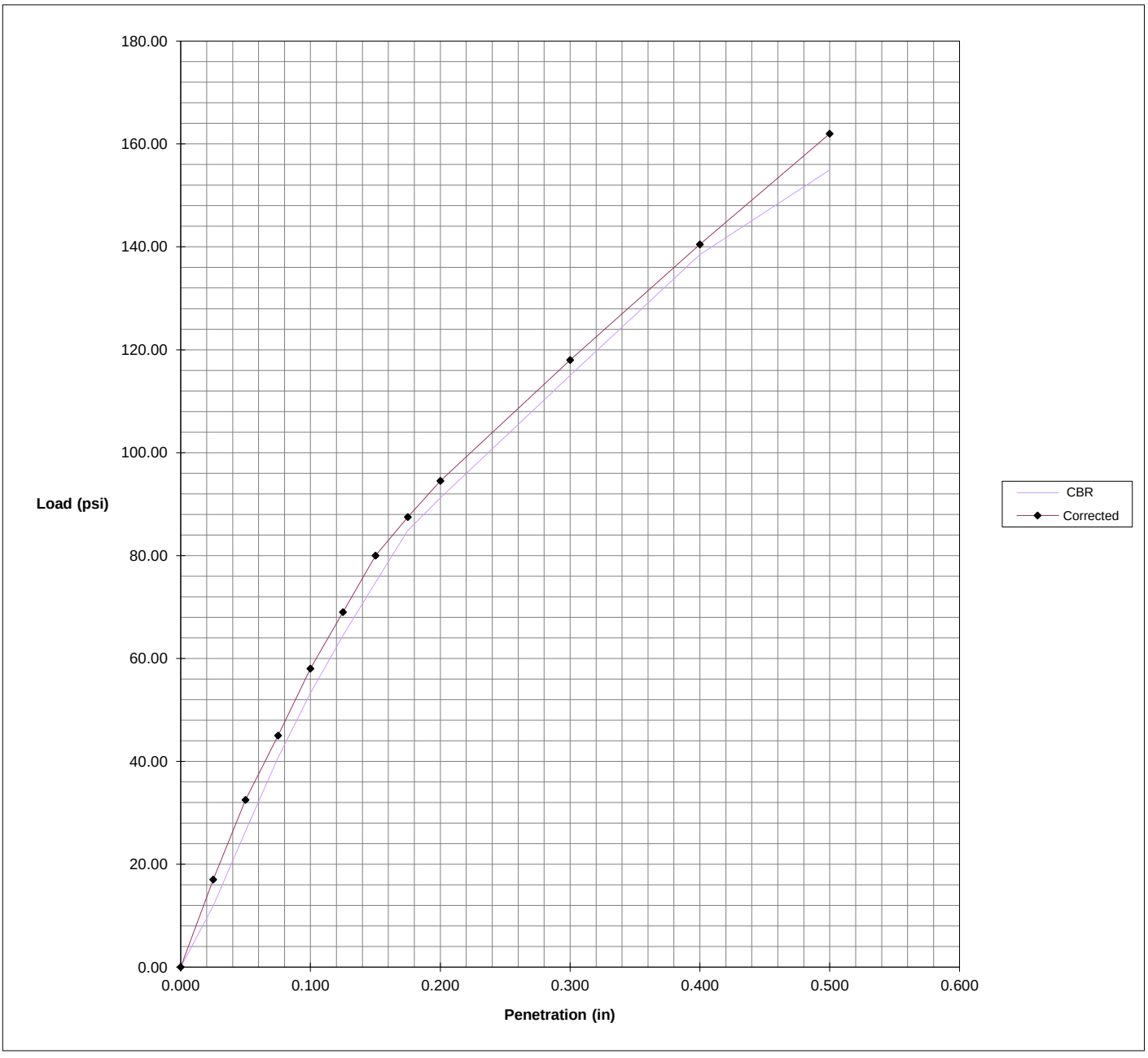

## Moisture - Density Relationship

Terracon
1392 13th Ave. SW
Great Falls, MT 59405
ph (406)-453-5400, fax (406)-761-6655

# CBR Data

| | | | | | |
|---|---|---|---|---|---|
| **Boring #:** | Composite TP-1 | **Soaked:** | X | **Max Dry Density** | 100.5 |
| **Depth:** | 4.0' | **Unsoaked:** | | **Opt. Moisture %** | 16.6 |
| **Surcharge:** | 10 lbs | | **Soil Classification:** | SILT with SAND (ML) | |

| Dry Density | MC% Obtained | % of Max Dry Density | CBR value @ .1" | CBR Value @ .2" |
|---|---|---|---|---|
| 95.9 | 16.3 | 95.4 | 5.80 | 6.30 |




| | | | |
|---|---|---|---|
| **Project** | Riley Pass Sediment Pond Cleanout | **Job No.:** | C4165045 |
| | Near Ludlow, South Dakota | **Date:** | 12/5/2016 |

**California Bearing Ratio**

**NTL Engineering & Geoscience**
Great Falls, MT 59405

# Summary of Laboratory Results



| BORING ID | Depth | USCS Classification and Soil Description | Compressive Strength (psf) | Liquid Limit | Plastic Limit | Plasticity Index | % <#200 Sieve | % Gravel | % Sand | % Silt | % Clay | Water Content (%) | Dry Density (pcf) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BP-01 (Browns) | 0 - 1.5 | | | | | | | | | | | 5.2 | |
| BP-01 (Browns) | 4.5 - 6 | | | | | | | | | | | 8.1 | |
| BP-01 (Browns) | 9.5 - 11 | CLAYEY SAND(SC) | | 25 | 16 | 9 | 47.4 | 0.1 | 52.5 | | | 14.8 | |
| BP-01 (Browns) | 14.5 - 16 | SANDY LEAN CLAY(CL) | | 29 | 12 | 17 | 56.1 | 0.1 | 43.8 | | | 24.6 | |
| BP-01 (Browns) | 19.5 - 21 | CLAYEY SAND(SC) | | 29 | 19 | 10 | 43.7 | 0.2 | 56.1 | | | 26.9 | |
| BP-01 (Browns) | 24.5 - 26 | SANDY LEAN CLAY(CL) | | 47 | 14 | 33 | 56.4 | 0.0 | 43.6 | 27.2 | 29.2 | 31.1 | |
| BP-01 (Browns) | 29.5 - 31 | | | | | | | | | | | 30.5 | |
| BP-01 (Browns) | 34.5 - 36 | | | | | | | | | | | 27.5 | |
| BP-01 (Browns) | 39.5 - 41 | | | | | | | | | | | 37.9 | |
| BP-01 (Browns) | 44.5 - 46 | | | | | | | | | | | 31.6 | |
| BP-02 (Browns) | 4.5 - 6 | | | | | | | | | | | 8.5 | |
| BP-02 (Browns) | 9.5 - 11 | | | | | | | | | | | 5.0 | |
| BP-02 (Browns) | 14.5 - 16 | | | | | | | | | | | 22.4 | |
| BP-02 (Browns) | 19.5 - 21.5 | CLAYEY SAND(SC) | | 35 | 13 | 22 | 49.0 | 1.3 | 49.7 | | | 21.4 | 100.1 |
| BP-02 (Browns) | 21.5 - 23 | | | | | | | | | | | 19.8 | |
| BP-02 (Browns) | 24.5 - 26 | | | | | | | | | | | 31.3 | |
| BP-02 (Browns) | 29.5 - 31 | | | | | | | | | | | 20.1 | |
| BP-02 (Browns) | 34.5 - 36 | | | | | | | | | | | 33.4 | |
| BP-02 (Browns) | 39.5 - 41 | | | | | | | | | | | 33.2 | |
| DCP 2 | 1 | SANDY LEAN CLAY (SC) | | | | | 60.7 | 0.8 | 38.5 | | | 8.5 | |
| DCP 3 | 1 | CLAYEY SAND (SC) | | | | | 48.3 | 0.0 | 51.7 | | | 3.3 | |
| DCP 4 | 1 | SANDY LEAN CLAY (SC) | | | | | 63.4 | 0.0 | 36.6 | | | 12.9 | |
| DCP 5 | 1 | SANDY LEAN CLAY (SC) | | | | | 53.4 | 2.3 | 44.3 | | | 6.3 | |
| FSR 3123-01 | 2.5 - 4 | | | | | | | | | | | 8.3 | |
| FSR 3123-01 | 5 - 6.5 | | | | | | | | | | | 7.2 | |
| FSR 3123-01 | 7.5 - 9 | | | | | | | | | | | 24.7 | |
| FSR 3123-01 | 10 - 11.5 | | | | | | | | | | | 21.5 | |
| FSR 3123-01 | 15 - 16.5 | FAT CLAY | | 59 | 24 | 35 | | | | | | 28.8 | |
| FSR 3123-01 | 20 - 21.5 | FAT CLAY | | 53 | 21 | 32 | | | | | | 26.7 | |
| FSR 3123-01 | 25 - 27 | SANDY LEAN CLAY(CL) | | 49 | 19 | 30 | 67.3 | 0.0 | 32.7 | | | 36.0 | 77.0 |
| FSR 3123-01 | 27 - 28.5 | FAT CLAY | | 52 | 21 | 31 | | | | | | 29.5 | |
| FSR 3123-01 | 30 - 31.5 | FAT CLAY | | 59 | 22 | 37 | | | | | | 31.2 | |
| FSR 3123-01 | 35 - 36.5 | | | | | | | | | | | | |
| FSR 3123-01 | 40 - 41.5 | | | | | | | | | | | 23.1 | |
| FSR 3123-02 | 2.5 - 4 | | | | | | | | | | | 33.5 | |
| FSR 3123-02 | 5 - 6.5 | FAT CLAY with SAND(CH) | | 55 | 23 | 32 | 73.1 | 0.0 | 26.9 | | | 29.3 | |
| FSR 3123-02 | 7.5 - 9 | FAT CLAY | | 55 | 21 | 34 | | | | | | 31.8 | |
| FSR 3123-02 | 10 - 11.5 | FAT CLAY | | 62 | 23 | 39 | | | | | | 36.4 | |
| FSR 3123-02 | 15 - 16.5 | FAT CLAY with SAND(CH) | | 84 | 19 | 65 | 74.6 | 0.0 | 25.4 | | | 32.9 | |
| FSR 3123-02 | 20 - 22 | CLAYEY SAND(SC) | | 117 | 20 | 97 | 43.0 | 0.0 | 57.0 | 15.5 | 27.5 | 25.5 | 98.2 |
| FSR 3123-02 | 22 - 23.5 | | | | | | | | | | | 24.9 | |
| FSR 3123-02 | 25 - 26.5 | CLAYEY SAND(SC) | | 65 | 15 | 50 | 43.7 | 0.0 | 56.3 | | | 24.9 | |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

SITE: Custer Gallatin National Forest Near Ludlow, South Dakota

Terracon
1392 13th Ave SW
Great Falls, MT

PROJECT NUMBER: C4165045

CLIENT: Allied Engineering Services, Inc. Bozeman, Montana

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. OLD-LAB SUMMARY: USCS C4165045.RILEY PASS SEDIMENT POND CLEANOUT-SITE CHARACTERIZATION.GPJ TERRACON2012.GDT 1/25/17

# Summary of Laboratory Results



| BORING ID | Depth | USCS Classification and Soil Description | Compressive Strength (psf) | Liquid Limit | Plastic Limit | Plasticity Index | % <#200 Sieve | % Gravel | % Sand | % Silt | % Clay | Water Content (%) | Dry Density (pcf) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FSR 3123-02 | 30 - 31.5 | CLAYEY SAND(SC) | | 63 | 14 | 49 | 49.8 | 0.0 | 50.2 | | | 19.8 | |
| FSR 3123-02 | 35 - 36.5 | SANDY LEAN CLAY(CL) | | 49 | 17 | 32 | 52.7 | 0.0 | 47.3 | | | 22.1 | |
| FSR 3123-02 | 40 - 41.5 | SANDY LEAN CLAY(CL) | | 44 | 13 | 31 | 68.2 | 1.4 | 30.4 | | | 21.6 | |
| FSR 3123-03 | 3.5 - 4.9 | | | | | | | | | | | 5.8 | |
| FSR 3123-03 | 8.5 - 10 | | | | | | | | | | | 9.4 | |
| FSR 3123-03 | 13.5 - 15 | | | | | | | | | | | 12.4 | |
| FSR 3123-03 | 18.5 - 20 | | | | | | | | | | | 4.6 | |
| FSR 3123-03 | 23.5 - 25 | | | | | | | | | | | 6.4 | |
| FSR 3123-03 | 28.5 - 30 | | | | | | | | | | | 13.5 | |
| FSR 3123-03 | 33.5 - 34.9 | | | | | | | | | | | 14.3 | |
| FSR 3123-03 | 38.5 - 40 | SILT with SAND(ML) | | NP | NP | NP | 73.7 | 0.2 | 26.1 | | | 17.3 | |
| FSR 3123-03 | 43.5 - 45 | | | | | | | | | | | 21.5 | |
| FSR 3123-03 | 48.5 - 50 | LEAN CLAY(CL) | | 36 | 22 | 14 | 88.6 | 0.0 | 11.4 | | | 20.8 | |
| FSR 3123-03 | 53.5 - 55 | | | | | | | | | | | 16.5 | |
| LSDR | 0 - 1.5 | | | | | | | | | | | 12.3 | |
| LSDR | 4.5 - 6.5 | SANDY LEAN CLAY(CL) | | 30 | 18 | 12 | 58.7 | 0.0 | 41.3 | | | 14.7 | 107.8 |
| LSDR | 9.5 - 11 | | | | | | | | | | | 20.5 | |
| LSDR | 12.5 - 14.5 | | | | | | | | | | | | |
| LSDR | 14 - 15.5 | | | | | | | | | | | 18.8 | |
| LSDR | 19.5 - 21 | | | | | | | | | | | 24.3 | |
| LSDR | 24.5 - 26 | | | | | | | | | | | 20.6 | |
| LSDR | 29.5 - 31 | | | | | | | | | | | 32.0 | |
| LSDR | 34.5 - 36 | | | | | | | | | | | 25.2 | |
| LSDR | 39.5 - 41 | | | | | | | | | | | 24.9 | |
| POND 5 | 0 | FAT CLAY(CH) | | 120 | 23 | 97 | 99.6 | 0.0 | 0.4 | | | 191.2 | 26.6 |
| POND 5 | 0.5 | | | | | | | | | | | 173.6 | 28.2 |
| Sed. Rep. | 0 - 1.5 | | | | | | | | | | | 18.5 | |
| Sed. Rep. | 4.5 - 6.5 | | | | | | | | | | | 20.6 | |
| Sed. Rep. | 9.5 - 11 | | | | | | | | | | | 7.0 | |
| Sed. Rep. | 14.5 - 16 | | | | | | | | | | | 16.9 | |
| SP1 (Pond 1) | 4.5 - 6 | | | | | | | | | | | 16.1 | |
| SP1 (Pond 1) | 9.5 - 11 | | | | | | | | | | | 19.3 | |
| SP1 (Pond 1) | 14.5 - 16 | | | | | | | | | | | 15.7 | |
| SP1 (Pond 1) | 19.5 - 21 | CLAYEY SAND(SC) | | 29 | 15 | 14 | 43.3 | 0.0 | 56.7 | | | 23.4 | |
| SP1 (Pond 1) | 24.5 - 26 | | | | | | | | | | | 55.8 | |
| SP2 (Pond 2) | 4.5 - 6 | | | | | | | | | | | 12.2 | |
| SP2 (Pond 2) | 9.5 - 11 | SANDY LEAN CLAY(CL) | | 33 | 14 | 19 | 52.3 | 0.5 | 47.2 | | | 17.7 | |
| SP2 (Pond 2) | 14.5 - 16 | | | | | | | | | | | 19.8 | |
| SP2 (Pond 2) | 19.5 - 21 | LEAN CLAY with SAND(CL) | | 45 | 16 | 29 | 77.8 | 2.8 | 19.4 | | | 27.4 | |
| SP2 (Pond 2) | 24.5 - 26 | | | | | | | | | | | 24.7 | |
| SP2 (Pond 2) | 29.5 - 30.4 | | | | | | | | | | | 72.4 | |
| SP3 (Pond 3) | 0 - 1.5 | | | | | | | | | | | 6.4 | |

PROJECT: Riley Pass Sediment Pond Cleanout - Site Characterization

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# Summary of Laboratory Results



| BORING ID | Depth | USCS Classification and Soil Description | Compressive Strength (psf) | Liquid Limit | Plastic Limit | Plasticity Index | % <#200 Sieve | % Gravel | % Sand | % Silt | % Clay | Water Content (%) | Dry Density (pcf) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SP3 (Pond 3) | 4.5 - 6 | | | | | | | | | | | 13.6 | |
| SP3 (Pond 3) | 9.5 - 11 | SANDY LEAN CLAY(CL) | | 31 | 15 | 16 | 63.3 | 0.9 | 35.8 | | | 17.1 | |
| SP3 (Pond 3) | 14.5 - 16 | SILTY SAND(SM) | | 26 | 22 | 4 | 33.3 | 0.3 | 66.4 | | | 12.5 | |
| SP3 (Pond 3) | 19.5 - 21 | SILTY, CLAYEY SAND(SC-SM) | | 24 | 20 | 4 | 48.8 | 3.5 | 47.7 | | | 20.3 | |
| SP3 (Pond 3) | 24.5 - 26 | | | | | | | | | | | 21.5 | |
| SP3 (Pond 3) | 29.5 - 31 | | | | | | | | | | | 26.5 | |
| SP3 (Pond 3) | 34.5 - 35.1 | | | | | | | | | | | 78.2 | |
| SP4 (Pond 4) | 2.5 - 4 | | | | | | | | | | | 18.1 | |
| SP4 (Pond 4) | 5 - 6.5 | | | | | | | | | | | 23.8 | |
| SP4 (Pond 4) | 7.5 - 9 | SANDY LEAN CLAY(CL) | | 35 | 14 | 21 | 62.2 | 0.6 | 37.2 | | | 25.8 | |
| SP4 (Pond 4) | 10 - 11.5 | SANDY LEAN CLAY(CL) | | 36 | 13 | 23 | 61.8 | 0.1 | 38.1 | | | 26.8 | |
| SP4 (Pond 4) | 12.5 - 14 | | | | | | | | | | | 24.5 | |
| SP4 (Pond 4) | 15 - 16.5 | | | | | | | | | | | 35.6 | |
| SP4 (Pond 4) | 20 - 21.5 | | | | | | | | | | | 30.6 | |
| SP4 (Pond 4) | 22.5 - 24 | | | | | | | | | | | | |
| SP4 (Pond 4) | 25 - 27 | | | | | | | | | | | | |
| SP5 (Pond 5) | 0 - 1.5 | | | | | | | | | | | 6.2 | |
| SP5 (Pond 5) | 4.5 - 6 | | | | | | | | | | | 11.8 | |
| SP5 (Pond 5) | 9.5 - 11 | | | | | | | | | | | 19.5 | |
| SP5 (Pond 5) | 14.5 - 16 | | | | | | | | | | | 24.0 | |
| SP5 (Pond 5) | 19.5 - 21 | | | | | | | | | | | 25.9 | |
| TP- 1 | 1 - 2 | FAT CLAY | | 60 | 23 | 37 | | | | | | 26.6 | 90.5 |
| TP- 1 | 4 - 8 | SILT with SAND(ML) | | 27 | 26 | 1 | 78.3 | 0.0 | 21.7 | | | | |
| TP- 2 | 3 | | | | | | | | | | | 1.9 | |
| TP- 2 | 6 | | | | | | | | | | | 15.8 | |
| TP- 2 | 14 | | | | | | | | | | | 38.0 | |
| TP- 2 | 23 | CLAYEY SAND(SC) | | 65 | 15 | 50 | 31.6 | 0.0 | 68.4 | | | 24.0 | |
| TP- 3 | 1 | | | | | | | | | | | 31.3 | |
| TP- 3 | 2 | LEAN CLAY with SAND(CL) | | 45 | 22 | 23 | 84.8 | 0.0 | 15.2 | | | 18.5 | |
| TP- 3 | 4 | | | | | | | | | | | 25.5 | |
| TP- 3 | 6 | | | | | | | | | | | 23.8 | |
| TP- 4 | 3 | FAT CLAY with SAND(CH) | | 84 | 33 | 51 | 79.5 | 0.8 | 19.7 | | | 33.4 | |
| TP- 5 | 3 | SANDY LEAN CLAY(CL) | | 35 | 15 | 20 | 62.8 | 0.0 | 37.2 | | | 31.9 | |
| TP- 6 | 1.5 | | | | | | | | | | | 26.4 | |
| TP- 6 | 6 | CLAYEY SAND(SC) | | 26 | 14 | 12 | 42.1 | 0.4 | 57.5 | | | 18.7 | |
| TP- 7 | 5 | SANDY LEAN CLAY(CL) | | 26 | 18 | 8 | 52.2 | 0.0 | 47.8 | 35.2 | 17.0 | 21.8 | |
| TP- 7 | 9 | | | | | | | | | | | | |
| TP- 9 | 0 | | | | | | | | | | | | |
| TP-10 | 2 | FAT CLAY(CH) | | 113 | 23 | 90 | 99.8 | 0.0 | 0.2 | 4.4 | 95.4 | 83.1 | |
| TP-10 | 7 | | | | | | | | | | | 127.8 | |
| TP-11 | 1.5 | | | | | | | | | | | 124.0 | |
| TP-11 | 2 | | | | | | | | | | | 33.3 | |

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# Summary of Laboratory Results



| BORING ID | Depth | USCS Classification and Soil Description | Compressive Strength (psf) | Liquid Limit | Plastic Limit | Plasticity Index | % <#200 Sieve | % Gravel | % Sand | % Silt | % Clay | Water Content (%) | Dry Density (pcf) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TP-11 | 3 | LEAN CLAY with SAND(CL) | | 34 | 17 | 17 | 78.9 | 0.0 | 21.1 | 54.3 | 24.6 | 43.4 | |
| TP-11 | 6 | | | | | | | | | | | 34.5 | |
| TP-12 | 4.5 | SILTY SAND (SM) | | | | | 16.9 | 2.0 | 81.1 | 11.0 | 5.9 | 22.1 | |
| TP-12 | 7.5 | | | | | | 21.1 | 21.2 | 57.7 | | | 23.7 | |
| TP-13 | 5 | | | | | | | | | | | 29.3 | |
| TP-14 | 5.5 | | | | | | | | | | | 31.9 | |
| TP-15 | 4 | | | | | | | | | | | 21.7 | |
| TP-17 | 0 | POORLY GRADED SAND(SP) | | | | | 4.4 | 3.4 | 92.2 | | | 21.2 | |
| TP-17 | 6.5 | SANDY LEAN CLAY(CL) | | 41 | 13 | 28 | 69.9 | 0.0 | 30.1 | | | 28.3 | |
| TP-18 | 6 | LEAN CLAY (CL) | | | | | 90.0 | 0.0 | 10.0 | | | 44.5 | |
| TP-18 | 10 | SILTY SAND (SM) | | | | | 21.1 | 0.2 | 78.7 | | | 22.2 | |
| TP-18 | 12 | | | | | | | | | | | 26.7 | |
| TP-19 | 2 | WELL GRADED SAND WITH SILT | | | | | 10.4 | 0.2 | 89.4 | | | 16.3 | |
| | | (SW-SM) | | | | | | | | | | | |
| TP-19 | 7 | CLAYEY SAND (SC) | | | | | 39.3 | 0.0 | 60.7 | | | 29.9 | |
| TP-20 | 2 | SILTY SAND (SM) | | | | | 17.9 | 0.6 | 81.5 | | | 22.5 | |
| TP-20 | 4 | SANDY LEAN CLAY(CL) | | 42 | 17 | 25 | 69.5 | 0.0 | 30.5 | | | 61.2 | |
| TP-20 | 6 | SANDY LEAN CLAY (CL) | | | | | 56.3 | 0.0 | 43.7 | | | 22.8 | |
| USDR | 0 - 1.5 | | | | | | | | | | | 8.0 | |
| USDR | 4.5 - 6 | | | | | | | | | | | 12.8 | |
| USDR | 9.5 - 11.5 | CLAYEY SAND(SC) | 1961 | 31 | 14 | 17 | 48.2 | 0.0 | 51.8 | | | 20.9 | 97.2 |
| USDR | 11.5 - 13 | | | | | | | | | | | 19.5 | |
| USDR | 14.5 - 16 | | | | | | | | | | | 12.2 | |
| USDR | 19.5 - 21 | | | | | | | | | | | 30.0 | |
| USDR | 24.5 - 26 | | | | | | | | | | | 23.8 | |
| USDR | 29.5 - 31 | | | | | | | | | | | 20.8 | |

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Terracon

Organic Content, ASTM D2974

| Sample I.D. | Depth (ft) | Classification | Specific Gravity | Moisture Content (%) | Organic Content (%) |
|---|---|---|---|---|---|
| TP-1 | 1.0 | CLAY SHALE | 2.51 | 26.6 | 9.2 |
| TP-1 | 4.0 | SILT WITH SAND | 2.68 | 8.5 | |
| TP-4 | 3.0 | CLAY SHALE | | 33.4 | 8.08 |
| TP-5 | 3.0-6.0 | SANDY LEAN CLAY | | 31.9 | 5.4 |
| TP-6 | 6.0 | FAT CLAY | | 18.7 | 4.2 |
| TP-7 | 5.0-7.0 | SANDY LEAN CLAY | | 21.8 | 6.1 |
| TP-10 | 10.0 | FAT CLAY | | 83.1 | 10 |
| TP-11 | 3.0 | SANDY LEAN CLAY | | 43.4 | 5.9 |
| TP-12,13,14 | 7.5,5,5.5 | FAT CLAY | 2.62 | | |
| FSR-3123-01 | 15.0-16.5 | FAT CLAY | | 28.8 | 8 |
| FSR-3123-01 | 20.0-21.5 | FAT CLAY | | 26.7 | 9.8 |
| FSR-3123-01 | 25.0-27.0 | SANDY LEANCLAY | | 36 | 25.3 |
| FSR-3123-01 | 27.0-28.5 | FAT CLAY | | 29.5 | 8 |
| FSR-3123-01 | 30.0-31.5 | FAT CLAY | | 31.2 | 7.4 |
| FSR-3123-01 | 35.0-36.5 | FAT CLAY | | 23.1 | 3.8 |
| FSR-3123-02 | 5.0-6.5 | FAT CLAY WITH SAND | | 29.3 | 13.5 |
| FSR-3123-02 | 7.5-9.0 | FAT CLAY WITH SAND | | 31.8 | 9 |
| FSR-3123-02 | 10.0-11.5 | FAT CLAY | | 36.4 | 9.8 |
| FSR-3123-02 | 20.0-22.0 | CLAYEY SAND | | 25.5 | 1.7 |
| Pond 5 | 0 | FAT CLAY | 2.66 | 174/191 | |

# B2 – ANALYTICAL TESTING FROM ENERGY LABORATORIES

# ANALYTICAL SUMMARY REPORT

December 13, 2016

Custer Gallatin National Forest
PO Box 130
Bozeman, MT 59771

Work Order: B16102253 Quote ID: B3970

Project Name: Riley Pass

Energy Laboratories Inc Billings MT received the following 19 samples for Custer Gallatin National Forest on 10/27/2016 for analysis.

| Lab ID | Client Sample ID | Collect Date | Receive Date | Matrix | Test |
|---|---|---|---|---|---|
| B16102253-001 | HA-1 @ 7.0 Feet (Pond 3) | 10/24/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Cation Exchange Capacity<br>Metals, NH4OAC Extractable<br>Metals, Saturated Paste<br>Conductivity, Saturated Paste Extract<br>Anions, Saturated Paste Extract<br>Nitrate as N, KCL Extract<br>pH, Saturated Paste<br>Phosphorus-Olsen<br>Digestion, Total Metals<br>NH4AC Soil Extraction for CEC<br>Gamma Sample Preparation<br>Ammonium Acetate Extraction<br>Saturated Paste Extraction<br>Gross Gamma<br>Sodium Adsorption Ratio<br>Saturation Percentage |
| B16102253-002 | HA-2 @ 3.0-3.5 Feet (Pond 2) | 10/25/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Digestion, Total Metals<br>Gamma Sample Preparation<br>Gross Gamma |
| B16102253-003 | HA-2 @ 5.5-6.0 Feet (Pond 2) | 10/25/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Cation Exchange Capacity<br>Metals, NH4OAC Extractable<br>Metals, Saturated Paste<br>Conductivity, Saturated Paste Extract<br>Anions, Saturated Paste Extract<br>Nitrate as N, KCL Extract<br>pH, Saturated Paste<br>Phosphorus-Olsen<br>Digestion, Total Metals<br>NH4AC Soil Extraction for CEC<br>Gamma Sample Preparation<br>Ammonium Acetate Extraction<br>Saturated Paste Extraction<br>Gross Gamma<br>Sodium Adsorption Ratio<br>Saturation Percentage |
| B16102253-004 | HA-3 @ 5.5-6.0 Feet (Pond 1) | 10/25/16 0:00 | 10/27/16 | Soil | Same As Above |

# ANALYTICAL SUMMARY REPORT

| | | | | | |
|---|---|---|---|---|---|
| B16102253-005 | HA-4 @ 1.5-2.0 Feet (Pond 5) | 10/25/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Digestion, Total Metals<br>Gamma Sample Preparation<br>Gross Gamma |
| B16102253-006 | HA-5 @ 3.5-4.0 Feet (Upper Schliechart) | 10/25/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Cation Exchange Capacity<br>Metals, NH4OAC Extractable<br>Metals, Saturated Paste<br>Conductivity, Saturated Paste Extract<br>Anions, Saturated Paste Extract<br>Nitrate as N, KCL Extract<br>pH, Saturated Paste<br>Phosphorus-Olsen<br>Digestion, Total Metals<br>NH4AC Soil Extraction for CEC<br>Ammonium Acetate Extraction<br>Saturated Paste Extraction<br>Sodium Adsorption Ratio<br>Saturation Percentage |
| B16102253-007 | HA-5 @ 5.5-6.0 Feet (Upper Schliechart) | 10/25/16 0:00 | 10/27/16 | Soil | Gamma Sample Preparation<br>Gross Gamma |
| B16102253-008 | HA-6 @ 3.0-3.5 Feet (Lower Schliechart) | 10/25/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Digestion, Total Metals<br>Gamma Sample Preparation<br>Gross Gamma |
| B16102253-009 | HA-7 @ 1.5-2.0 Feet (Brown's Pond) | 10/25/16 0:00 | 10/27/16 | Soil | Same As Above |
| B16102253-010 | HA-7 @ 4.2-4.8 Feet (Brown's Pond) | 10/25/16 0:00 | 10/27/16 | Soil | Same As Above |
| B16102253-011 | HA-3 @ 4.0-4.5 Feet (Pond 1) | 10/25/16 0:00 | 10/27/16 | Soil | Same As Above |
| B16102253-012 | Pond 5 Sump Grab | 10/26/16 9:16 | 10/27/16 | Aqueous | Metals by ICP/ICPMS, Total<br>pH<br>Metals Preparation by EPA 200.2<br>Gross Gamma |
| B16102253-013 | TP-19 @ 3.8-4.0 Feet (Pond 2) | 10/26/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Cation Exchange Capacity<br>Metals, NH4OAC Extractable<br>Metals, Saturated Paste<br>Conductivity, Saturated Paste Extract<br>Anions, Saturated Paste Extract<br>Nitrate as N, KCL Extract<br>pH, Saturated Paste<br>Phosphorus-Olsen<br>Digestion, Total Metals<br>NH4AC Soil Extraction for CEC<br>Ammonium Acetate Extraction<br>Saturated Paste Extraction<br>Sodium Adsorption Ratio<br>Saturation Percentage |
| B16102253-014 | TP-19 @ 4.0 Feet (pond 2) Lignite Sand Deposit | 10/26/16 0:00 | 10/27/16 | Soil | Gamma Sample Preparation<br>Gross Gamma |

# ANALYTICAL SUMMARY REPORT

| | | | | | |
|---|---|---|---|---|---|
| B16102253-015 | TP-8 @ 1.0 Foot (Pond 5 Upstream Seds) | 10/25/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Cation Exchange Capacity<br>Metals, NH4OAC Extractable<br>Metals, Saturated Paste<br>Conductivity, Saturated Paste Extract<br>Anions, Saturated Paste Extract<br>Nitrate as N, KCL Extract<br>pH, Saturated Paste<br>Phosphorus-Olsen<br>Digestion, Total Metals<br>NH4AC Soil Extraction for CEC<br>Gamma Sample Preparation<br>Ammonium Acetate Extraction<br>Saturated Paste Extraction<br>Gross Gamma<br>Sodium Adsorption Ratio<br>Saturation Percentage |
| B16102253-016 | TP-8 @ 3.0 Feet (Pond 5 Upstream Seds) | 10/25/16 0:00 | 10/27/16 | Soil | Same As Above |
| B16102253-017 | TP-15 @ 2.0-3.0 Feet (Pond 4) | 10/26/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Digestion, Total Metals<br>Gamma Sample Preparation<br>Gross Gamma |
| B16102253-018 | TP-15 @ 1.25 Feet (Pond 4) | 10/26/16 0:00 | 10/27/16 | Soil | Same As Above |
| B16102253-019 | TP-16 @ 2.0-3.0 Feet (Pond 4) | 10/26/16 0:00 | 10/27/16 | Soil | Metals by ICP/ICPMS, Total or Soluble<br>Cation Exchange Capacity<br>Metals, NH4OAC Extractable<br>Metals, Saturated Paste<br>Conductivity, Saturated Paste Extract<br>Anions, Saturated Paste Extract<br>Nitrate as N, KCL Extract<br>pH, Saturated Paste<br>Phosphorus-Olsen<br>Digestion, Total Metals<br>NH4AC Soil Extraction for CEC<br>Gamma Sample Preparation<br>Ammonium Acetate Extraction<br>Saturated Paste Extraction<br>Gross Gamma<br>Sodium Adsorption Ratio<br>Saturation Percentage |

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By:

**CLIENT:** Custer Gallatin National Forest
**Project:** Riley Pass
**Work Order:** B16102253

**Report Date:** 12/13/16

# CASE NARRATIVE

Tests associated with analyst identified as ELI-CA were subcontracted to Energy Laboratories, PO Box 247, Casper, WY, EPA Number WY00002 and WY00937.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-001
**Client Sample ID:** HA-1 @ 7.0 Feet (Pond 3)

**Report Date:** 12/13/16
**Collection Date:** 10/24/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **SATURATED PASTE EXTRACT** | | | | | | | |
| pH, sat. paste | 8.6 | s.u. | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Conductivity, sat. paste | 1.2 | mmhos/cm | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Saturation | 27.3 | % | | 0.1 | | USDA27a | 11/09/16 10:30 / srm |
| Calcium, sat. paste | 0.96 | meq/L | | 0.05 | | SW6010B | 11/09/16 19:13 / jh |
| Magnesium, sat. paste | 0.78 | meq/L | | 0.08 | | SW6010B | 11/09/16 19:13 / jh |
| Sodium, sat. paste | 11.7 | meq/L | | 0.04 | | SW6010B | 11/09/16 19:13 / jh |
| Sodium Adsorption Ratio (SAR) | 12.6 | unitless | | 0.01 | | Calculation | 11/11/16 10:43 / srm |
| Sulfate | 176 | mg/L | D | 2 | | E300.0 | 11/09/16 14:20 / jpv |
| **CHEMICAL CHARACTERISTICS** | | | | | | | |
| Cation Exchange Capacity | 15.2 | meq/100g | | 0.09 | | SW6010B | 11/09/16 16:48 / jh |
| Phosphorus, Olsen | 4 | mg/kg | | 1 | | ASA24-5 | 11/11/16 08:29 / srm |
| Nitrate as N, KCL Extract | 2 | mg/kg | | 1 | | ASA33-8 | 11/11/16 10:32 / srm |
| **METALS, AMMONIUM ACETATE EXTRACTABLE** | | | | | | | |
| Potassium | 89 | mg/kg | | 1 | | SW6010B | 11/08/16 17:08 / jh |
| Sodium | 1750 | mg/kg | | 1 | | SW6010B | 11/08/16 17:08 / jh |
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 21 | mg/kg | | 1 | | SW6020 | 11/03/16 18:48 / jpv |
| Cadmium | ND | mg/kg | | 1 | | SW6020 | 11/03/16 18:48 / jpv |
| Copper | 7 | mg/kg | | 1 | | SW6020 | 11/03/16 18:48 / jpv |
| Lead | 8 | mg/kg | | 1 | | SW6020 | 11/03/16 18:48 / jpv |
| Molybdenum | 2 | mg/kg | | 1 | | SW6020 | 11/03/16 18:48 / jpv |
| Uranium | 2 | mg/kg | | 1 | | SW6020 | 11/03/16 18:48 / jpv |
| Zinc | 29 | mg/kg | | 1 | | SW6020 | 11/03/16 18:48 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 1.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.07 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
D - RL increased due to sample matrix.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-002
**Client Sample ID:** HA-2 @ 3.0-3.5 Feet (Pond 2)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 48 | mg/kg | | 1 | | SW6020 | 11/03/16 19:06 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 6.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 2.9 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.7 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-003
**Client Sample ID:** HA-2 @ 5.5-6.0 Feet (Pond 2)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **SATURATED PASTE EXTRACT** | | | | | | | |
| pH, sat. paste | 7.4 | s.u. | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Conductivity, sat. paste | 2.4 | mmhos/cm | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Saturation | 88.7 | % | | 0.1 | | USDA27a | 11/09/16 10:30 / srm |
| Calcium, sat. paste | 1.89 | meq/L | | 0.05 | | SW6010B | 11/09/16 19:20 / jh |
| Magnesium, sat. paste | 1.51 | meq/L | | 0.08 | | SW6010B | 11/09/16 19:20 / jh |
| Sodium, sat. paste | 22.1 | meq/L | D | 0.08 | | SW6010B | 11/09/16 19:20 / jh |
| Sodium Adsorption Ratio (SAR) | 16.9 | unitless | | 0.01 | | Calculation | 11/11/16 10:43 / srm |
| Sulfate | 979 | mg/L | D | 2 | | E300.0 | 11/09/16 15:04 / jpv |
| **CHEMICAL CHARACTERISTICS** | | | | | | | |
| Cation Exchange Capacity | 32.6 | meq/100g | D | 0.3 | | SW6010B | 11/09/16 17:02 / jh |
| Phosphorus, Olsen | 9 | mg/kg | | 1 | | ASA24-5 | 11/11/16 08:35 / srm |
| Nitrate as N, KCL Extract | ND | mg/kg | | 1 | | ASA33-8 | 11/11/16 10:34 / srm |
| **METALS, AMMONIUM ACETATE EXTRACTABLE** | | | | | | | |
| Potassium | 298 | mg/kg | | 1 | | SW6010B | 11/08/16 17:12 / jh |
| Sodium | 1600 | mg/kg | | 1 | | SW6010B | 11/08/16 17:12 / jh |
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 40 | mg/kg | | 1 | | SW6020 | 11/03/16 19:17 / jpv |
| Cadmium | ND | mg/kg | | 1 | | SW6020 | 11/03/16 19:17 / jpv |
| Copper | 13 | mg/kg | | 1 | | SW6020 | 11/03/16 19:17 / jpv |
| Lead | 12 | mg/kg | | 1 | | SW6020 | 11/03/16 19:17 / jpv |
| Molybdenum | 10 | mg/kg | | 1 | | SW6020 | 11/03/16 19:17 / jpv |
| Uranium | 11 | mg/kg | | 1 | | SW6020 | 11/03/16 19:17 / jpv |
| Zinc | 46 | mg/kg | | 1 | | SW6020 | 11/03/16 19:17 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.07 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 226 precision (±) | 0.006 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 226 MDC | 0.004 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 228 | 0.009 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 228 precision (±) | 0.004 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 228 MDC | 0.007 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
D - RL increased due to sample matrix.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-004
**Client Sample ID:** HA-3 @ 5.5-6.0 Feet (Pond 1)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **SATURATED PASTE EXTRACT** | | | | | | | |
| pH, sat. paste | 7.9 | s.u. | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Conductivity, sat. paste | 3.0 | mmhos/cm | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Saturation | 47.4 | % | | 0.1 | | USDA27a | 11/09/16 10:30 / srm |
| Calcium, sat. paste | 1.51 | meq/L | | 0.05 | | SW6010B | 11/09/16 19:34 / jh |
| Magnesium, sat. paste | 1.69 | meq/L | | 0.08 | | SW6010B | 11/09/16 19:34 / jh |
| Sodium, sat. paste | 30.8 | meq/L | D | 0.08 | | SW6010B | 11/09/16 19:34 / jh |
| Sodium Adsorption Ratio (SAR) | 24.4 | unitless | | 0.01 | | Calculation | 11/11/16 10:43 / srm |
| Sulfate | 1150 | mg/L | D | 5 | | E300.0 | 11/09/16 15:18 / jpv |
| **CHEMICAL CHARACTERISTICS** | | | | | | | |
| Cation Exchange Capacity | ND | meq/100g | D | 1 | | SW6010B | 11/09/16 17:09 / jh |
| Phosphorus, Olsen | 5 | mg/kg | | 1 | | ASA24-5 | 11/11/16 08:36 / srm |
| Nitrate as N, KCL Extract | ND | mg/kg | | 1 | | ASA33-8 | 11/11/16 10:34 / srm |
| **METALS, AMMONIUM ACETATE EXTRACTABLE** | | | | | | | |
| Potassium | 161 | mg/kg | | 1 | | SW6010B | 11/08/16 17:25 / jh |
| Sodium | 2800 | mg/kg | | 1 | | SW6010B | 11/08/16 17:25 / jh |
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 27 | mg/kg | | 1 | | SW6020 | 11/03/16 19:19 / jpv |
| Cadmium | ND | mg/kg | | 1 | | SW6020 | 11/03/16 19:19 / jpv |
| Copper | 9 | mg/kg | | 1 | | SW6020 | 11/03/16 19:19 / jpv |
| Lead | 10 | mg/kg | | 1 | | SW6020 | 11/03/16 19:19 / jpv |
| Molybdenum | 7 | mg/kg | | 1 | | SW6020 | 11/03/16 19:19 / jpv |
| Uranium | 9 | mg/kg | | 1 | | SW6020 | 11/03/16 19:19 / jpv |
| Zinc | 37 | mg/kg | | 1 | | SW6020 | 11/03/16 19:19 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.6 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 1.9 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.1 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
D - RL increased due to sample matrix.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-005
**Client Sample ID:** HA-4 @ 1.5-2.0 Feet (Pond 5)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 18 | mg/kg | | 1 | | SW6020 | 11/03/16 19:22 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 1.6 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-006
**Client Sample ID:** HA-5 @ 3.5-4.0 Feet (Upper Schliechart)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **SATURATED PASTE EXTRACT** | | | | | | | |
| pH, sat. paste | 8.5 | s.u. | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Conductivity, sat. paste | 2.7 | mmhos/cm | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Saturation | 187 | % | | 0.1 | | USDA27a | 11/09/16 10:30 / srm |
| Calcium, sat. paste | 0.88 | meq/L | | 0.05 | | SW6010B | 11/09/16 19:37 / jh |
| Magnesium, sat. paste | 0.68 | meq/L | | 0.08 | | SW6010B | 11/09/16 19:37 / jh |
| Sodium, sat. paste | 26.2 | meq/L | D | 0.08 | | SW6010B | 11/09/16 19:37 / jh |
| Sodium Adsorption Ratio (SAR) | 29.6 | unitless | | 0.01 | | Calculation | 11/11/16 10:43 / srm |
| Sulfate | 996 | mg/L | D | 5 | | E300.0 | 11/09/16 15:33 / jpv |
| **CHEMICAL CHARACTERISTICS** | | | | | | | |
| Cation Exchange Capacity | 46.9 | meq/100g | D | 0.3 | | SW6010B | 11/09/16 17:12 / jh |
| Phosphorus, Olsen | 7 | mg/kg | | 1 | | ASA24-5 | 11/11/16 08:38 / srm |
| Nitrate as N, KCL Extract | 1 | mg/kg | | 1 | | ASA33-8 | 11/11/16 10:35 / srm |
| **METALS, AMMONIUM ACETATE EXTRACTABLE** | | | | | | | |
| Potassium | 490 | mg/kg | | 1 | | SW6010B | 11/08/16 17:32 / jh |
| Sodium | 4320 | mg/kg | | 1 | | SW6010B | 11/08/16 17:32 / jh |
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 23 | mg/kg | | 1 | | SW6020 | 11/03/16 19:24 / jpv |
| Cadmium | ND | mg/kg | | 1 | | SW6020 | 11/03/16 19:24 / jpv |
| Copper | 14 | mg/kg | | 1 | | SW6020 | 11/03/16 19:24 / jpv |
| Lead | 15 | mg/kg | | 1 | | SW6020 | 11/03/16 19:24 / jpv |
| Molybdenum | 3 | mg/kg | | 1 | | SW6020 | 11/03/16 19:24 / jpv |
| Uranium | 4 | mg/kg | | 1 | | SW6020 | 11/03/16 19:24 / jpv |
| Zinc | 51 | mg/kg | | 1 | | SW6020 | 11/03/16 19:24 / jpv |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-007
**Client Sample ID:** HA-5 @ 5.5-6.0 Feet (Upper Schliechart)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.03 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 226 precision (±) | 0.004 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 226 MDC | 0.003 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 228 | 0.009 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 228 precision (±) | 0.004 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 228 MDC | 0.004 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-008
**Client Sample ID:** HA-6 @ 3.0-3.5 Feet (Lower Schliechart)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 9 | mg/kg | | 1 | | SW6020 | 11/03/16 19:30 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 2.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 2.1 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.08 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-009
**Client Sample ID:** HA-7 @ 1.5-2.0 Feet (Brown's Pond)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 24 | mg/kg | | 1 | | SW6020 | 11/08/16 23:31 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 1.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.1 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 1.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-010
**Client Sample ID:** HA-7 @ 4.2-4.8 Feet (Brown's Pond)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 9 | mg/kg | | 1 | | SW6020 | 11/03/16 19:32 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.8 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.1 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.1 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 1.1 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.08 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-011
**Client Sample ID:** HA-3 @ 4.0-4.5 Feet (Pond 1)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 47 | mg/kg | | 1 | | SW6020 | 11/03/16 19:35 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 6.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 2.9 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.6 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-012
**Client Sample ID:** Pond 5 Sump Grab

**Report Date:** 12/13/16
**Collection Date:** 10/26/16 09:16
**DateReceived:** 10/27/16
**Matrix:** Aqueous

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **PHYSICAL PROPERTIES** | | | | | | | |
| pH | 7.8 | s.u. | H | 0.1 | | A4500-H B | 10/28/16 13:46 / pjw |
| **METALS, TOTAL** | | | | | | | |
| Arsenic | 0.412 | mg/L | | 0.001 | | E200.8 | 11/02/16 14:36 / rlh |
| Cadmium | ND | mg/L | | 0.001 | | E200.8 | 11/02/16 14:36 / rlh |
| Copper | 0.011 | mg/L | | 0.005 | | E200.8 | 11/02/16 14:36 / rlh |
| Lead | ND | mg/L | | 0.001 | | E200.8 | 11/07/16 18:02 / rlh |
| Molybdenum | 0.118 | mg/L | | 0.001 | | E200.8 | 11/02/16 14:36 / rlh |
| Uranium | 0.0746 | mg/L | | 0.0003 | | E200.8 | 11/09/16 11:56 / rlh |
| Zinc | ND | mg/L | | 0.01 | | E200.8 | 11/02/16 14:36 / rlh |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.03 | pCi/L | | | | E901.1 | 11/16/16 08:47 / eli-ca |
| Radium 226 precision (±) | 0.01 | pCi/L | | | | E901.1 | 11/16/16 08:47 / eli-ca |
| Radium 226 MDC | 0.02 | pCi/L | | | | E901.1 | 11/16/16 08:47 / eli-ca |
| Radium 228 | 0.02 | pCi/L | U | | | E901.1 | 11/16/16 08:47 / eli-ca |
| Radium 228 precision (±) | 0.02 | pCi/L | | | | E901.1 | 11/16/16 08:47 / eli-ca |
| Radium 228 MDC | 0.04 | pCi/L | | | | E901.1 | 11/16/16 08:47 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
U - Not detected at minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-013
**Client Sample ID:** TP-19 @ 3.8-4.0 Feet (Pond 2)

**Report Date:** 12/13/16
**Collection Date:** 10/26/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **SATURATED PASTE EXTRACT** | | | | | | | |
| pH, sat. paste | 6.5 | s.u. | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Conductivity, sat. paste | 3.4 | mmhos/cm | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Saturation | 47.8 | % | | 0.1 | | USDA27a | 11/09/16 10:30 / srm |
| Calcium, sat. paste | 4.31 | meq/L | | 0.05 | | SW6010B | 11/09/16 19:41 / jh |
| Magnesium, sat. paste | 3.91 | meq/L | | 0.08 | | SW6010B | 11/09/16 19:41 / jh |
| Sodium, sat. paste | 29.1 | meq/L | D | 0.08 | | SW6010B | 11/09/16 19:41 / jh |
| Sodium Adsorption Ratio (SAR) | 14.4 | unitless | | 0.01 | | Calculation | 11/11/16 10:43 / srm |
| Sulfate | 1480 | mg/L | D | 5 | | E300.0 | 11/09/16 15:47 / jpv |
| **CHEMICAL CHARACTERISTICS** | | | | | | | |
| Cation Exchange Capacity | 33.2 | meq/100g | D | 0.3 | | SW6010B | 11/09/16 17:16 / jh |
| Phosphorus, Olsen | 7 | mg/kg | | 1 | | ASA24-5 | 11/11/16 08:40 / srm |
| Nitrate as N, KCL Extract | ND | mg/kg | | 1 | | ASA33-8 | 11/11/16 10:36 / srm |
| **METALS, AMMONIUM ACETATE EXTRACTABLE** | | | | | | | |
| Potassium | 159 | mg/kg | | 1 | | SW6010B | 11/08/16 17:36 / jh |
| Sodium | 1410 | mg/kg | | 1 | | SW6010B | 11/08/16 17:36 / jh |
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 45 | mg/kg | | 1 | | SW6020 | 11/08/16 23:34 / jpv |
| Cadmium | ND | mg/kg | | 1 | | SW6020 | 11/09/16 21:50 / rlh |
| Copper | 13 | mg/kg | | 1 | | SW6020 | 11/08/16 23:34 / jpv |
| Lead | 10 | mg/kg | | 1 | | SW6020 | 11/08/16 23:34 / jpv |
| Molybdenum | 53 | mg/kg | | 1 | | SW6020 | 11/08/16 23:34 / jpv |
| Uranium | 73 | mg/kg | | 1 | | SW6020 | 11/08/16 23:34 / jpv |
| Zinc | 39 | mg/kg | D | 2 | | SW6010B | 11/01/16 23:18 / jh |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-014
**Client Sample ID:** TP-19 @ 4.0 Feet (pond 2) Lignite Sand Deposit

**Report Date:** 12/13/16
**Collection Date:** 10/26/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.1 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 226 precision (±) | 0.01 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 226 MDC | 0.004 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 228 | 0.02 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 228 precision (±) | 0.009 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |
| Radium 228 MDC | 0.02 | pCi/g-dry | | | | E901.1 | 12/05/16 05:00 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-015
**Client Sample ID:** TP-8 @ 1.0 Foot (Pond 5 Upstream Seds)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **SATURATED PASTE EXTRACT** | | | | | | | |
| pH, sat. paste | 8.4 | s.u. | | 0.1 | | ASA10-3 | 12/08/16 14:52 / srm |
| Conductivity, sat. paste | 2.8 | mmhos/cm | | 0.1 | | ASA10-3 | 12/08/16 14:52 / srm |
| Saturation | 29.7 | % | | 0.1 | | USDA27a | 12/08/16 14:52 / srm |
| Calcium, sat. paste | 1.63 | meq/L | | 0.05 | | SW6010B | 12/09/16 00:16 / jh |
| Magnesium, sat. paste | 2.19 | meq/L | | 0.08 | | SW6010B | 12/09/16 00:16 / jh |
| Sodium, sat. paste | 26.4 | meq/L | D | 0.08 | | SW6010B | 12/09/16 00:16 / jh |
| Sodium Adsorption Ratio (SAR) | 19.1 | unitless | | 0.01 | | Calculation | 12/09/16 13:45 / srm |
| Sulfate | 1060 | mg/L | D | 4 | | E300.0 | 12/09/16 13:12 / mej |
| Sulfate | 1130 | mg/L | D | 2 | | E300.0 | 12/12/16 23:23 / mej |
| **CHEMICAL CHARACTERISTICS** | | | | | | | |
| Cation Exchange Capacity | 16.3 | meq/100g | D | 0.3 | | SW6010B | 12/08/16 23:51 / jh |
| Phosphorus, Olsen | 1 | mg/kg | | 1 | | ASA24-5 | 12/12/16 14:12 / srm |
| Nitrate as N, KCL Extract | 2 | mg/kg | | 1 | | ASA33-8 | 12/12/16 11:53 / srm |
| **METALS, AMMONIUM ACETATE EXTRACTABLE** | | | | | | | |
| Potassium | 83 | mg/kg | | 1 | | SW6010B | 12/09/16 00:34 / jh |
| Sodium | 1530 | mg/kg | | 1 | | SW6010B | 12/09/16 00:34 / jh |
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 29 | mg/kg | | 1 | | SW6020 | 11/03/16 19:37 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 1.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.1 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.07 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
D - RL increased due to sample matrix.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-016
**Client Sample ID:** TP-8 @ 3.0 Feet (Pond 5 Upstream Seds)

**Report Date:** 12/13/16
**Collection Date:** 10/25/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **SATURATED PASTE EXTRACT** | | | | | | | |
| pH, sat. paste | 8.2 | s.u. | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Conductivity, sat. paste | 3.0 | mmhos/cm | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Saturation | 57.3 | % | | 0.1 | | USDA27a | 11/09/16 10:30 / srm |
| Calcium, sat. paste | 1.19 | meq/L | | 0.05 | | SW6010B | 11/09/16 19:44 / jh |
| Magnesium, sat. paste | 2.73 | meq/L | | 0.08 | | SW6010B | 11/09/16 19:44 / jh |
| Sodium, sat. paste | 29.4 | meq/L | D | 0.08 | | SW6010B | 11/09/16 19:44 / jh |
| Sodium Adsorption Ratio (SAR) | 21.0 | unitless | | 0.01 | | Calculation | 11/11/16 10:43 / srm |
| Sulfate | 1170 | mg/L | D | 5 | | E300.0 | 11/09/16 16:02 / jpv |
| **CHEMICAL CHARACTERISTICS** | | | | | | | |
| Cation Exchange Capacity | ND | meq/100g | D | 1 | | SW6010B | 11/09/16 17:20 / jh |
| Phosphorus, Olsen | 4 | mg/kg | | 1 | | ASA24-5 | 11/11/16 08:42 / srm |
| Nitrate as N, KCL Extract | 1 | mg/kg | | 1 | | ASA33-8 | 11/11/16 10:36 / srm |
| **METALS, AMMONIUM ACETATE EXTRACTABLE** | | | | | | | |
| Potassium | 128 | mg/kg | | 1 | | SW6010B | 11/08/16 17:39 / jh |
| Sodium | 1430 | mg/kg | | 1 | | SW6010B | 11/08/16 17:39 / jh |
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 19 | mg/kg | | 1 | | SW6020 | 11/03/16 19:40 / jpv |
| Cadmium | ND | mg/kg | | 1 | | SW6020 | 11/03/16 19:40 / jpv |
| Copper | 8 | mg/kg | | 1 | | SW6020 | 11/03/16 19:40 / jpv |
| Lead | 10 | mg/kg | | 1 | | SW6020 | 11/03/16 19:40 / jpv |
| Molybdenum | 2 | mg/kg | | 1 | | SW6020 | 11/03/16 19:40 / jpv |
| Uranium | 3 | mg/kg | | 1 | | SW6020 | 11/03/16 19:40 / jpv |
| Zinc | 36 | mg/kg | | 1 | | SW6020 | 11/03/16 19:40 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 1.8 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 1.8 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
D - RL increased due to sample matrix.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-017
**Client Sample ID:** TP-15 @ 2.0-3.0 Feet (Pond 4)

**Report Date:** 12/13/16
**Collection Date:** 10/26/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 14 | mg/kg | | 1 | | SW6020 | 11/03/16 19:50 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 2.5 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-018
**Client Sample ID:** TP-15 @ 1.25 Feet (Pond 4)

**Report Date:** 12/13/16
**Collection Date:** 10/26/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 14 | mg/kg | | 1 | | SW6020 | 11/03/16 19:53 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 0.5 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 3.1 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.09 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

**Client:** Custer Gallatin National Forest
**Project:** Riley Pass
**Lab ID:** B16102253-019
**Client Sample ID:** TP-16 @ 2.0-3.0 Feet (Pond 4)

**Report Date:** 12/13/16
**Collection Date:** 10/26/16
**DateReceived:** 10/27/16
**Matrix:** Soil

| Analyses | Result | Units | Qualifiers | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **SATURATED PASTE EXTRACT** | | | | | | | |
| pH, sat. paste | 8.4 | s.u. | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Conductivity, sat. paste | 6.0 | mmhos/cm | | 0.1 | | ASA10-3 | 11/09/16 10:30 / srm |
| Saturation | 180 | % | | 0.1 | | USDA27a | 11/09/16 10:30 / srm |
| Calcium, sat. paste | 4.78 | meq/L | | 0.05 | | SW6010B | 11/09/16 19:48 / jh |
| Magnesium, sat. paste | 6.89 | meq/L | | 0.08 | | SW6010B | 11/09/16 19:48 / jh |
| Sodium, sat. paste | 62.4 | meq/L | D | 0.2 | | SW6010B | 11/09/16 19:48 / jh |
| Sodium Adsorption Ratio (SAR) | 25.8 | unitless | | 0.01 | | Calculation | 11/11/16 10:43 / srm |
| Sulfate | 3100 | mg/L | D | 10 | | E300.0 | 11/09/16 16:16 / jpv |
| **CHEMICAL CHARACTERISTICS** | | | | | | | |
| Cation Exchange Capacity | 48.6 | meq/100g | D | 0.3 | | SW6010B | 11/09/16 17:23 / jh |
| Phosphorus, Olsen | 8 | mg/kg | | 1 | | ASA24-5 | 11/11/16 08:43 / srm |
| Nitrate as N, KCL Extract | 3 | mg/kg | | 1 | | ASA33-8 | 11/11/16 10:37 / srm |
| **METALS, AMMONIUM ACETATE EXTRACTABLE** | | | | | | | |
| Potassium | 351 | mg/kg | | 1 | | SW6010B | 11/08/16 17:43 / jh |
| Sodium | 5310 | mg/kg | | 1 | | SW6010B | 11/08/16 17:43 / jh |
| **METALS, TOTAL - EPA SW846** | | | | | | | |
| Arsenic | 18 | mg/kg | | 1 | | SW6020 | 11/03/16 19:56 / jpv |
| Cadmium | ND | mg/kg | | 1 | | SW6020 | 11/03/16 19:56 / jpv |
| Copper | 9 | mg/kg | | 1 | | SW6020 | 11/03/16 19:56 / jpv |
| Lead | 9 | mg/kg | | 1 | | SW6020 | 11/03/16 19:56 / jpv |
| Molybdenum | 1 | mg/kg | | 1 | | SW6020 | 11/03/16 19:56 / jpv |
| Uranium | 2 | mg/kg | | 1 | | SW6020 | 11/03/16 19:56 / jpv |
| Zinc | 37 | mg/kg | | 1 | | SW6020 | 11/03/16 19:56 / jpv |
| **RADIONUCLIDES - GAMMA** | | | | | | | |
| Radium 226 | 2.4 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 precision (±) | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 226 MDC | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 | 2.8 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 precision (±) | 0.3 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |
| Radium 228 MDC | 0.2 | pCi/g-dry | | | | E901.1 | 12/06/16 10:32 / eli-ca |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
D - RL increased due to sample matrix.

# Chain of Custody & Analytical Request Record

ENERGY LAB — Trust our People. Trust our Data.

www.energylab.com



**Account Information** *(Billing information)*

| | |
|---|---|
| Company/Name | Custer Gallatin National Forest |
| Contact | Peter Werner |
| Phone | (406) 587-6962 |
| Mailing Address | 10 E. Babcock |
| City, State, Zip | Bozeman, MT 59715 |
| Email | pgwerner@fs.fed.us |
| Receive Invoice | ■Hard Copy ■Email |
| Receive Report | ■Hard Copy ■Email |
| Purchase Order | |
| Quote | |
| Bottle Order | |

**Report Information** *(if different than Account Information)*

| | |
|---|---|
| Company/Name | Allied Engineering Services, Inc. |
| Contact | Ron Orton |
| Phone | (406) 582-0221 |
| Mailing Address | 32 Discovery Dr. |
| City, State, Zip | Bozeman, MT 59718 |
| Email | rorton@alliedengineering.com |
| Receive Report | ☐Hard Copy ■Email |

Special Report/Formats: ☐ LEVEL IV ☐ NELAC ☐ EDD/EDT *(contact laboratory)* ☐ Other_____

**Comments**

Collection date taken from original Chain of Custody 9m 11-3-16 and sample containers

**Project Information**

| | |
|---|---|
| Project Name, PWSID, Permit, etc. | Riley Pass |
| Sampler Name | Doug Chandler/Ron Orto |
| Sampler Phone | (406) 582-0221 |
| Sample Origin State | South Dakota |
| EPA/State Compliance | ☐ Yes ■ No |

MINING CLIENTS, please indicate sample type.
*If ore has been processed or refined, call before sending.
☐ Byproduct 11 (e)2 material ☐ Unprocessed ore (NOT ground or refined)*

**Matrix Codes**

A - Air; W - Water; S - Soils/Solids; V - Vegetation; B - Bioassay; O - Other; DW - Drinking Water

All turnaround times are standard unless marked as RUSH.

Energy Laboratories MUST be contacted prior to RUSH sample submittal for charges and scheduling – See Instructions Page

| | Sample Identification (Name, Location, Interval, etc.) | Collection Date | Collection Time | Number of Containers | Matrix (See Codes Above) | As, Gamma 901 (Ra226) | Cd, Cu, Mo, Pb, U, Zn, | | Sat. Paste Ext B3970c | Chem. Char. B3970c | Meatls, Am. B3970c | | | | See Attached | RUSH TAT | EL Laboratory ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | TP-19 @ 3.8'-4.0' (Pond 2) | 10-26-16 9m | | | S | ✓ | | | | | | | | | | | B16102253-013 |
| 2 | TP-19 @ 4.0' (Pond 2) Lignite sand deposit | 10-26-16 | | | S | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | -014 |
| 3 | TP-8 @ 1.0' (Pond 5 upstream seds) | 10-25-16 | | | S | ✓ | | | | | | | | | | | -015 |
| 4 | TP-8 @ 3.0' (Pond 5 upstream seds) | 10-25-16 | | | S | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | -016 |
| 5 | TP-15 @ 2.0'-3.0' (Pond 4) | 10-26-16 | | | S | ✓ | | | | | | | | | | | -017 |
| 6 | TP-15 @ 1.25' (Pond 4) | 10-26-16 | | | S | ✓ | | | | | | | | | | | -018 |
| 7 | TP-16 @ 2.0'-3.0' (Pond 4) | 10-26-16 | | | S | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | -019 |
| 8 | HA-1 @ 7.0' (Pond 3) | 10-24-16 | | | S | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | -001 |
| 9 | HA-2 @ 3.0'-3.5" (Pond 2) | 10-25-16 | | | S | ✓ | | | | | | | | | | | -002 |
| 10 | HA-2 @ 5.5'-6.0' (Pond 2) | 10-25-16 9m | | | S | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | -003 |

| Custody Record MUST be signed | Relinquished by (print) | Date/Time | Signature | Received by (print) | Date/Time | Signature |
|---|---|---|---|---|---|---|
| | Relinquished by (print) | Date/Time | Signature | Received by laboratory (print) | Date/Time 10/27/16 | Signature 0800 |

LABORATORY USE ONLY

| Shipped By | Cooler ID(s) | Custody Seals Y N C B | Intact Y N | Receipt Temp °C | Temp Blank Y N | On Ice Y N | Payment Type CC Cash Check_____ | Amount $ | Receipt Number *(cash/check only)* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All subcontracted data will be clearly notated on your analytical report.

ENERGY LABORATORIES
Trust our People. Trust our Data.

# Chain of Custody & Analytical Request Record

www.energylab.com



## Account Information *(Billing information)*

| | |
|---|---|
| Company/Name | Custer Gallatin National Forest |
| Contact | Peter Werner |
| Phone | (406) 587-6962 |
| Mailing Address | 10 E. Babcock |
| City, State, Zip | Bozeman, MT 59715 |
| Email | pgwerner@fs.fed.us |
| Receive Invoice | ☒Hard Copy ☒Email |
| Receive Report | ☒Hard Copy ☒Email |
| Purchase Order | |
| Quote | B970a |
| Bottle Order | |

## Report Information *(if different than Account Information)*

| | |
|---|---|
| Company/Name | Allied Engineering Services, Inc. |
| Contact | Ron Orton |
| Phone | (406) 582-0221 |
| Mailing Address | 32 Discovery Dr. |
| City, State, Zip | Bozeman, MT 59718 |
| Email | rorton@alliedengineering.com |
| Receive Report | ☐Hard Copy ☒Email |

Special Report/Formats:
☐ LEVEL IV ☐ NELAC ☐ EDD/EDT *(contact laboratory)* ☐ Other_____

## Comments

## Project Information

| | |
|---|---|
| Project Name, PWSID, Permit, etc. | Riley Pass |
| Sampler Name | Doug Chandler/Ron Orto |
| Sampler Phone | (406) 582-0221 |
| Sample Origin State | South Dakota |
| EPA/State Compliance | ☐ Yes ☒ No |

MINING CLIENTS, please indicate sample type.
*If ore has been processed or refined, call before sending.
☐ Byproduct 11 (e)2 material ☐ Unprocessed ore (NOT ground or refined)*

**Matrix Codes**
A - Air
W - Water
S - Soils/Solids
V - Vegetation
B - Bioassay
O - Other
DW - Drinking Water

All turnaround times are standard unless marked as RUSH.
Energy Laboratories MUST be contacted prior to RUSH sample submittal for charges and scheduling – See Instructions Page

| | Sample Identification *(Name, Location, Interval, etc.)* | Collection Date | Collection Time | Number of Containers | Matrix *(See Codes Above)* | As, Gamma 901 (Ra226) | Cd, Cu, Mo, Pb, U, Zn | | Sat. Paste Ext B3970c | Chem. Char. B3970c | Meatls, Am. B3970c | pH | | | See Attached | RUSH TAT | Lab ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HA-3 @ 5.5'-6.0' (Pond 1) | 10/25/16 | | 1 | S | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | B16102253-004 |
| 2 | HA-3 @ 4.0'-4.5' (Pond 1) | 10/25/16 | | 1 | S | ✓ | | | | | | | | | | | -011 |
| 3 | HA-4 @ 1.5'-2.0' (Pond 5) | 10/25/16 | | 1 | S | ✓ | | | | | | | | | | | -005 |
| 4 | HA-5 @ 3.5'-4.0' (Upper Schliechart) | 10/25/16 | | 1 | S | ✓ | | | | | | | | | | | -006 |
| 5 | HA-5 @ 5.5'-6.0' (Upper Schliechart) | 10/25/16 | | 1 | S | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | -007 |
| 6 | HA-6 @ 3.0'-3.5' (Lower Schliechart) | 10/25/16 | | 1 | S | ✓ | | | | | | | | | | | -008 |
| 7 | HA-7 @ 1.5'-2.0' (Brown's Pond) | 10/25/16 | | 1 | S | ✓ | | | | | | | | | | | -009 |
| 8 | HA-7 @ 4.2'-4.8' (Brown's Pond) | 10/25/16 | | 1 | S | ✓ | | | | | | | | | | | -010 |
| 9 | Pond 5 water grab (Pond 5) | 10/26/16 | | | W | ✓ | ✓ | | | | | ✓ | | | | | -012 |
| 10 | | | | | | | | | | | | | | | | | |

| Custody Record MUST be signed | Relinquished by (print) | Date/Time | Signature | Received by (print) | Date/Time | Signature |
|---|---|---|---|---|---|---|
| | Relinquished by (print) | Date/Time | Signature | Received by Laboratory (print) | Date/Time | Signature |

**LABORATORY USE ONLY**

| Shipped By | Cooler ID(s) | Custody Seals Y N C B | Intact Y N | Receipt Temp °C | Temp Blank Y N | On Ice Y N | Payment Type CC Cash Check_____ | Amount $ | Receipt Number *(cash/check only)* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested.
This serves as notice of this possibility. All subcontracted data will be clearly notated on your analytical report.

# APPENDIX C

# DRAINAGE BASIN EXHIBITS

# Sediment Pond 1

**Region ID:**

SD

**Workspace ID:**

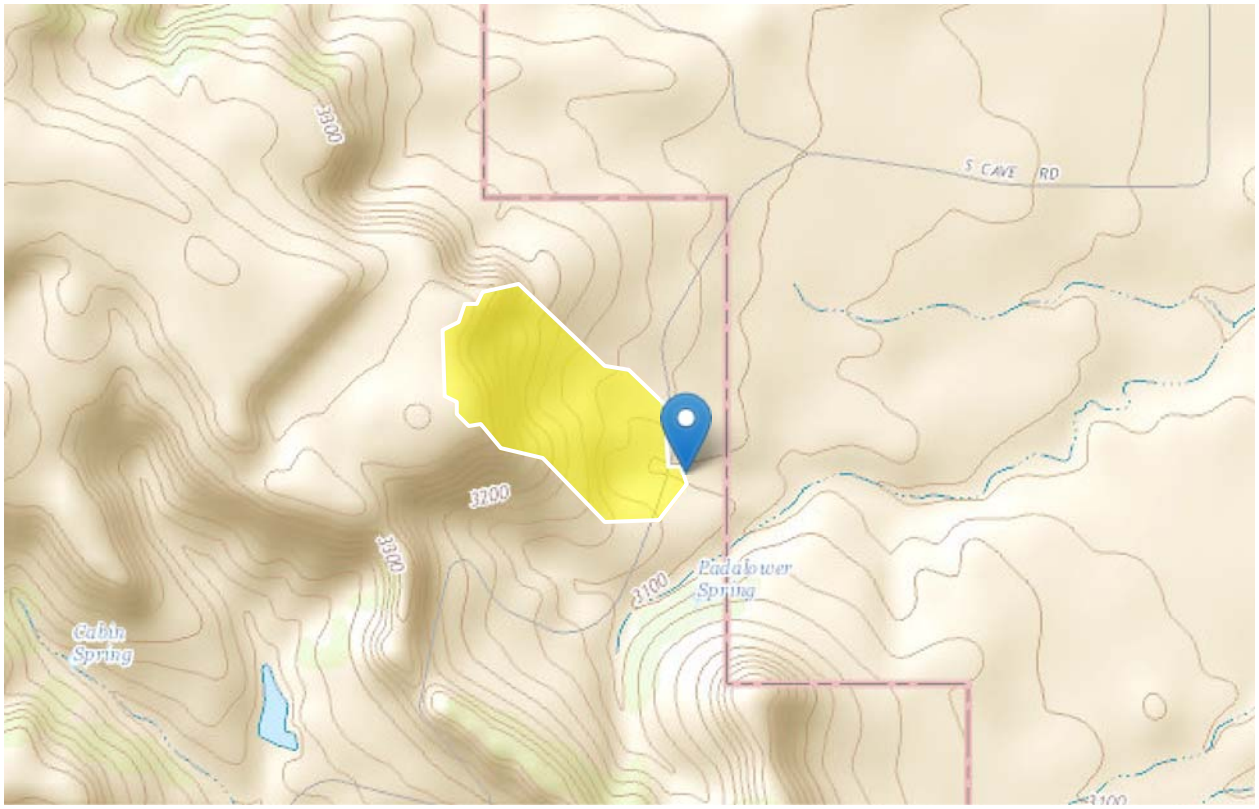
SD20161208100420928000

**Clicked Point (Latitude, Longitude):**

45.84478,-103.47089

**Time:**

2016-12-08 10:07:26 -0700



Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| CONTDA | Area that contributes flow to a point on a stream (total drainage area minus non-contributing areas within basin) | 0.03 | square miles |
| PII_SD | Maximum 24-hour precipitation that occurs on average once in 2 years minus 1.5 inches | 0 | inches |
| DRNAREA | Area that drains to a point on a stream | 0.03 | square miles |
| STORNWI | Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory | 0 | percent |

Peak-Flow Statistics Parameters [100.00 Percent Subregion C]

| Parameter | Value | Min Limit | Max Limit |
|---|---|---|---|
| Contributing Drainage Area | 0.03 | 0.06 | 904 |

Peak-Flow Statistics Disclaimers [100.00 Percent Subregion C]

**One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors**

Peak-Flow Statistics Flow Report [100.00 Percent Subregion C]

| Statistic | Value | Unit | Prediction Error |
|---|---|---|---|
| 2 Year Peak Flood | 3.4 | ft^3/s | -- |
| 5 Year Peak Flood | 9.552 | ft^3/s | -- |
| 10 Year Peak Flood | 16.412 | ft^3/s | -- |
| 25 Year Peak Flood | 27.756 | ft^3/s | -- |
| 50 Year Peak Flood | 38.755 | ft^3/s | -- |
| 100 Year Peak Flood | 52.082 | ft^3/s | -- |
| 500 Year Peak Flood | 94.503 | ft^3/s | -- |

Peak-Flow Statistics Citations

Sando, Steven K., 1998, A Method for Estimating Magnitude and Frequency of Floods in South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4055, 48 p.

# Sediment Pond 2

**Region ID:**

SD

**Workspace ID:**

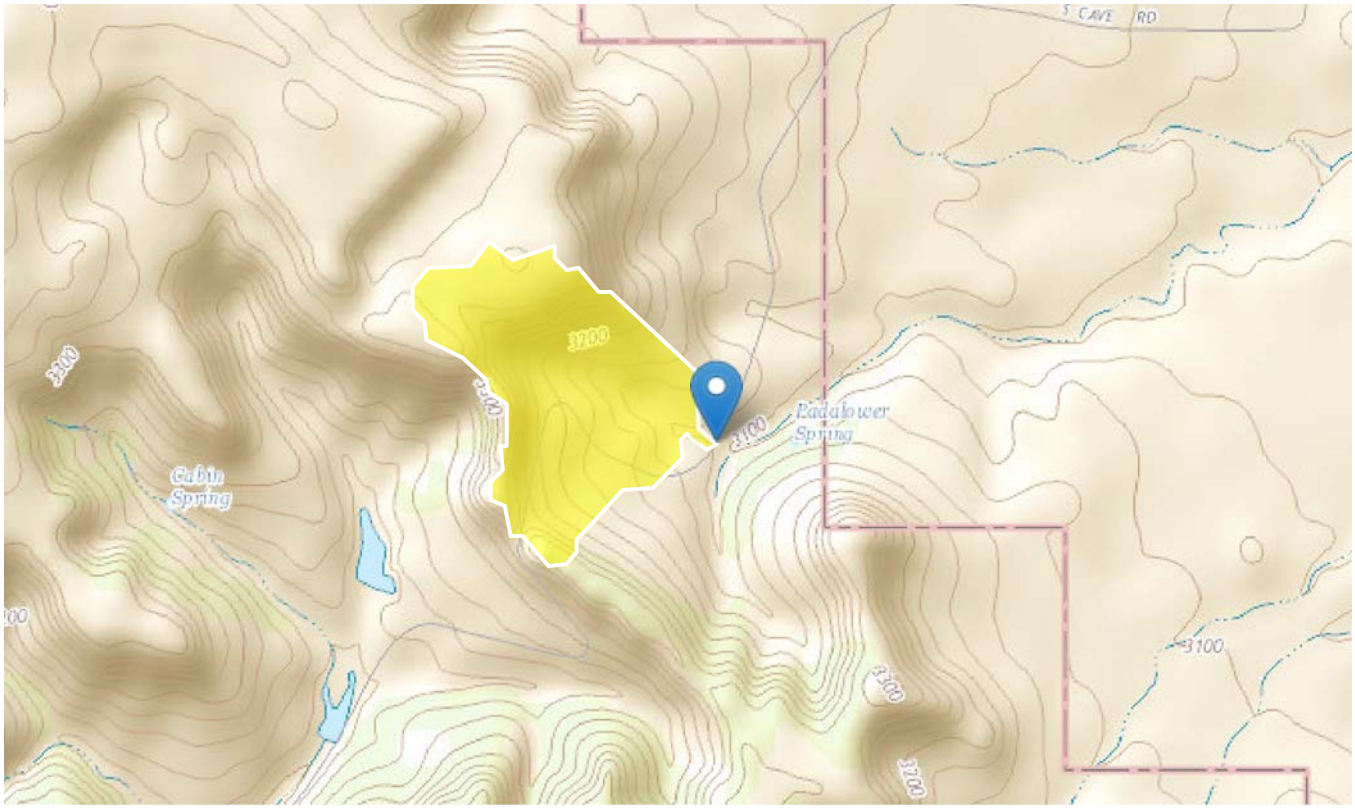
SD20161208101530607000

**Clicked Point (Latitude, Longitude):**

45.84288,-103.47186

**Time:**

2016-12-08 10:19:31 -0700



Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| CONTDA | Area that contributes flow to a point on a stream (total drainage area minus non-contributing areas within basin) | 0.05 | square miles |
| PII_SD | Maximum 24-hour precipitation that occurs on average once in 2 years minus 1.5 inches | 0 | inches |
| DRNAREA | Area that drains to a point on a stream | 0.05 | square miles |
| STORNWI | Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory | 0 | percent |

Peak-Flow Statistics Parameters [100.00 Percent Subregion C]

| Parameter | Value | Min Limit | Max Limit |
|---|---|---|---|
| Contributing Drainage Area | 0.05 | 0.06 | 904 |

Peak-Flow Statistics Disclaimers [100.00 Percent Subregion C]

**One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors**

Peak-Flow Statistics Flow Report [100.00 Percent Subregion C]

| Statistic | Value | Unit | Prediction Error |
|---|---|---|---|
| 2 Year Peak Flood | 4.546 | ft^3/s | -- |
| 5 Year Peak Flood | 12.833 | ft^3/s | -- |
| 10 Year Peak Flood | 22.06 | ft^3/s | -- |
| 25 Year Peak Flood | 37.195 | ft^3/s | -- |
| 50 Year Peak Flood | 51.854 | ft^3/s | -- |
| 100 Year Peak Flood | 69.543 | ft^3/s | -- |
| 500 Year Peak Flood | 126 | ft^3/s | -- |

Peak-Flow Statistics Citations

Sando, Steven K., 1998, A Method for Estimating Magnitude and Frequency of Floods in South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4055, 48 p.

# Sediment Pond 3

**Region ID:**

SD

**Workspace ID:**

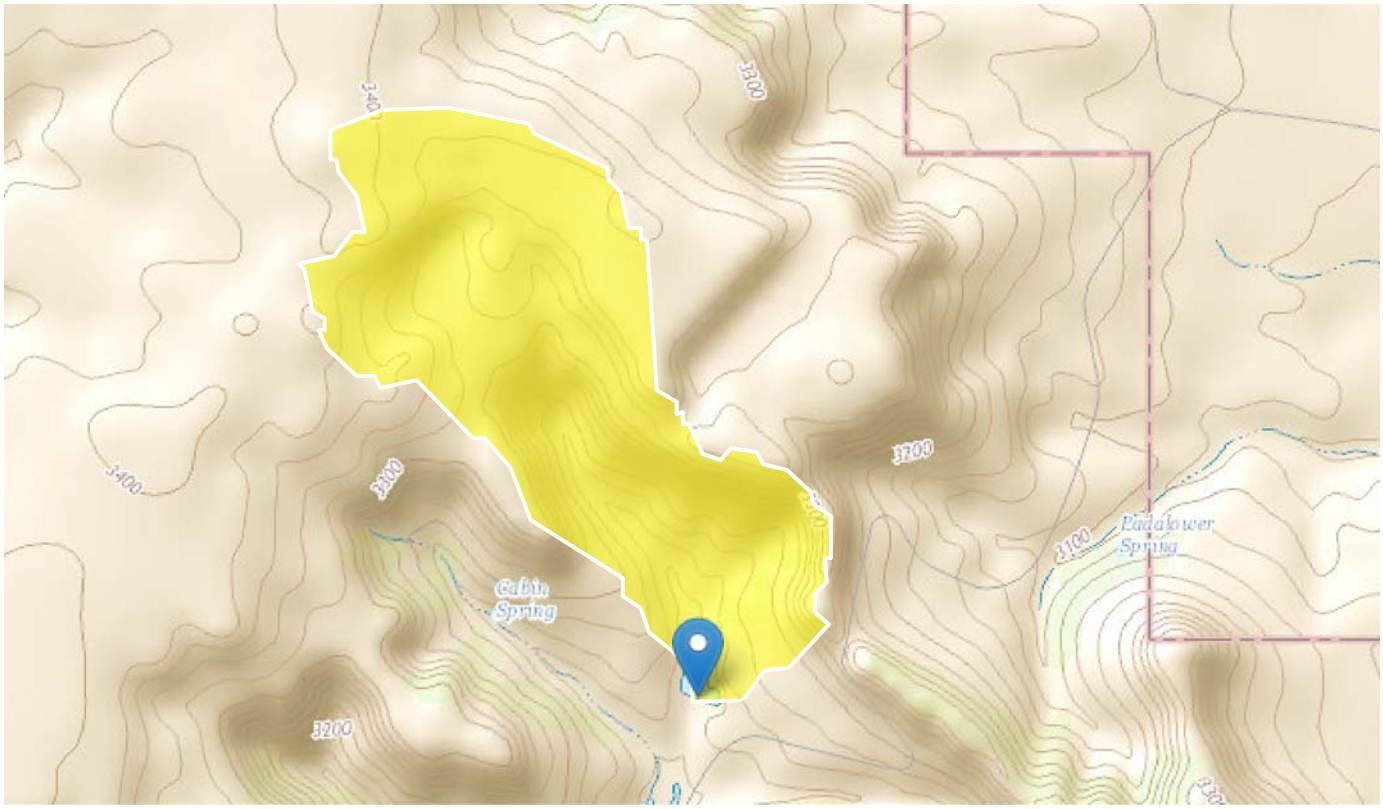
SD20161208082227944000

**Clicked Point (Latitude, Longitude):**

45.84070,-103.47924

**Time:**

2016-12-08 08:22:57 -0700



Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| CONTDA | Area that contributes flow to a point on a stream (total drainage area minus non-contributing areas within basin) | 0.15 | square miles |
| DRNAREA | Area that drains to a point on a stream | 0.15 | square miles |
| PII_SD | Maximum 24-hour precipitation that occurs on average once in 2 years minus 1.5 inches | 0 | inches |
| STORNWI | Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory | 0.754 | percent |

Peak-Flow Statistics Parameters [100.00 Percent Subregion C]

| Parameter | Value | Min Limit | Max Limit |
|---|---|---|---|
| Contributing Drainage Area | 0.15 | 0.06 | 904 |

Peak-Flow Statistics Flow Report [100.00 Percent Subregion C]

| Statistic | Value | Unit | Prediction Error |
|---|---|---|---|
| 2 Year Peak Flood | 8.494 | ft^3/s | 108 |
| 5 Year Peak Flood | 24.217 | ft^3/s | 67 |
| 10 Year Peak Flood | 41.674 | ft^3/s | 58 |
| 25 Year Peak Flood | 69.802 | ft^3/s | 53 |
| 50 Year Peak Flood | 96.992 | ft^3/s | 53 |
| 100 Year Peak Flood | 130 | ft^3/s | 55 |
| 500 Year Peak Flood | 231 | ft^3/s | 65 |

Peak-Flow Statistics Citations

**Sando, Steven K., 1998, A Method for Estimating Magnitude and Frequency of Floods in South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4055, 48 p. (http://pubs.water.usgs.gov/wri98-4055/)**

# Sediment Pond 4

**Region ID:**

SD

**Workspace ID:**

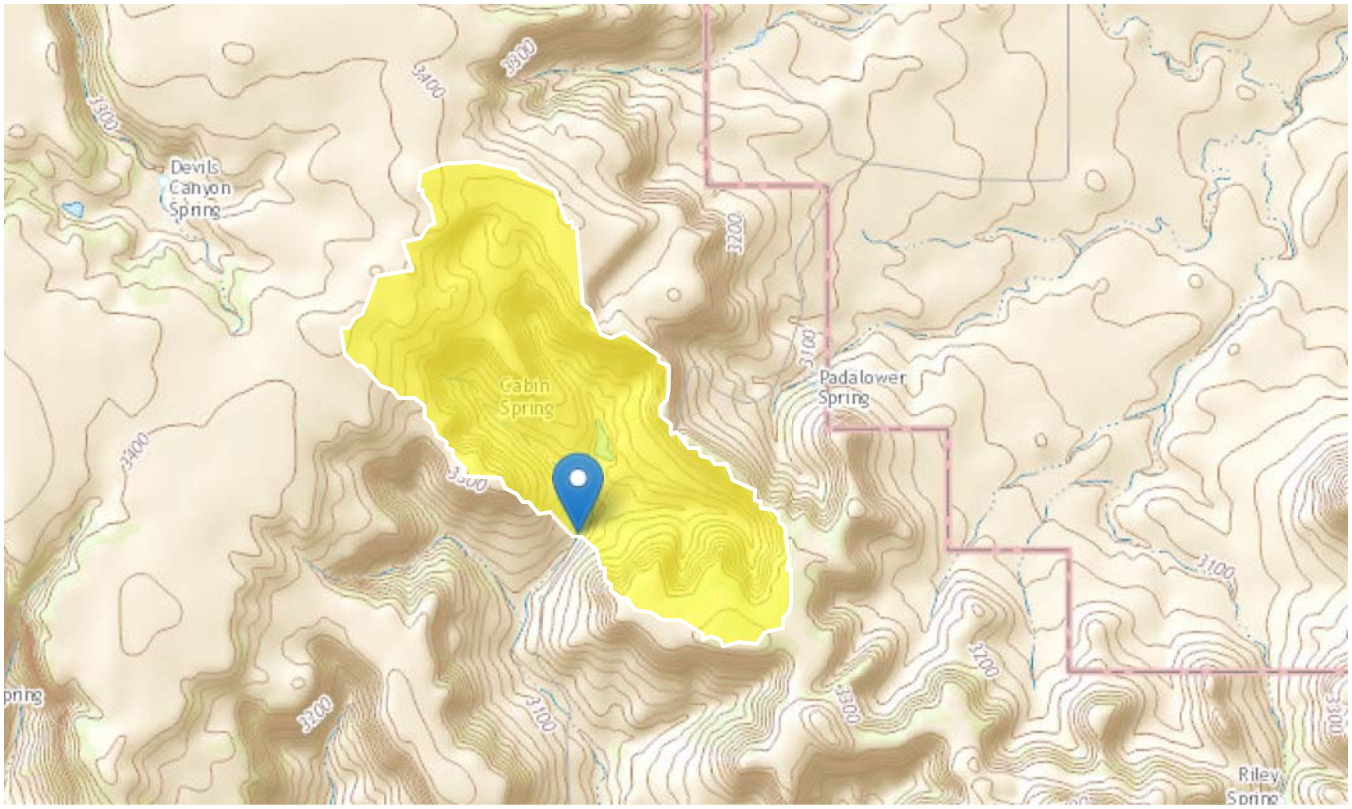
SD20161208103028900000

**Clicked Point (Latitude, Longitude):**

45.83837,-103.48022

**Time:**

2016-12-08 10:35:54 -0700



Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| CONTDA | Area that contributes flow to a point on a stream (total drainage area minus non-contributing areas within basin) | 0.42 | square miles |
| PII_SD | Maximum 24-hour precipitation that occurs on average once in 2 years minus 1.5 inches | 0 | inches |
| DRNAREA | Area that drains to a point on a stream | 0.42 | square miles |
| STORNWI | Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory | 0.279 | percent |

Peak-Flow Statistics Parameters [100.00 Percent Subregion C]

| Parameter | Value | Min Limit | Max Limit |
|---|---|---|---|
| Contributing Drainage Area | 0.42 | 0.06 | 904 |

Peak-Flow Statistics Flow Report [100.00 Percent Subregion C]

| Statistic | Value | Unit | Prediction Error |
|---|---|---|---|
| 2 Year Peak Flood | 15.261 | ft^3/s | 108 |
| 5 Year Peak Flood | 43.911 | ft^3/s | 67 |
| 10 Year Peak Flood | 75.643 | ft^3/s | 58 |
| 25 Year Peak Flood | 126 | ft^3/s | 53 |
| 50 Year Peak Flood | 174 | ft^3/s | 53 |
| 100 Year Peak Flood | 232 | ft^3/s | 55 |
| 500 Year Peak Flood | 410 | ft^3/s | 65 |

Peak-Flow Statistics Citations

**Sando, Steven K., 1998, A Method for Estimating Magnitude and Frequency of Floods in South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4055, 48 p. (http://pubs.water.usgs.gov/wri98-4055/)**

# Sediment Pond 5

**Region ID:**

SD

**Workspace ID:**

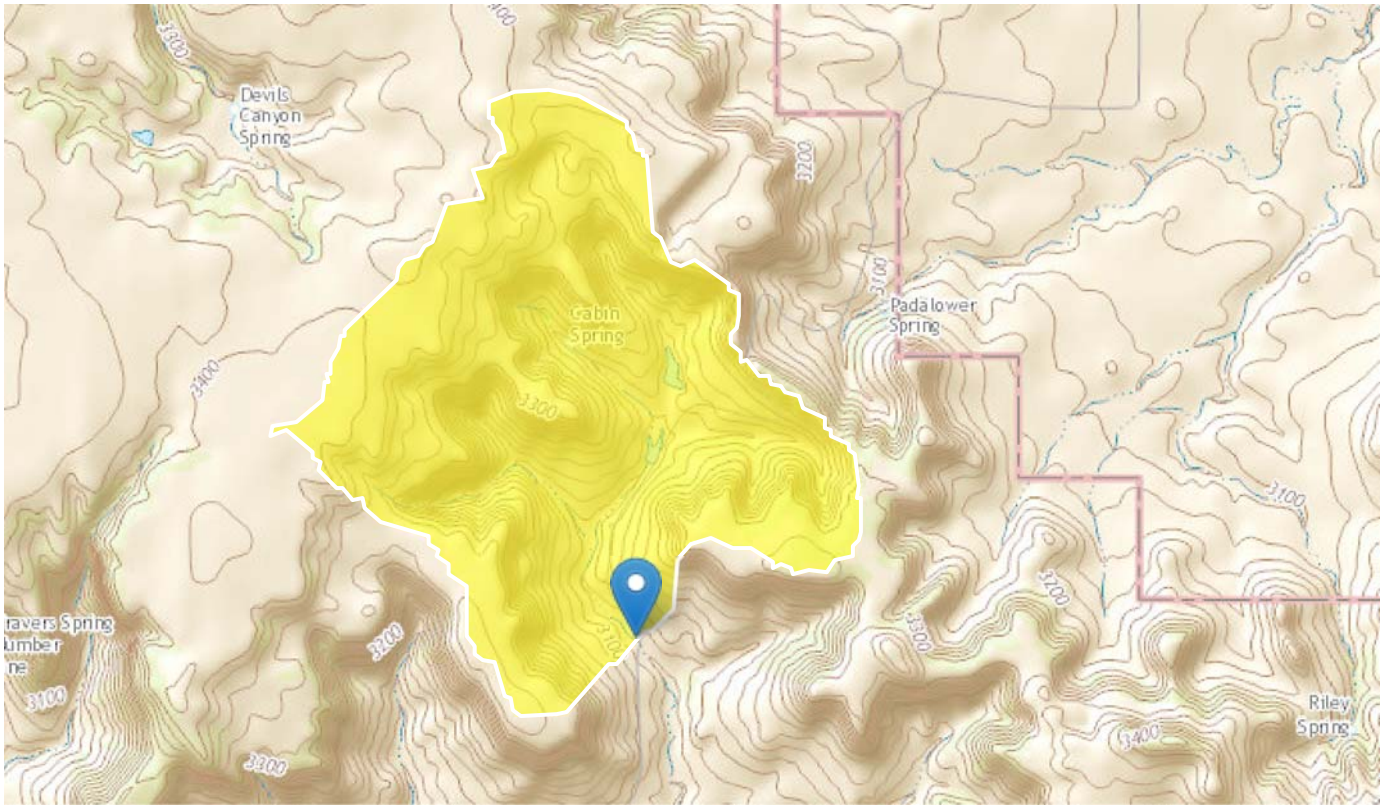
SD20161208122752021000

**Clicked Point (Latitude, Longitude):**

45.83314,-103.48070

**Time:**

2016-12-08 12:28:18 -0700



Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| CONTDA | Area that contributes flow to a point on a stream (total drainage area minus non-contributing areas within basin) | 0.79 | square miles |
| PII_SD | Maximum 24-hour precipitation that occurs on average once in 2 years minus 1.5 inches | 0 | inches |
| DRNAREA | Area that drains to a point on a stream | 0.79 | square miles |
| STORNWI | Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory | 0.146 | percent |

Peak-Flow Statistics Parameters [100.00 Percent Subregion C]

| Parameter | Value | Min Limit | Max Limit |
|---|---|---|---|
| Contributing Drainage Area | 0.79 | 0.06 | 904 |

Peak-Flow Statistics Flow Report [100.00 Percent Subregion C]

| Statistic | Value | Unit | Prediction Error |
|---|---|---|---|
| 2 Year Peak Flood | 21.862 | ft^3/s | 108 |
| 5 Year Peak Flood | 63.265 | ft^3/s | 67 |
| 10 Year Peak Flood | 109 | ft^3/s | 58 |
| 25 Year Peak Flood | 181 | ft^3/s | 53 |
| 50 Year Peak Flood | 250 | ft^3/s | 53 |
| 100 Year Peak Flood | 332 | ft^3/s | 55 |
| 500 Year Peak Flood | 582 | ft^3/s | 65 |

Peak-Flow Statistics Citations

**Sando, Steven K., 1998, A Method for Estimating Magnitude and Frequency of Floods in South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4055, 48 p. (http://pubs.water.usgs.gov/wri98-4055/)**

# Upper Schleichart Draw Reservoir

**Region ID:**

SD

**Workspace ID:**

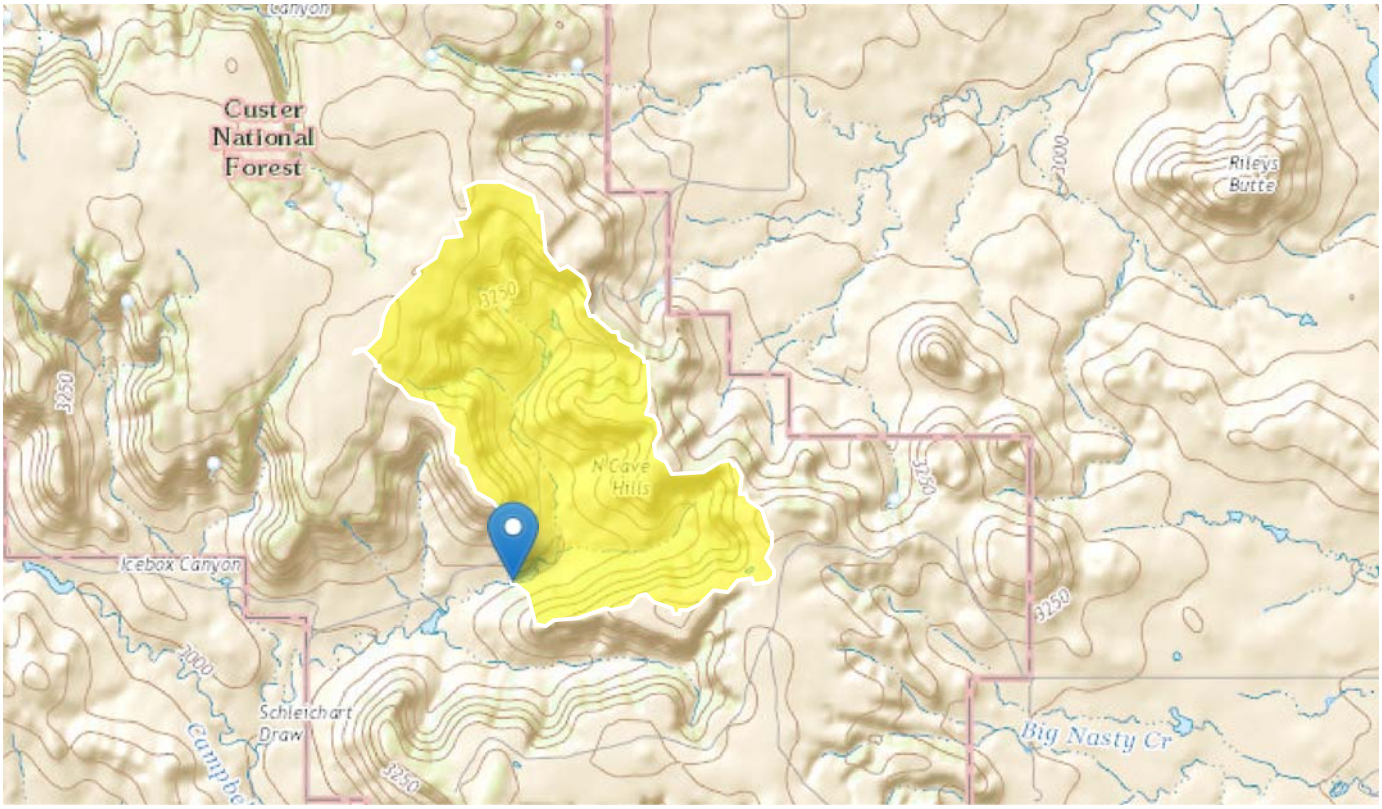
SD20161208123052978000

**Clicked Point (Latitude, Longitude):**

45.82551,-103.48301

**Time:**

2016-12-08 12:31:18 -0700



Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| CONTDA | Area that contributes flow to a point on a stream (total drainage area minus non-contributing areas within basin) | 1.48 | square miles |
| PII_SD | Maximum 24-hour precipitation that occurs on average once in 2 years minus 1.5 inches | 0 | inches |
| DRNAREA | Area that drains to a point on a stream | 1.48 | square miles |
| STORNWI | Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory | 0.618 | percent |

Peak-Flow Statistics Parameters [100.00 Percent Subregion C]

| Parameter | Value | Min Limit | Max Limit |
|---|---|---|---|
| Contributing Drainage Area | 1.48 | 0.06 | 904 |

Peak-Flow Statistics Flow Report [100.00 Percent Subregion C]

| Statistic | Value | Unit | Prediction Error |
|---|---|---|---|
| 2 Year Peak Flood | 31.248 | ft^3/s | 108 |
| 5 Year Peak Flood | 90.939 | ft^3/s | 67 |
| 10 Year Peak Flood | 157 | ft^3/s | 58 |
| 25 Year Peak Flood | 259 | ft^3/s | 53 |
| 50 Year Peak Flood | 358 | ft^3/s | 53 |
| 100 Year Peak Flood | 473 | ft^3/s | 55 |
| 500 Year Peak Flood | 826 | ft^3/s | 65 |

Peak-Flow Statistics Citations

**Sando, Steven K., 1998, A Method for Estimating Magnitude and Frequency of Floods in South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4055, 48 p. (http://pubs.water.usgs.gov/wri98-4055/)**

# Lower Schleichart Draw Reservoir

**Region ID:**

SD

**Workspace ID:**

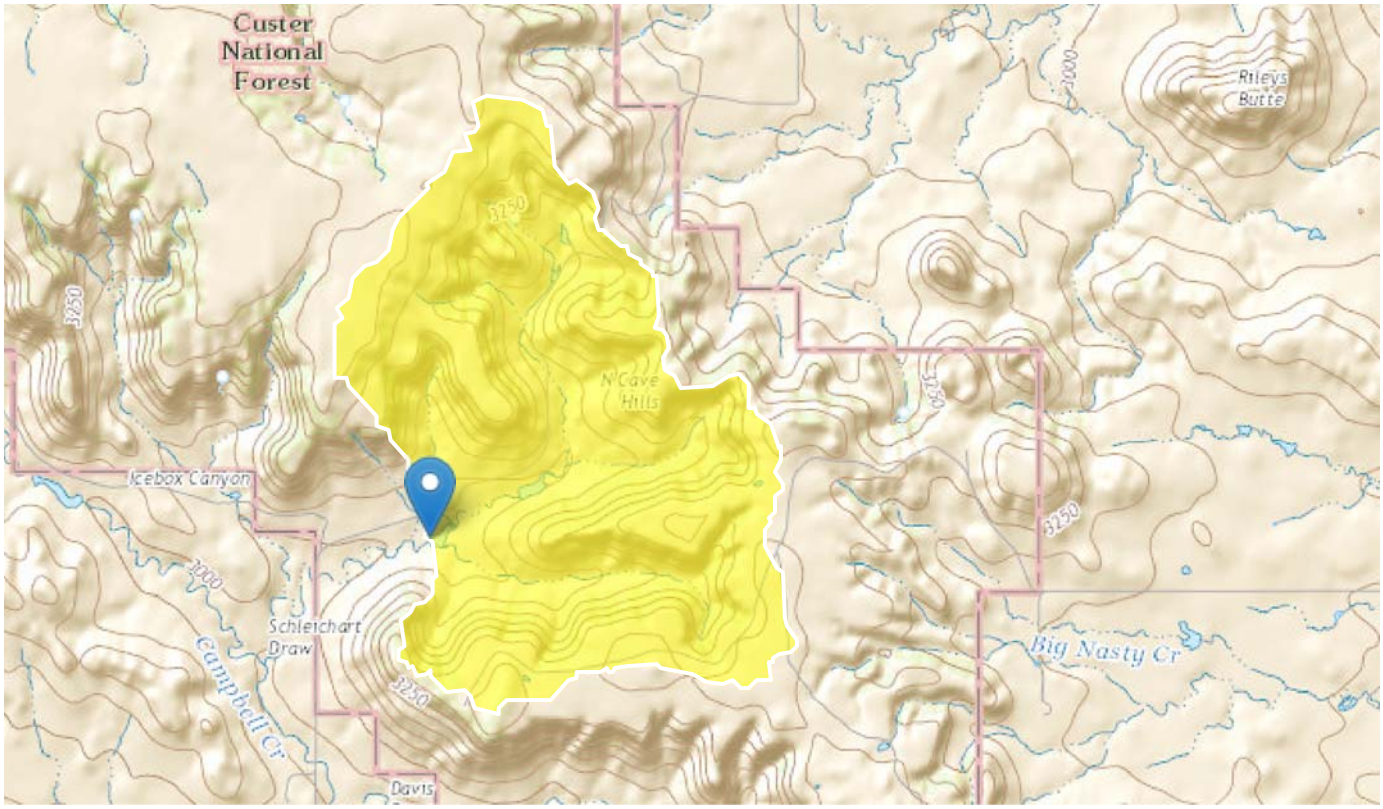
SD20161208123321637000

**Clicked Point (Latitude, Longitude):**

45.82297,-103.49082

**Time:**

2016-12-08 12:33:50 -0700



Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| CONTDA | Area that contributes flow to a point on a stream (total drainage area minus non-contributing areas within basin) | 2.95 | square miles |
| PII_SD | Maximum 24-hour precipitation that occurs on average once in 2 years minus 1.5 inches | 0 | inches |
| DRNAREA | Area that drains to a point on a stream | 2.95 | square miles |
| STORNWI | Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory | 0.388 | percent |

Peak-Flow Statistics Parameters [100.00 Percent Subregion C]

| Parameter | Value | Min Limit | Max Limit |
|---|---|---|---|
| Contributing Drainage Area | 2.95 | 0.06 | 904 |

Peak-Flow Statistics Flow Report [100.00 Percent Subregion C]

| Statistic | Value | Unit | Prediction Error |
|---|---|---|---|
| 2 Year Peak Flood | 46.267 | ft^3/s | 108 |
| 5 Year Peak Flood | 135 | ft^3/s | 67 |
| 10 Year Peak Flood | 234 | ft^3/s | 58 |
| 25 Year Peak Flood | 385 | ft^3/s | 53 |
| 50 Year Peak Flood | 530 | ft^3/s | 53 |
| 100 Year Peak Flood | 699 | ft^3/s | 55 |
| 500 Year Peak Flood | 1210 | ft^3/s | 65 |

Peak-Flow Statistics Citations

**Sando, Steven K., 1998, A Method for Estimating Magnitude and Frequency of Floods in South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4055, 48 p. (http://pubs.water.usgs.gov/wri98-4055/)**

# Browns Pond

**Region ID:**

SD

**Workspace ID:**

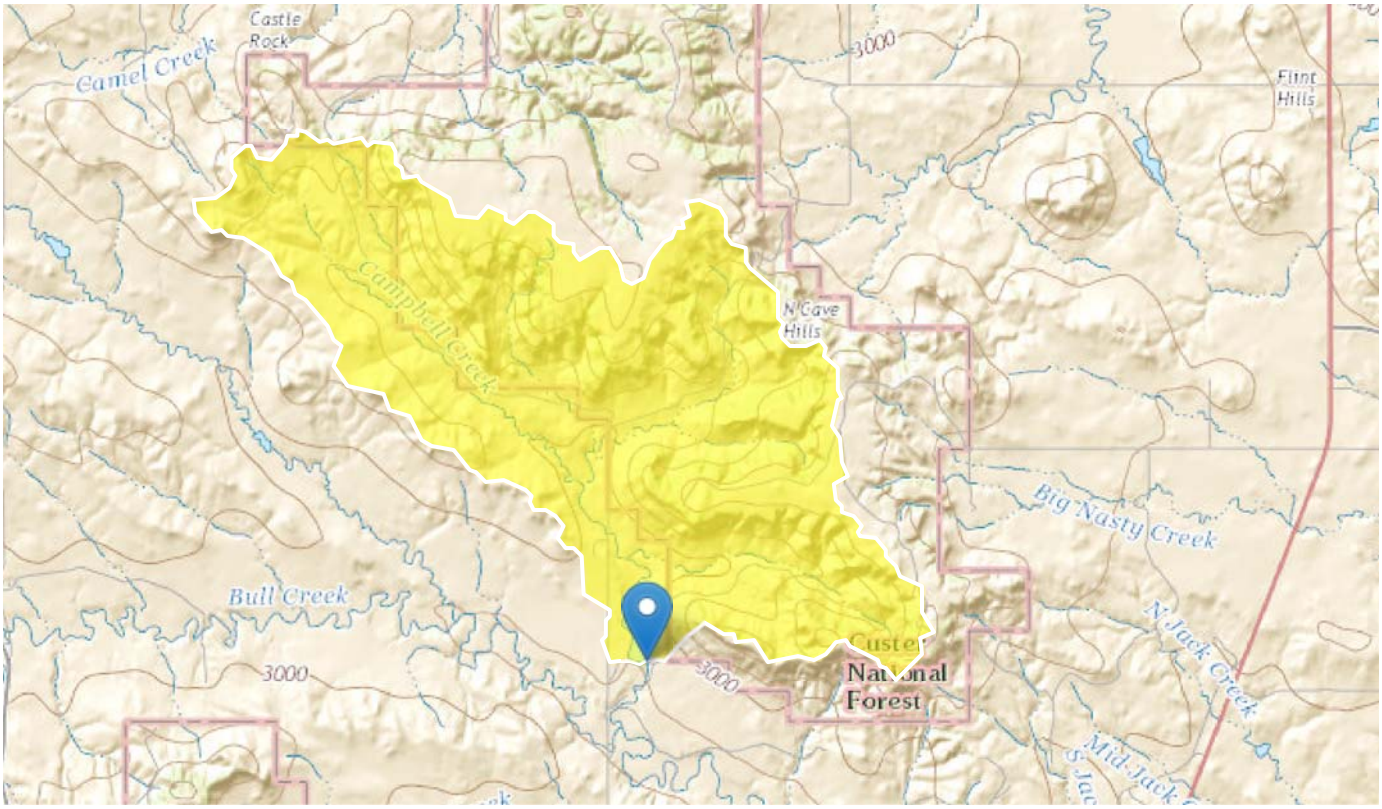
SD20161208123828706000

**Clicked Point (Latitude, Longitude):**

45.79446,-103.49409

**Time:**

2016-12-08 12:38:54 -0700



Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| CONTDA | Area that contributes flow to a point on a stream (total drainage area minus non-contributing areas within basin) | 12.65 | square miles |
| PII_SD | Maximum 24-hour precipitation that occurs on average once in 2 years minus 1.5 inches | 0 | inches |
| DRNAREA | Area that drains to a point on a stream | 12.65 | square miles |
| STORNWI | Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory | 0.791 | percent |

Peak-Flow Statistics Parameters [100.00 Percent Subregion C]

| Parameter | Value | Min Limit | Max Limit |
|---|---|---|---|
| Contributing Drainage Area | 12.65 | 0.06 | 904 |

Peak-Flow Statistics Flow Report [100.00 Percent Subregion C]

| Statistic | Value | Unit | Prediction Error |
|---|---|---|---|
| 2 Year Peak Flood | 106 | ft^3/s | 108 |
| 5 Year Peak Flood | 314 | ft^3/s | 67 |
| 10 Year Peak Flood | 543 | ft^3/s | 58 |
| 25 Year Peak Flood | 886 | ft^3/s | 53 |
| 50 Year Peak Flood | 1210 | ft^3/s | 53 |
| 100 Year Peak Flood | 1590 | ft^3/s | 55 |
| 500 Year Peak Flood | 2720 | ft^3/s | 65 |

Peak-Flow Statistics Citations

**Sando, Steven K., 1998, A Method for Estimating Magnitude and Frequency of Floods in South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4055, 48 p. (http://pubs.water.usgs.gov/wri98-4055/)**

# APPENDIX D

## SITE PHOTOS

Terracon Bore Hole Drilling Rig – Looking North - October 24, 2016

**Location:**

45° 50’ 24.57”N

103° 28’ 58.50” W


Test Pit 1 – Excavating into adjacent Hillside – Looking North - October 24, 2016

**Location:**

45° 50’ 24.57”N

103° 28’ 58.50” W

Drainage Hole above Road Failure – Looking East - October 24, 2016

**Location:**

45° 50’ 23.97”N

103° 28’ 59.98” W

Overlook of Pond 4 while BH-SP4 is being drilled – Looking East - October 24, 2016

**Location:**

45° 50’ 23.14”N

103° 28’ 59.01” W

| Upper Sediment Repository Bluff – Looking Northwest – October, 25 2016 | |
|---|---|
| **Location:**<br><br>45° 50’ 50.95”N<br><br>103° 29’ 06.82” W |  |
| Upper Sediment Repository Dry Pond – Looking Southwest - October, 25 2016 | |
| **Location:**<br><br>45° 50’ 51.47”N<br><br>103° 29’ 01.08” W |  |

Test Pit 9 – Excavating into Pond 5 – Looking East - October, 25 2016

**Location:**

45° 49’ 58.26”N

103° 28’ 51.69” W

Test Pit 10 – Excavation into Upper Schleichart – Looking South - October, 25 2016

**Location:**

45° 49’ 32.25”N

103° 28’ 58.96” W

| Test Pit 11 – Excavating into Lower Schleichart – Looking East - October, 25 2016 | |
|---|---|
| **Location:**<br><br>45° 49’ 23.75”N<br><br>103° 29’ 24.78” W |  |
| Test Pit 8 – Excavation Upstream of Pond 5 – Looking West - October, 26 2016 | |
| **Location:**<br><br>45° 50’ 03.50”N<br><br>103° 28’ 57.01” W |  |

Test Pit 18 – Excavating into Pond 3 – Looking West - October, 26 2016

**Location:**

45° 50’ 29.61”N

103° 28’ 45.52” W

Test Pit 20 – Excavation into Pond 1 – Looking West - October, 26 2016

**Location:**

45° 50’ 41.40”N

103° 28’ 16.00” W

Hand Auger 2 Location at Pond 2 – Looking East - October, 25 2016

**Location:**

45° 50’ 34.89”N

103° 28’ 19.90” W

Hand Auger 7 Location at Browns Pond – Looking North - October, 25 2016

**Location:**

45° 47’ 42.37”N

103° 29’ 49.16” W

# LIST OF ATTACHMENTS

1 - Existing Conditions Sheets

- C1-1 – Pond 1 Plan and Profile
- C1-2 – Pond 2 Plan and Profile
- C1-3 – Pond 3 Plan and Profile
- C1-4 – Pond 4 Plan and Profile
- C1-5 – Pond 5 Plan and Profile
- C1-6 – Upper Schleichart Plan and Profile
- C1-7 – Upper Schleichart Plan and Profile
- C1-8 – Brown's Pond Plan and Profile

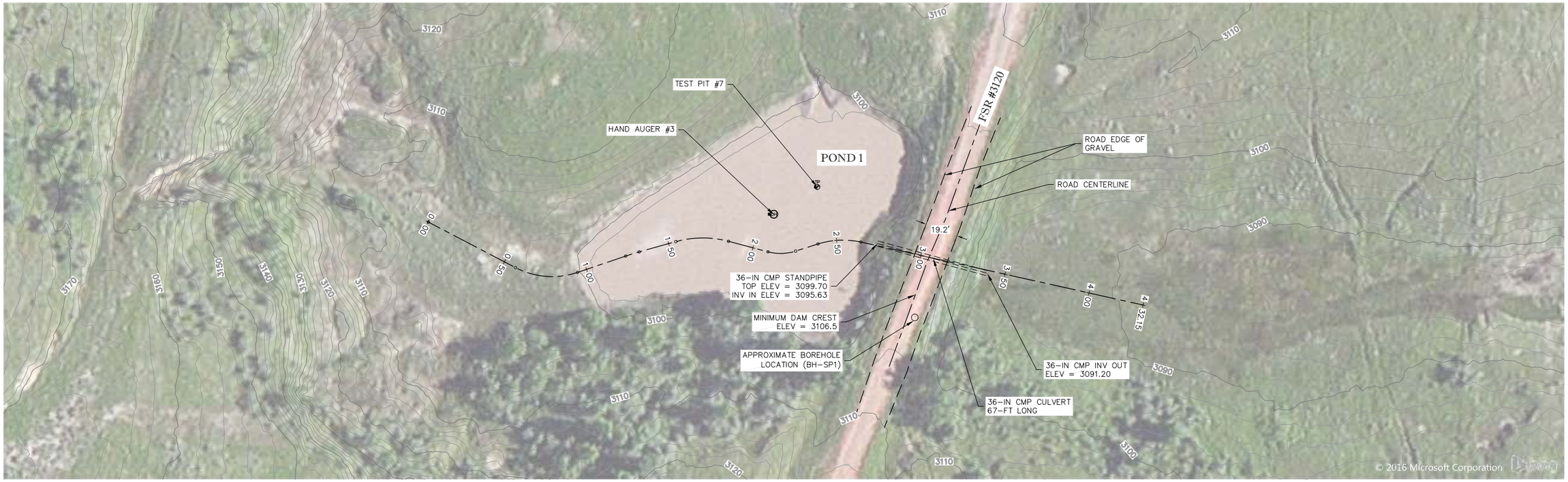
2 - Preliminary Sediment Volume Exhibits

- S-1 – Pond 1 Sediment Volume Estimation
- S-2 – Pond 2 Sediment Volume Estimation
- S-3 – Pond 3 Sediment Volume Estimation
- S-4 – Pond 4 Sediment Volume Estimation
- S-5 – Pond 5 Sediment Volume Estimation
- S-6 – Upper Schleichart Sediment Volume Estimation
- S-7 – Lower Schleichart Sediment Volume Estimation
- S-8 – Brown's Pond Sediment Volume Estimation

# ATTACHMENT 1

## EXISTING CONDITIONS SHEETS

- C1-1 – Pond 1 Plan and Profile
- C1-2 – Pond 2 Plan and Profile
- C1-3 – Pond 3 Plan and Profile
- C1-4 – Pond 4 Plan and Profile
- C1-5 – Pond 5 Plan and Profile
- C1-6 – Upper Schleichart Plan and Profile
- C1-7 – Upper Schleichart Plan and Profile
- C1-8 – Brown's Pond Plan and Profile

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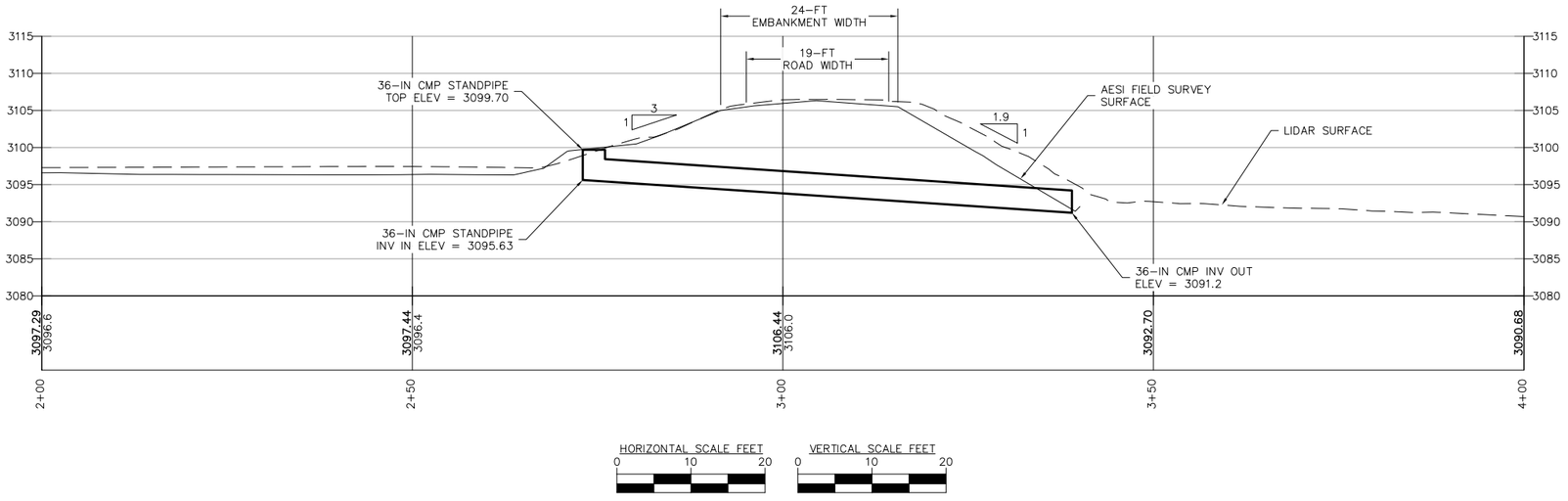
POND 1 – LOOKING WEST

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# RILEY PASS SEDIMENT POND CLEANOUT
## POND 1 - EXISTING CONDITIONS
### CUSTER GALLATIN NATIONAL FOREST, SOUTH DAKOTA


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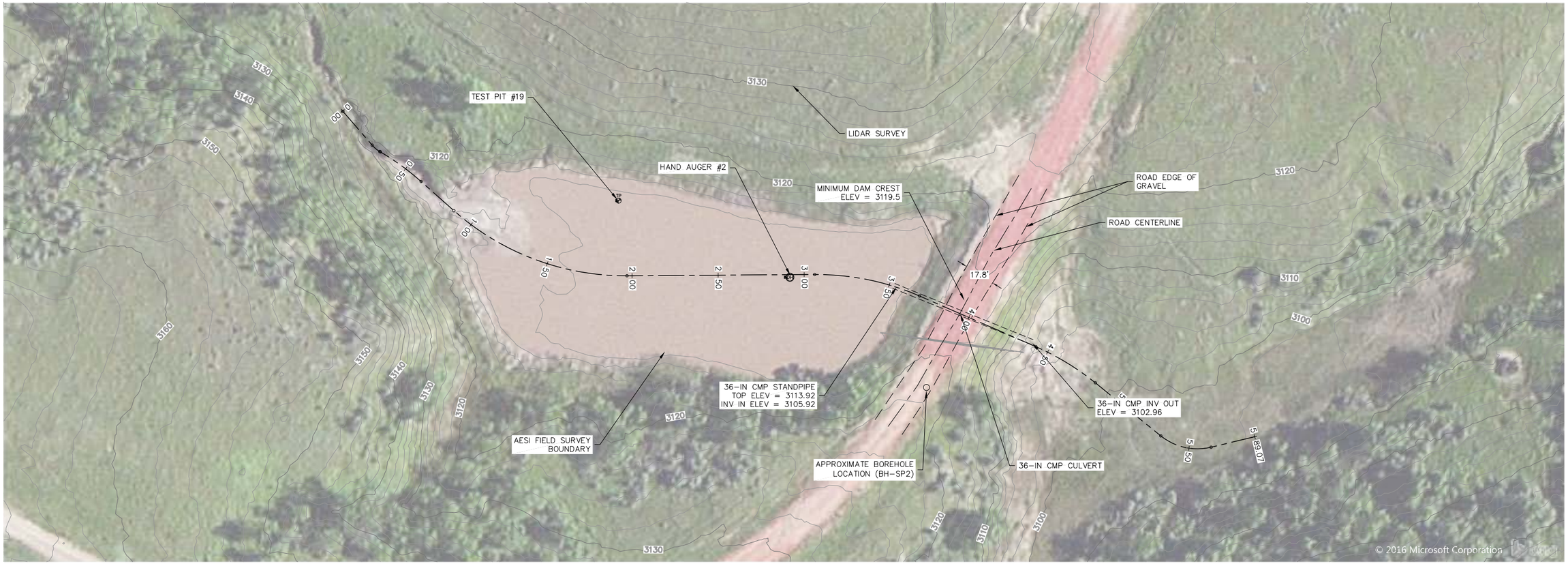


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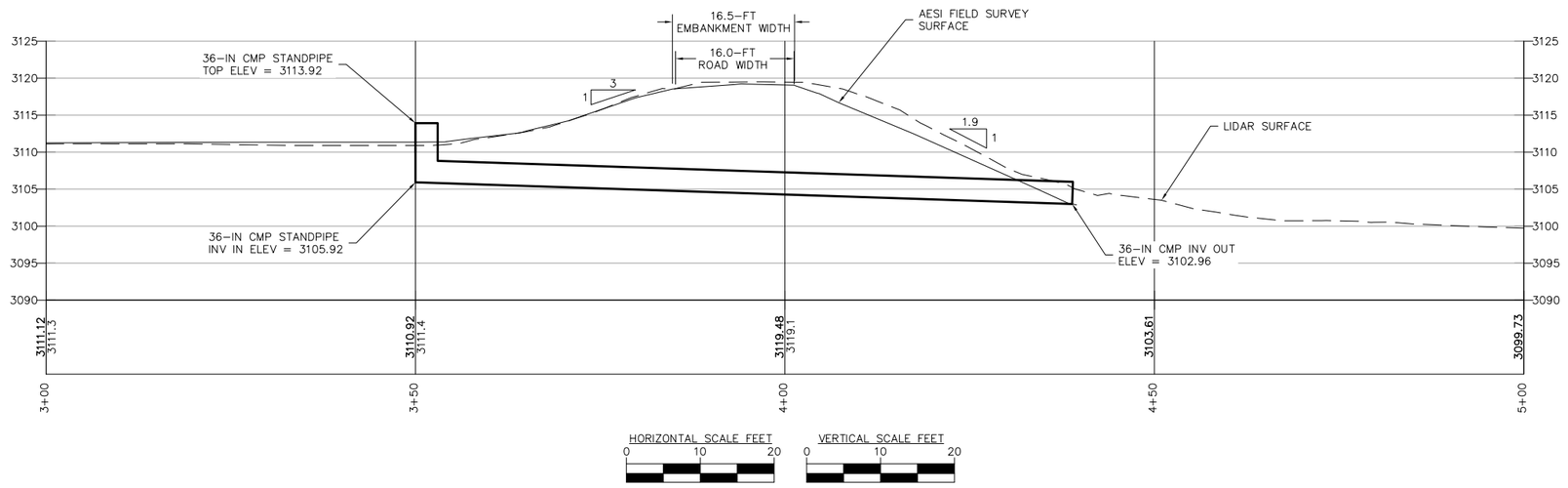


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# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## POND 2 - EXISTING CONDITIONS
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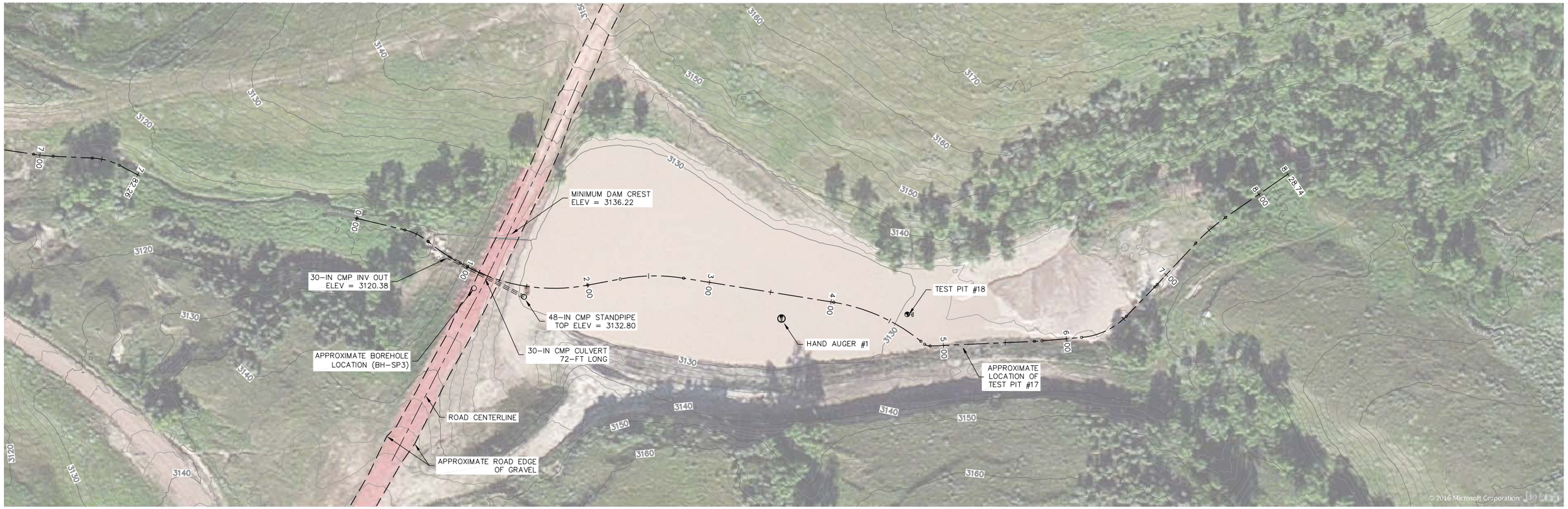
SHEET
C1-2




POND 3 – LOOKING NORTH

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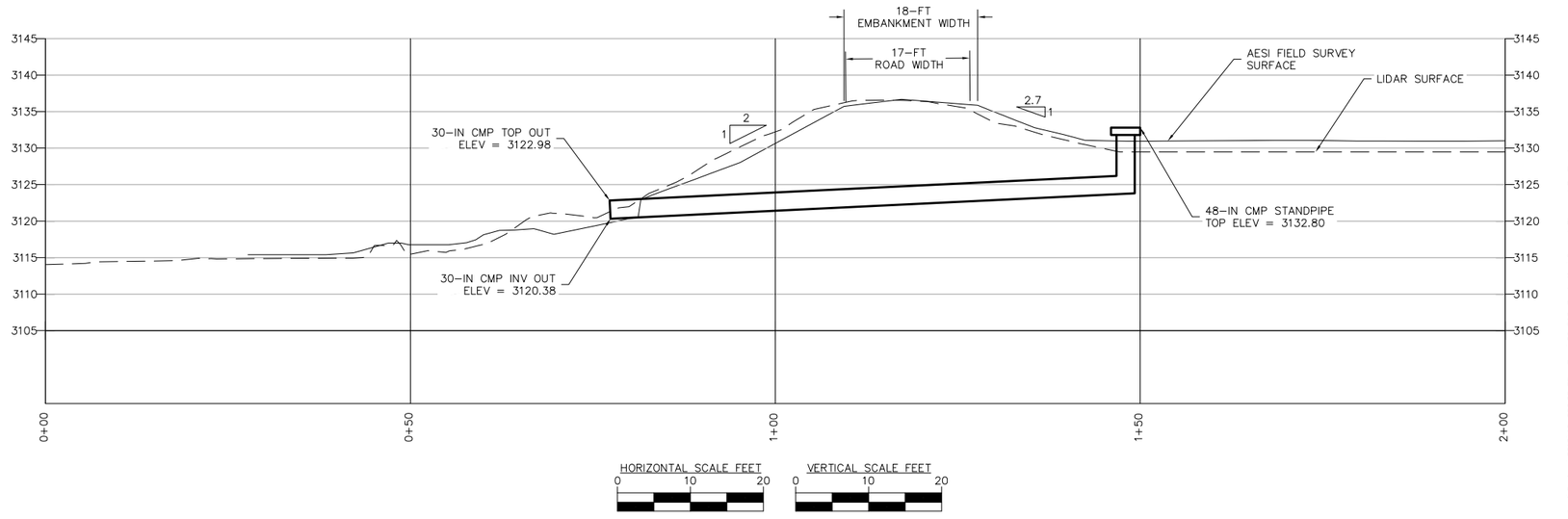


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# RILEY PASS SEDIMENT POND CLEANOUT
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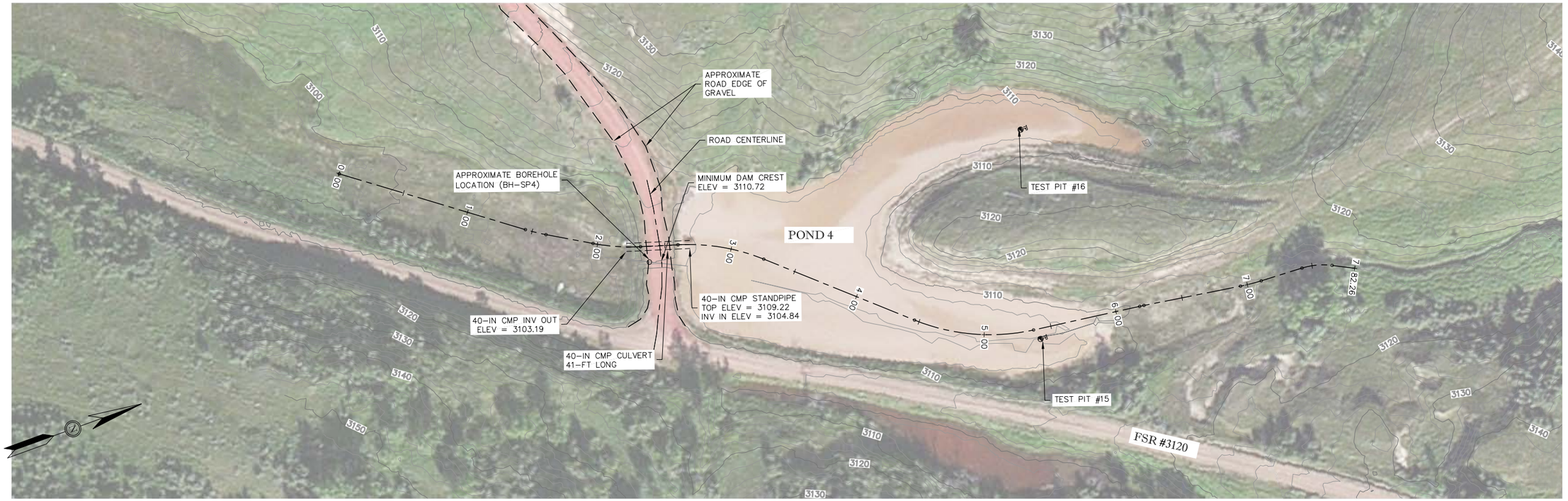


POND 4 – LOOKING NORTH

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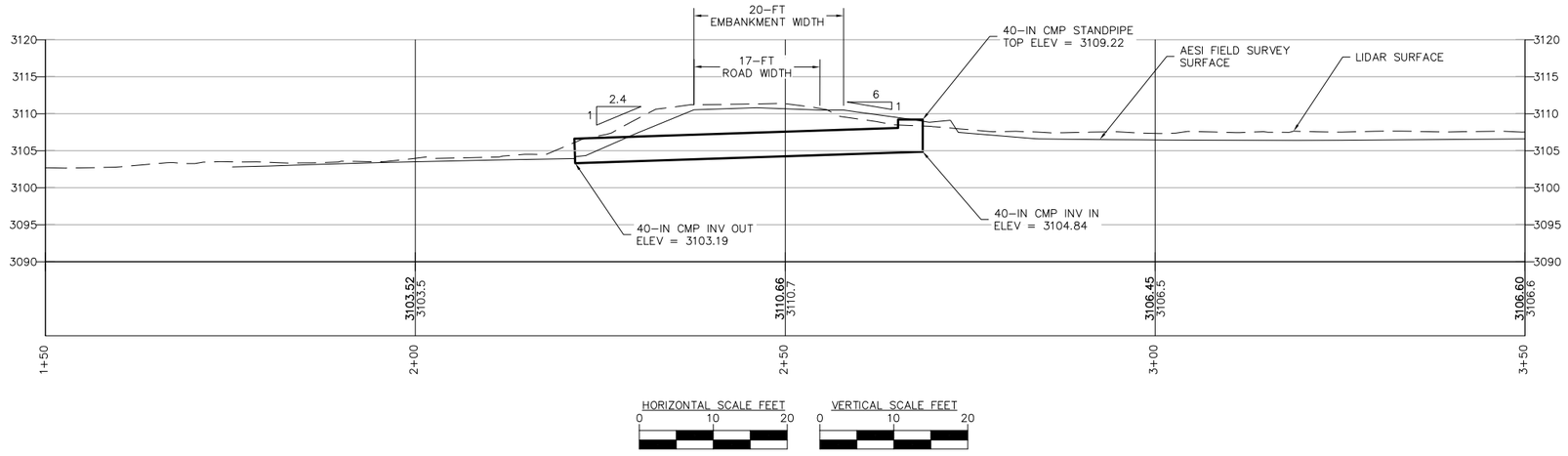


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# RILEY PASS SEDIMENT POND CLEANOUT
## POND 4 - EMBANKMENT PLAN AND PROFILE
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| PLAN AND PROFILES | |

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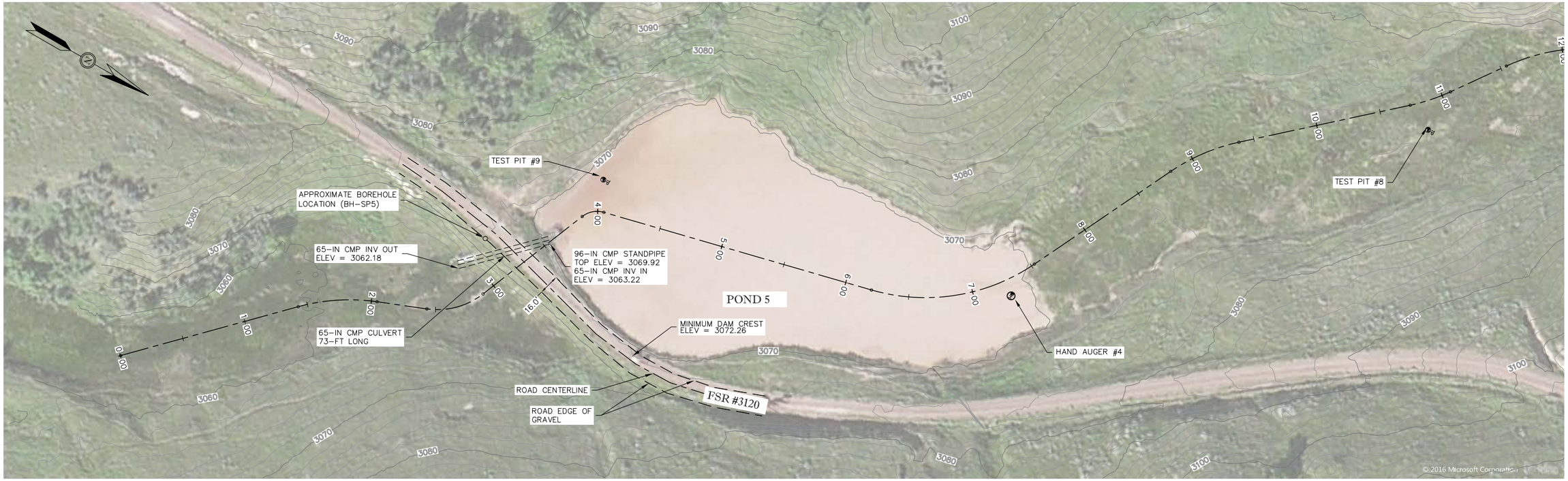


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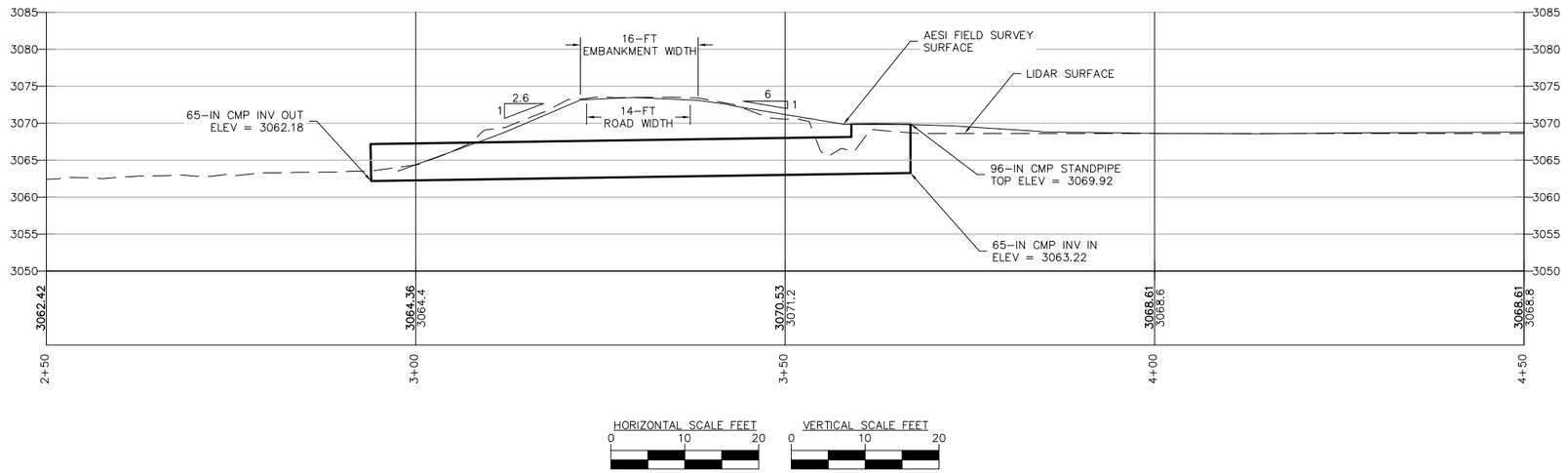
SCALE (FEET)

POND 5 – LOOKING SOUTHWEST

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# RILEY PASS SEDIMENT POND CLEANOUT
## POND 5 - EXISTING CONDITIONS
### CUSTER GALLATIN NATIONAL FOREST, SOUTH DAKOTA

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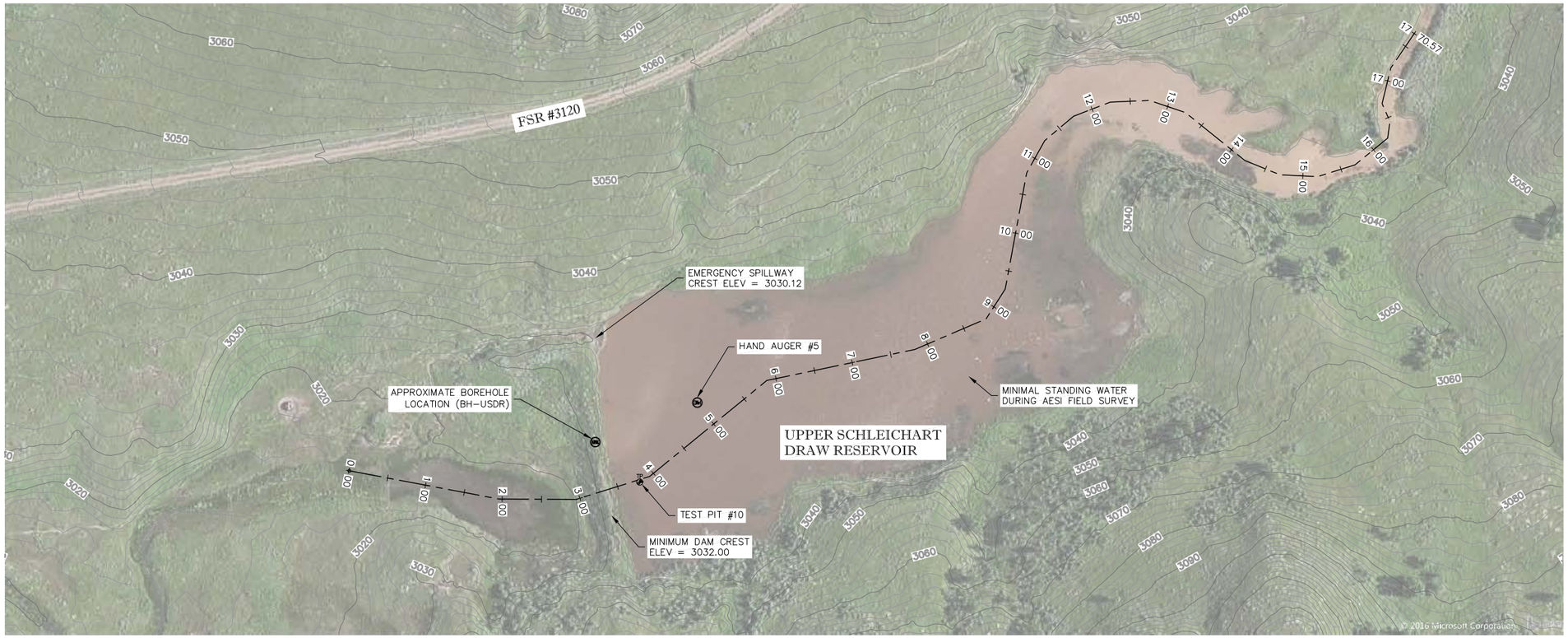


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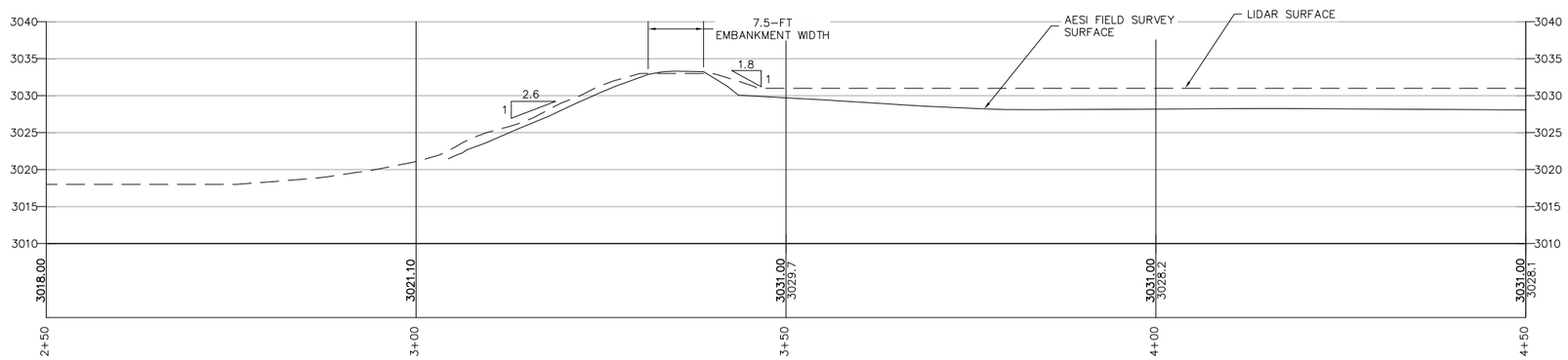
UPPER SCHLEICHART – LOOKING SOUTH

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# RILEY PASS SEDIMENT POND CLEANOUT
## UPPER SCHLEICHART - EXISTING CONDITIONS
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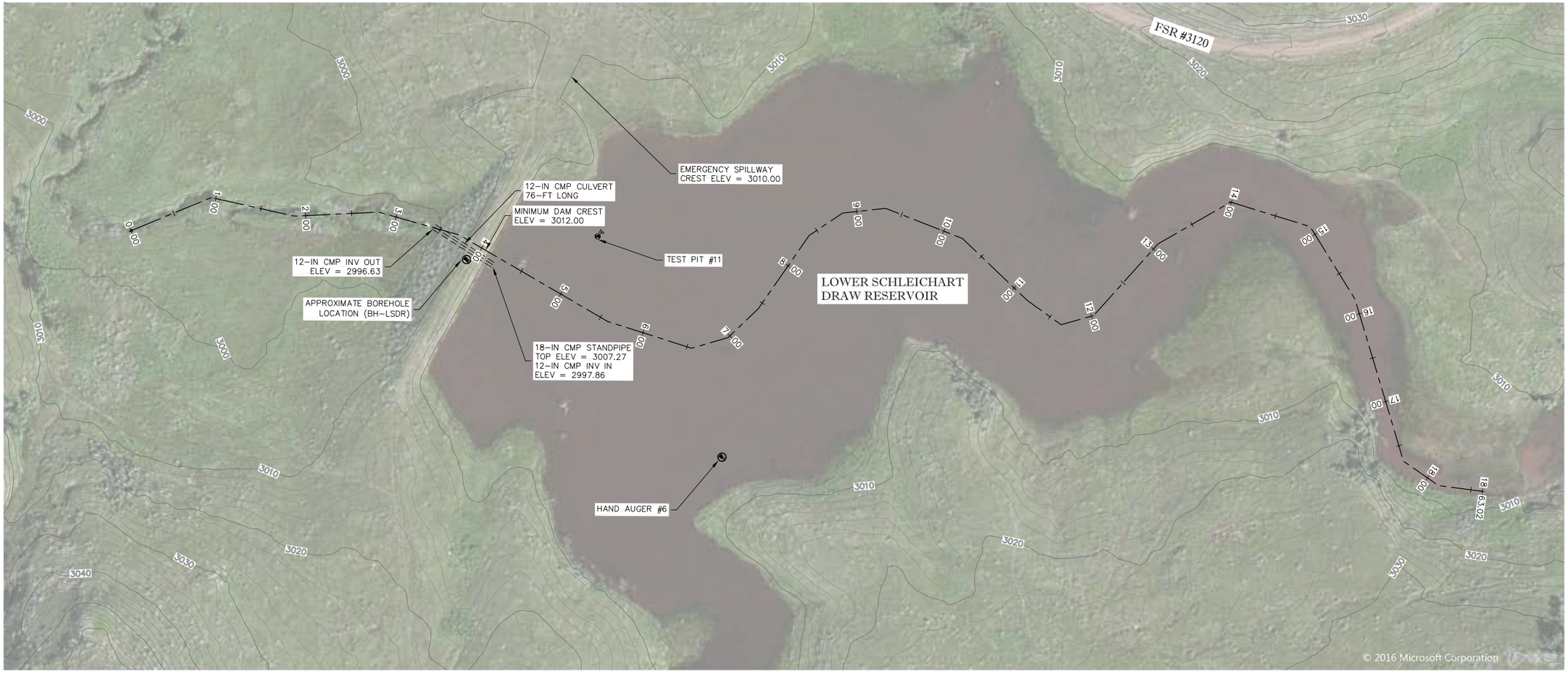


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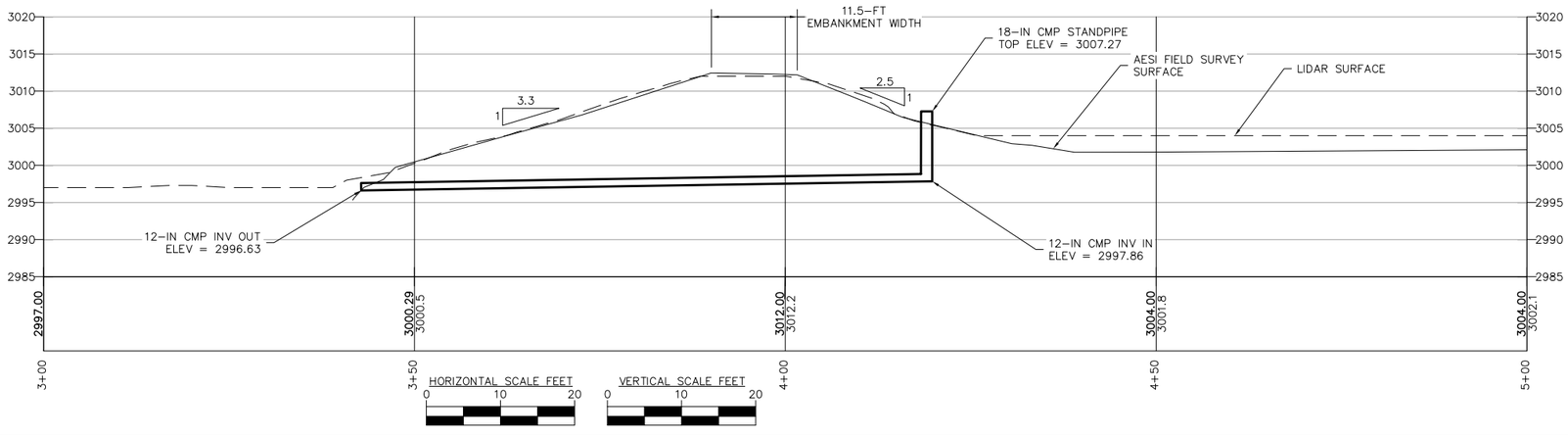
LOWER SCHLEICHART – LOOKING NORTH

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# RILEY PASS SEDIMENT POND CLEANOUT
## LOWER SCHLEICHART - EXISTING CONDITIONS
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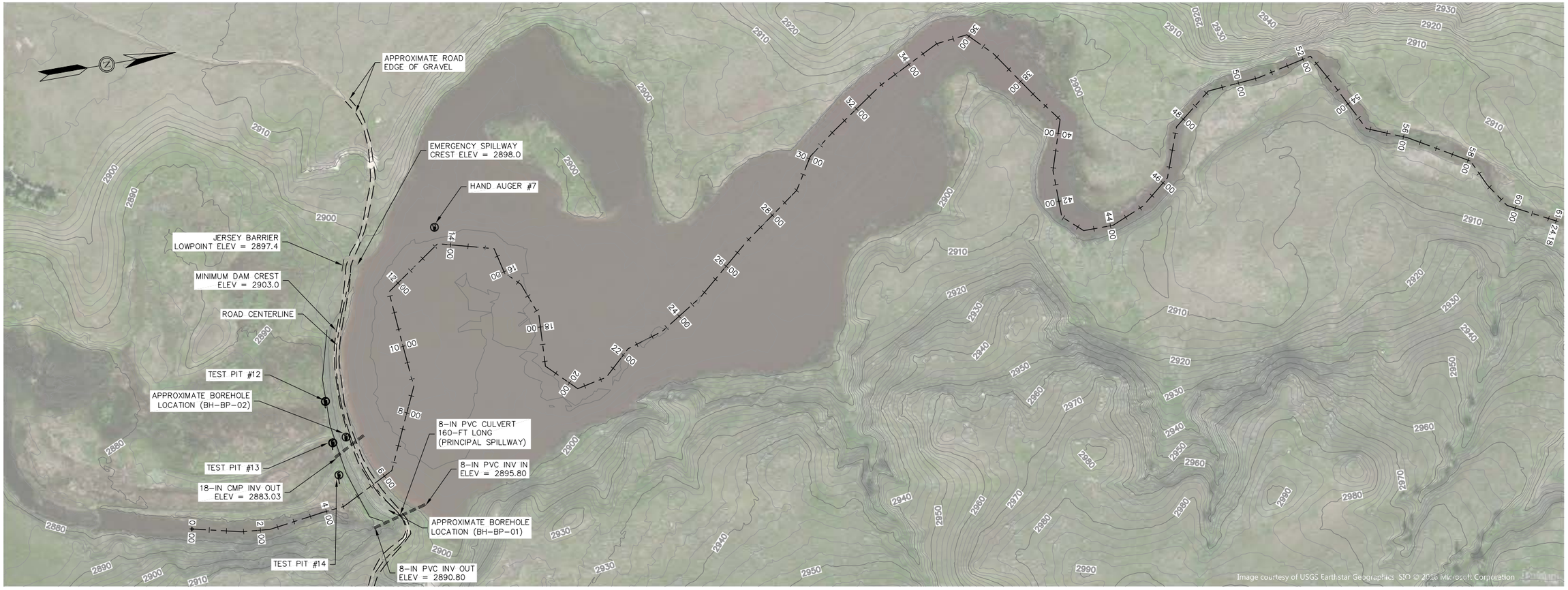
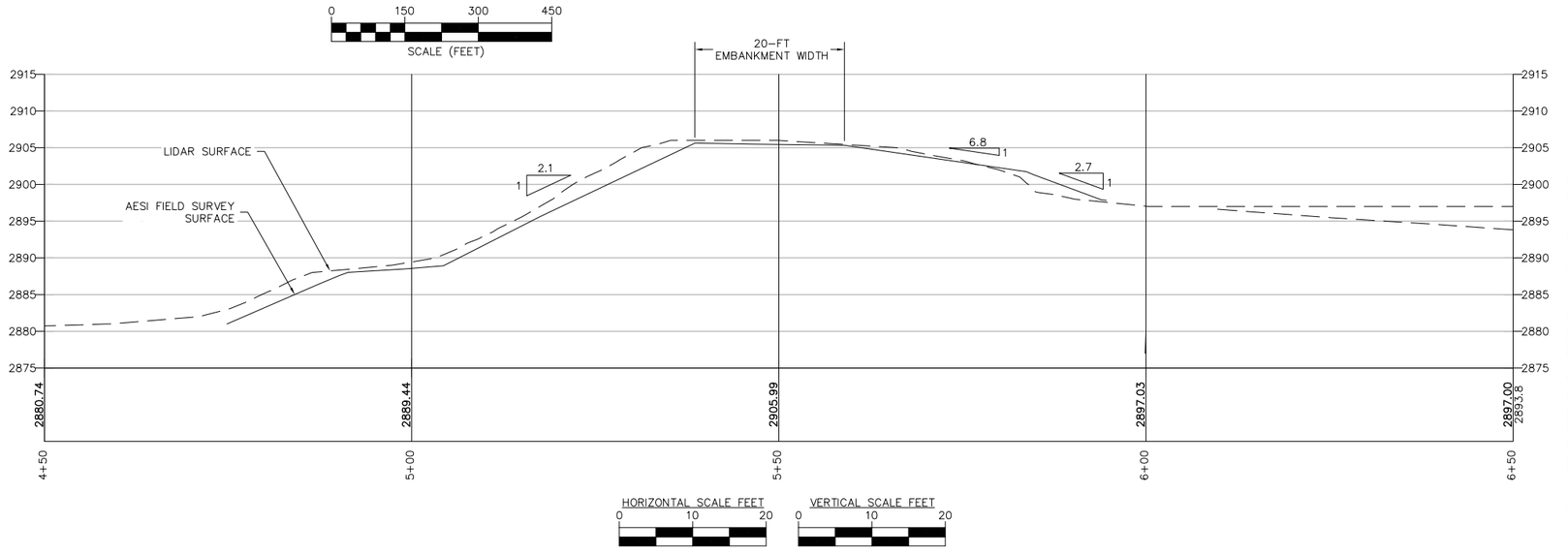



BROWNS POND – LOOKING NORTH

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# RILEY PASS SEDIMENT POND CLEANOUT
## BROWNS POND - EXISTING CONDITIONS
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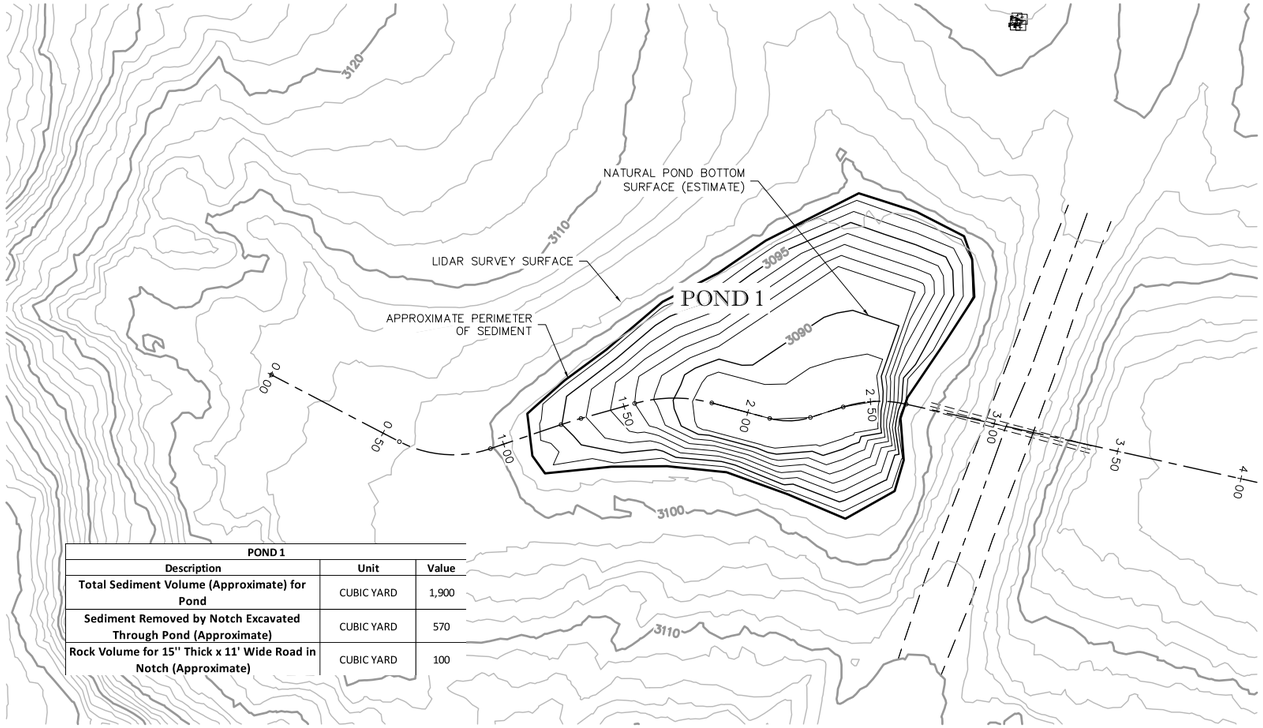
| PLAN AND PROFILES | |

# ATTACHMENT 2

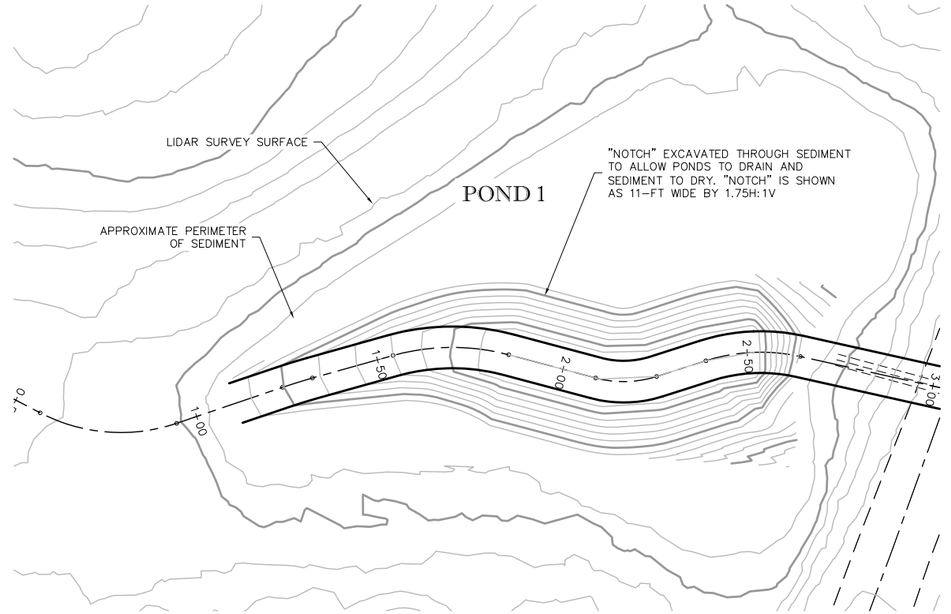
# PRELIMINARY SEDIMENT VOLUME EXHIBITS

- S-1 – Pond 1 Sediment Volume Estimation
- S-2 – Pond 2 Sediment Volume Estimation
- S-3 – Pond 3 Sediment  Volume Estimation
- S-4 – Pond 4 Sediment Volume Estimation
- S-5 – Pond 5 Sediment Volume Estimation
- S-6 – Upper Schleichart Sediment Volume Estimation
- S-7 – Lower Schleichart Sediment Volume Estimation
- S-8 – Brown's Pond Sediment Volume Estimation




| POND 1 | | |
|---|---|---|
| Description | Unit | Value |
| Total Sediment Volume (Approximate) for Pond | CUBIC YARD | 1,900 |
| Sediment Removed by Notch Excavated Through Pond (Approximate) | CUBIC YARD | 570 |
| Rock Volume for 15" Thick x 11' Wide Road in Notch (Approximate) | CUBIC YARD | 100 |

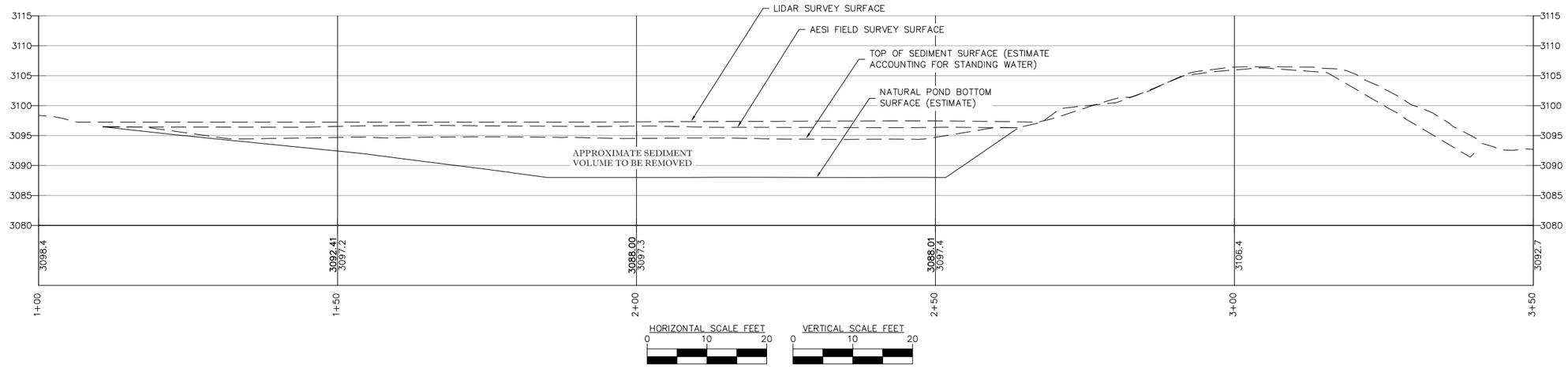
(NATURAL) POND BOTTOM SURFACE CREATED BASED ON EXISTING DATA




"NOTCH" EXCAVATED THROUGH POND (SED DRYING ALTERNATIVE)

0 30 60 90
SCALE (FEET)

0 20 40 60
SCALE (FEET)

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PROJECT ENGINEER: DSC | DRAWN BY: GDF
DESIGNED BY: GDF | REVIEWED BY:

# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## POND 1 - SEDIMENT VOLUME ESTIMATION
### CUSTER GALLATIN NATIONAL FOREST, SOUTH DAKOTA


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VOLUME

SHEET
S-1

RILEY PASS

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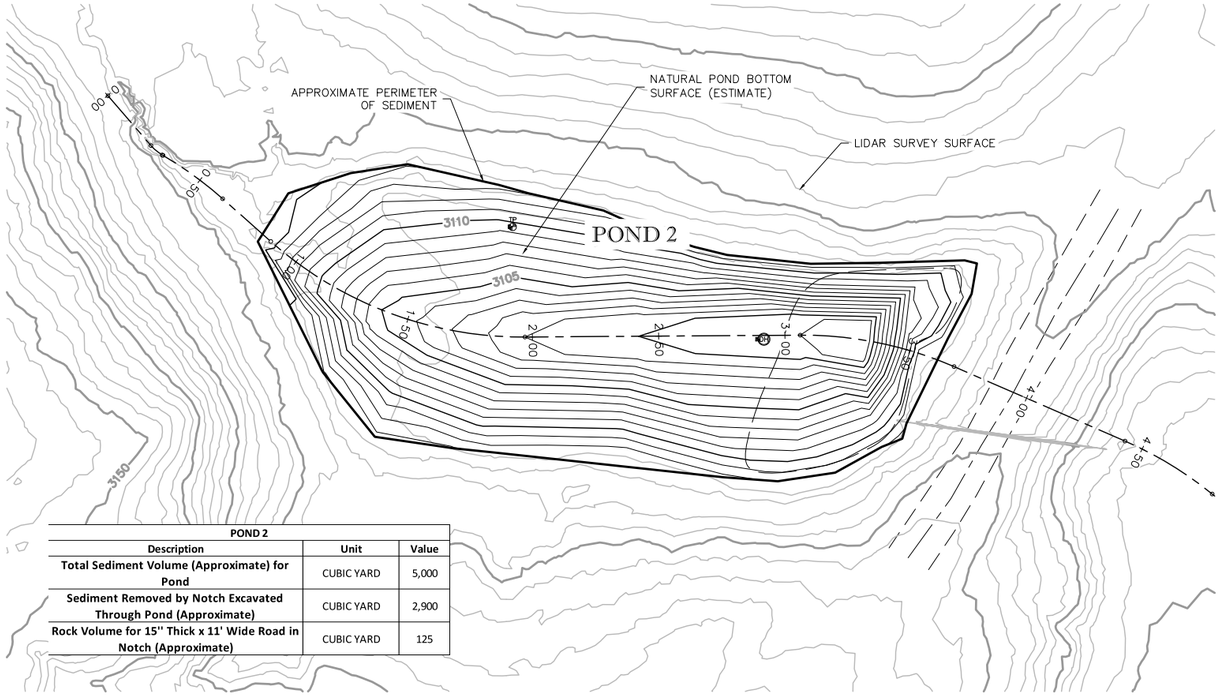
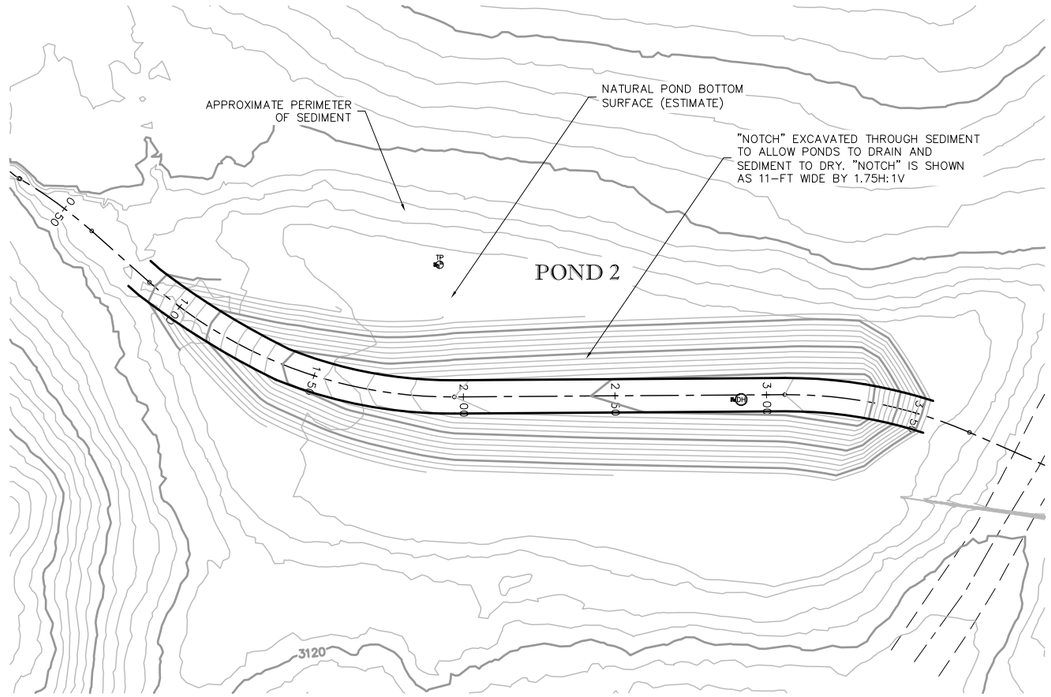



| POND 2 | | |
|---|---|---|
| Description | Unit | Value |
| Total Sediment Volume (Approximate) for Pond | CUBIC YARD | 5,000 |
| Sediment Removed by Notch Excavated Through Pond (Approximate) | CUBIC YARD | 2,900 |
| Rock Volume for 15'' Thick x 11' Wide Road in Notch (Approximate) | CUBIC YARD | 125 |

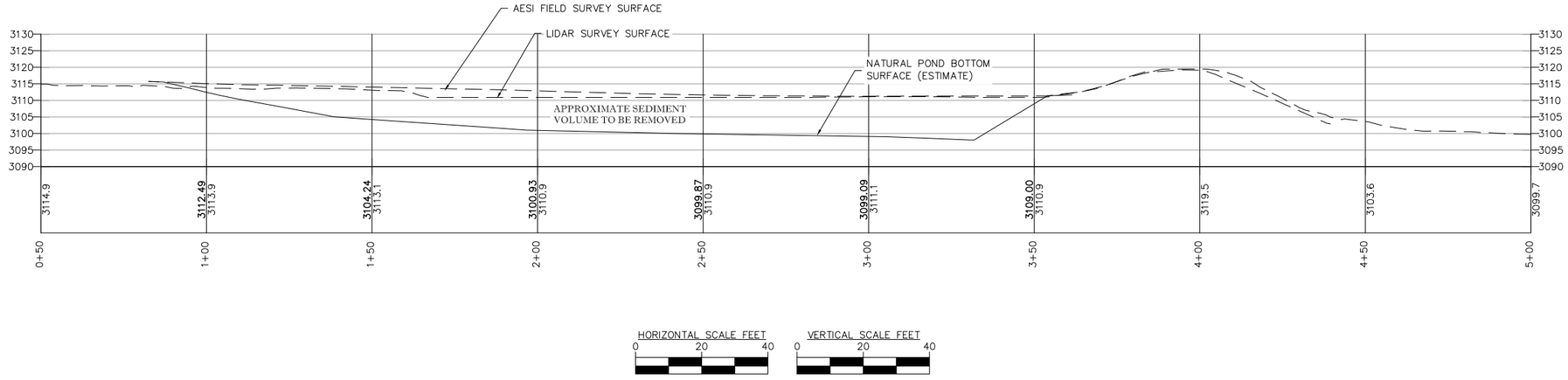
(NATURAL) POND BOTTOM SURFACE CREATED BASED ON EXISTING DATA

0 30 60 90
SCALE (FEET)




"NOTCH" EXCAVATED THROUGH POND (SED DRYING ALTERNATIVE)

0 25 50 75
SCALE (FEET)




HORIZONTAL SCALE FEET
0 20 40

VERTICAL SCALE FEET
0 20 40

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PROJECT ENGINEER: DSC | DRAWN BY: GDF
DESIGNED BY: GDF | REVIEWED BY:

# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## POND 2 - SEDIMENT VOLUME ESTIMATION
CUSTER GALLATIN NATIONAL FOREST, SOUTH DAKOTA

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SHEET
S-2

RILEY PASS

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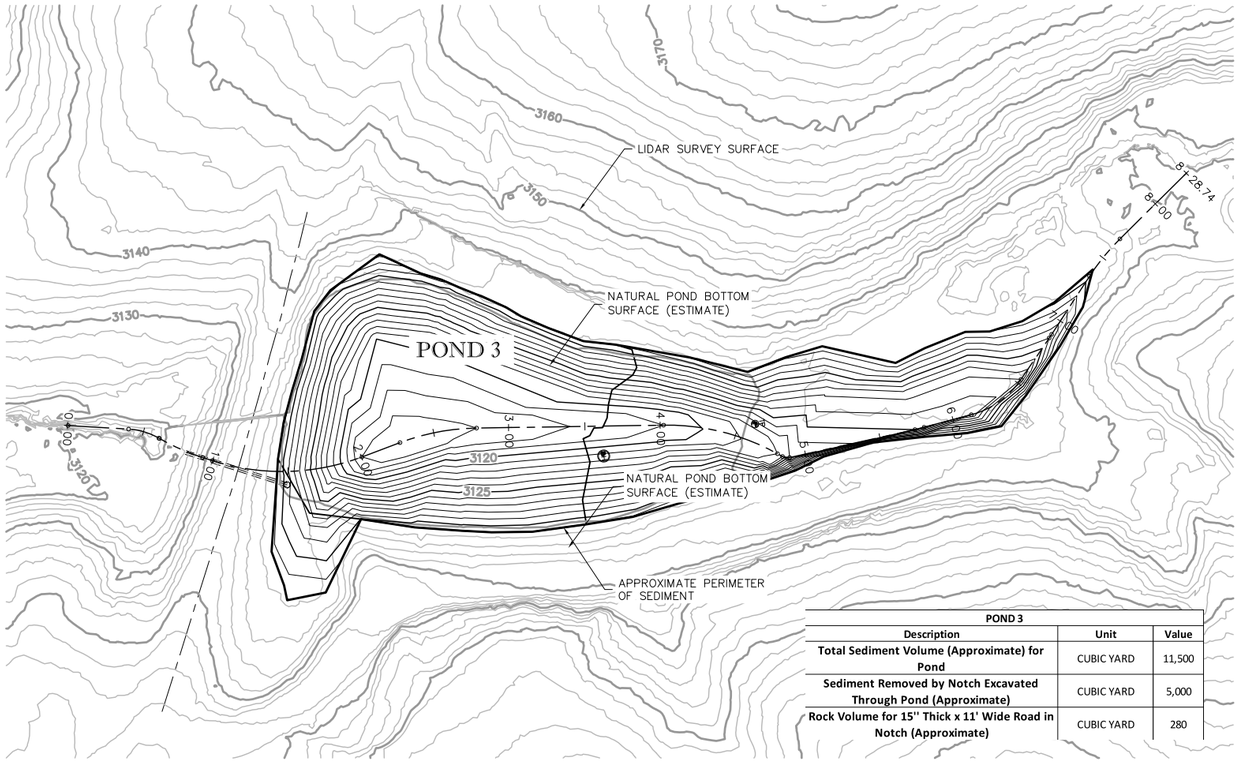
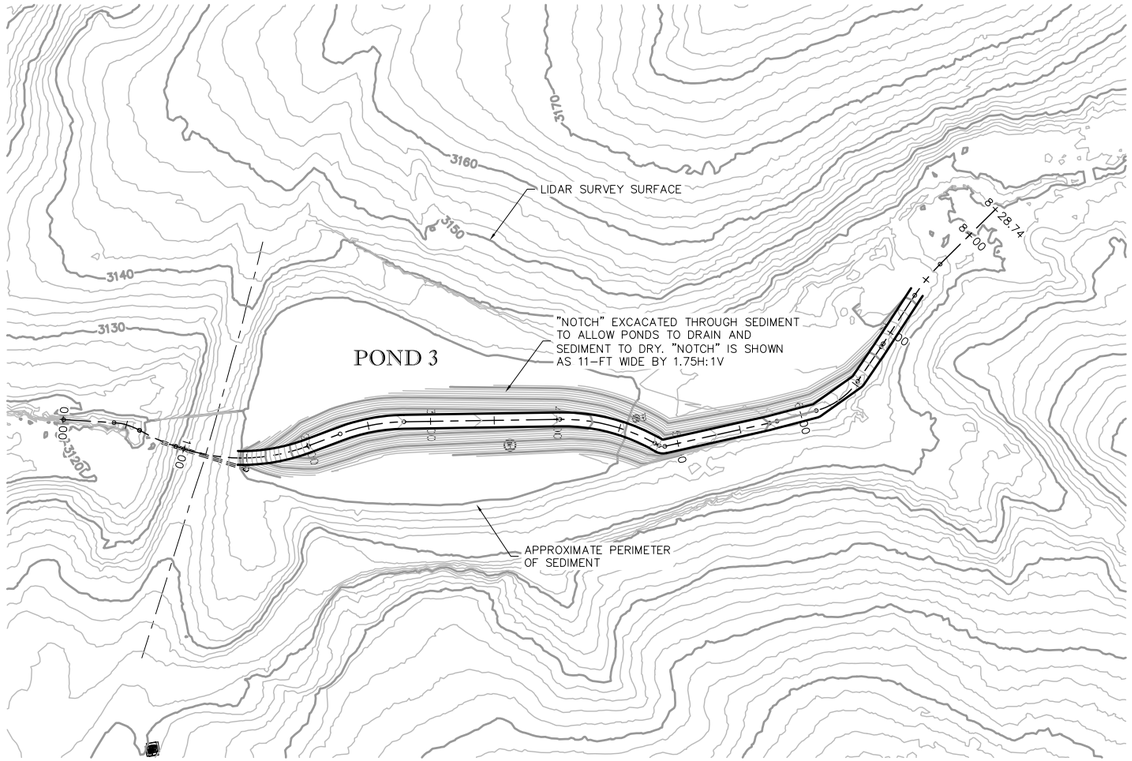



| POND 3 | | |
|---|---|---|
| Description | Unit | Value |
| Total Sediment Volume (Approximate) for Pond | CUBIC YARD | 11,500 |
| Sediment Removed by Notch Excavated Through Pond (Approximate) | CUBIC YARD | 5,000 |
| Rock Volume for 15'' Thick x 11' Wide Road in Notch (Approximate) | CUBIC YARD | 280 |

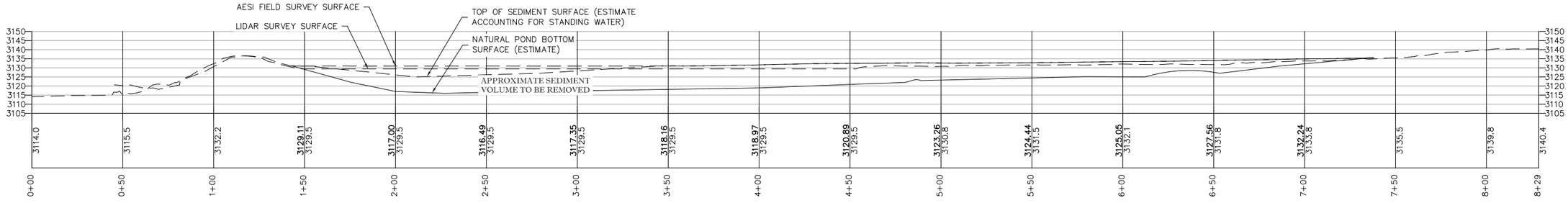
(NATURAL) POND BOTTOM SURFACE CREATED BASED ON EXISTING DATA

0 50 100 150
SCALE (FEET)




"NOTCH" EXCAVATED THROUGH POND (SED DRYING ALTERNATIVE)

0 60 120 180
SCALE (FEET)




HORIZONTAL SCALE FEET
0 30 60

VERTICAL SCALE FEET
0 30 60

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PROJECT ENGINEER: DSC | DRAWN BY: GDF
DESIGNED BY: GDF | REVIEWED BY:

# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## POND 3 - SEDIMENT VOLUME ESTIMATION
CUSTER GALLATIN NATIONAL FOREST, SOUTH DAKOTA

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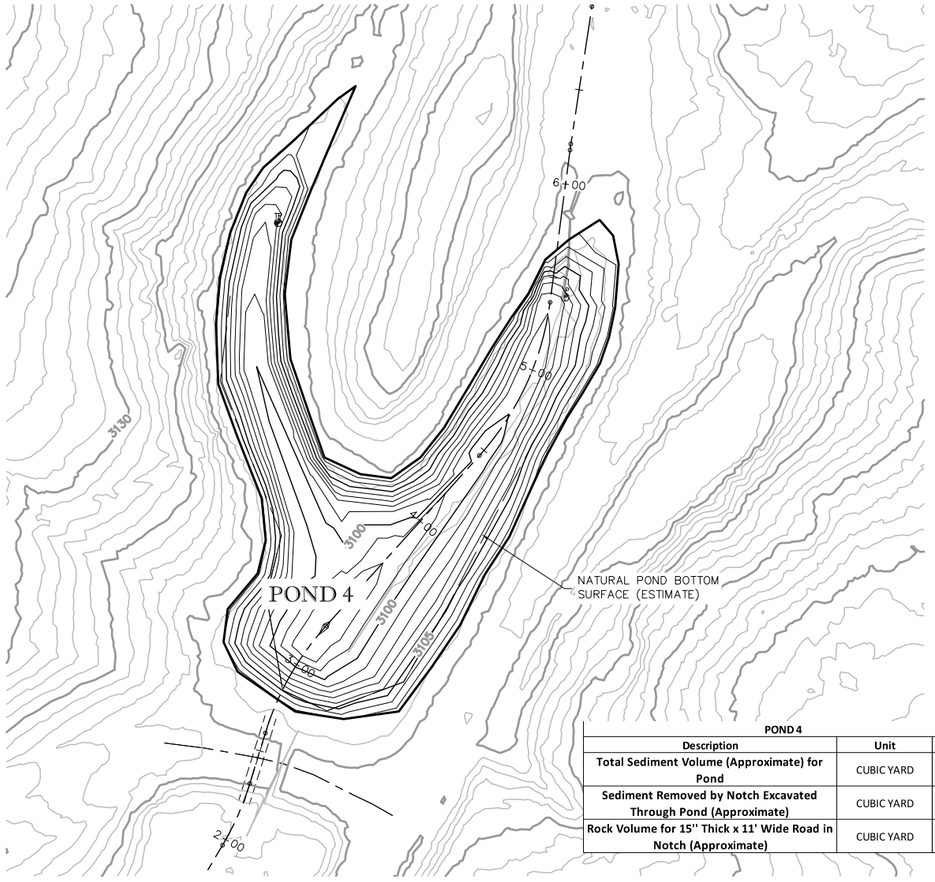
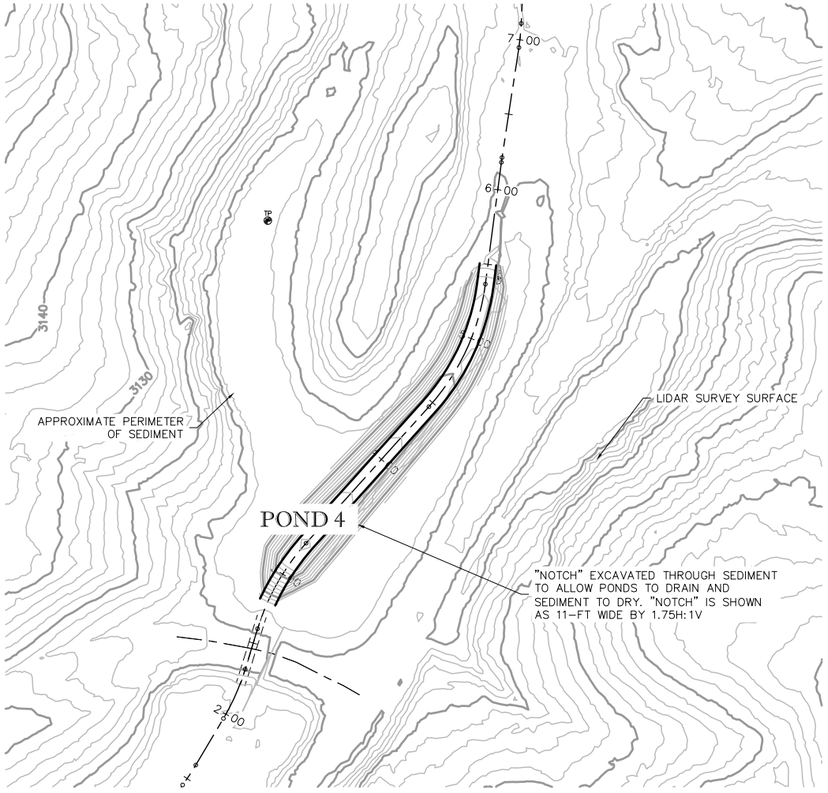



| POND 4 | | |
|---|---|---|
| Description | Unit | Value |
| Total Sediment Volume (Approximate) for Pond | CUBIC YARD | 4,500 |
| Sediment Removed by Notch Excavated Through Pond (Approximate) | CUBIC YARD | 1,800 |
| Rock Volume for 15'' Thick x 11' Wide Road in Notch (Approximate) | CUBIC YARD | 125 |

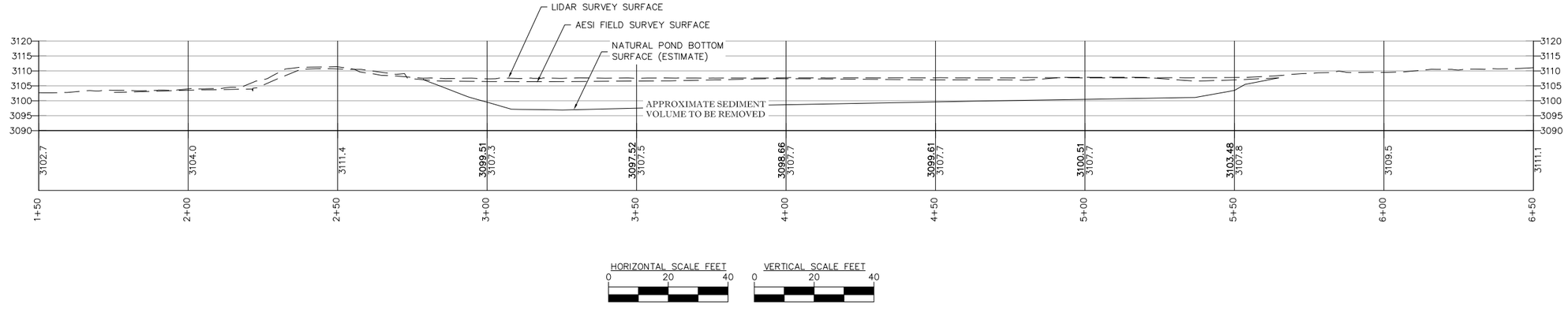
(NATURAL) POND BOTTOM SURFACE CREATED BASED ON EXISTING DATA

0 40 80 120
SCALE (FEET)




"NOTCH" EXCAVATED THROUGH POND (SED DRYING ALTERNATIVE)

0 50 100 150
SCALE (FEET)




HORIZONTAL SCALE FEET
0 20 40

VERTICAL SCALE FEET
0 20 40

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PROJECT ENGINEER: DSC | DRAWN BY: GDF
DESIGNED BY: GDF | REVIEWED BY:

# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## POND 4 - SEDIMENT VOLUME ESTIMATION
CUSTER GALLATIN NATIONAL FOREST, SOUTH DAKOTA

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RILEY PASS

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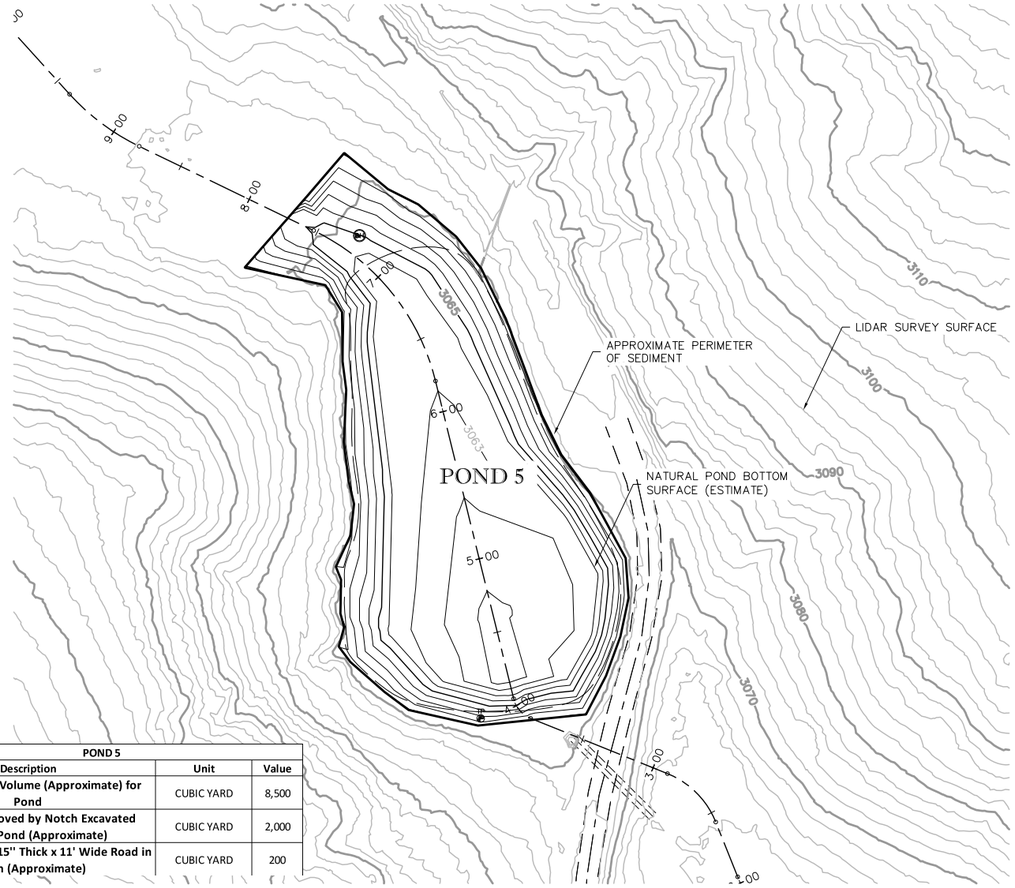
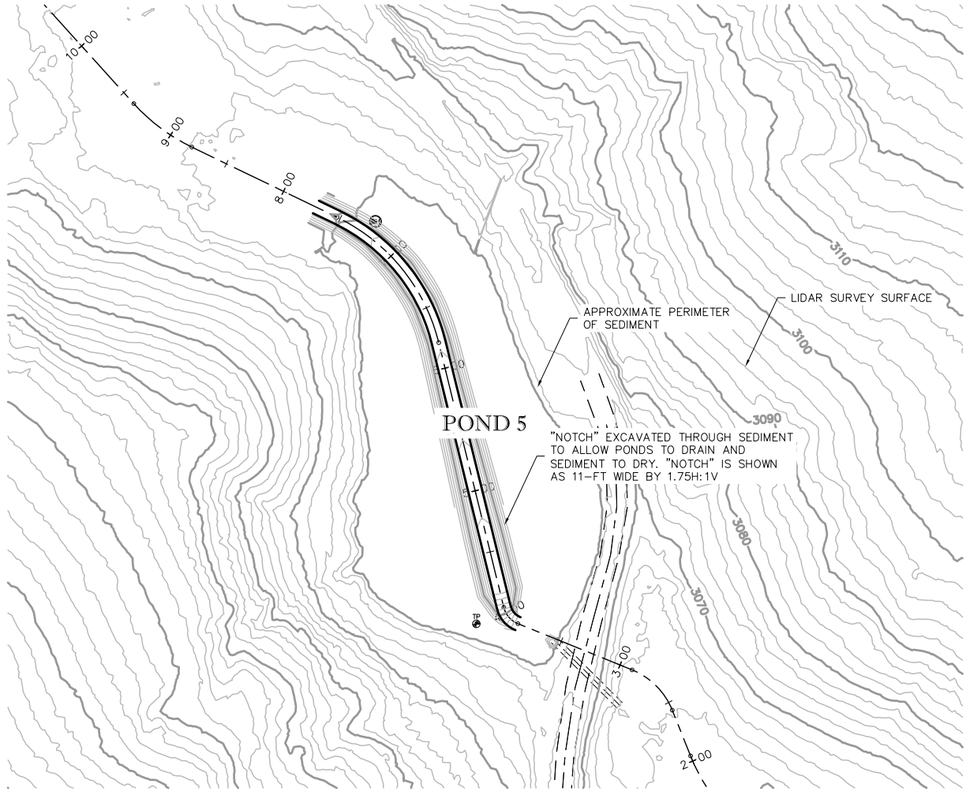



| POND 5 | | |
|---|---|---|
| **Description** | **Unit** | **Value** |
| **Total Sediment Volume (Approximate) for Pond** | CUBIC YARD | 8,500 |
| **Sediment Removed by Notch Excavated Through Pond (Approximate)** | CUBIC YARD | 2,000 |
| **Rock Volume for 15'' Thick x 11' Wide Road in Notch (Approximate)** | CUBIC YARD | 200 |

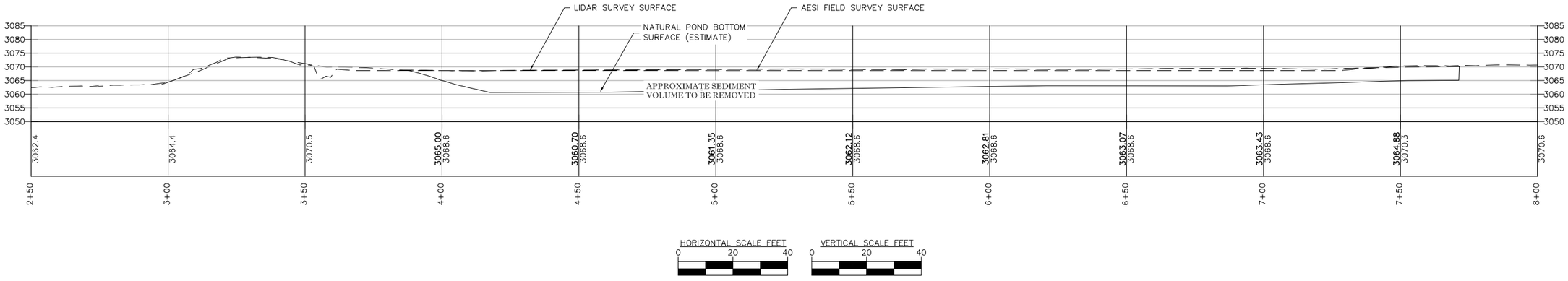
(NATURAL) POND BOTTOM SURFACE CREATED BASED ON EXISTING DATA

0 50 100 150
SCALE (FEET)




"NOTCH" EXCAVATED THROUGH POND (SED DRYING ALTERNATIVE)

0 60 120 180
SCALE (FEET)




HORIZONTAL SCALE FEET
0 20 40

VERTICAL SCALE FEET
0 20 40

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PROJECT ENGINEER: DSC | DRAWN BY: GDF
DESIGNED BY: GDF | REVIEWED BY:

# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## POND 5 - SEDIMENT VOLUME ESTIMATION
CUSTER GALLATIN NATIONAL FOREST, SOUTH DAKOTA


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| VOLUME | |
| RILEY PASS | |

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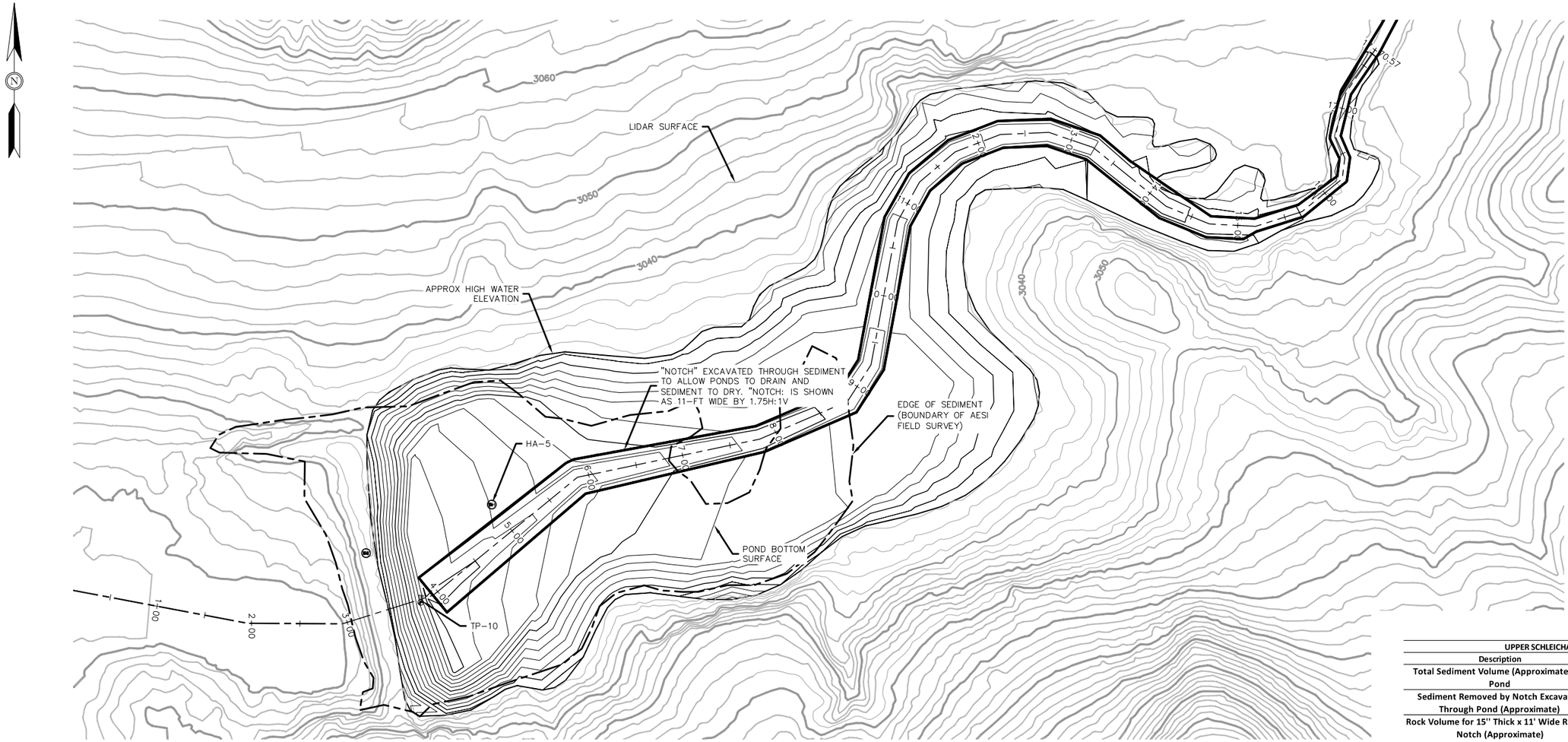
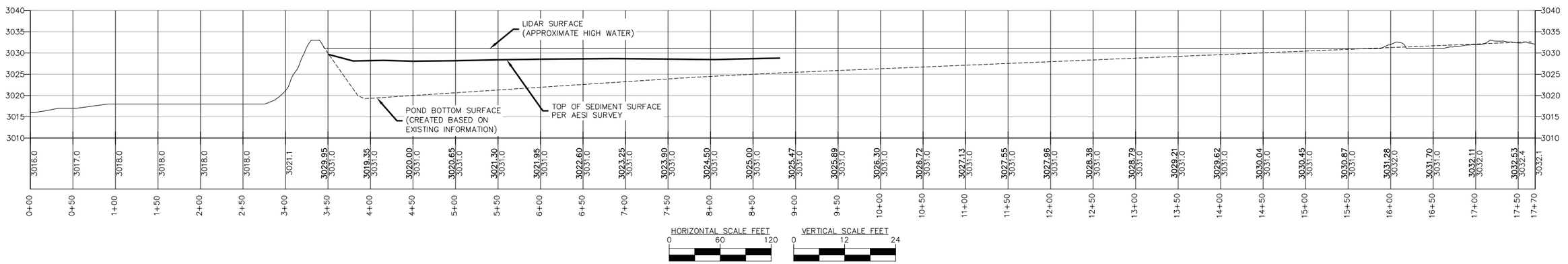



| UPPER SCHLEICHART DRAW | | |
|---|---|---|
| Description | Unit | Value |
| Total Sediment Volume (Approximate) for Pond | CUBIC YARD | 15,500 |
| Sediment Removed by Notch Excavated Through Pond (Approximate) | CUBIC YARD | 2,600 |
| Rock Volume for 15'' Thick x 11' Wide Road in Notch (Approximate) | CUBIC YARD | 450 |

0 60 120 180
SCALE (FEET)




HORIZONTAL SCALE FEET
0 60 120

VERTICAL SCALE FEET
0 12 24

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PROJECT ENGINEER: DSC | DRAWN BY: GDF
DESIGNED BY: GDF | REVIEWED BY:

# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## UPPER SCH - SEDIMENT VOLUME ESTIMATION
### CUSTER GALLATIN NATIONAL FOREST, SOUTH DAKOTA


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SHEET
S-6

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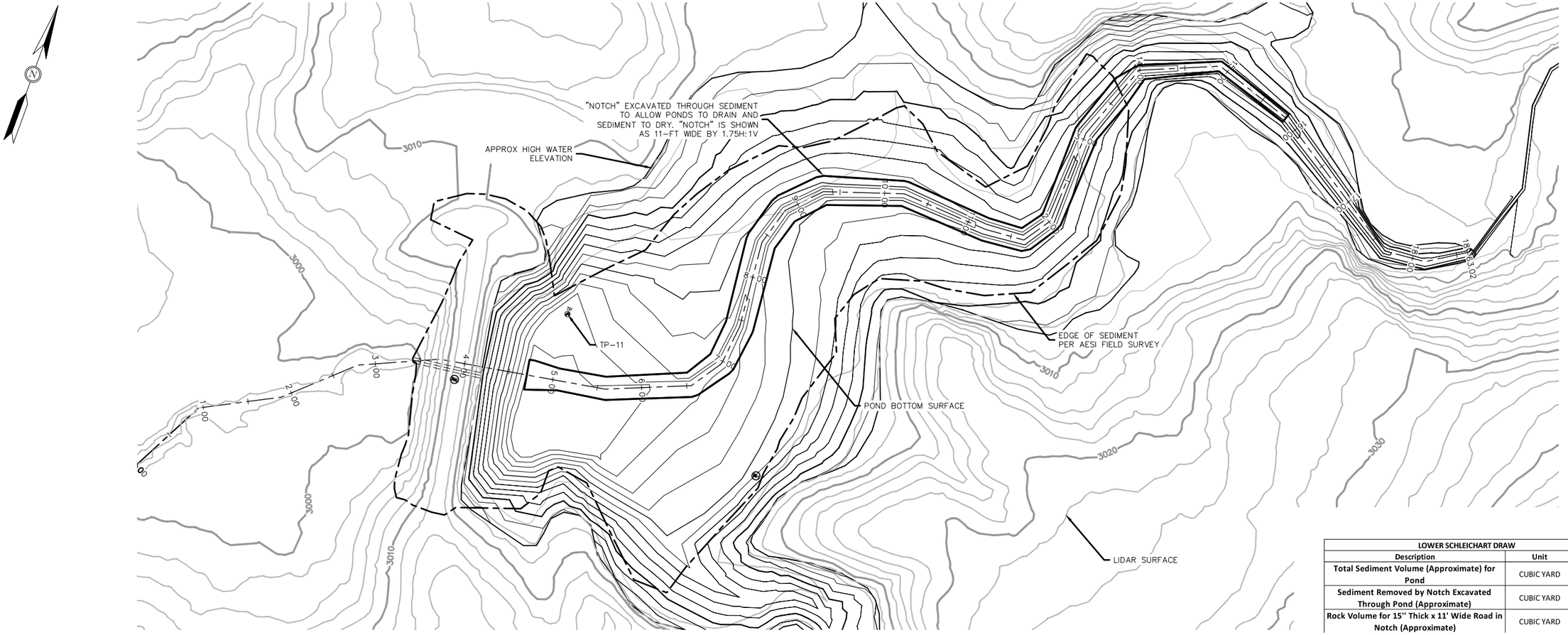
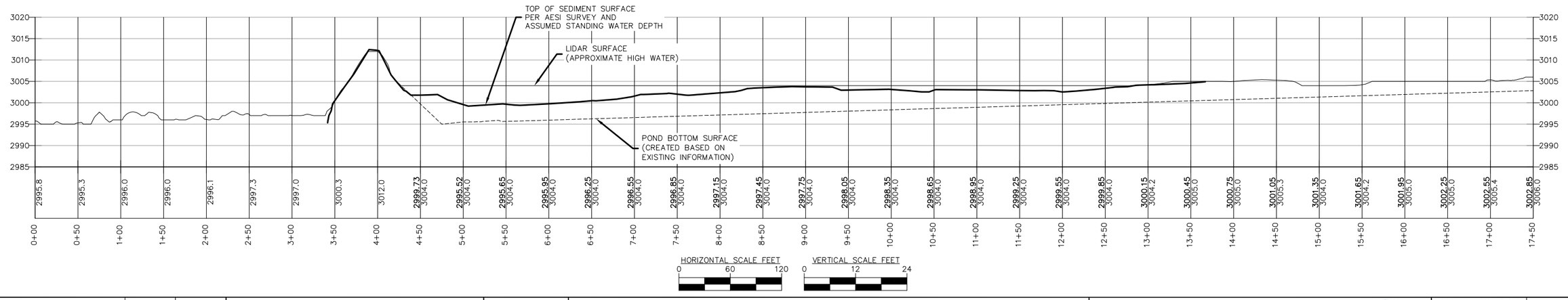



| LOWER SCHLEICHART DRAW | | |
|---|---|---|
| Description | Unit | Value |
| Total Sediment Volume (Approximate) for Pond | CUBIC YARD | 14,000 |
| Sediment Removed by Notch Excavated Through Pond (Approximate) | CUBIC YARD | 2,900 |
| Rock Volume for 15'' Thick x 11' Wide Road in Notch (Approximate) | CUBIC YARD | 450 |

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PROJECT ENGINEER: DSC | DRAWN BY: GDF
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# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## LOWER SCH - SEDIMENT VOLUME ESTIMATION
CUSTER NATIONAL FOREST, SOUTH DAKOTA

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RILEY PASS

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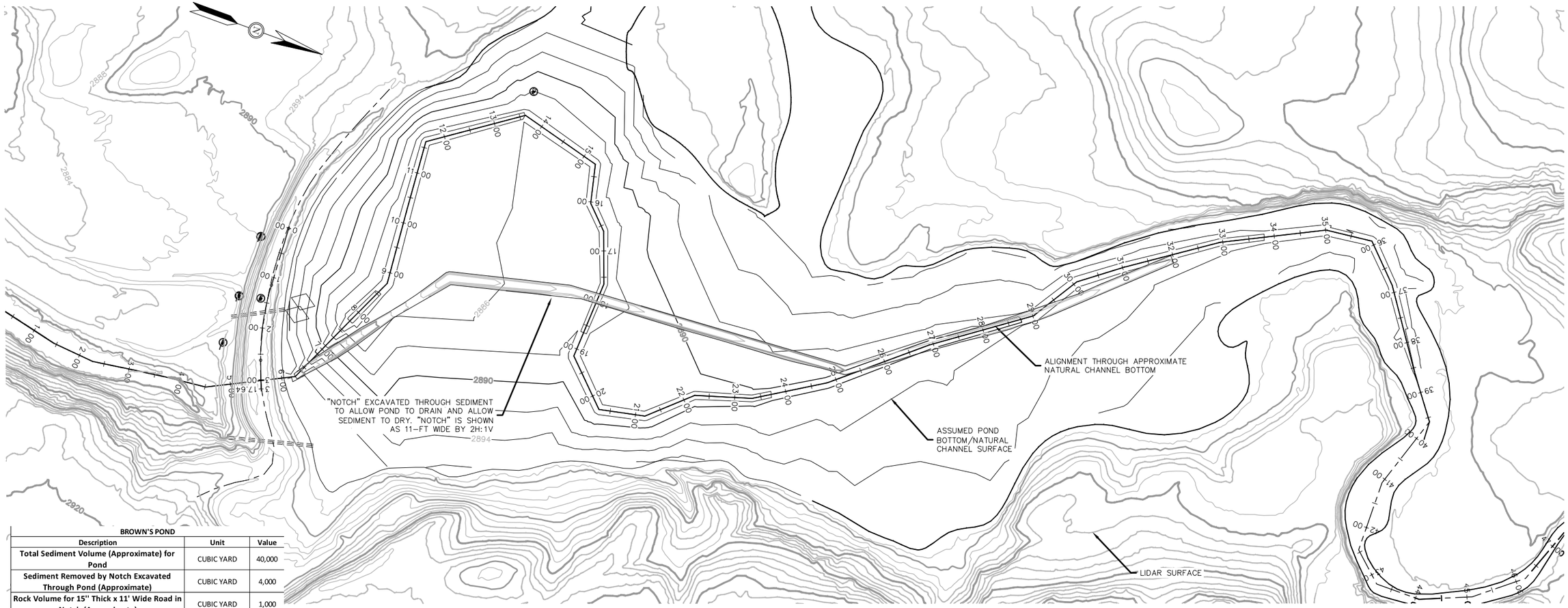
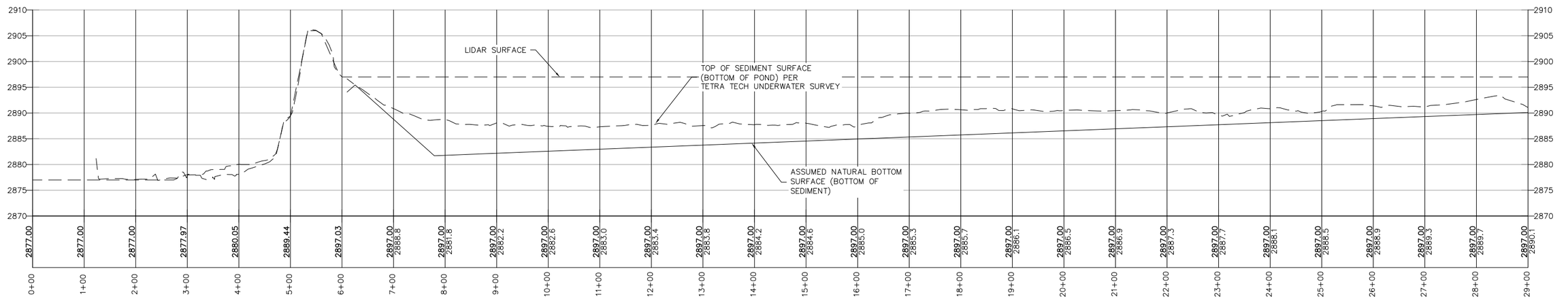



| BROWN'S POND | | |
|---|---|---|
| Description | Unit | Value |
| Total Sediment Volume (Approximate) for Pond | CUBIC YARD | 40,000 |
| Sediment Removed by Notch Excavated Through Pond (Approximate) | CUBIC YARD | 4,000 |
| Rock Volume for 15" Thick x 11' Wide Road in Notch (Approximate) | CUBIC YARD | 1,000 |

0 100 200 300
SCALE (FEET)

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HORIZONTAL SCALE FEET 0 100 200
VERTICAL SCALE FEET 0 10 20

PROJECT ENGINEER: DSC | DRAWN BY: GDF
DESIGNED BY: GDF | REVIEWED BY:

# RILEY PASS SEDIMENT POND CLEANOUT DESIGN
## BROWN'S POND - SEDIMENT VOLUME ESTIMATION
CUSTER GALLATIN NATIONAL FOREST, SOUTH DAKOTA


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SHEET S-8

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