GeoProfessional Innovation®

April 7, 2023
File: MO22154A

Mr. Jonathan Weaver, P.E.
Great West Engineering
P.O. Box 4817
Helena, MT 59601

RE: **Geotechnical Engineering Evaluation**
Sally Ann Creek Watershed Crossings AOP Design
Idaho County, Idaho

Greetings, Jonathan.

GeoProfessional Innovation Corporation (GPI) is pleased to provide Great West Engineering (Great West) with this geotechnical engineering evaluation report for 2 aquatic organism passage (AOP) stream crossing improvements along the Sally Ann Creek watershed, as well as the bridge crossing at Wall Creek in Idaho County, Idaho. This letter summarizes our subsurface exploration and geotechnical recommendations referencing the Phase 2 scope outlined in our July 15, 2022 proposal.

Read and implement this report in its entirety. Portions of this report cannot be relied upon individually without the supporting text of other pertinent sections and associated attachments or appendices. This report focuses on geotechnical aspects of culvert foundation design and construction. Other project aspects such as the culvert configuration, stream scour analysis, and surface grading and drainage are being designed by Great West.

It is our opinion that the project's success will depend in part on following this report's recommendations, good construction practices, and providing the necessary construction monitoring, testing, and consultation to verify the construction is completed as recommended. We recommend GPI be retained to provide monitoring, testing, and consultation services during geotechnical construction aspects to provide Great West and the Idaho County Road Department (County) with confidence that the project is constructed according to applicable plans and specifications.

We appreciate the opportunity to serve Great West and the County on this project. Please contact us if you have any questions or comments.

Sincerely,
GPI

Justin B. Maffey, P.E.
Project Engineer

Andrew J. Abrams, P.E.
Senior Engineer

PROFESSIONAL ENGINEER
REGISTERED
12481
4/7/23
STATE OF IDAHO
ANDREW J. ABRAMS

TJW/mg

Geotechnical Engineering Evaluation
Sally Ann Creek Watershed Crossings AOP Design
Idaho County, Idaho

PREPARED FOR:
Mr. Jonathan Weaver, P.E.
Great West Engineering
P.O. Box 4817
Helena, MT 59601

PREPARED BY:
GeoProfessional Innovation Corporation
6 O'Donnell Rd.
Pullman, WA 99163
(509) 339-2000

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Idaho County, Idaho

INTRODUCTION

GeoProfessional Innovation Corporation (GPI) performed the authorized geotechnical engineering evaluation for the Sally Ann Creek Watershed Aquatic Organism Passage (AOP) project that will replace the existing culverts crossing Sally Ann Creek and Wall Creek in Idaho County, Idaho. The approximate project locations are illustrated on Plates 1 through 3, *Exploration Maps.* GPI performed exploration at each site to assess subsurface conditions within the planned improvement alignments. In this report, we provide geotechnical engineering recommendations regarding foundation design and construction to aid Great West Engineering (Great West) in developing project design and construction documents. This geotechnical engineering evaluation included the following scope of services:

1. Coordinated subsurface exploration with Great West, the Idaho County Roads Department (County), and Idaho Digline to reduce the potential for damage to subsurface utilities. GPI subcontracted traffic control at each boring location.

2. Observed subsurface exploration via 7 exploratory borings extending 4.0 to 21.5 feet below ground surface.

3. Performed laboratory testing on selected samples from exploration referencing *ASTM International* (ASTM) procedures.

4. Provided our Phase 1 summary letter dated January 24, 2023 summarizing exploration findings, laboratory test results, and preliminary opinions regarding foundation support for the planned AOP watershed stream crossing structures.

5. Provided a Phase 2 draft report dated March 27, 2023 for Great West's review.

6. After additional discussions with Great West and addressing comments, prepared this Phase 2 final report, including our geotechnical recommendations, exploration and laboratory test results, and the necessary schematics to illustrate our recommendations.

PROJECT UNDERSTANDING

Our project understanding is based on our discussions with you and from reviewing the request for qualifications (RFQ) document provided by the Nez Perce Tribe Fisheries Watershed Division (NPT). The intent of this project is to design replacement structures for 2 existing culvert crossings and 1 bridge crossing in the Sally Ann Creek watershed. The structures contemplated for improvement under this project are delineated in the following bullets:

- **Sally Ann Crossing #1**: This is the first crossing in the Sally Ann Creek drainage, upstream of Highway 13 and the confluence with the South Fork Clearwater River. This 72-inch circular culvert plugged and failed in 2018, washing out Sally Ann Creek Road; it was subsequently replaced with the same culvert specifications due to funding limitations. In 2019, the culvert plugged again and damaged the culvert's inlet, sending debris and water down the road and ditch; the culvert did not completely fail but is not functioning at full capacity. Currently, the stream is eroding the material under the culvert inlet due to the poor alignment of the crossing with the stream channel. There is a significant outlet drop and the culvert is undersized to pass high water events. The crushed inlet further limits its capacity to pass water and material, and the circular pipe is likely too long and steep to pass fish without native bed material and habitat diversity within the crossing.

- **<u>Sally Ann Crossing #2:</u>** This crossing is the second County-managed crossing on Sally Ann Creek, upstream of the confluence with the South Fork Clearwater River. It is a 72-inch circular culvert that was severely damaged; during the high water in 2019, an approximate 6-foot extension was lost from the end of the pipe along with a significant portion of the surrounding road fill and shoulder. The culvert is rusted through with pin holes throughout the entire length, is undersized, and contains no substrate inside the pipe.

- **<u>Wall Creek Crossing:</u>** Wall Creek joins Sally Ann Creek approximately 1 mile upstream of the confluence with the South Fork Clearwater River. The bridge is located on Wall Creek Road near the intersection with Shira Road. It is undersized with a 10.3-foot span, serving as a pinch point in the stream channel. The structure is beginning to fail and the stream is undercutting the concrete footings. A concrete slab wingwall has fallen in the stream channel, and the steel decking material retaining road gravel on the road surface has large holes that allow materials and sediment to fall directly into the stream. The cross drain at the intersection of the 2 roads does not appear to be functioning properly; with the outboard slope of the road surface, the road surface runoff appears to drain toward the stream. Additionally, there is an informal stream crossing created by 4-wheelers immediately below the bridge resulting in displaced gravel and sediment. Sediment delivery is a primary concern at this site.

These culvert and bridge structures are undersized and impede fish passage at various flows while contributing sediment to the stream. Specifically, the Wall Creek bridge is a source of sediment and a failure risk, reducing the instream fish quality of the stream and watershed. These structures are owned and managed by the County. The surrounding agriculture, logging, and transportation system have increased sediment and water temperatures, decreased riparian conditions, and caused major changes in channel form and function within the Sally Ann Creek watershed and subsequently the South Fork Clearwater watershed.

A 3rd culvert exists along the Sally Ann Creek drainage (i.e. Sally Ann Creek #3) as was discussed in our Phase 1 summary letter. We understand that improvements are planned for Sally Ann #3, however it is not included as part of this initial project package. Therefore, geotechnical recommendations for replacing the Sally Ann #3 culvert are excluded from this report and will be addressed in a future deliverable.

Proposed Construction

Improvements at these locations are intended to increase the hydrologic capacity of the crossings, reduce the chances of future failure, prevent excess sediment from entering the Sally Ann Creek drainage into the South Fork Clearwater River, and negatively impacting aquatic life. The new structures will be designed in partnership with the County to improve aquatic organism passage and access to approximately 2.6 miles of stream.

The existing roadway at the Sally Ann crossing locations is asphalt-paved while the Wall Creek crossing remains gravel surfaced. The surrounding ground surface is covered with vegetation including grasses, weeds, and small trees at each crossing. The existing road surface at each crossing is relatively flat outside of the creek channel. Within the creek channel, the banks slope relatively steeply down to the water level at inclinations of approximately 1.5H:1V (horizontal to vertical) to 2H:1V with a grade change of approximately 8 to 10 feet between the road surface elevation and the typical water level.

At the Sally Ann #1 and #2 crossing locations, the existing culverts will be replaced by structural steel plate arches, supported on reinforced concrete abutment foundations. The Wall Creek Bridge will be replaced by a new, 3-sided, precast concrete box culvert with upstream and downstream wingwalls. Additional details provided by Great West for each planned structure are delineated in the following bullets.

- Sally Ann Crossing #1 – Structural Steel Plate Arch
  - Span: 19 feet
  - Rise: 6.3 feet
  - Length: 132 feet
  - Structural Loading (on each abutment footing):
    - Live Load: 3.59 kips per linear foot (klf)
    - Dead Load: 12.42 klf

- Sally Ann Crossing #2 – Structural Steel Plate Arch
  - Span: 19 feet
  - Rise: 6.3 feet
  - Length: 104 feet
  - Structural Loading (on each abutment footing):
    - Live Load: 3.59 klf
    - Dead Load: 12.42 klf

- Wall Creek Crossing – 3-sided Precast Box Culvert
  - Span: 19 feet
  - Rise: 4.0 feet
  - Length: 50 feet
  - Structural Loading (on each abutment footing):
    - Live Load: 3.40 klf
    - Dead Load: 11.30 klf

After reviewing our preliminary exploration summary, and with GPI's consultation, Great West selected typical shallow spread footings to support the planned abutment walls and wingwalls, which in turn will support the new steel plate arch and concrete box culvert structures.

Between the new abutment foundations, the existing grades will be lowered via excavation to remove the existing roadway, culvert/bridge, and roadway embankments, thereby opening up the stream channel. These excavations will extend 10 to 15 feet below the existing roadway surface. Riprap designed by Great West will be placed along the culvert footings for scour protection. The streambed will be slightly lowered and restored with streambed material meeting NPT'S requirements per Great West's design. Finished roadway surface grades will be raised between 1 and 3 feet vertically at each crossing location, and existing drainage patterns will remain unchanged. Roadway shoulders will be reconstructed at maximum 2H:1V inclinations at the conclusion of construction. No subsurface utilities or other improvements will be constructed as part of the project.

At the Sally Ann #1 and #2 crossings, approximately 150 feet of the existing road surface will be reconstructed. The new roadway surface will comprise hot mix asphalt (HMA) supported on crushed aggregate base course. From our experience with similar rural roadways, we estimate traffic along Sally Ann Creek Road comprises primarily passenger vehicles with periodic heavy truck traffic including recreational vehicles, garbage/delivery trucks, logging/harvest trucks, and snow plows. We do not anticipate Sally Ann Creek Road supports regular semi-tractor trailer traffic. At the Wall Creek crossing, approximately 500 feet of the existing roadway surface will be reconstructed comprising gravel surfacing to match existing grades.

SUBSURFACE EVALUATION PROCEDURES

GPI observed subsurface exploration October 24 through 26, 2022 and November 9, 2022 by documenting 7 exploratory borings drilled to depths ranging from approximately 4.0 to 21.5 feet below the ground surface. Borings were drilled and then loosely backfilled utilizing multiple drill rigs including CME-85 and Mobile B-57 drill rigs provided by Holt Services, Inc. and a CME 75 drill rig provided by Haz-Tech Drilling, Inc. Multiple mobilizations were required to complete drilling operations due to dense granular soil conditions refusing various drilling equipment. In addition, winter weather caused us to terminate exploration and return once conditions were safer for work in the roadway alignment. Approximate boring locations for each crossing location are illustrated on Plates 1 through 3, *Exploration Map*. GPI also retained traffic control services to help protect workers throughout exploration activities.

During exploration, our geologist visually classified, described, and logged the soil encountered according to the Unified Soil Classification System (USCS). The USCS is presented in Appendix A and should be used to interpret the soil conditions in this document and on the individual exploration logs. Standard penetration tests (SPT) were collected in each soil boring at approximate 2.5- to 5-foot intervals. Asphalt pavement section thicknesses were recorded where encountered and soil conditions, groundwater, bedrock, or other visually observable conditions were logged. Our borings were loosely backfilled and plugged with bentonite. Excess soil from borings was left on site.

SUBSURFACE CONDITIONS

The borings were located just off the roadway surface in the shoulder adjacent to the pavement. In these locations, no vegetation or organics were encountered at the ground surface, although isolated weeds and grasses were evident at the shoulder surface at each crossing location. Beneath the surface, subsurface soil conditions at each crossing's exploration location included layers of fill comprising gravel and sand mixtures. Fill material encountered during our exploration is considered undocumented as no documentation exists regarding its placement or compaction. However, the fill did not illustrate significant signs of settlement or instability and is presumed placed for embankments to the County standards for structural filling at the time of placement. Both the fill and underlying native soil atop bedrock contained varying amounts of coarse gravel, cobbles, and boulders that made drill exploration challenging. We anticipate groundwater levels at each crossing location will be primarily influenced by seasonal fluctuating water levels in Sally Ann Creek and Wall Creek. More specific descriptions of the subsurface conditions encountered at each crossing location are provided below:

Sally Ann #1 Crossing

- Undocumented Fill: Silty Sand with Gravel (SM), Silty Gravel (GM), and Poorly-graded Gravel (GP). Gray to brown loose to dense and moist to wet. Some cobbles and boulders were encountered in these soil units that were evident in the auger cuttings. Fill extended 5.5 feet below the existing ground surface (BGS).

- Alluvium: Clayey Gravel (GC) to Poorly-graded Gravel (GP). Brown to gray, dense, and moist to saturated. Some cobbles and boulders were encountered in this material that were evident by significant drill resistance and vibrations during exploration. This native alluvial soil unit extended to the exploration termination depth at 21.5 feet BGS.

- Neither bedrock nor groundwater were encountered in the depths or locations explored at the Sally Ann #1 crossing location.

Sally Ann #2 Crossing

- Undocumented Fill: Poorly-graded Gravel with Cobbles (GP). Gray, dense, and moist to wet. Fill extended approximately 9.0 feet BGS. Cobbles were encountered in this material that were evident in the auger cuttings and boulders may be encountered as evident through significant drill chatter and difficult drilling.

- Alluvium: Silty Sand with Gravel (SM). Dark brown, medium dense, and saturated. Isolated cobbles and boulders were encountered in this material that were evident by significant drill resistance and vibrations during exploration.

- Bedrock: Basalt (RX). Black to gray, highly weathered and moderately fractured. We encountered basalt bedrock at approximately 14.5 feet BGS. Our exploration equipment was able to penetrate bedrock 1 foot before being refused at 15.5 feet BGS.

- Groundwater was encountered at approximately 9.0 feet below the ground surface at the Sally Ann #2 crossing location.

Wall Creek Bridge Site

- Undocumented Fill: Poorly-graded Gravel with Cobbles (GP). Gray to black, very dense, and moist to wet. Fill extended 5.0 to 7.0 feet BGS. Some cobbles and boulders were encountered in this material that were evident by significant drill resistance and vibrations during exploration.

- Alluvium: Silty Gravel with Sand (GM). Gray, very dense, saturated. Alluvium was encountered beneath fill and extended 14.0 feet BGS.

- Bedrock: Basalt (RX). Black to gray, highly weathered and moderately fractured and hard. We encountered basalt bedrock at approximately 14.0 feet BGS. Our exploration equipment was able to penetrate bedrock 1 foot before being refused at 15.0 feet BGS.

- Groundwater was encountered at approximately 7.0 feet BGS at the Wall Creek bridge location.

LABORATORY TESTING

Laboratory testing was performed referencing ASTM and AASHTO test procedures to classify the soil and estimate soil engineering parameters. Laboratory tests included:

- Natural Moisture Content
- Grain-Size Distribution
- Modified Proctor

Laboratory test results are provided in Appendix B, *Laboratory Test Results*, and are also shown on the exploratory logs in Appendix A.

GEOTECHNICAL OPINIONS AND RECOMMENDATIONS

The following recommendations are prepared based on subsurface exploration, field and laboratory test results, engineering analyses, and our understanding of the planned construction outlined herein. Based on foundation loading, anticipated geologic conditions, and GPI's input, Great West selected conventional concrete spread footings to support the planned crossing structures. The following recommendations are provided to assist Great West with progressing design and construction documents based on this foundation approach.

Earthwork

Site Preparation

Topsoil was not encountered within the roadway surfaces or shoulders during exploration. However, topsoil containing vegetation and organics is evident on the ground surface outside the roadway alignments. Where encountered, topsoil containing vegetation and organics must be stripped and removed from beneath the planned culvert foundations, approach embankments, and other improvements. Extend stripping at least 5 feet laterally outside planned culvert and embankment footprints. The existing creek bank surfaces near the culvert location contain various shrubs, grasses, and small trees; all of which must be removed prior to earthwork and new culvert construction. Foundations, embankment, roadways or any structural fill **must not** bear over topsoil containing vegetation and organics or other deleterious soil. Topsoil may be stockpiled on site and later used as landscape material. We recommend an average topsoil stripping depth of 1.0 foot be used for estimating purposes, noting topsoil depth will vary across the planned improvement areas.

We recommend existing roadway asphalt and aggregate remain in place to the greatest extent possible within the construction areas. This will reduce subgrade disturbance, sediment track-out, and potentially reduce over-excavations due to soil disturbance. Surficial silty gravel and demolished asphalt may be reused as *General Structural Fill* provided it is processed to meet the requirements in Table 1 in this report.

Undocumented Fill

Drill exploration encountered fill in the upper 5 to 9 feet below the roadway surface. No documentation exists regarding this fill's placement or compaction. Based on the foundation and grading plan provided by Great West, excavations to construct new foundations will remove this material and expose native soil within the improvement area and below the planned culvert bearing surfaces.

The pavement surface along Sally Ann Creek Road appears to be in relatively good condition, indicating the fill material beneath the roadway surface has received previous compaction, sufficient to support the existing pavement section. Therefore, our opinion is existing undocumented fill may remain beneath reconstructed asphalt sections along the planned improvement alignments. Where this material is exposed at the roadway subgrade surface, it should be compacted referencing the *Establishing Subgrades* report section.

Excavation Characteristics

The site soil can be excavated using conventional excavation techniques, although mechanical thumbs may be required to manipulate existing structures, debris, and coarse material. Carefully plan, slope, shore, or brace excavations in accordance with the *Occupational Safety and Health Administration* (OSHA) guidelines. The site soil is classified as "Type C" soil per OSHA regulations when it remains dry, and may be temporarily sloped back 1.5H:1V or flatter. Due to the potential for varying soil and groundwater conditions with depth, the contractor should evaluate each excavation configuration specific to OSHA guidelines and to seek GPI's guidance to create safe and stable excavations. Surcharges from equipment, stockpiles, or material storage must not occur within a horizontal distance of half the height of any excavation.

Plan excavations with water collection points and utilize conventional sumps and pumps to remove nuisance water generated by runoff, seeps, springs, or precipitation. If site soil excavations are not immediately backfilled, they may degrade when exposed to runoff and require over-excavation and replacement with granular fill. Construction activities and excavation backfilling should be performed as rapidly as possible following excavation to reduce the potential for subgrades to degrade under construction traffic.

High water flows during spring and summer months can impact various construction activities. Contractors should be familiar with these conditions and readily have access and contingencies for pumps and/or the ability to create appropriate cofferdams. The contractor is solely responsible for determining dewatering means, methods, and requirements. Specifically, we expect excavations within the stream channel for new culvert foundations will extend below the normal water elevation in Sally Ann and Wall Creeks. Therefore, contractors must be prepared to construct cofferdams and/or stream bypasses as required to collect and direct creek flows away from excavations and other work areas. Water will still exist in excavations even if the creek is temporarily diverted. Continuous pumping that lowers groundwater to at least a foot below the subgrade should be expected by contractors to allow subgrade and foundation bearing surface preparations. Pumped water should not be directly returned to the creek without sediment treatment.

We anticipate excavations to achieve the planned grades within the improved creek channels will require careful consideration of procedures by the contractor to preclude disturbance to the sensitive environment surrounding the work areas and release of debris or turbid water into the streams. We recommend project specifications address the need for careful excavations and other construction procedures to protect the surrounding environment from such releases.

Rock Excavation Criteria

Exploration encountered basalt bedrock at depths ranging from 14 to 15 feet below the existing roadway surface in borings B-22154A-5 and -9 at Sally Ann #2 and Wall Creek, respectively. Bedrock excavation may be required within the planned excavation extents, where excavation for foundations extends beyond our exploration locations. Competent basalt bedrock is typically classified as “Stable Rock” referencing OSHA guidelines and can be cut near vertical for temporary applications.

In our opinion, the upper 1 to 2 feet of the bedrock surface is expected to be excavatable using large conventional rock excavation techniques and equipment. Excavating bedrock beyond 1 to 2 feet will be difficult and will require large, and possibly specialized, excavating equipment. We expect excavation equipment will need to be equipped with ripper shanks, rock teeth, and/or hydraulic breakers. We anticipate blasting is not allowed in the stream channel and due to the site’s proximity to multiple adjacent public features and private properties.

The following considerations can be incorporated into the project specifications or used as a general guide to facilitate bedrock excavation requirements. Earthwork and general contractors should consider the following with respect to accomplishing rock excavation.

1. Bedrock excavation shall be performed with late-model excavation equipment; configurations equipped with short-tip-radius rock buckets; rated at not less than 150 hp net flywheel power with a bucket-curling force of no less than 35,000 lbf and stick-crowd force of not less than 23,000 lbf.

2. A minimum 9,500 ft-lb hydraulic breaker is expected to breakout competent bedrock in confined spaces when not fractured or weathered. The contractor shall maintain contingencies for mobilizing such equipment.

3. Other rock excavation methods, including predrilling, chemical agents, and others, may be considered to achieve the required excavation depths. However, potential impacts of each method must be carefully evaluated by the County and any prospective contractor.

4. For reuse as *Structural Fill*, bedrock excavation must reduce the excavated material to a maximum 0.7-foot particle size unless oversize bedrock boulders are removed from structural fill products.

As part of any bedrock excavation process, it is critical that the overall bedrock removal limits be clearly outlined to contractors such that appropriate methods are utilized to prevent fracturing at or below subgrade elevations and that rock removal extend laterally to the prescribed limits.

Wet Soil/Weather Construction

Construction should be performed during dry months of the year (typically August through October) when streamflow is at its lowest. Groundwater was encountered during exploration at approximately 9 and 7 feet below the existing roadway surface at Sally Ann #2 and Wall Creek crossings, respectively. Based on the invert elevation of the existing culvert, we anticipate this elevation range corresponds to the normal water elevation in the Sally Ann and Wall Creek channels. Groundwater was not encountered during exploration at Sally Ann #1, however it is expected at the creek bed and to fluctuate with flow levels in Sally Ann Creek. Where construction extends below these elevations, or if construction is performed during wet weather conditions or high stream flows, water will be encountered in excavations for stream improvement, culvert foundation construction, and other improvements. If encountered, remove the water with conventional sumps and pumps prior to foundation construction. Sumps and pumps must be maintained 24 hours per day, and backup pumping systems must be in place and functional at all times during footing construction.

During construction, intersect runoff from rainfall, snowfall, and creeks, and temporarily divert it to help prevent water ponding on the project site, specifically in foundation and embankment areas. Always seal, adequately slope, and daylight subgrades to help direct water away from the construction area at the end of each day or before precipitation.

Establishing Subgrades

Following site stripping, excavation to achieve project subgrades, and prior to structural fill or concrete placement, expose dense native gravel and sand or basalt bedrock beneath culvert foundations. Prepare culvert foundation and pavement subgrades referencing *Idaho Standards for Public Works Construction* (ISPWC) Section 204-3.1. This requires scarifying the exposed subgrade and recompacting to achieve *Structural Fill* conditions.

Careful construction and earthwork procedures are critical to achieving adequate subgrade preparation and reducing over-excavation. Specifically, these procedures could include, but are not limited to, carefully staging equipment and/or stockpiles and routing construction equipment away from subgrades. It is the contractor's responsibility to protect subgrades throughout construction. Subgrade disturbance that occurs due to the contractor's means and methods must be repaired at no cost to the NPT or County.

Structural Fill

All fill for this project must be placed as structural fill. The recommended material requirements for structural fill reference the ISPWC requirements. Our recommendations for various structural fill products are shown in Table 1, *Structural Fill Products and Allowable Uses*.

Table 1. Structural Fill Products and Allowable Uses

Structural Fill Product	Allowable Use	Material Specifications
General Structural Fill	• General site grading and utility trench backfilling	• Soil classified as GP, GM, GW, SP, SM, or SW according to the USCS • Soil may not contain particles larger than 0.7 feet in median diameter • Soil consisting of inert earth materials with less than 3 percent organics or other deleterious substances (wood, metal, plastic, waste, etc.)
Granular Structural Fill	• Culvert backfill • Backfilling over-excavations • General Structural Fill applications	• Soil meeting requirements stated in *Section 801 – Uncrushed Aggregates* in the latest ISPWC Specifications (crushed products are acceptable)
Crushed Aggregate	• Foundation leveling course • Pavement support aggregate • Granular structural fill applications	• Aggregate meeting requirements stated in *Section 802 – Crushed Aggregates* in the latest ISPWC Specifications
Unsatisfactory Soil	NONE	• Soil classified as ML, CL, MH, OH, CH, OL, or PT may not be used at the project site • Over-optimum moisture conditions does not render a soil unsuitable, attempt moisture conditioning

<u>Site Soil Reuse</u>

Granular site soil may be reused as *Granular Structural Fill* but requires processing including removing coarse particles to meet the requirements in Table 1 and to facilitate efficient, effective reuse. Excavated site soil may be reused as culvert backfill but not reused as roadway surfacing aggregate.

<u>Required Compaction</u>

All fill and subgrade surfaces for the planned improvements must be compacted per requirements presented in ISPWC Sections 202 and 204. This includes foundation subgrades, surfaces to receive embankment fill, and all backfill or embankment fill placed for the planned construction. ISPWC Sections 202 and 204 generally require placing fill material in maximum 1-foot layers prior to compaction. Coarse granular fill products may be placed in fill layers up to 1.5 feet thick. Our experience is that moisture conditioning (i.e. wetting or drying soil) to near optimum moisture content is required to efficiently achieve compaction requirements.

The contractor is responsible for selecting compaction equipment suitable for achieving compaction requirements. Thicker, coarse fill products placed in layers thicker than 1 foot require large equipment and more passes to achieve compaction requirements. Place structural fill only over approved subgrades. Never place structural fill over frozen or soft subgrades.

Culvert Backfill/Roadway Embankment Construction

Structural fill embankments adjacent to the culvert sides will be constructed to facilitate finished grades. Construct embankments with structural fill conforming to this report's requirements. Key structural embankment fill into the excavation side slopes per the latest ISPWC Section 202 requirements. Adequate keying into existing slopes, subgrade preparations, and structural fill placements should be accomplished; otherwise, differential performance of the roadway surface and fill slopes can be expected.

Great West plans new embankment slopes at 2H:1V. These relatively steep slopes will be subject to erosion and shallow surface failures when they are constructed with soil containing significant fines content. To reduce these risks, we recommend all embankment fill comprise *Granular Structural Fill*, consistent with the requirements outlined in Table 1. Alternatively, armor all finished embankment slopes with riprap.

These measures can be, in part, accomplished by following an *Environmental Protection Agency* (EPA) approved *Stormwater Pollution Prevention Plan* (SWPPP). A vegetation and maintenance program is strongly recommended to be initiated immediately after construction reducing the potential for erosion and surface sloughing. In addition, a maintenance program should prescribe visual observation of the slope conditions at different times of the year.

New embankments constructed to achieve finished roadway grades will be within 1 to 3 feet of existing roadway grades. We estimate embankment settlement will be less than 0.5 inches, with half of this settlement occurring during construction, while the remainder will occur 6 months post-construction, as the soil comes to equilibrium under new embankment loads.

Geotechnical Documentation

Successful earthwork activities are important to the project's long-term performance. Retaining experienced earthwork contractors is the first step in having confidence that earthwork will be performed in reference to this report's requirements. Providing the necessary testing and engineering documentation of earthwork activities is the second step. The criteria below outline the minimum testing and observation frequencies to implement during earthwork and infrastructure construction.

1. Culvert foundation subgrades exposed prior to fill placement: compact over-excavated subgrades per ISPWC Section 204-3.1.

2. Structural fill placement/culvert backfilling: 2 compaction tests on each side of the culvert, per fill lift, minimum 3 tests per testing event.

3. Roadway aggregate placement: 1 compaction test every 50 linear foot (lf) per lane, per fill lift; minimum 3 tests, whichever results in the greater number of tests.

4. Asphalt pavement construction: 1 compaction test every 50 lf per lane, per lift. One laboratory test suite on a loose mix sample of HMA for each day of paving to determine oil content, extracted gradation, and theoretical maximum specific gravity and density (Rice).

Foundation Design

From our exploration near each of the planned crossing alignments, we anticipate foundation excavations at each location will extend through surface fill deposits and will encounter dense alluvial gravel and sand mixtures or hard basalt bedrock. Exposed subgrades must be compacted and prepared per the *Establishing Subgrades* report section. If desired for a uniform bearing pad, a *Crushed Aggregate* levelling course may be applied atop the compacted native subgrades.

The following text presents our design and construction recommendations for culvert foundations bearing atop dense, compacted alluvial sand and gravel subgrades, bedrock, or *Crushed Aggregate* levelling course placed atop approved subgrades.

<u>Design Criteria</u>

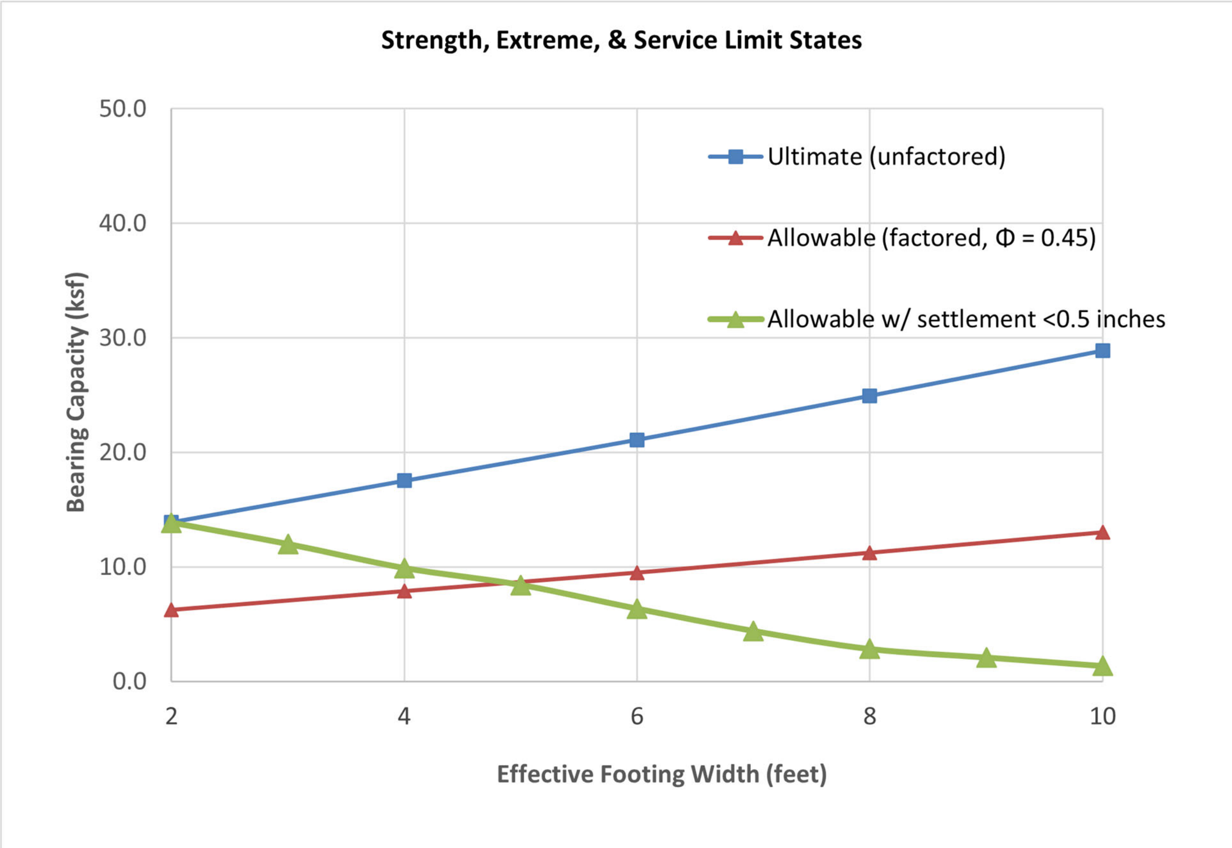
Foundations must be designed according to the latest *American Association of State Highway and Transportation Officials* (AASHTO) *Load Resistance Factor Design* (LRFD) *Bridge Design Specifications*. Foundations must bear at least 2.5 feet below the adjacent finished ground surface for frost protection. We understand Great West will design riprap cover or other scour protection measures to preclude scour from impacting the planned culvert foundations.

Graphs showing the bearing capacities as a function of effective foundation width for the planned culvert foundations are presented below. Given the subgrade conditions are anticipated to dense native gravel or hard bedrock, we recommend these graphs be used for design of foundations at each crossing location. These graphs are developed for LRFD design at the strength limit states and service limit state for the anticipated structures, and assume the subgrade preparation criteria outlined in the *Earthwork* report section is accomplished based on dense gravel subgrades for conservatism.

The nominal (ultimate) bearing capacities in Figure 1 were estimated using Vesic's bearing capacity equation (Coduto, 2001). The ultimate bearing capacity plot is shown in blue. Per the *AASHTO LRFD Specifications, Table 10.5.5.2.2-1,* a resistance factor of 0.45 shall be applied to the ultimate bearing capacities to delineate the factored (allowable) bearing capacities vs. footing width, as shown in red in Figure 1.

The presumptive bearing pressure for the service limit state is presented in Figure 1 as the green plot. The service limit state is based on an estimated 0.5 inches of total estimated settlement. Along the individual foundations and between the 2 culvert sides, total estimated settlement could be realized entirely as differential between the 2 foundations under service loading conditions. Based on AASHTO Section 10.5.5.1, resistance factors for service limit state for foundation design are taken as 1.0. Figure 1 is developed based on our settlement analysis using elastic theory for allowable pressure (Terzaghi & Peck, 1967). Additionally, Figure 1 represents bearing capacities vs. footing width assuming foundations bear directly on recompacted native sand and gravel subgrades. Plate 4, *Foundation Construction Schematic*, illustrates the foundation construction process

Figure 1. Bearing Capacity vs. Footing Width



Lateral loads on foundations may be resisted by friction between the bottom of the footing and the underlying bearing material. For design purposes, a base sliding friction coefficient of 0.50 should be used for footings cast on dense native gravel, bedrock, or *Crushed Aggregate*. With reference to AASHTO LRFD *Bridge Design Specifications Section 10.5.5.2.2*, a lateral sliding resistance factor of 0.9 should be used for precast concrete foundations and a resistance factor of 0.8 should be used for cast-in-place concrete foundations.

Foundation Preparations

Excavations for footing construction must expose dense, native alluvial gravel and sand or bedrock prepared per the *Establishing Subgrades* report section. If required prior to foundation placement, place and compact a *Crushed Aggregate* levelling course to achieve the foundation bearing surface elevation. A schematic illustrating abutment foundation construction is provided on Plate 4. Please note where full scour protection is not provided via Great West's riprap design or other means, scour action can erode material placed beneath bridge foundations and cause reduced bridge foundation support.

Lateral Pressures and Backfill

Backfill culverts and abutment walls using *Granular Structural Fill* per Table 1 in this report. Compact backfill per ISPWC Section 204. Lateral earth pressures will be realized on the culvert sides from retained soil behind the structure as well as any surcharge from traffic, equipment, or material placed adjacent to the abutments.

Estimate lateral earth pressures for culvert sides and wingwalls, backfilled with *Granular Structural Fill*, using the following equivalent fluid weights (EFW) from Table 2.

Table 2. Static Equivalent Fluid Pressures (EFP)

Granular Structural Fill (*Φ = 35º, ɣ=130 pcf*)	**Equivalent Fluid Weight (EFW)[1]**	
Rankine Lateral Earth Pressure Case	Above Groundwater Elevation	Below Groundwater Elevation
At-rest case (no wall movement)	55 pcf	90 pcf
Active case (wall movement away from soil mass)	35 pcf	80 pcf
Passive case (wall movement toward soil mass)	480[2,3] pcf	250[2,3] pcf

1. Assumes flat backfill and no hydrostatic pressure behind abutment walls.
2. Assumes ¾ inch of allowable lateral movement to mobilize passive resistance.
3. Neglect passive resistance within upper 2 feet below ground surface due to potential for erosion, frost action and other disturbance.

The equivalent fluid weights in Table 2 (above groundwater) assume flat backfill, fully drained conditions and no hydrostatic forces acting on the culvert sides. The EFW's below the groundwater elevation assume flat backfill. Lateral surcharge pressures due to equipment, traffic, slopes, storage loads, etc., have not been included in the above lateral earth pressure recommendations. To estimate the lateral pressures on abutment walls from traffic, equipment, temporarily stored material, and other surcharges, use the following equation, referencing Equation 3.11.6.1-1 in the *AASHTO LRFD Bridge Design Specifications*:

$$\Delta_p = k_s * q_s$$

Where:

- Δ_p = horizontal earth pressure increase due to uniform surcharge pressure (pounds per square foot, psf)
- k_s = at rest earth pressure coefficient, estimated at 0.43 for *Granular Structural Fill* (Φ = 35º, ɣ=130 pcf)
- q_s = uniform surface surcharge (psf)

Fill, debris, and loose soil should be removed before placing culvert backfill. Care should be taken to avoid over compacting the backfill so that the culvert is not displaced or damaged.

Seismic Design

Based on the subsurface conditions encountered during exploration and from *Section 3.10.3.1* in the AASHTO LRFD Manual, we recommend a seismic site class "C" be used in structural design for this project. The following seismic parameters in Table 3 are recommended for design.

Table 3. Seismic Response Criteria[1]

Period (seconds)	**Standard Acceleration Coefficients[2] for Site Class B (g)**	**Site Factor for Site Class C**	**Design Spectral Acceleration Parameters for Site Class C (g)**
0.0 (Peak)	PGA = 0.082	FPGA = 1.2	As = 0.098
0.2 (Short)	SS = 0.183	Fa = 1.2	SDS = SS*Fa = 0.220
1.0	S1 = 0.062	Fv = 1.7	SD1 = S1*Fv = 0.105

1. Values for Sally Ann Creek Watershed.
2. Acceleration coefficients based on *Figures 3.10.2.1-1, 3.10.2.1-2* and *3.10.2.1-3* in the *AASHTO LRFD Bridge Design Manual*.

Liquefaction is a common concern in low-density sand and non-plastic silt with a potential for saturated conditions. The liquefaction potential rapidly decreases when the soil density increases and the percentage of cohesive fine-grained soil increases. The subsurface conditions are predominantly dense, coarse gravel with sand. Therefore, in our opinion, the potential risk for liquefaction to impact the planned foundations is low.

Pavement Section Design

To evaluate and design pavement sections, we assume pavement subgrades will consist of recompacted sand and gravel fill encountered near the existing ground surface in our explorations, or imported *Granular Structural Fill*. The following report sections present our traffic loading assumptions, pavement design parameters, references, and the resulting flexible HMA pavement section design recommendations.

<u>Traffic Loading</u>

From information provided by the County, we understand projected average daily traffic (ADT) along Sally Ann Creek Road is estimated at 500 vehicles. Consistent with similar rural roadways, we estimate the ADT comprises up to 5 percent truck traffic (HL-93). From this information, as well as an assumed 5 percent annual growth rate over a 20-year design period, we estimate a total of 566,500 Equivalent Single Axle Loads (ESALs) along the Sally Ann Creek Road alignment.

We specifically note that the quantity and type of trucks, recreational or maintenance vehicles, busses and other heavily loaded traffic can have significant impacts on roadway performance and on ESALs calculated based on their respective equivalent axle load factor (EALF) value. Further, our traffic load estimates do not include construction traffic. We recommend paving be accomplished after construction is substantially complete. Heavy construction traffic loads traversing the pavements that exceed the loads outlined above can result in damage in as little as 1 pass.

<u>Pavement Subgrades</u>

Pavement subgrades shall be prepared according to the *Establishing Subgrades* report section. Based on our exploration, we anticipate pavement subgrade soil will consist of coarse sand and gravel mixtures. Based on our laboratory test results and experience with similar soil types, we used a design resilient modulus (Mr) value of 12,000 pounds per square inch (psi) for the anticipated subgrade referencing AASHTO published correlations.

<u>Pavement Section Thicknesses</u>

To provide the specified pavement section design, we referenced the subsurface conditions encountered, laboratory test results, and anticipated traffic loading conditions. Accordingly, we referenced the AASHTO design methodology in our pavement section evaluation. Table 4 summarizes the design parameters we used to prepare the pavement design section for the Sally Ann Creek Road crossings.

Table 4: Flexible Asphalt Pavement Section Design Parameters

Design Parameter	Value Used	Reference
Reliability (R)	85%	AASHTO
Standard Deviation (S)	0.45	AASHTO
Initial Serviceability (PSIi)	4.2	Typical area values
Terminal Serviceability (PSIz)	2.2	Typical area values
Traffic Loading	Sally Ann Creek Road 566,500 ESALS	See *Traffic Loading* section
Design Life	20 years	Typical area value for asphalt pavement
Resilient Modulus	12,000 psi	Based on Mr correlations to soil type
New Asphalt Layer Coefficient (a1)	0.42	Figure 2.5 AASHTO

New Aggregate Layer Coefficient (a2)	0.12	Figure 2.6 AASHTO
Drainage Coefficient	0.9	Table 2.4 AASHTO for "fair" drainage

Referencing the pavement section design parameters in Table 4, we present our pavement thickness recommendations in Table 5 for each roadway.

Table 5: Flexible Asphalt Pavement Section Design

Pavement Section Material	Minimum Thickness (feet)	Material Specifications
Flexible Asphalt Pavement	0.25	Conforming to ISPWC Section 810 – Plant Mix Pavement
Crushed Aggregate	1.00	Shall conform to Section 802 – Crushed Aggregates

Pavement Maintenance

We recommend crack maintenance be accomplished on all pavement surfaces every 3 to 5 years to reduce the potential for surface water infiltration into the underlying pavement subgrade. All pavements should be maintained by annually identifying cracking and any soil piping that may be evident at joints. Cracks should be sealed at least annually by removing foreign material, and applying asphaltic crack seal material for asphalt pavements. Pavement maintenance and reducing water to pavement subgrades will slow pavement distress and may extend pavement life.

Site Drainage

We understand existing drainage patterns will be maintained outside of the new culvert alignment. Surface runoff from the roadway surface shall be conveyed to existing drainage patterns. Ground surfaces surrounding the culvert, roadway, or other improvements should slope away at 2 percent for a minimum of 10 feet to rapidly convey surface water and roadway runoff away from foundations.

Backfill culverts and abutment walls with *Granular Structural Fill* or *Crushed Aggregate* to help facilitate drained conditions, as shown on Plate 4. Granular fill shall extend the full length of the culvert and wing walls. Standard weep hole and drain pipe installations are recommended for wing walls to preclude the buildup of ponded water behind these structures.

GEOTECHNICAL DESIGN CONTINUITY

The information contained in this report is based on our knowledge of planned construction as well as the results of our site exploration and laboratory testing. Changes in planned grading, drainage, site configurations, loading conditions, and geometry can significantly alter our opinions and recommendations. Therefore, it is critical GPI provide geotechnical continuity through final planning and design for the project.

Our experience is that having consultants from the design team review the construction documents helps reduce the potential for errors, and also reduces costly changes to the contract during construction. If GPI is not provided such opportunities, we cannot be responsible for geotechnical-related design or construction errors, omissions, delays, or increased costs that are identified during construction.

We recommend Great West or the County retain GPI to observe and document the foundation subgrades align with the conditions anticipated for design and construction preparation activities, to conform that our report recommendations are incorporated into the actual construction. Such observation is an important part of the geotechnical design process and can help reduce the potential for soil engineering- or construction-related errors or omissions.

EVALUATION LIMITATIONS

This report is prepared to assist project planning design and construction for the proposed Sally Ann AOP project that will replace the existing culverts crossing Sally Ann Creek and Wall Creek in Idaho County, Idaho. The geotechnical findings and opinions provided herein are developed based on the authorized subsurface exploration and laboratory testing, as well as our current project understanding. The geotechnical design recommendations are specific to the planned culvert improvements and should not be extrapolated to other future improvements. Our scope did not include an engineering evaluation of site grading and drainage, erosion control, scour analysis or scour protection design, site specific seismic response, evaluating multiple foundation systems, stream diversion design, retaining wall design and layout, project surveying, civil design, structural design, developing a project safety plan, specification development or construction observation.

GPI's services consist of professional opinions and findings made in accordance with generally accepted geotechnical engineering principles and practices in the area at the time of this report. The geotechnical recommendations provided herein are based on the premise that appropriate geotechnical consultation during subsequent project phases is implemented and an adequate program of tests and observations will be conducted by GPI during construction to verify compliance with the recommendations and to confirm conditions between exploration locations.

Soil borings reveal only a small portion of the conditions throughout the planned improvement areas. Subsurface variations may exist between or beyond our explorations, specifically in a high energy alluvial environment such as the Sally Ann Creek drainage. Such variation can impact the geotechnical recommendations in this report. This acknowledgment is in lieu of all warranties either express or implied.

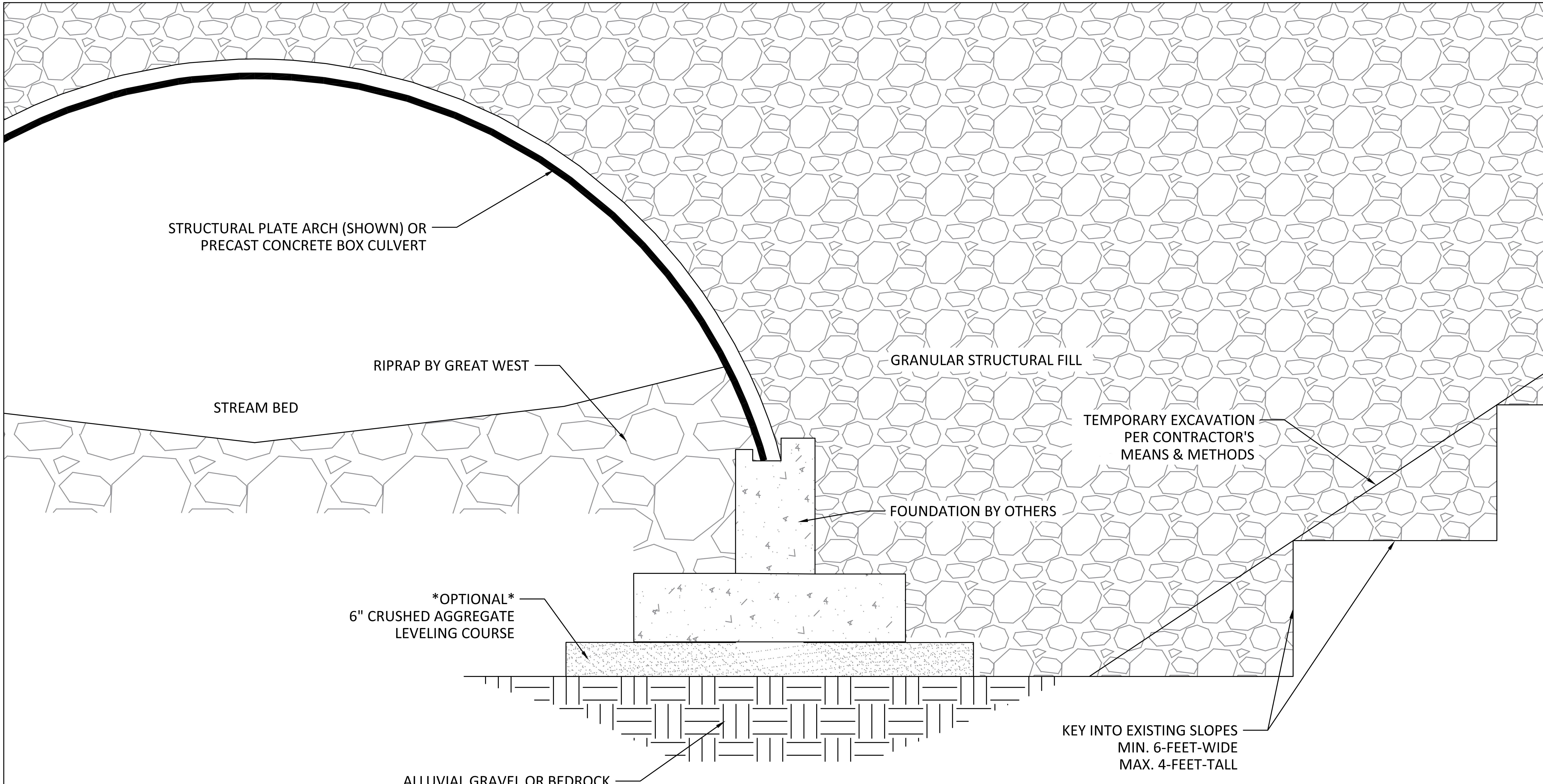
The following plates and appendices accompany this report:

Plates 1 - 3:	Exploration Map
Plate 4:	Foundation Construction Schematic
Appendix A:	Unified Soil Classification System (USCS) and Exploration Logs
Appendix B:	Laboratory Test Results

Reference: Base image from Google Maps, 2023. No Scale Intended

Reference: Base image from Google Maps, 2023. No Scale Intended

Reference: Base image from Google Maps, 2023. No Scale Intended



FOUNDATION CONSTRUCTION SCHEMATIC
Sally Ann Watershed Crossings
Sally Ann Creek Road & Wall Creek Road
Idaho County, Idaho

GeoProfessional Innovation.

MO22154A	PLATE: 4

Notes: Not a structural detail, for reference only. No Scale Intended.

APPENDIX A

Unified Soil Classification System (USCS)
Exploration Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE GRAINED SOIL	GRAVEL	CLEAN GRAVEL		GW	WELL-GRADED GRAVEL, GRAVEL-SAND MIXTURES.
				GP	POORLY-GRADED GRAVEL, GRAVEL-SAND MIXTURES.
		GRAVEL WITH FINES		GM	SILTY GRAVEL, GRAVEL-SAND-SILT MIXTURES.
				GC	CLAYEY GRAVEL, GRAVEL-SAND-CLAY MIXTURES.
	SAND	CLEAN SAND		SW	WELL-GRADED SAND, GRAVELLY SAND.
				SP	POORLY-GRADED SAND, GRAVELLY SAND.
		SAND WITH FINES		SM	SILTY SAND, SAND-SILT MIXTURES.
				SC	CLAYEY SAND, SAND-CLAY MIXTURES.
FINE GRAINED SOIL	SILT AND CLAY LIQUID LIMIT LESS THAN 50%			ML	INORGANIC SILT, SANDY OR CLAYEY SILT.
				CL	INORGANIC CLAY OF LOW TO MEDIUM PLASTICITY, SANDY OR SILTY CLAY.
				CL-ML	INORGANIC MIXED CLAY AND SILT.
				OL	ORGANIC SILT AND CLAY OF LOW PLASTICITY.
	SILT AND CLAY LIQUID LIMIT GREATER THAN 50%			MH	INORGANIC SILT, MICA- CEOUS SILT, PLASTIC SILT.
				CH	INORGANIC CLAY OF HIGH PLASTICITY, FAT CLAY.
				OH	ORGANIC CLAY OF MEDIUM TO HIGH PLASTICITY.
				PT	PEAT, MUCK AND OTHER HIGHLY ORGANIC SOILS.

BORING LOG SYMBOLS

STANDARD 2 INCH OD SPLIT SPOON SAMPLE

CALIFORNIA MODIFIED 3 INCH OD SPLIT SPOON SAMPLE

ROCK CORE

SHELBY TUBE 3 INCH OD UNDISTURBED SAMPLE

TEST PIT LOG SYMBOLS

GRAB BAG SAMPLE

BG

BULK SAMPLE

BK

RING SAMPLE

RG

GROUNDWATER SYMBOLS

GROUNDWATER AFTER 24 HOURS

GROUNDWATER AT TIME OF EXPLORATION

GROUNDWATER AT THE END OF EXPLORATION

GeoProfessional Innovation

USCS Description	Depth (ft)	Symbol	Sample Type	SPT Blows Per 6 Inches	SPT N	Dry Density (pcf)	TEST RESULTS: Pocket Penetrometer, TSF ▲ (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5); SPT, N-Value ●; % Passing No. 200 Sieve ★; PL MC LL (20 40 60 80)	Remarks (Note: BGS = Below Ground Surface)
FILL - SILTY GRAVEL WITH COBBLES, (GM) gray, loose to dense, damp to wet	0.0	GM	BK					No vegetation or organics noted in soil.
FILL - POORLY-GRADED GRAVEL WITH COBBLES, (GP) gray, dense, moist	2.5	GP		15 22 23	45		●	Boring backfilled with auger cuttings and capped with bentonite upon completion.
Borehole Terminated at 5.0 Feet.	5.0							Boring refused at 5.0-feet within dense gravel and cobbles.

Client: Great West Engineering	**Boring Number:** B-22154A-1
Project: MO22154A	**Date Drilled:** 10-25-2022
Drill Rig: B-57	**Borehole Diameter:** 8
Depth to Groundwater: N.E.	**Logged By:** JTK

GeoProfessional Innovation.

EXPLORATORY BORING LOG

EXPLORATORY BORING LOG

USCS Description	Depth (ft)	Symbol	Sample Type	SPT Blows Per 6 Inches	SPT N	Dry Density (pcf)	TEST RESULTS: Pocket Penetrometer, TSF ▲ (0.5–4.5); SPT, N-Value ●; % Passing No. 200 Sieve ★; PL / MC / LL (20, 40, 60, 80)	Remarks (Note: BGS = Below Ground Surface)
FILL - SILTY GRAVEL WITH COBBLES, (GM) gray, medium dense, moist	0.0	GM						No vegetation or organics noted in soil.
FILL - POORLY-GRADED GRAVEL WITH COBBLES, (GP) gray, dense, moist	2.5	GP	SPT	10 16 19	35		● 35	Boring backfilled with auger cuttings and capped with bentonite upon completion.
Borehole Terminated at 4.5 Feet.								Boring refused at 4.5-feet within dense gravel and cobbles.

Client: Great West Engineering	**Boring Number:** B-22154A-2
Project: MO22154A	**Date Drilled:** 10-25-2022
Drill Rig: B-57	**Borehole Diameter:** 8
Depth to Groundwater: N.E.	**Logged By:** JTK

GeoProfessional Innovation.

EXPLORATORY BORING LOG

Sheet 1 Of 1

EXPLORATORY BORING LOG

USCS Description	Depth (ft)	Symbol	Sample Type	SPT Blows Per 6 Inches	SPT N	Dry Density (pcf)	Remarks
FILL - SILTY SAND WITH GRAVEL, (SM) gray to brown, medium dense, moist	0	SM					No vegetation or organics noted in soil. Drill chatter from 1.0- to 6.0-feet. Cobbles evident in cuttings.
			BK				ASTM D1557: Modified Proctor Optimum Moisture Content: 6.0% Maximum Dry Density: 141.0 pcf
	5			10 12 6	18		
ALLUVIUM - CLAYEY GRAVEL, (GC) dark brown, medium dense, moist to wet		GC					
	10			12 10 6	16		
ALLUVIUM - POORLY-GRADED GRAVEL WITH COBBLES, (GP) brown to gray, dense, moist to saturated		GP					Drill chatter observed at 14.0-feet BGS.
	15			14 14 20	34		
	20			18 28 18	46		Boring backfilled with auger cuttings and capped with bentonite upon completion.

TEST RESULTS

Pocket Penetrometer, TSF ▲

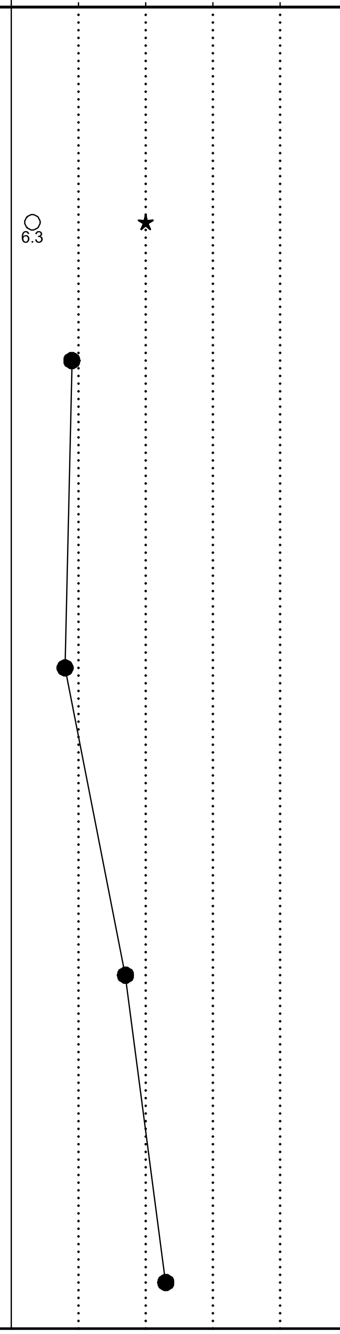
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5

SPT, N-Value ●

% Passing No. 200 Sieve ★

PL MC LL

20 40 60 80



Note: BGS = Below Ground Surface

Borehole Terminated at 21.5 Feet.

Client: Great West Engineering	**Boring Number:** B-22154A-3	GeoProfessional Innovation.
Project: MO22154A	**Date Drilled:** 11-09-2022	**EXPLORATORY BORING LOG**
Drill Rig: CME 75	**Borehole Diameter:** 8	
Depth to Groundwater: N.E.	**Logged By:** JTK	Sheet 1 Of 1

USCS Description	Depth (ft)	Symbol	Sample Type	SPT Blows Per 6 Inches	SPT N	Dry Density (pcf)	TEST RESULTS: Pocket Penetrometer, TSF ▲ (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5); SPT, N-Value ●; % Passing No. 200 Sieve ★; PL MC LL (20 40 60 80)	Remarks Note: BGS = Below Ground Surface
FILL - POORLY-GRADED GRAVEL WITH COBBLES, (GP) gray, dense, moist	0.0	GP						No vegetation or organics noted in soil.
								Drill chatter and very hard drilling observed at 2.0-feet BGS.
	2.5			10 15 26	41		● 41	Boring backfilled with auger cuttings and capped with bentonite upon completion.
Borehole Terminated at 4.0 Feet.								Boring refused at 4.0-feet within dense gravel and cobbles.

Client: Great West Engineering	**Boring Number:** B-22154A-4	GeoProfessional Innovation.	**EXPLORATORY BORING LOG**
Project: MO22154A	**Date Drilled:** 10-25-2022		
Drill Rig: B-57	**Borehole Diameter:** 8		
Depth to Groundwater: N.E.	**Logged By:** JTK		Sheet 1 Of 1

USCS Description	Depth (ft)	Symbol	Sample Type	SPT Blows Per 6 Inches	SPT N	Dry Density (pcf)	TEST RESULTS Pocket Penetrometer, TSF ▲ (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5) SPT, N-Value ● % Passing No. 200 Sieve ★ PL MC LL 20 40 60 80	Remarks Note: BGS = Below Ground Surface
FILL - POORLY-GRADED GRAVEL WITH ANGULAR COBBLES, (GP) gray, medium dense, wet	0	GP						No vegetation or organics noted in soil.
	5			16 12 15	27			
ALLUVIUM - SILTY SAND WITH GRAVEL, (SM) dark brown, medium dense, saturated	10	SM		2 8 18	26			
			BK				★ 24.4	ASTM D1557: Modified Proctor Optimum Moisture Content: 9.5% Maximum Dry Density: 127.3 pcf
(RX) BEDROCK - BASALT, highly weathered, moderately fractured, black to gray	15	RX		50/3.0"	50+		50+	Boring backfilled with auger cuttings and capped with bentonite upon completion.
Borehole Terminated at 15.5 Feet.								Boring refused at 15.5-feet within basalt bedrock.

Client: Great West Engineering	**Boring Number:** B-22154A-5	GeoProfessional Innovation	**EXPLORATORY BORING LOG**
Project: MO22154A	**Date Drilled:** 11-09-2022		
Drill Rig: CME 75	**Borehole Diameter:** 8		
Depth to Groundwater: 9'	**Logged By:** JTK		Sheet 1 Of 1

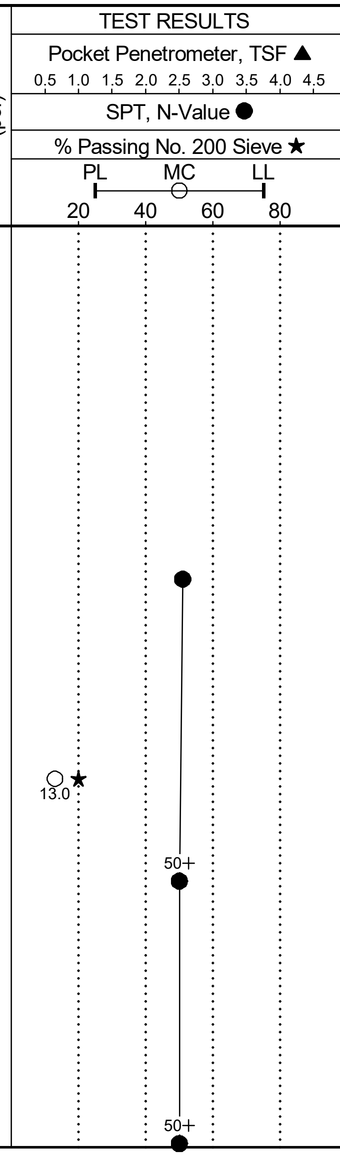
USCS Description	Depth (ft)	Symbol	Sample Type	SPT Blows Per 6 Inches	SPT N	Dry Density (pcf)	TEST RESULTS Pocket Penetrometer, TSF ▲ (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5) SPT, N-Value ● % Passing No. 200 Sieve ★ PL MC LL (20 40 60 80)	Remarks Note: BGS = Below Ground Surface
FILL - POORLY GRADED GRAVEL WITH COBBLES, (GP) gray, dense, moist	0.0	GP						No vegetation or organics noted in soil. Cobbles at 0.5-feet BGS Drill chatter at 1.0-feet BGS
	2.5			15 29 31	44		●	
	5.0							
Borehole Terminated at 5.0 Feet.								Boring refused at 5.0-feet within very dense gravel and cobbles.

Client: Great West Engineering	**Boring Number:** B-22154A-8	GeoProfessional Innovation.	**EXPLORATORY BORING LOG**
Project: MO22154A	**Date Drilled:** 10-26-2022		
Drill Rig: CME 850	**Borehole Diameter:** 8		
Depth to Groundwater: N.E.	**Logged By:** JTK		Sheet 1 Of 1

USCS Description	Depth (ft)	Symbol	Sample Type	SPT Blows Per 6 Inches	SPT N	Dry Density (pcf)	Remarks
FILL - POORLY-GRADED GRAVEL WITH COBBLES, (GP) gray to black, very dense, moist to wet	0	GP					No vegetation or organics noted in soil.
	5			19 28 23	51		
ALLUVIUM - SILTY GRAVEL WITH SAND AND COBBLES, (GM) gray, very dense, saturated		GM	BK				Significant drill chatter observed from 8.0- to 15.0-feet BGS.
	10			10 26 50/4.0"	50+		
(RX) BEDROCK - BASALT, highly weathered, moderately fractured, black to gray		RX					Boring backfilled with auger cuttings and capped with bentonite upon completion.
	15			50/1.0"	50+		Boring refused at 15.0-feet after encountering basalt bedrock.

Borehole Terminated at 15.0 Feet.

Note: BGS = Below Ground Surface



Client: Great West Engineering	**Boring Number:** B-22154A-9
Project: MO22154A	**Date Drilled:** 11-09-2022
Drill Rig: CME 75	**Borehole Diameter:** 8
Depth to Groundwater: 7'	**Logged By:** JTK

GeoProfessional Innovation

EXPLORATORY BORING LOG

Sheet 1 Of 1

APPENDIX B

Laboratory Test Results

GeoProfessional Innovation.

Project Name: Sally Ann Creek Watershed Crossings AOP Designs
Project Number: MO222154A
Client: Great West Engineering
Report Date: 3/24/2023

Test Results Summary

Boring B	Crossing Alignment	Depth (feet)	Lab Number	Description (U.S.C.S. Classification)	In situ Moisture, %	Max Dry Density, pcf	Optimum Moisture, %	#200 Sieve Passing, %
B-22154A-3	Sally Ann #1	3.0-4.0	14125	Silty Sand with Gravel (SM)	6.3	141.0	6.0	40
B-22154A-5	Sally Ann #2	12.0-13.0	14123	Silty Sand with Gravel (SM)	24.4	127.3	9.5	19
B-22154A-9	Wall Creek	8.0-10.0	14124	Silty Gravel with Sand (GM)	13.0	-	-	20

Reviewed by: ______________________

MOISTURE-DENSITY RELATIONSHIP CURVE
ASTM D 1557
Method C

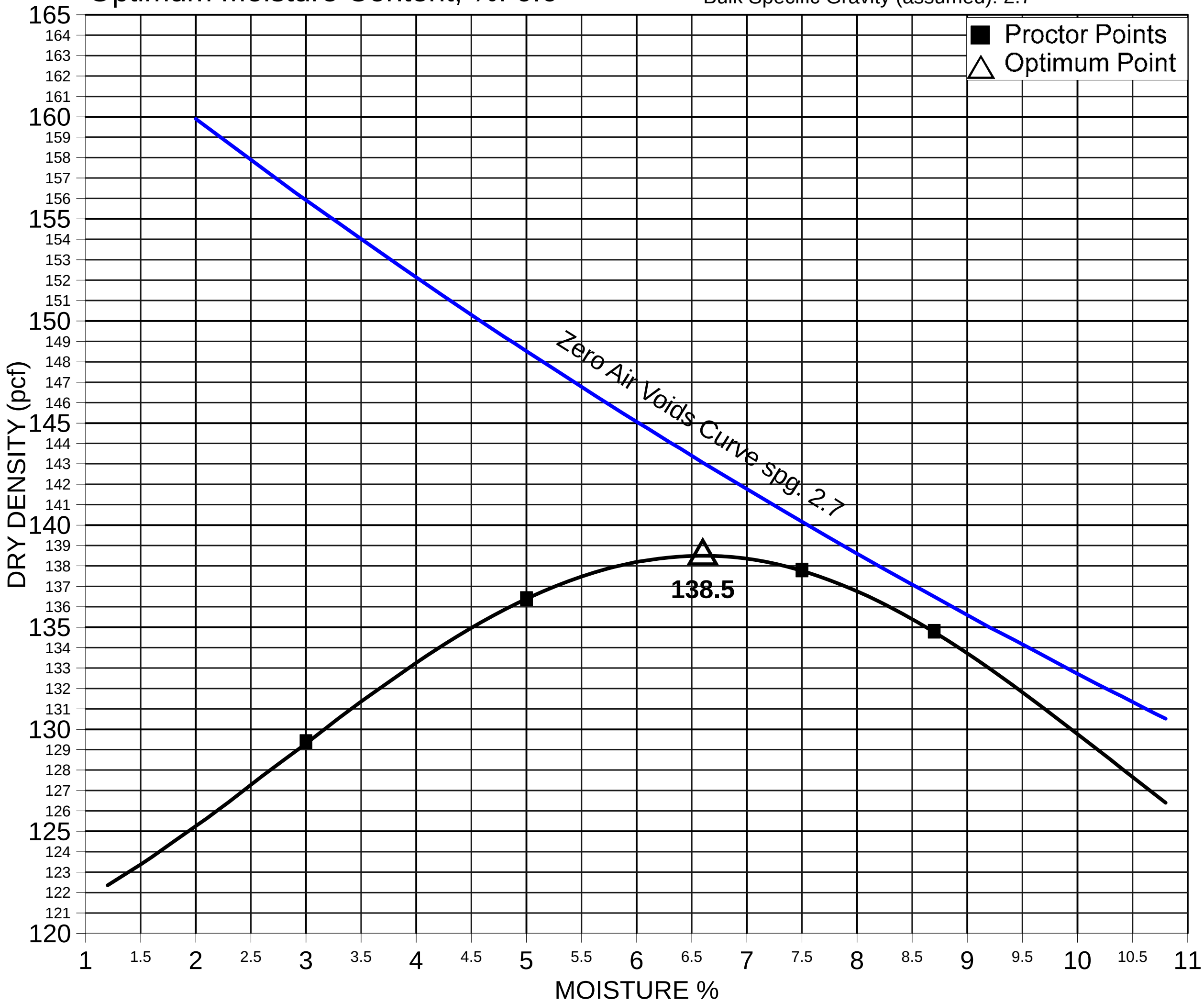
Project: Sally Ann Creek Wastershed Crossing AOP Design
Client: Great West Engineering
Project Number: MO22154A
Lab Number: 14125
Sample Location: Sally Ann #1, B-22154A-3 @ 3.0-4.0 feet BGS
Sample Classification: Silty Sand with Gravel (SM)
Date Tested: 12/20/2022 By: LMC
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
1.5"	100	100
1.0"	98	100
3/4"	94	100
1/2"	89	89
3/8"	87	87
#4	79	79
#8	72	72
#16	66	66
#30	61	61
#50	55	55
#100	50	50
#200	40	40

Maximum Dry Density, pcf : 138.5
Optimum Moisture Content, %: 6.6

Corrected Dry Density, pcf: 141.0
Corrected Moisture Content, %: 6.0
Coarse Aggregate Correction, %: 6
Bulk Specific Gravity (assumed): 2.7



Reviewed By:

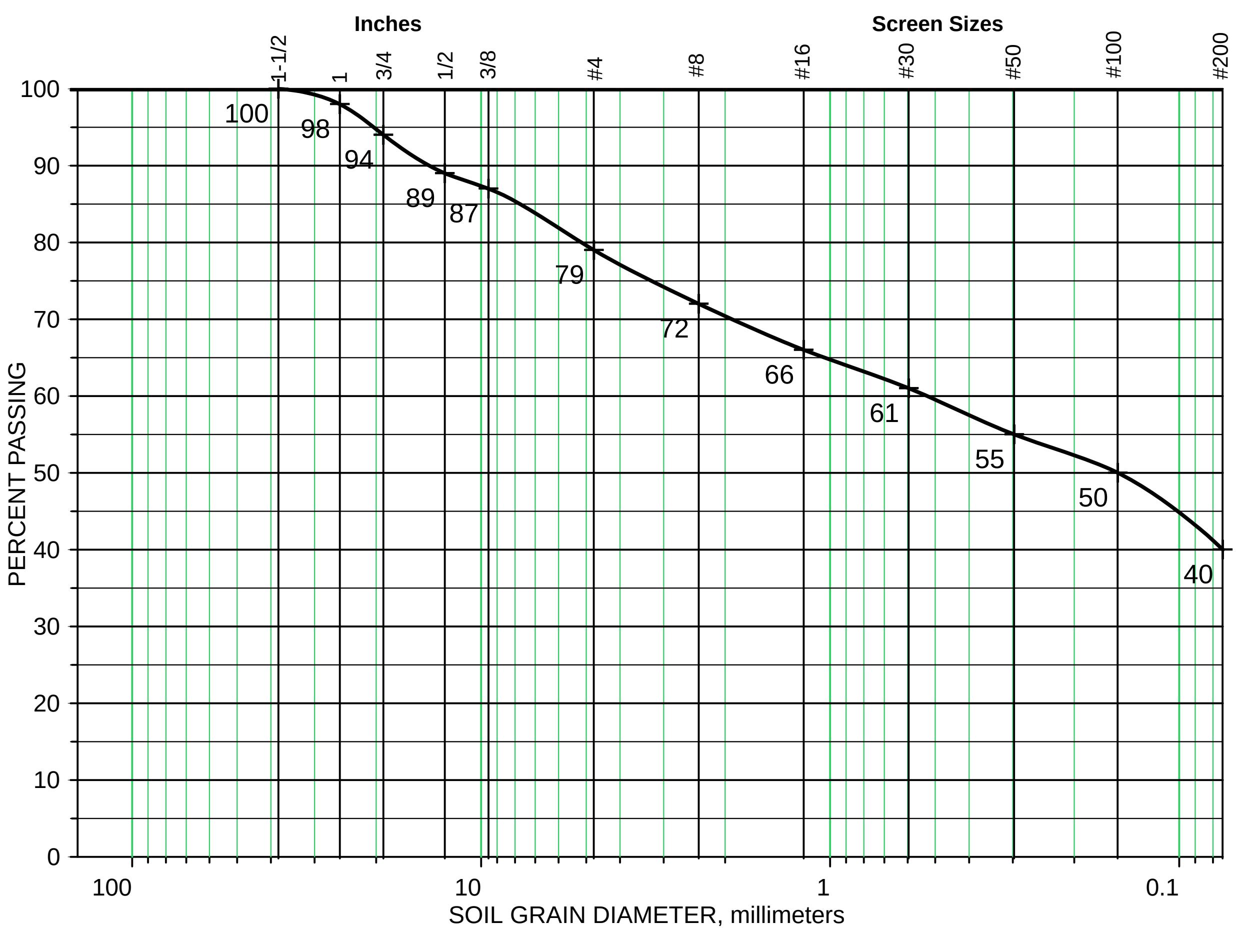
GeoProfessional Innovation.

GRADATION ANALYSIS

ASTM D6913

Project: Sally Ann Creek Watershed Crossings AOP Design
Client: Great West Engineering
Project Number: MO22154A
Sample No: 14125
Sample Location: Sally Ann #1, B-22154A-3 @ 3.0-4.0 feet BGS
Sample Classification: Silty Sand with Gravel (SM)
Date tested: 12/21/2022   By: LMC

Cobbles	Gravel		Sand		
	Coarse	Fine	Coarse	Medium	Fine



Reviewed by: ______________________

GeoProfessional Innovation.

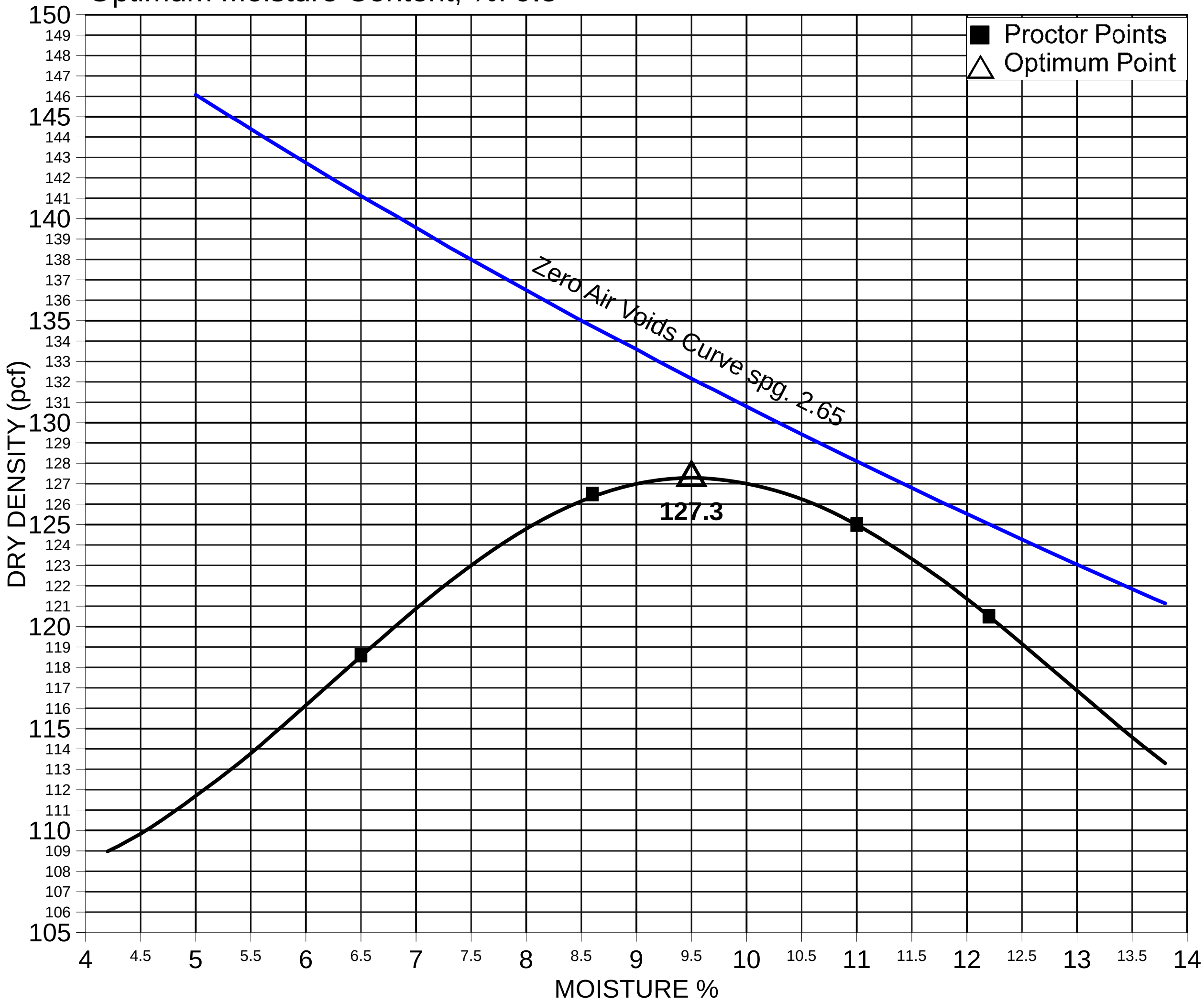
MOISTURE-DENSITY RELATIONSHIP CURVE
ASTM D 1557
Method C

Project: Sally Ann Creek Wastershed Crossing AOP Design
Client: Great West Engineering
Project Number: MO22154A
Lab Number: 14123
Sample Location: Sally Ann #2, B-22154A-2 @ 12.0-13.0 feet BGS
Sample Classification: Silty Sand with Gravel (SM)
Date Tested: 12/14/2022 By: JS
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
3"	100	100
2"	97	100
1.5"	96	100
1.0"	94	100
3/4"	92	100
1/2"	85	85
3/8"	78	78
#4	64	64
#8	54	54
#16	47	47
#30	41	41
#100	29	29
#200	19	19

Maximum Dry Density, pcf : 127.3
Optimum Moisture Content, %: 9.5



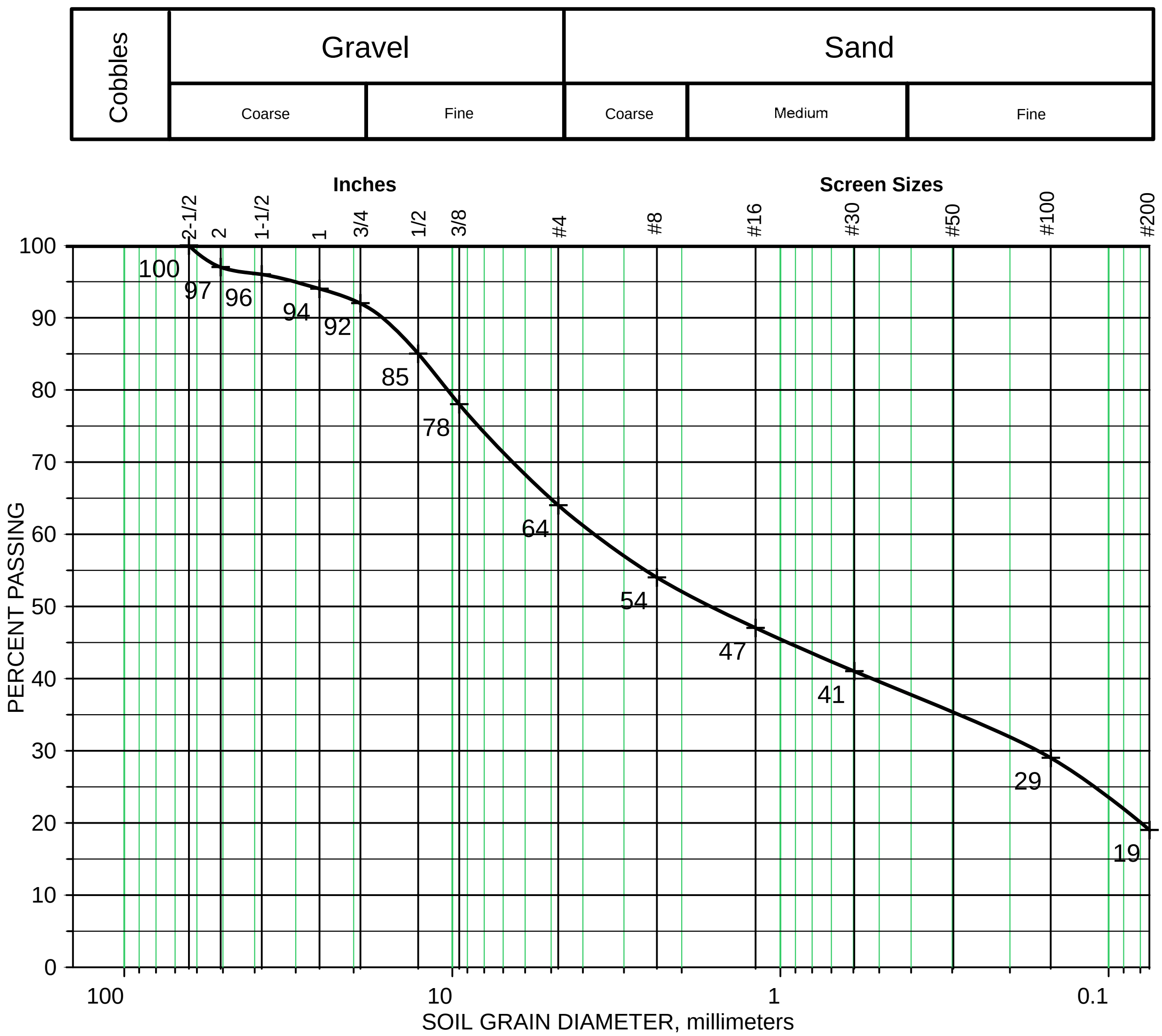
Reviewed By:

GeoProfessional Innovation.

GRADATION ANALYSIS

ASTM D6913

Project: Sally Ann Creek Watershed Crossings AOP Design
Client: Great West Engineering
Project Number: MO22154A
Sample No: 14123
Sample Location: Sally Ann #2, B-22145A-5 @ 12.0-13.0 feet BGS
Sample Classification: Silty Sand with Gravel (SM)
Date tested: 12/21/2022 By: LMC



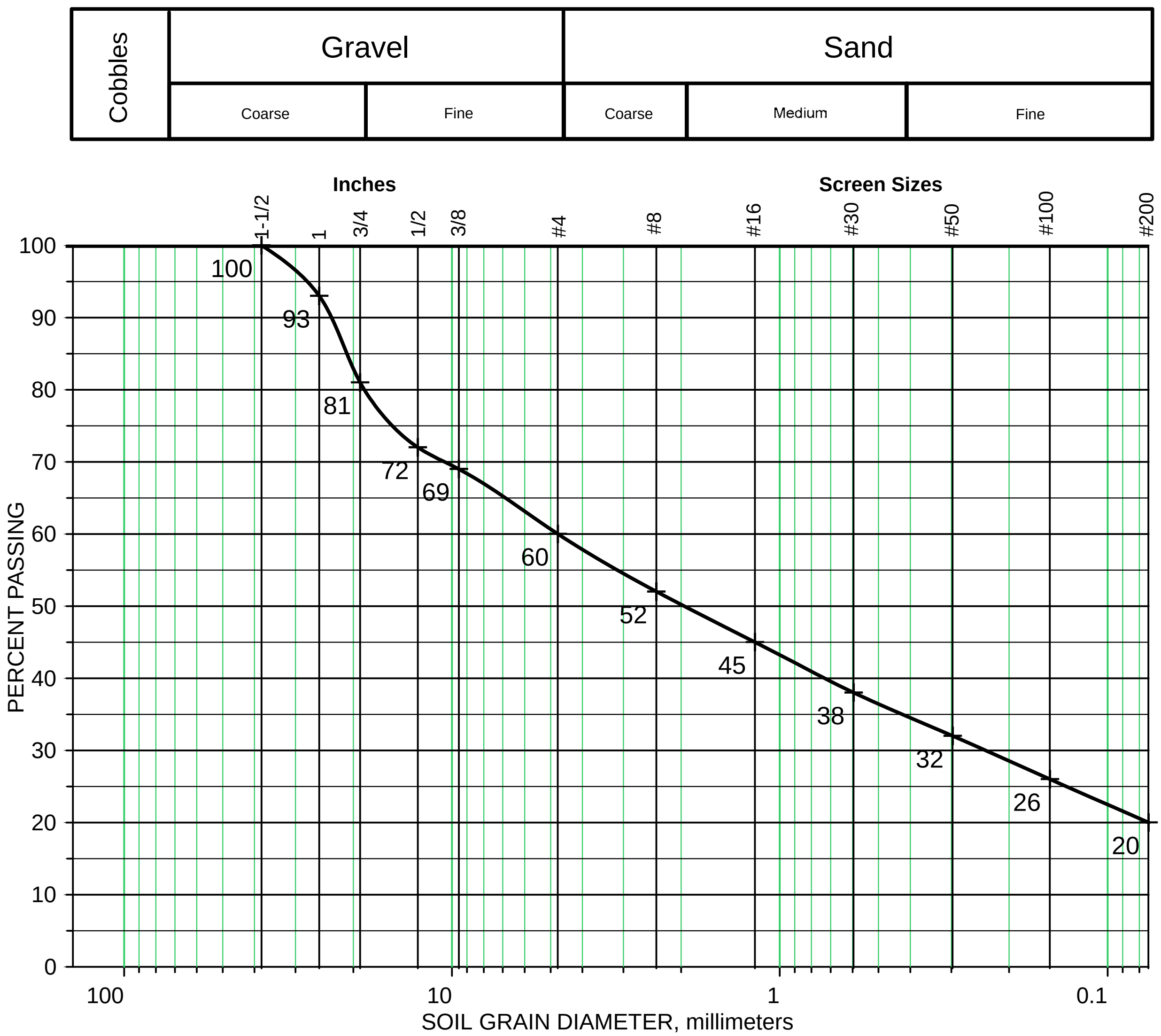
Reviewed by: ____________________

GeoProfessional Innovation.

GRADATION ANALYSIS

ASTM D6913

Project: Sally Ann Creek Watershed Crossings AOP Design
Client: Great West Engineering
Project Number: MO22154A
Sample No: 14124
Sample Location: Wall Creek, B-22145A-9 @ 8.0-10.0 feet BGS
Sample Classification: Silty Gravel with Sand (GM)
Date tested: 12/21/2022   By: LMC



Reviewed by: ____________________

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