INL/EXT-18-44789
Revision: 0

Project No.: 32780

Materials and Fuels Complex West Campus Utility Corridor Preliminary Engineering Report

March 2018

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance

Idaho National Laboratory

Prepared for the Idaho National Laboratory by:

J·U·B ENGINEERS, INC.

WALSH ENGINEERING SERVICES

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Materials and Fuels Complex West Campus Utility Corridor Preliminary Engineering Report

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March 2018

PROFESSIONAL ENGINEER
REGISTERED
03/27/18
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STATE OF IDAHO
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Prepared for the
U.S. Department of Energy
Office of Nuclear Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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Chapter 1

Introduction

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND AND HISTORY

The Materials and Fuels Complex (MFC) is located in Bingham County, Idaho at the Idaho National Laboratory (INL). MFC is operated for the United States Department of Energy (DOE) by Battelle Energy Alliance, LLC (BEA). Walsh Engineering Services, PC (Walsh) is contracted by BEA to provide facility engineering services for MFC. J-U-B ENGINEERS, Inc. (J-U-B) has been subcontracted by Walsh to develop this Preliminary Engineering Report (PER) to evaluate the existing system and to develop preliminary improvements for addressing future growth and regulatory requirements. This PER will provide MFC with the information necessary to make sound decisions regarding future improvements to the facility.

The MFC Complex has an existing sanitary sewer system to collect and treat domestic wastewater from the facility. A majority of the facility is served for wastewater by a collection system consisting of gravity sewers and several lift stations and force mains. The collected wastewater is eventually conveyed to a central lift station (MFC-778) which pumps the wastewater to three total containment sewage lagoons for final disposal and evaporation. There are some small areas of MFC that are serviced by local onsite subsurface disposal systems and are independent of the wastewater collection system.

Figure 1 provides a vicinity map for the MFC area.

1.2 PURPOSE AND NEED

The current MFC wastewater system provides reliable and adequate disposal to the facilities within MFC; however, in anticipation of immediate and future growth, MFC desires to make upgrades to accommodate increased staffing levels and additional facilities at the complex.

1.3 SELECTED IMPROVEMENTS

BEA has worked with J-U-B to evaluate the current wastewater system and to identify future improvements to the facility to provide wastewater service for future growth. This PER summarizes the improvements in accordance with Idaho Administrative Code IDAPA 58.01.16.411. These improvements are part of the MFC West Campus Utility Corridor project and consist of a new gravity collection system, pressurized forcemains, and a lift station. The approximate location of these proposed improvements is shown in **Figure 2**. Preliminary drawings are also included in **Appendix A** of this document.

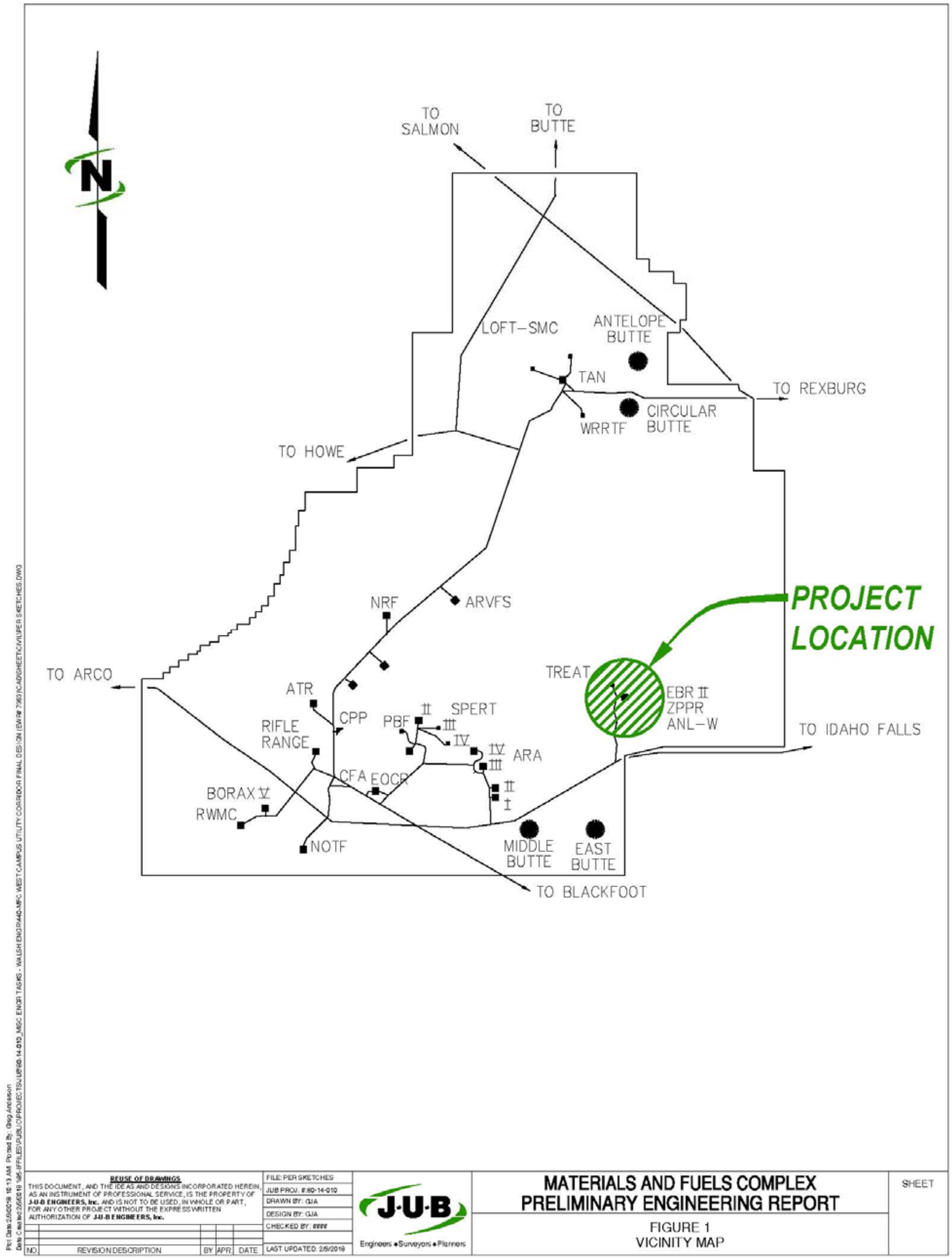

Figure 1 – Vicinity Map

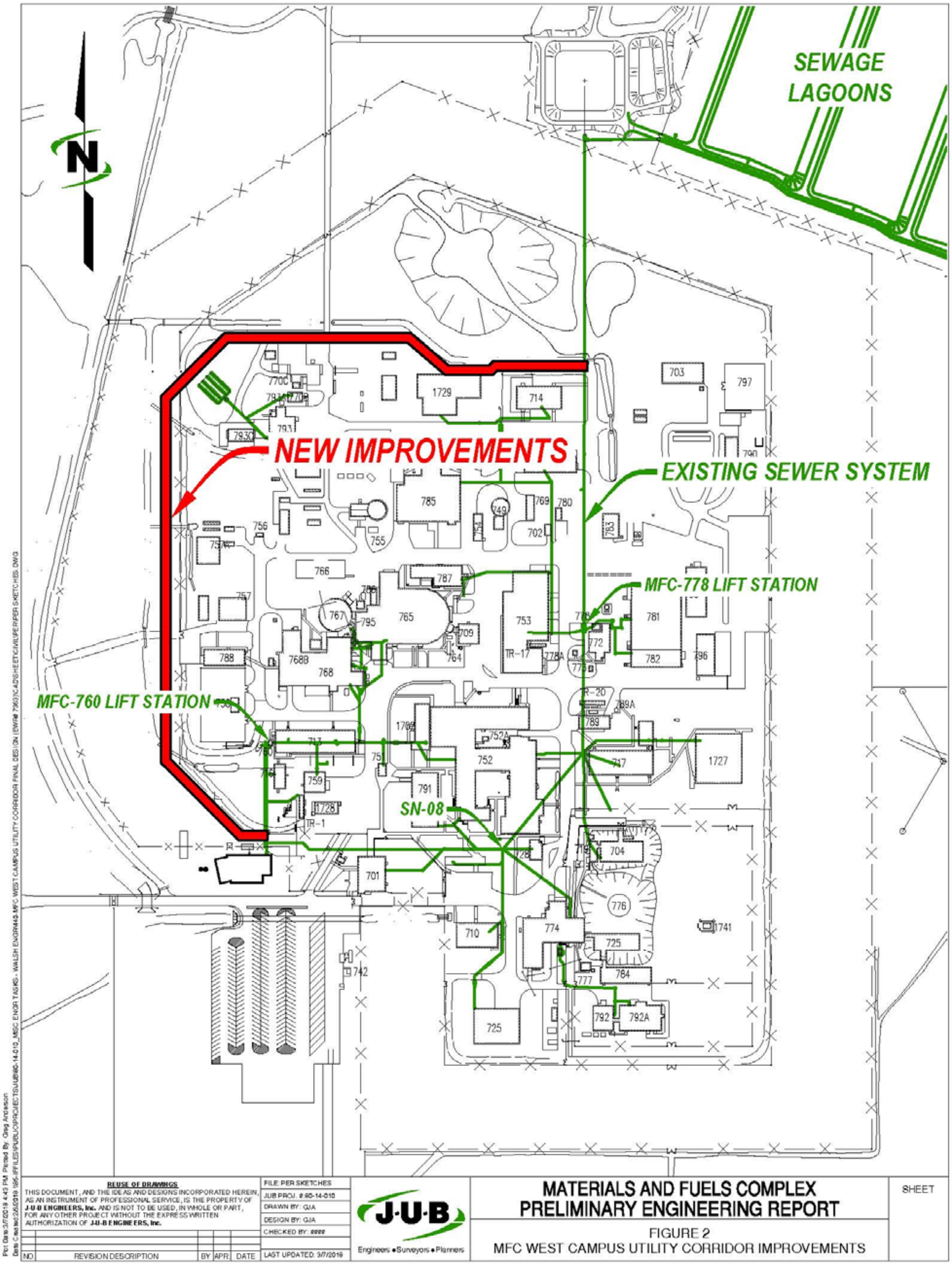

Figure 2 – MFC West Campus Utility Corridor Improvements

Chapter 2

Basis of Design

CHAPTER 2 BASIS OF DESIGN

2.1 MFC MASTER PLAN

The MFC Campus Development Organization (CDO) has developed a Master Plan for future development. The majority of the growth is anticipated to occur on the west and north sides of the MFC Complex. The MFC West Campus Utility Corridor project would provide services (potable/fire water distribution, sanitary sewer, electrical distribution, telecommunications/alarm distribution) to future development on the west and north sides of MFC. Based on the "2017 INL Master Plan", the MFC West Campus Utility Corridor project plans to provide sewer service for approximately 230,000 square feet of new building space and 500 additional people.

2.2 FUTURE FLOWS AND LOADS

The area to be served by the new sewer improvements consists of the new area to the west and north identified in the INL Master Plan and described in the previous section of this document. The new sewer improvements will also serve the future Research Collaboration Building (RCB), which is located near the southwest corner of the MFC Complex. In addition, the improvements will accommodate the existing flows from the MFC-760 lift station (see **Figure 2** for location). Due to the age and condition of the existing force main from MFC-760 to Manhole SN-08 (cast iron pipe that was installed as early as the 1960s), these flows will be rerouted to the new improvements. The MFC-760 lift station currently services the following facilities:

- Modular Office Buildings T-13 (MFC-713)
- Modular Office Building T-16A (MFC-716)
- Fuel Conditioning Facility (MFC-765)
- Power Plant (MFC-768)
- Emergency Re-Entry Building (MFC-759)
- Safeguards and Security Support Building (MFC-751)
- Portion of the Laboratory and Office Building (MFC-752)

The MFC Wastewater Facility Plan (October 2010) assumed that the average wastewater flow for the MFC Complex is 13 gallons per capita per day (gpcd). It also used a peaking factor to convert the average daily flow to peak flow of 2.5. Using these assumptions, **Table 1** summarizes the design flow calculations for the MFC West Campus Utility Corridor project. It should be noted that no industrial waste flows will be routed into the MFC West Campus Utility Corridor project or eventually into the existing lagoons.

Additional capacity for unknowns such as inflow and infiltration (I/I) will not be considered due to the lack of shallow groundwater at the site and the new condition of the improvements.

Table 1 – Design Flows

Description	Number of Employees	Average Daily Flow (gpd)	Average Daily Flow (gpm)	Peaking Factor	Design Peak Flow (gpm)
Future Growth (West Campus)	500 [A]	6,500	4.51	2.5	11.28
Research Collaboration Building	58 [A]	754	0.52	2.5	1.31
MFC-760 Lift Station	-	-	4.9 [A]	2.5	12.25
Totals			*9.94*		*24.84*

A. Provided by MFC project personnel.

2.3 DESIGN CONSIDERATIONS

2.3.1 Existing Lagoon Capacity

The existing MFC wastewater lagoons were designed for flows of approximately 14,950 gpd. Based on information provided by MFC staff, in 2017, the average daily flow to the lagoons was approximately 7,840 gpd. Based on **Table 1**, the MFC West Campus future projects will produce an average daily flow of 7,254 gpd for a total flow of 15,094 gpd. This is just slightly above the design flows for the existing lagoons (less than 1%). The MFC West Campus future projects are based on a 23-year buildout (2017-2030) and the existing lagoons, built in 2012, were based on a buildout to the year 2020. Hence, the lagoons appear to have adequate capacity for the MFC West Campus future projects.

2.3.2 Geotechnical Investigation

A geotechnical investigation was completed by Materials Testing and Inspection (MTI). The investigation included 15 borings along the alignment of the MFC West Campus Utility Corridor project as well as 28 additional borings located near the future project site for the Sample Preparation Laboratory (SPL) not associated with this project. However, the geotechnical information gathered for the SPL will be used for the MFC West Campus Utility Corridor project. This geotechnical engineering evaluation is included in **Appendix B**, which includes a detailed description of the evaluation along with recommendations.

In general, poorly graded gravel with silt and sand fill materials were encountered at the ground surface. These fill materials were brownish gray, slightly moist to moist, and medium dense to dense, with fine to coarse-grained sand and 2-inch minus gravel. Varying silt-clay-sand mixtures were encountered beneath fill materials. These soils were brown, slightly moist to moist, and soft to very stiff, with fine-grained sand. Intermittent gravel content was noted within the deeper portions of these horizons.

Basalt bedrock was encountered in many of the borings with depths varying from 1.3 to over 14 feet below the ground surface along with proposed alignment. It is anticipated that rock removal techniques will be employed to install the new lift station, manholes, gravity and pressure pipelines (e.g., rock trencher, rock hammer, etc.). No explosives or blasting will be allowed.

Groundwater was not encountered during the geotechnical investigation and is not anticipated during construction.

It is anticipated that site soils will generally be used for trench backfill above the pipe bedding; although, import trench backfill material may be required in areas where unsuitable soils are excavated.

2.3.3 Environmental Considerations

An Environmental Checklist is currently being developed by BEA project personnel and is planned to be completed by the completion of final design. The National Environmental Policy Act (NEPA) review process will consider the utility corridor's impact to nearby Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) areas, the industrial wastewater piping and industrial waste ditch regulated by Idaho Department of Environmental Quality Reuse Permit I-160-02, Modification 1, and storm water ditches, as well as other environmental aspects affected. The new utility corridor will also cross two existing permitted industrial waste water lines. These existing lines will be retained and protected during construction as required by the permit.

2.3.4 Safety Considerations

The MFC West Campus Utility Corridor project has the potential to impact the Irradiated Materials Characterization Laboratory (IMCL) nuclear facility located at the northern portion of the MFC Complex. Excavation of trenches on the north side of IMCL will need to be evaluated to ensure that the integrity of the structure and footings is not compromised.

There are no special considerations with construction safety beyond the normal OSHA-controlled aspects.

2.3.5 Security and Safeguards Considerations

The MFC West Campus Utility Corridor project lies within the existing security perimeter area enclosed by two security fences. Equipment and infrastructure installed between the security fences in the isolation zone will be installed below grade or no more than 4 inches above grade to ensure security equipment operates properly.

During construction, some equipment may remain within the security area, but mobile equipment must be moved out of the area each night. The construction area will be bounded by additional fencing on the north and south to enclose it within the security area. Compensatory measures may be required in areas where the trench will cross the fence.

After construction and during operation of the new improvements, access to the lift stations, manholes, and other appurtenances will be by authorized personnel only.

2.3.6 Operations and Maintenance

BEA oversees the maintenance and operations of the wastewater collection and treatment systems at the MFC Complex. An operations and maintenance manual will be prepared at the completion of the project which will identify specific operation and maintenance tasks. In general, the operation and maintenance of the facility will be similar to that of the other submersible lift stations, pressurized, and gravity sewer pipelines located in the MFC Complex.

2.3.7 Applicable Standards, Codes, and Permits

Following are the anticipated standards, codes, and permits that are applicable to the wastewater portion of the project:

- 2017 Idaho Standards for Public Works Construction (ISPWC)
- Project-specific Specifications

- Idaho Administrative Code IDAPA 58.01.16 Wastewater Rules
- Idaho National Laboratory STD-139 INL Engineering Standards
- 10 States Standards Recommended Standards for Wastewater Facilities
- LWP-13014 Determining Quality Levels
- LWP-10500 Configuration Information Management
- 2014 National Electric Code (with Idaho State amendments)
- 2009 Idaho State Plumbing Code (with 2014 updates)

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Chapter 3

Preliminary Design

CHAPTER 3 PRELIMINARY DESIGN

3.1 PRESSURE AND GRAVITY SEWER MAINS

3.1.1 Description and Layout

Appendix A includes preliminary drawings that illustrate the proposed alignment of the new pressure and gravity sewer mains. The alignment begins with the new pressure main connecting into the existing MFC-760 force main located directly north of the future RCB. This new force main will run in a westerly direction and then to the north between the perimeter security fences where it will discharge into a new manhole located directly west of MFC-788. From this point, a new gravity sewer line will run parallel with the existing security fence until it discharges into a new lift station located north of SPL. The new lift station will convey the wastewater through a new pressure main and connect into the existing force main.

The gravity sewer mains will consist of 8-inch diameter pipe constructed of ASTM D-3034 SDR 35 PVC sewer pipe. Standard pre-cast manholes will be used at every change in direction and spaced a minimum 400 feet.

The pressure sewer mains will consist of 4-inch diameter pressure class pipe constructed of C-900 PVC or C-906 HDPE. Pressure clean-outs have also been installed on the pressure main to permit flushing of the line, if necessary.

3.1.2 Pipe Depth

In general, the pressurized mains will be buried below anticipated frost penetration which is 5 feet per INL-STD-139. However, due to conflicts with other buried utilities and/or rock, the pressure main may be installed at greater or lesser depths to avoid conflicts and crossings. In the event that the mains are installed at depths less than 5 feet below the ground surface, measures to ensure the pipe does not freeze will be necessary such as insulation and/or heat trace cabling. It is anticipated that the design of the pressure main will be such that there is a positive grade from the lift station to the tie-in points so that no air release valves will be needed.

It is generally anticipated that the gravity sewer mains will be installed with cover depths ranging from 5-12 feet below the ground surface. Rock excavation will be necessary in some areas due to the shallow depths encountered during the geotechnical investigation.

3.1.3 Utilities Crossing Considerations

There are numerous existing utilities that will be crossed by the new sewer alignment. Existing underground utilities along the proposed sewer main alignment have been located via a subsurface investigation performed by BEA. The marked locations of these underground utilities, as well as above ground utilities and surface features, were surveyed and will be identified on the final construction drawings. Known utilities that will be crossed are potable water, storm drain, industrial waste, electrical/communication conduits and ductbanks, and power poles.

All potable water crossings will be designed in accordance with IDAPA 58.01.16.430.02. Other than potential crossing conflicts, no other impacts to the drinking water system at MFC are anticipated.

It is anticipated that all other crossings will be constructed without disturbing the existing utilities. If existing utilities are disturbed, they will be replaced and reinstalled to their original condition.

3.1.4 Preliminary Design Criteria

Table 2 summarizes the preliminary design criteria for the gravity collection system improvements. Preliminary design calculations can be found in **Appendix C**. As shown in the table, the gravity pipeline sizes and slopes are adequate to convey the proposed peak hour flows.

Table 3 summarizes the preliminary design criteria for the new pressure sewer main. The velocity in the pressure main at the design pumping rate for the lift station (i.e., 120 gpm) is approximately 3 feet per second (fps). This velocity is greater than the minimum regulatory requirement of 2 fps (IDAPA 58.01.16.44.10.a).

Table 2 – Gravity Collection System Preliminary Design Criteria

Pipe Segment	Pipe Material [A]	Pipe Size (in)	Pipe Length (ft)	Pipe Slope (%)	Capacity at 75% Full (gpm)	Adequate Capacity for Peak Hour Flow? [B]	Approx Pipe Bury Depth (ft)	Depth to Rock from Pipe Invert (ft)	Installation Method
MH 1 to MH 2	PVC	8	400	0.40	330	Yes	5-6	0-1	Open Trench/Rock Trencher
MH 2 to MH 3	PVC	8	240	0.40	330	Yes	6-8	0-5	Open Trench/Rock Trencher
MH 3 to MH 4	PVC	8	203	0.40	330	Yes	8-11	2-5	Open Trench
MH 4 to LS	PVC	8	400	0.40	330	Yes	9-10	1-3	Open Trench

A. PVC pipe conforming to ASTM D3034
B. Peak hour flow = 25 gpm

Table 3 – Pressure Sewer Main Preliminary Design Criteria

Parameter	Value
Pipe Material	PVC (ASTM D2241)
Pipe Size	4 inch
Pipe Slope	Varies (positive grade)
Minimum Bury Depth	5 feet
Minimum Velocity at Design Pumping Rate	3.0 fps

3.1.5 Corrosion Protection

Corrosion within the sewer pipelines will be mitigated via construction materials. All new sewer mains will be constructed of corrosion resistant materials (PVC, HDPE). MFC project personnel have stated that corrosion of their concrete manholes has historically not been an issue.

3.1.6 Odor Control

Odor has generally not been a concern for the wastewater system at the MFC Complex. As a result, odor is not anticipated to be an issue and mitigation strategies are not included in this PER or final design of the proposed improvements. If odors become an issue, MFC may need to revisit them in the future.

3.2 LIFT STATION

3.2.1 Description and Layout

As shown in the preliminary drawings included in **Appendix A**, the new lift station will be located directly north of the IMCL building. The lift station will be located within the perimeter security fence, which is monitored by MFC security personnel at all times. The lift station will receive wastewater from the new 8-inch gravity sewer main and discharge it through a single 4-inch pressure main that will connect to an existing 4-inch pressure main, eventually conveying the wastewater to the treatment lagoons.

The lift station will consist of a wet-well mounted pumping station with duplex, submersible, non-clog pumps and a concrete wet-well structure. The pumps will alternate on pumping cycles to provide even wear. Each pump will be capable of handling the ordinary peak flows, which will provide redundancy and allow maintenance of one pump and still leave the lift station in service. A high level float switch will turn on both pumps to provide for extra large peak flows which may occur at infrequent intervals. The pumps will be grinder pumps which will grind the sewage into a slurry and pump to a pressurized sewer main.

A back-up portable diesel generator and automatic transfer switch will be available near the lift station to provide auxiliary power in the event of an outage. The electrical and control panels will be located on a free-standing equipment rack near the lift station. Alarm outputs will be included in the control panel and will include power failure, pump failure, high water level, and low water level alarms. Each of these alarm signals will be sent to a local alarm and light at the lift station to inform the maintenance staff of the status of the lift station.

Since the new lift station and new collection system will be capable of serving a much larger service area than what will be originally required, the wastewater will be stored in the lift station wet well during initial operation for an extended period of time until the wastewater level rises high enough to start a pump. This extended storage time in the lift station may result in odor issue as well as other maintenance issues. For these reasons, carbon filters on the wet well vents will be installed to mitigate odor problems. During initial operation with low flows, the pump ON/OFF level set-points should be tightened as much as possible to minimize the operating volumes and cycle times. However, a minimum operating volume should be maintained to provide reliable level control and avoid cycling of the pumps in excess of the manufacturer's recommendations (typically less than 8 to 10 starts per hour). Also, it may be necessary to supplement the wastewater flow with additional clean water to keep the pumps cycling more often (e.g. 2-3 times per day) since the initial flows will be lower than designed for. Any infrastructure to add clean water will need to comply with cross-connection control regulations with approved backflow prevention measures.

3.2.2 Preliminary Design Criteria

Table 4 summarizes the preliminary design criteria for the lift station. Preliminary design calculations can be found in **Appendix C.**

Table 4 – Lift Station Preliminary Design Criteria

Parameter	Preliminary Design Value
Design Peak Hour Flow	25 gpm
Configuration	Wet-Well Mounted, Duplex, Submersible, Non-Clog Pumps
Number of Pumps	2
Motor Horsepower per Pump	1.5 Hp
Flow per Pump	120 gpm
Head/TDH per Pump	16 ft ±
Nominal Pump Speed	1150 rpm (Constant Speed)
Wet-Well	60-inch Diameter x 18.5 feet Deep, Precast Concrete Structure
Flow Meter Vault	4' Diameter x 6' Deep, Precast Concrete Structure
Flow Measurement	6" Magnetic Flow Meter
Level Controls/Instrumentation	Ultrasonic Level Transducer, Float Switches for High and Low Water Levels
Alarms	Low Water Level, High Water Level, Pump Failure, Motor Overload, Motor Overtemp, Pump Seal Failure, Power Monitor

3.2.3 Flow Measurement

Flow measurement will consist of a magnetic flow meter located on the force main within a vault directly downstream of the wet well and valve vault. The flow meter transmitter will be placed on the electrical panel. The flow meter will measure the flow from the new lift station.

3.2.4 Controls and Operation

The lift station will include an ultrasonic level or pressure transducer and two back-up float switches. Primary control of the pumps will be from the transducer device based on water levels in the wet-well. As water levels rise in the wet-well to a set-point, the lead pump will be turned on. Under normal conditions, the lead pump will draw the water level down to a low water level set-point and turn off. If the lead pump is unable to keep up with influent flows and water levels continues to rise, the second (lag) pump will be turned on to draw water levels down to the shut-off set point. This cycle will be repeated with the pumps alternating in the lead/lag position.

Back-up float switches will be used to alarm the operator if the water level rises above a high water level set-point or decreases below a low water level set-point in the wet-well. The pump will also be shut-off in a low water level condition to prevent overheating.

The electrical and control panels will be located on a free-standing equipment rack beneath a shade structure. The operator will be able to control the pumps in automatic and manual mode from a local control panel. Since the MFC Complex does not have a Supervisory Control and Data Acquisition (SCADA) system, alarms will be distributed from the control panels through an autodialer. An automatic transfer switch will turn on the generator to power the lift station in the event of a power outage.

3.2.5 Buoyancy Considerations

Groundwater was not encountered in any of the rock borings near the lift station site. As a result, structure buoyancy should not be a concern.

3.2.6 Flooding Potential

The finished top of slab elevations for the wet-well and flow meter vault will be approximately 3 inches above the finished ground to prevent any run-off from entering the structures. The area surrounding the structures will be graded to drain away from them. The site is not located within a designated flood plain and MFC has stated that flooding has not historically been an issue at the site.

3.2.7 Odor Potential

Since the new lift station will be situated in a relatively remote location and near the treatment lagoons, it is anticipated that there will be negligible additional odors after construction of the new lift station. Additionally, the operating volume in the lift station wet-well will be set such that the retention time of the wastewater is minimized. This will reduce the potential for anaerobic conditions and the generation of odors.

3.2.8 Consideration of Future Expansion

The wet-well will be sized to accommodate future larger pumps and to provide sufficient operating volume for the build-out flows. The flow meter will be sized to measure the build-out flows, as well.

3.3 EXISTING MFC-760 LIFT STATION

The MFC-760 lift station and a portion of the existing 4-inch diameter force main (approximately 250 linear feet) will remain and a new 4-inch diameter force main will be connected as described in Chapter 2 of this PER. The lift station originally had sewage pumps designed for 70 gpm at 18 feet of TDH. In 2001, these pumps were replaced with Goulds Model 3888D4M pumps which appear to be capable of similar performance as the original pumps. This indicates that the existing lift station should have ample capacity to accommodate the existing flows, as well as the additional flows from the RCB.

Chapter 4

Project Costs and Schedule

CHAPTER 4 PROJECT COSTS AND SCHEDULE

4.1 COST SUMMARY

An opinion of probable construction costs in 2018 dollars for the MFC West Campus Utility Corridor project improvements is summarized in **Table 5**. The project will be funded through the Department of Energy.

Table 5 – Opinion of Probable Construction Costs

Item	Total Cost
General Requirements/Mobilization/Demobilization	$189,900
Lift Station	$1,350,900
Collection System Improvements	$494,400
Stormwater Management	$87,300
Sub-Total Construction Costs	*$2,122,500*
Contingency (20%)	$424,500
Total Construction Costs	*$2,547,000*

A. Costs do not include BEA oversight, procurement, environmental, safety, or engineering
B. Costs do not include fire water, electrical, or communication improvements

4.2 PROJECT SCHEDULE

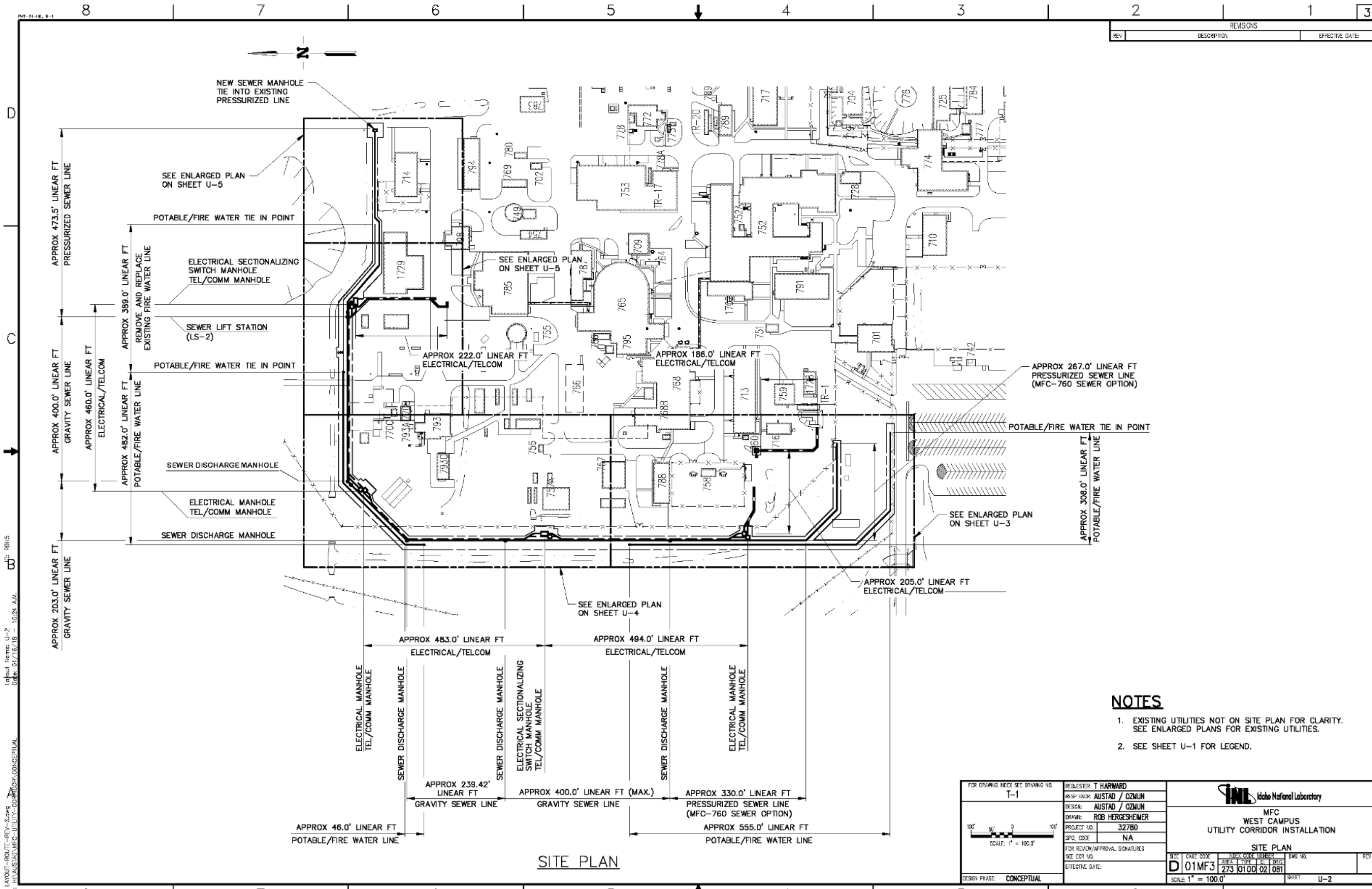
Table 6 summarizes the preliminary project schedule for the MFC West Campus Utility Corridor project:

Table 6 – Preliminary Project Schedule

Task	Start Date	End Date
Conceptual Design	November 2017	January 2018
Final Design	January 2018	April 2018
Bid and Award	April 2018	July 2018
Construction	July 2018	September 2019

Appendix A

Preliminary Design Drawings


NEW SEWER MANHOLE
TIE INTO EXISTING
PRESSURIZED LINE
SEE ENLARGED PLAN
ON SHEET U-5
POTABLE/FIRE WATER TIE IN POINT
ELECTRICAL SECTIONALIZING
SWITCH MANHOLE
TEL/COMM MANHOLE
SEWER LIFT STATION
(LS-2)
POTABLE/FIRE WATER TIE IN POINT
SEWER DISCHARGE MANHOLE
ELECTRICAL MANHOLE
TEL/COMM MANHOLE
SEWER DISCHARGE MANHOLE
APPROX 473.5' LINEAR FT
PRESSURIZED SEWER LINE
APPROX 389.0' LINEAR FT
REMOVE AND REPLACE
EXISTING FIRE WATER LINE
APPROX 400.0' LINEAR FT
GRAVITY SEWER LINE
APPROX 460.0' LINEAR FT
ELECTRICAL/TELCOM
APPROX 482.0' LINEAR FT
POTABLE/FIRE WATER LINE
APPROX 203.0' LINEAR FT
GRAVITY SEWER LINE
SEE ENLARGED PLAN
ON SHEET U-5
APPROX 222.0' LINEAR FT
ELECTRICAL/TELCOM
APPROX 186.0' LINEAR FT
ELECTRICAL/TELCOM
APPROX 267.0' LINEAR FT
PRESSURIZED SEWER LINE
(MFC-760 SEWER OPTION)
POTABLE/FIRE WATER TIE IN POINT
APPROX 308.0' LINEAR FT
POTABLE/FIRE WATER LINE
SEE ENLARGED PLAN
ON SHEET U-3
APPROX 205.0' LINEAR FT
ELECTRICAL/TELCOM
SEE ENLARGED PLAN
ON SHEET U-4
APPROX 483.0' LINEAR FT
ELECTRICAL/TELCOM
APPROX 494.0' LINEAR FT
ELECTRICAL/TELCOM
ELECTRICAL MANHOLE
TEL/COMM MANHOLE
SEWER DISCHARGE MANHOLE
SEWER DISCHARGE MANHOLE
ELECTRICAL SECTIONALIZING
SWITCH MANHOLE
TEL/COMM MANHOLE
SEWER DISCHARGE MANHOLE
ELECTRICAL MANHOLE
TEL/COMM MANHOLE
APPROX 239.42'
LINEAR FT
GRAVITY SEWER LINE
APPROX 400.0' LINEAR FT (MAX.)
GRAVITY SEWER LINE
APPROX 330.0' LINEAR FT
PRESSURIZED SEWER LINE
(MFC-760 SEWER OPTION)
APPROX 46.0' LINEAR FT
POTABLE/FIRE WATER LINE
APPROX 555.0' LINEAR FT
POTABLE/FIRE WATER LINE
SITE PLAN
REVISIONS
REV
DESCRIPTION
EFFECTIVE DATE
NOTES
1. EXISTING UTILITIES NOT ON SITE PLAN FOR CLARITY. SEE ENLARGED PLANS FOR EXISTING UTILITIES.
2. SEE SHEET U-1 FOR LEGEND.
FOR DRAWING INDEX SEE DRAWING NO.
T-1
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REQUESTER T HARWARD
RESP UNOR. AUSTAD / OZMUN
DESIGN AUSTAD / OZMUN
DRAWN ROB HERGESHEIMER
PROJECT NO. 32780
SPEC. CODE NA
FOR REVIEW/APPROVAL SIGNATURES SEE CCR NO.
EFFECTIVE DATE:
Idaho National Laboratory
MFC
WEST CAMPUS
UTILITY CORRIDOR INSTALLATION
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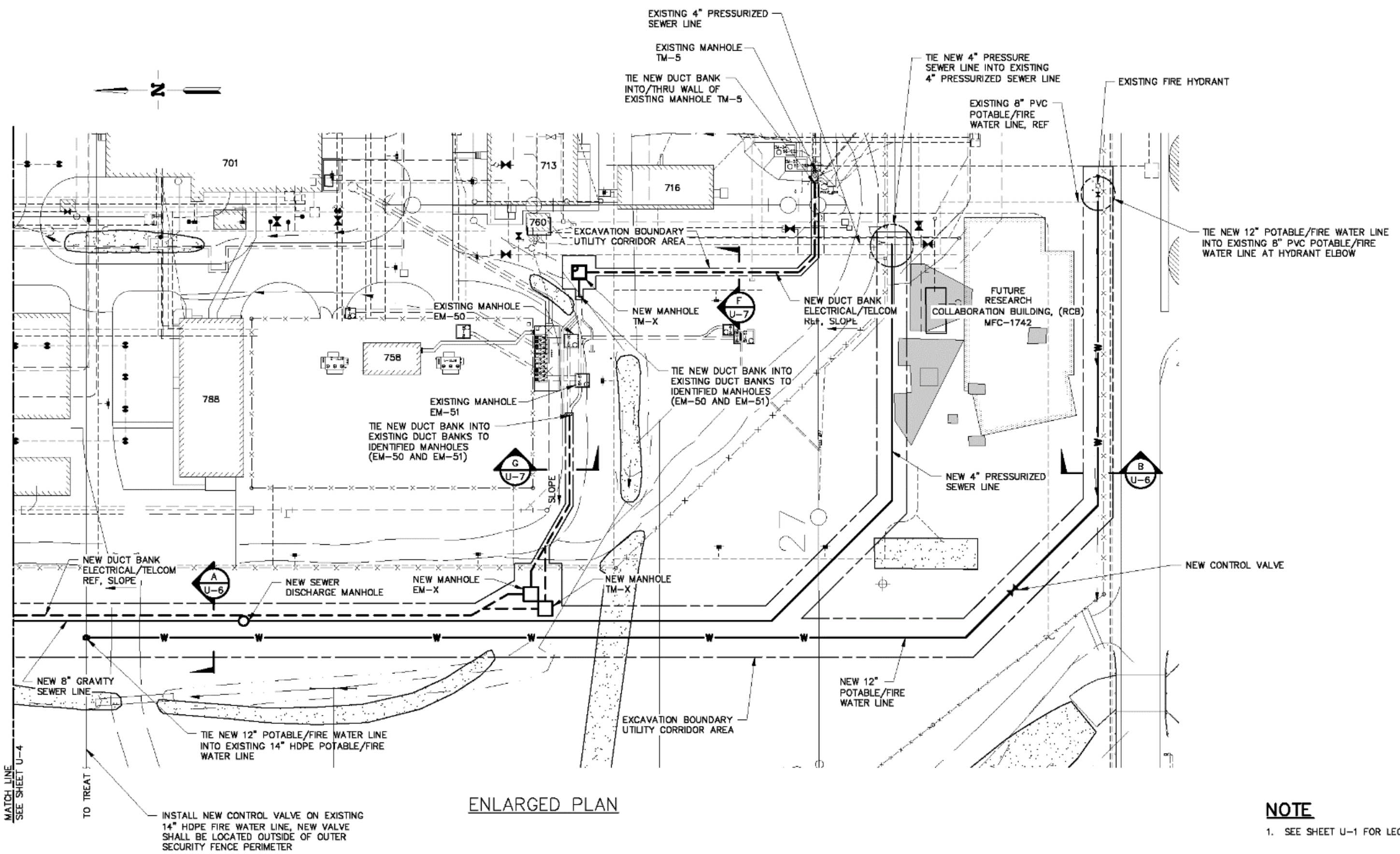
SIZE D
CAGE CODE 01MF3
273 0100 02 081
SCALE 1" = 100.0'
SHEET U-2



ENLARGED PLAN

NOTE

1. SEE SHEET U-1 FOR LEGEND.

FOR DRAWING INDEX SEE DRAWING NO. T-1	REQUESTER: T HARWARD	Idaho National Laboratory
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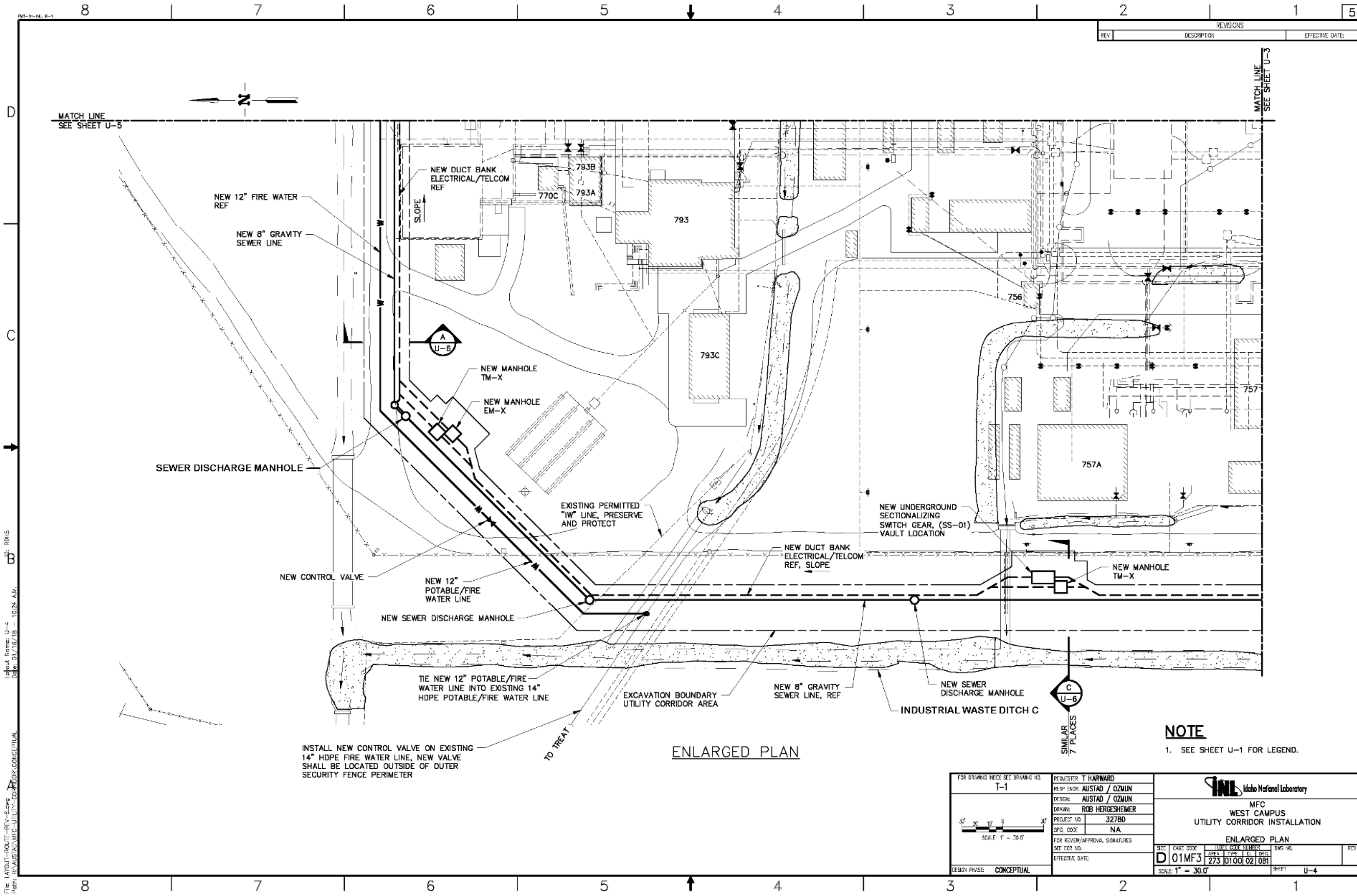
MATCH LINE
SEE SHEET U-5
MATCH LINE
SEE SHEET U-3
REVISIONS
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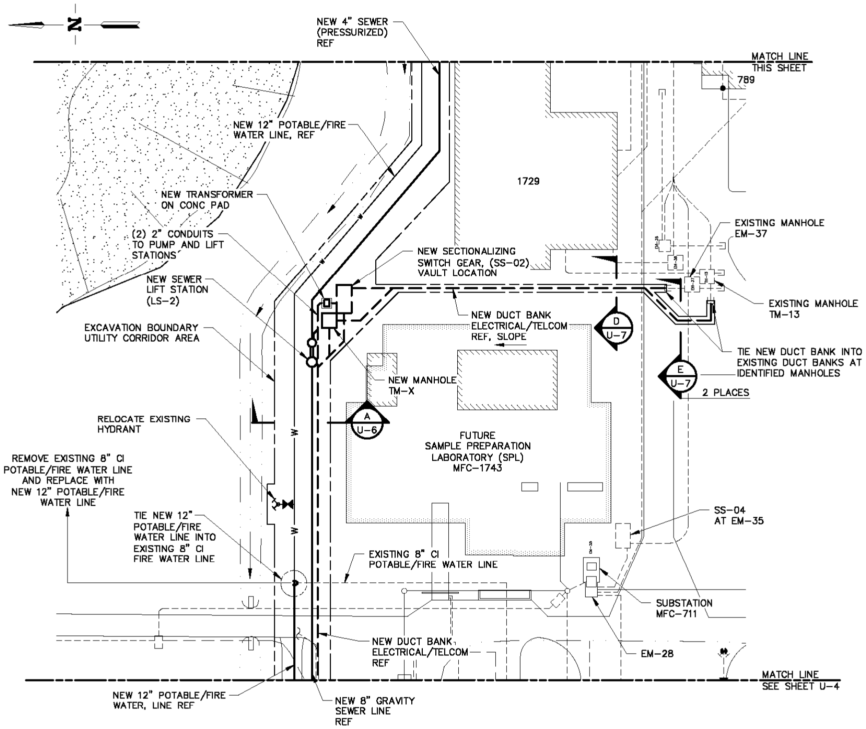
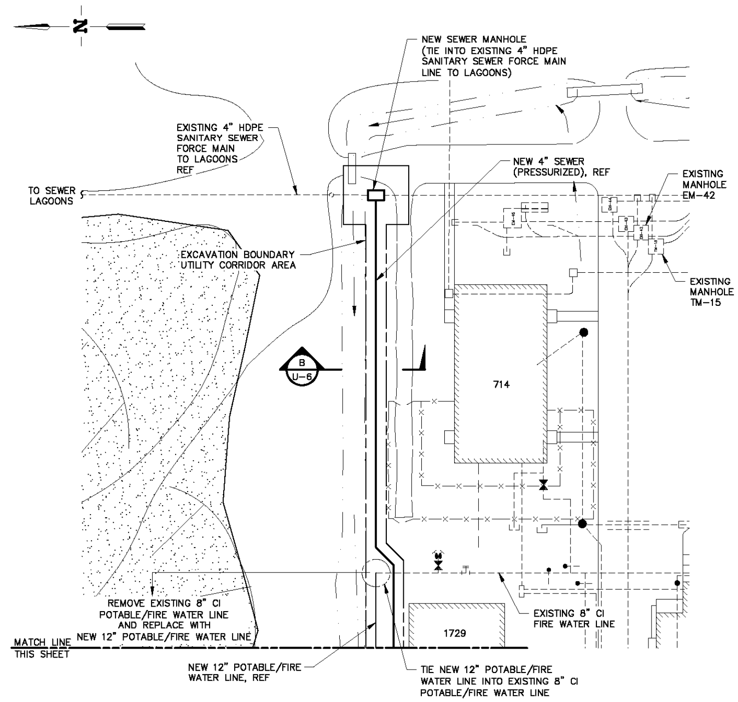
DESCRIPTION
EFFECTIVE DATE
NEW 12" FIRE WATER
REF
NEW 8" GRAVITY
SEWER LINE
NEW DUCT BANK
ELECTRICAL/TELCOM
REF
SLOPE
770C
793B
793A
793
793C
756
757
757A
NEW MANHOLE
TM-X
NEW MANHOLE
EM-X
SEWER DISCHARGE MANHOLE
EXISTING PERMITTED
"IW" LINE, PRESERVE
AND PROTECT
NEW CONTROL VALVE
NEW 12"
POTABLE/FIRE
WATER LINE
NEW SEWER DISCHARGE MANHOLE
NEW DUCT BANK
ELECTRICAL/TELCOM
REF, SLOPE
NEW UNDERGROUND
SECTIONALIZING
SWITCH GEAR, (SS-01)
VAULT LOCATION
NEW MANHOLE
TM-X
TIE NEW 12" POTABLE/FIRE
WATER LINE INTO EXISTING 14"
HDPE POTABLE/FIRE WATER LINE
EXCAVATION BOUNDARY
UTILITY CORRIDOR AREA
NEW 8" GRAVITY
SEWER LINE, REF
NEW SEWER
DISCHARGE MANHOLE
INDUSTRIAL WASTE DITCH C
SIMILAR
7 PLACES
TO TREAT
INSTALL NEW CONTROL VALVE ON EXISTING
14" HDPE FIRE WATER LINE, NEW VALVE
SHALL BE LOCATED OUTSIDE OF OUTER
SECURITY FENCE PERIMETER
ENLARGED PLAN
NOTE
1. SEE SHEET U-1 FOR LEGEND.
FOR DRAWING INDEX SEE DRAWING NO.
T-1
SCALE: 1" = 30.0'
DESIGN PHASE: CONCEPTUAL
REQUESTER: T HARWARD
RESP ENGR: AUSTAD / OZMUN
DESIGN: AUSTAD / OZMUN
DRAWN: ROB HERGESHEIMER
PROJECT NO. 32780
SPC. CODE NA
FOR REVIEW/APPROVAL SIGNATURES SEE CCR NO.
EFFECTIVE DATE:
Idaho National Laboratory
MFC
WEST CAMPUS
UTILITY CORRIDOR INSTALLATION
ENLARGED PLAN
SIZE D
CAGE CODE 01MF3
273 0100 02 081
SCALE: 1" = 30.0'
SHEET U-4



ENLARGED PLAN



NOTE

1. SEE SHEET U-1 FOR LEGEND.

REVISIONS		
REV	DESCRIPTION	EFFECTIVE DATE:

FOR DRAWING INDEX SEE DRAWING NO. T-1	
SCALE: 1" = 30.0' (30' 20' 10' 0 30')	
DESIGN PHASE: CONCEPTUAL	
REQUESTER:	T HARWARD
RESP ENGR:	AUSTAD / OZMUN
DESIGN:	AUSTAD / OZMUN
DRAWN:	ROB HERGESHEIMER
PROJECT NO.	32780
SPCL CODE	NA
FOR REVIEW/APPROVAL SIGNATURES SEE ECR NO.	
EFFECTIVE DATE:	

Idaho National Laboratory

MFC
WEST CAMPUS
UTILITY CORRIDOR INSTALLATION

ENLARGED PLAN

SIZE	CAGE CODE	AREA	TYPE	CL	ORIG	DWG NO.	REV
D	01MF3	273	0100	02	081		

SCALE: 1" = 30.0' SHEET U-5

Appendix B

Geotechnical Report

MATERIALS TESTING & INSPECTION

❑ Environmental Services ❑ Geotechnical Engineering ❑ Construction Materials Testing ❑ Special Inspections

GEOTECHNICAL ENGINEERING REPORT
of
Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Prepared for:

Battelle Energy Alliance, LLC
2525 Fremont Avenue, PO Box 1625
Idaho Falls, ID 83415

MTI File Number E170233g
Contract 194331

1230 N Skyline Drive, Suite C • Idaho Falls, ID 83402 • (208) 529-8242 • Fax (208) 529-6911
www.mti-id.com • mti@mti-id.com

MATERIALS TESTING & INSPECTION

❑ Environmental Services ❑ Geotechnical Engineering ❑ Construction Materials Testing ❑ Special Inspections

Ms. Elise Miller
Battelle Energy Alliance, LLC
2525 Fremont Avenue, PO Box 1625
Idaho Falls, ID 83415
208-526-2196

Re: Geotechnical Engineering Report
Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Dear Ms. Miller:

In compliance with your instructions, MTI has conducted a soils exploration and foundation evaluation for the above referenced development. Fieldwork for this investigation was conducted from 11 to 19 January 2018. Data have been analyzed to evaluate pertinent geotechnical conditions. Results of this investigation, together with our recommendations, are to be found in the following report. We have provided a PDF copy for your review and distribution.

Often, questions arise concerning soil conditions because of design and construction details that occur on a project. MTI would be pleased to continue our role as geotechnical engineers during project implementation. Additionally, MTI can provide materials testing and special inspection services during construction of this project. If you will advise us of the appropriate time to discuss these engineering services, we will meet with you at your convenience.

MTI appreciates this opportunity to be of service to you and looks forward to working with you in the future. If you have questions, please call (208) 529-8242.

Respectfully Submitted,
Materials Testing & Inspection

Clint Wyllie, G.I.T.
Staff Geologist

PROFESSIONAL ENGINEER LICENSED 14898 3-22-18 STATE OF IDAHO ELIZABETH BROWN

Reviewed by: Elizabeth Brown, P.E.
Geotechnical Services Manager

Reviewed by: David O. Cram, P.E.
General Manager

TABLE OF CONTENTS

INTRODUCTION

This report presents results of a geotechnical investigation and analysis in support of data utilized in design of structures as defined in the 2015 International Building Code (IBC). Information in support of groundwater and stormwater issues pertinent to the practice of Civil Engineering is included. Observations and recommendations relevant to the earthwork phase of the project are also presented. Revisions in plans or drawings for the proposed development from those enumerated in this report should be brought to the attention of the soils engineer to determine whether changes in the provided recommendations are required. Deviations from noted subsurface conditions, if encountered during construction, should also be brought to the attention of the soils engineer.

Project Description

The proposed development is in the northern portion of Bingham County, ID, and occupies a portion of the NW¼NW¼ of Section 13, Township 3 North, Range 32 East, Boise Meridian. This project will consist of construction of a 14,884 square-foot, three-story office building with a centrally located two-story, shielded hot cell. The hot cell will be constructed with 4-foot thick reinforced concrete walls. An overhead crane will operate inside of the structure. Additionally, an approximately 1,400 linear-foot utility corridor will be constructed to service the new structure.

The scope of work for the project indicated that the maximum tolerable differential settlement for the structure is ¼-inch. MTI was informed by Walsh Engineering that the structure was being designed for an allowable soil bearing pressure of 2,500 pounds per square foot (psf).

Authorization

Authorization to perform this exploration and analysis was given in the form of a written authorization to proceed from Ms. Elise Miller of Battelle Energy Alliance, LLC to M. Brad Tanberg of Materials Testing and Inspection (MTI), on 20 November 2018. Said authorization is subject to terms, conditions, and limitations described in the Professional Services Contract entered into between Battelle Energy Alliance, LLC and MTI.

Purpose

The purpose of this Geotechnical Engineering Report is to determine various soil profile components and their engineering characteristics for use by either design engineers or architects in:

- Preparing or verifying suitability of foundation design and placement
- Preparing site drainage designs
- Indicating issues pertaining to earthwork construction

Scope of Investigation

The scope of this investigation included review of geologic literature and existing available geotechnical studies of the area, visual site reconnaissance of the immediate site, subsurface exploration of the site, field and laboratory testing of materials collected, and engineering analysis and evaluation of foundation materials. Our scope of work did not include pavement design recommendations.

Warranty and Limiting Conditions

MTI warrants that findings and conclusions contained herein have been formulated in accordance with generally accepted professional engineering practice in the fields of foundation engineering, soil mechanics, and engineering geology only for the site and project described in this report. These engineering methods have been developed to provide the client with information regarding apparent or potential engineering conditions relating to the site within the scope cited above and are necessarily limited to conditions observed at the time of the site visit and research. Field observations and research reported herein are considered sufficient in detail and scope to form a reasonable basis for the purposes cited above.

Exclusive Use

This report was prepared for exclusive use of the property owner(s), at the time of the report, and their retained design consultants ("Client"). Conclusions and recommendations presented in this report are based on the agreed-upon scope of work outlined in this report together with the Contract for Professional Services between the Client and Materials Testing and Inspection ("Consultant"). Use or misuse of this report, or reliance upon findings hereof, by parties other than the Client is at their own risk. Neither Client nor Consultant make representation of warranty to such other parties as to accuracy or completeness of this report or suitability of its use by such other parties for purposes whatsoever, known or unknown, to Client or Consultant. Neither Client nor Consultant shall have liability to indemnify or hold harmless third parties for losses incurred by actual or purported use or misuse of this report. No other warranties are implied or expressed.

Report Recommendations are Limited and Subject to Misinterpretation

There is a distinct possibility that conditions may exist that could not be identified within the scope of the investigation or that were not apparent during our site investigation. Findings of this report are limited to data collected from noted explorations advanced and do not account for unidentified fill zones, unsuitable soil types or conditions, and variability in soil moisture and groundwater conditions. To avoid possible misinterpretations of findings, conclusions, and implications of this report, MTI should be retained to explain the report contents to other design professionals as well as construction professionals.

Since actual subsurface conditions on the site can only be verified by earthwork, note that construction recommendations are based on general assumptions from selective observations and selective field exploratory sampling. Upon commencement of construction, such conditions may be identified that require corrective actions, and these required corrective actions may impact the project budget. Therefore, construction recommendations in this report should be considered preliminary, and MTI should be retained to observe actual subsurface conditions during earthwork construction activities to provide additional construction recommendations as needed.

Since geotechnical reports are subject to misinterpretation, **do not** separate the soil logs from the report. Rather, provide a copy of, or authorize for their use, the complete report to other design professionals or contractors. Locations of exploratory sites referenced within this report should be considered approximate locations only. For more accurate locations, services of a professional land surveyor are recommended.

This report is also limited to information available at the time it was prepared. In the event additional information is provided to MTI following publication of our report, it will be forwarded to the client for evaluation in the form received.

Environmental Concerns

Comments in this report concerning either onsite conditions or observations, including soil appearances and odors, are provided as general information. These comments are not intended to describe, quantify, or evaluate environmental concerns or situations. Since personnel, skills, procedures, standards, and equipment differ, a geotechnical investigation report is not intended to substitute for a geoenvironmental investigation or a Phase II/III Environmental Site Assessment. If environmental services are needed, MTI can provide, via a separate contract, those personnel who are trained to investigate and delineate soil and water contamination.

SITE DESCRIPTION

Site Access

Access to the site may be gained via Highway 20 westbound from Idaho Falls to its intersection with Taylor Boulevard. Proceed north on Taylor Boulevard for approximately 3.1 miles where the road turns to the east and enters the Materials and Fuels Complex. The site is located within the northern portion of the complex. Presently the site exists as a gravel surfaced laydown yard. The location is depicted on site map plates included in the **Appendix**.

Regional Geology

The site is located within the broad expanse of the Snake River Valley, which is directly underlain by a thick sequence of Upper Pleistocene to Holocene (1.6 million to 10,000 years ago) olivine tholeiite basalt lava flows. These flows covered a great majority of the Eastern Snake River Plain. Quaternary rhyolite domes dated back some 300,000 to 600,000 years ago penetrated these formations, and remain visible to the present. Sediments in the surrounding area were deposited as river floodplain from the Snake River, wind-blown loess, and from erosion of the surrounding buttes (Hughes and Thackray, 1999).

General Site Characteristics

This proposed development (sample preparation laboratory and utility corridor) consists of relatively flat and level to gently undulating terrain. In the location of the proposed sample preparation laboratory, the surface slopes gently from the south to the north. Throughout the majority of the site, poorly graded gravel fill materials were encountered at ground surface and were underlain by either native clayey or silty soils. No vegetation was noted on the project site.

Regional drainage is north and west toward Big Lost River. Stormwater drainage for the site is achieved by percolation through surficial soils. The site is situated so that it is unlikely that it will receive any stormwater drainage from off-site sources. Stormwater drainage collection and retention systems are not in place on the project site. However, drainage structures are present to the north and south of the proposed building location.

Regional Site Climatology and Geochemistry

According to the Western Regional Climate Center, the average precipitation for the area is on the order of 10 to 12 inches per year, with an annual snowfall of approximately 78 inches and a range from 29 to 150 inches. The monthly mean daily temperatures range from 14°F to 87°F, with daily extremes ranging from -51°F to 100°F. Winds are generally from the north or south-southwest with an annual average wind speed of approximately 9 miles per hour. Soils and sediments in the area are primarily derived from siliceous materials and exhibit low electro-chemical potential for corrosion of metals or concretes. Local aggregates are generally appropriate for Portland cement and lime cement mixtures. Surface water, groundwater, and soils in the region typically have pH levels ranging from 7.2 to 8.2.

Seismic Site Evaluation

Geoseismic Setting

Soils on site are classed as Site Class C in accordance with Chapter 20 of the American Society of Civil Engineers (ASCE) publication ASCE/SEI 7-10. Structures constructed on this site should be designed per IBC requirements for such a seismic classification. Our investigation did not reveal hazards resulting from potential earthquake motions including: slope instability, liquefaction, and surface rupture caused by faulting or lateral spreading. Incidence and anticipated acceleration of seismic activity in the area is low.

Regional Faults

The site is situated within the Eastern Snake River Plain (ESRP). The ESRP is a structural downwarp that was formed during the Tertiary Period beginning around 17 million years ago from the migration of the North American Plate over the Yellowstone Hotspot. According to geologic maps, the nearest faults are located approximately 10 miles to the southeast of the site in the vicinity of Hells Half Acre Lava Field. However, according to a USGS Interactive Fault Map, no active faults are present in the vicinity of the project site.

Historical Seismicity

According to the USGS Earthquake Hazard Program, two historical earthquakes have been reported within approximately 50 miles of the project site with magnitudes ranging from 3.0 to 3.1. Additionally, according the the National Geophysical Data Center (http://ngdc.noaa.gov/), no significant earthquakes have been recorded within approximately 50 miles of the project site. However, the 1983 Mount Borah Earthquake (6.9 magnitude) occurred approximately 67 miles to the northwest of the project site.

Seismic Shaking

The USGS U.S. Seismic Design Maps were used to obtain values for ground motion at the project site. The USGS program indicates a peak ground acceleration of 0.055 (i.e., 5.5 percent of gravitational acceleration) for a probability of exceedance of 10% in 50 years and 0.106 for a probability of exceedance of 2% in 50 years at the location of the project site using a Site Class C.

	10% PE in 50 Years	2% PE in 50 Years
PGA	5.5	10.6
0.2 sec SA	12.1	23.84
1.0 sec SA	4.86	8.99

Seismic Design Parameter Values

The United States Geological Survey National Seismic Hazard Maps (2008), includes a peak ground acceleration map. The map for 2% probability of exceedance in 50 years in the Western United States in standard gravity (g) indicates that a probability of 0.106 is appropriate for the project site.

The following section provides an assessment of the earthquake-induced earthquake loads for the site, including identification of the earthquake spectral response acceleration for short periods, S_{MS}, and at 1-second period, S_{M1}, adjusted for site class effects as required by the 2015 IBC based on the following equations:

$$S_{MS} = F_a S_s$$

$$S_{M1} = F_v S_1$$

Where:

F_a = Site coefficient defined in 2009 NEHRP Provisions.
F_v = Site coefficient defined in 2009 NEHRP Provisions.
S_s = The mapped spectral accelerations for short periods.
S_1 = The mapped spectral accelerations for 1-second periods.

The USGS National Seismic Hazards Mapping Project includes a program that provides values for ground motion at a selected site based on the same data that were used to prepare the USGS ground motion maps. The maps were developed using attenuation relationships for soft rock sites; the source model, assumptions, and empirical relationships used in preparation of the maps are described in Petersen and others (1996). The following values are based on a site specific Site Class of C.

S_s and S_1 = Mapped Spectral Acceleration Values
Site Class C
F_a = 1.200
F_v = 1.676

Period (sec)	S_a (g)
0.2	0.313 (S_S, Site Class C)
1.0	0.124 (S_1, Site Class C)

$$S_{MS} = 0.376$$
$$S_{M1} = 0.207$$

Design spectral response acceleration parameters as presented in the 2015 IBC are defined as a 5% damped design spectral response acceleration at short periods, S_{DS}, and at 1-second period, S_{D1}, as calculated from the following equations:

$$S_{DS} = \frac{2}{3} S_{MS}$$

$$S_{D1} = \frac{2}{3} S_{M1}$$

For the proposed project site, the 5% damped design spectral response acceleration at short periods, as calculated using the program supplied by the USGS are as follows:

$$S_{DS} = 0.251$$
$$S_{D1} = 0.138$$

Geologic Hazard Assessment

This section provides an assessment of the geologic hazards for the site, including the potential for surface fault rupture, seismically induced settlements, seismically induced landsliding, lateral spreading, flooding, and collapsible soils. The hazard evaluation methodology involved on or two steps. First, the potential for occurrence of each type of geologic phenomenon is assessed. If there is a potential for a phenomenon to occur, the second step is to assess whether the phenomenon likely will result in a significant hazard for designated structures. For this evaluation, a significant hazard is defined as one that results in structural damage and threatens life-safety.

Seismically Induced Surface Rupture, Settlements, and Lateral Spreading

Earthquakes generally are caused by a sudden slip or displacement along a zone of weakness, termed a fault, in the Earth's crust. Surface fault rupture, which is a manifestation of the fault displacement at the ground surface, usually is associated with moderate to large-magnitude earthquakes (magnitudes of about 6 or larger) occurring on active faults having mapped traces or zones at the ground surface. The amount of surface fault displacement can be as much as 10 feet (3 meters) or more, depending on the earthquake magnitude and other factors. The displacements associated with surface fault rupture can have devastating effects on structures and lifelines situated astride the zone of rupture.

As mentioned above, no active faults have been mapped in the vicinity of the site. Based on the absence of nearby active faults, it is the opinion of MTI that the probability of the occurrence of seismically induced surface rupture, settlements, and lateral spreading is negligible. Based on the topographic relief across the site, the potential for flood waters at the site is negligible.

Seismically Induced Landsliding

Earthquake ground shaking can reduce the stability of a slope and cause sliding or falling of the soil or rock materials composing the slope. During ground shaking, seismic inertia forces are induced within the slope, increasing the loads that the slope materials must sustain to resist landsliding (or rockfalls). If the forces tending to cause landsliding exceed the strength of the materials resisting landsliding, a temporary instability is created that is manifested by lateral or downslope displacement of the slope materials, reducing their ability to resist the forces that cause landsliding.

Possible consequences of landsliding include differential lateral and vertical movements of structures siruated within the landslide zone, undermining of structures upslope of the landslide, burial or filling of facilities downslope of the landslide, increased loading against structures in the path of the landslide, and decreased stability of slopes above the landslide.

As discussed in the **General Site Characteristics** section of this report, the site is on generally flat and level ground. There are no slopes in the vicinity of the site that could fail in a "flowing" manner and impact the buildings. Based on this information, MTI concludes that the potential for seismically induced landslides at the site is low.

Collapsible Potential

Collapsible soils are soils that compact and collapse with increased moisture content. Soil particles are originally loosely packed and barely touch each other before moisture soaks into the ground. As water is added to the soils and moves downward, it wets the contacts between soil particles and allows them to slip past each other to become more tightly packed. Water also affects the clay between other soil particles so that it first expands, and then collapses like a house of cards. Another term for collapsible soils is "hydrocompactive soils" because they compact after water is added. After comparison of in-situ soil densities and general maximum densities for silt soils, collapsible soils are not anticipated on the site.

SOILS EXPLORATION

Exploration and Sampling Procedures

Field exploration conducted to determine engineering characteristics of subsurface materials included a reconnaissance of the project site and investigation by soil boring. Borings were located in the field by INL personnel. GPS coordinates and a site map showing boring locations were provided to MTI. Borings were advanced by means of a truck-mounted drilling rig equipped with continuous flight hollow-stem augers. At specified depths, samples were obtained using a standard split-spoon sampler and a modified California sampler, and Standard Penetration Test (SPT) blow counts were recorded. Uncorrected SPT blow counts are provided on logs, which can be found in the **Appendix**. At completion of exploration, borings were backfilled with bentonite holeplug and topped with 1 to 2 feet of excavated materials.

Within bedrock, cores were advanced by means of diamond core wireline drilling using an HQ (2.5 inch) tube size. Percent recovery and Rock Quality Designation (RQD) were measured and recoded for each run of core. RQD is determined by adding together the length of core pieces 4 inches long and greater, then dividing by the run length. Cores were subsequently placed in core boxes for later reference.

Samples have been visually classified in the field by professional staff, identified according to boring number and depth, placed in sealed containers, and transported to our laboratory for additional testing. Subsurface materials have been described in detail on logs provided in the **Appendix**. Results of field and laboratory tests are also presented in the **Appendix**. MTI recommends that these logs **not** be used to estimate fill material quantities.

Laboratory Testing Program

Along with our field investigation, a supplemental laboratory testing program was conducted to determine additional pertinent engineering characteristics of subsurface materials necessary in an analysis of anticipated behavior of the proposed structures. Laboratory tests were conducted in accordance with current applicable American Society for Testing and Materials (ASTM) specifications, and results of these tests are to be found on the accompanying logs located in the **Appendix**. The laboratory testing program for this report included: Atterberg Limits Testing – ASTM D4318, Grain Size Analysis – ASTM C117/C136, Compressive Strength of Intact Rock Core – ASTM D7012, Laboratory Compaction Characteristics of Soil Using Modified Effort – ASTM D1557, Electrical Resistivity of Soil – ASTM G187-12a, Soil Density Determination – ASTM D7263, Paticle Size Analysis of Soils – ASTM D422, and California Bearing Ratio analysis (CBR value) – ASTM D1883.

Soil and Sediment Profile

The profile below represents a generalized interpretation for the project site. Note that on site soils strata, encountered between boring locations, may vary from the individual soil profiles presented in the logs, which can be found in the **Appendix**.

Sample Preparation Laboratory

Poorly graded gravel with silt and sand fill materials were encountered at ground surface throughout the majority of the site. These fill materials were brownish gray, slightly moist to moist, and medium dense to dense, with fine to coarse-grained sand and 2-inch minus gravel. Varying native silt-clay-sand mixtures were encountered beneath fill materials. These soils were brown, slightly moist to moist, and soft to very stiff, with fine-grained sand. Intermittent gravel content was noted within the deeper portions of these horizons. Basalt cinders were encountered at various depths in borings SP-1, SP-4, SP-10, and SS-10. Cinders were classified as reddish brown, slightly moist, and very dense. Basalt bedrock was encountered at depth in the borings. Basalt was dark gray, moderately to slightly weathered, very closely to widely fractured, and weak to strong.

Utility Corridor

Silty gravel with sand fill materials were encountered at ground surface in PRH-3. These materials were brown, slightly moist to moist, and medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel. Silt with sand soils were observed at ground surface in PRH-6. These soils were brown, slightly moist, and stiff to very stiff, with fine-grained sand. Sandy, silty clay soils underlain by sandy, silty clay with gravel soils were encountered beneath fill materials in PRH-3. These soils were brown, slightly moist, and very stiff to hard, with fine-grained sand and 1.5-inch-minus gravels. A basalt boulder was encountered in PRH-3 from 3.8 to 7.5 feet bgs. Lean clays were encountered at depth in PRH-6. These soils were brown, slightly moist, and stiff to very stiff.

During excavation, boring sidewalls were generally stable. However, moisture contents will affect wall competency with saturated soils having a tendency to readily slough when under load and unsupported.

Volatile Organic Scan

No environmental concerns were identified prior to commencement of the investigation. Therefore, soils obtained during on-site activities were not assessed for volatile organic compounds by portable photoionization detector. Samples obtained during our exploration activities exhibited no odors or discoloration typically associated with this type of contamination. No groundwater was encountered.

SITE HYDROLOGY

Existing surface drainage conditions are defined in the **General Site Characteristics** section. Information provided in this section is limited to observations made at the time of the investigation. Either regional or local ordinances may require information beyond the scope of this report.

Groundwater

During this field investigation, groundwater was not encountered in borings advanced to a maximum depth of 25.0 feet bgs. Soil moistures in the borings were generally slightly moist to moist throughout. In the vicinity of the project site, groundwater levels are controlled in large part by seasonal precipitation and runoff. Maximum groundwater elevations likely occur during late spring to early summer runoff season. According to Idaho Department of Water Resources (IDWR) well driller's reports in the vicinity of the project site, groundwater was measured at depths in excess of 600 feet bgs. For construction purposes, groundwater depth can be assumed to remain greater than 20 feet bgs throughout the year.

Soil Infiltration Rates

Soil permeability, which is a measure of the ability of a soil to transmit a fluid, was not tested in the field. Given the absence of direct measurements, for this report an estimation of infiltration is presented using generally recognized values for each soil type and gradation. Of soils comprising the generalized soil profile for this study, sandy lean clay, sandy lean clay with gravel, silt with sand, silt with gravel, silty clay, and silty clay with gravel soils generally offer little permeability, with typical hydraulic infiltration rates of less than 2 inches per hour. Sandy silt and sandy silt with gravel soils will commonly exhibit infiltration rates from 2 to 4 inches per hour. Infiltration rates through basalt rock can be highly variable, ranging from nearly zero to greater than 6 inches per hour in some cases. Infiltration testing is required to determine site-specific infiltration rates for drainage design once proposed locations of infiltration facilities are determined.

LATERAL EARTH PRESSURES

Retaining, below-grade, or basement walls will be subject to lateral earth pressures. The magnitude of earth pressure is a function of both type and compaction of backfill behind walls within the "active" zone, and allowable rotation of the top of the wall. The active zone is defined as the wedge of soil between the surface of the wall and a plane inclined 31 degrees from vertical passing through the base of the wall. <u>All clayey soils must be completely removed from within the active zone.</u> When dealing with lateral earth pressures on a gravity block, a sliding frictional coefficient of 0.45 is appropriate considering granular structural fill (SP/GP) under typical conditions.

A state of plastic equilibrium is when the subject material is considered to be 1) homogeneous and unbounded and 2) at the point of incipient instability. This state is evaluated on the basis of unit weight, mechanical properties, and the definition of instability. For the purpose of this report, it is assumed that native relatively free draining soils and imported granular fill material will be the materials of concern regarding lateral earth pressures. If other materials are considered for use, MTI must be contacted to provide alternate lateral earth pressure information. Furthermore, changes in natural soil moisture, such as can be imposed by site stormwater systems, can change the values listed below.

Below-grade restrained walls, such as basement walls, should be designed based on at-rest pressures. Active pressures are appropriate under conditions where the wall moves or rotates away from the soil mass at failure. Passive pressures are used for conditions where the wall moves toward the soil mass at failure. Rotation, or lateral movement, of the top of the wall equal to 0.002 times the height of the wall will be necessary for on-site soil backfill to achieve an "active" loading condition. Lateral movement of the top of the wall equal to 0.001 times the height of the wall will be necessary for the "active" pressure condition for imported SP/GP structural backfill.

Retaining Wall Backfill Materials

For lateral earth pressure analysis, MTI anticipates that the soils of interest will be the native sandy silt/silt with sand (ML) soils encountered in the borings. <u>Clayey soils are not suitable for use as backfill on the soil side of walls.</u> Seismic lateral earth pressures have also been provided in the following tables, and were calculated per the Whitman method. For ML soils, the following values are applicable under non-surcharged, drained conditions.

Lateral Earth Pressure Values for Native Soil

Soil Type: Sandy Silt/Silt with Sand			
Internal Friction Angle:	28 °	Dry Unit Weight:	105 pcf
Cohesion:	100 psf	Bouyant Unit Weight:	68 pcf
Natural Void Ratio:	0.7	Natural Moisture:	16 %
Wall slope to horizontal:	90 °	Backfill slope:	0 °
Wall friction angle[3]:	14 °	Ground Acceleration[2]:	0.106
At rest lateral earth pressure:	65 pcf[1]		K_o= 0.53
Active lateral earth pressure:	44 pcf[1]		K_a= 0.36
Passive lateral earth pressure:	337 pcf[1]		K_p= 2.77
Seismic active lateral earth pressure:	54 pcf[1]		K_{ae}= 0.44
Seismic passive lateral earth pressure:	302 pcf[1]		K_{pe}= 2.48

[1]Lateral earth pressure values are in pounds per square foot, per foot of wall (psf/ft). Alternately, the values presented may also be considered as equivalent fluid with units of pounds per cubic foot (pcf).
[2]Ground acceleration obtained from the USGS Earthquake Hazards Program.
[3]Values based on assumption that wall will be formed concrete.

Imported, compacted, structural material, which is used to backfill the soil side of walls, must demonstrate the following characteristics:

Lateral Earth Pressure Values for Fill Materials

Soil Type: Compacted Sandy Gravel			
Internal Friction Angle:	35 °	Dry Unit Weight:	128 pcf
Cohesion:	NA psf	Bouyant Unit Weight:	83 pcf
Natural Void Ratio:	0.4	Natural Moisture:	5 %
Wall slope to horizontal:	90 °	Backfill slope:	0 °
Wall friction angle[3]:	24 °	Ground Acceleration[2]:	0.106
At rest lateral earth pressure:	57 pcf[1]		K_o= 0.43
Active lateral earth pressure:	36 pcf[1]		K_a= 0.27
Passive lateral earth pressure:	496 pcf[1]		K_p= 3.69
Seismic active lateral earth pressure:	47 pcf[1]		K_{ae}= 0.35
Seismic passive lateral earth pressure:	443 pcf[1]		K_{pe}= 3.30

[1]Lateral earth pressure values are in pounds per square foot, per foot of wall (psf/ft). Alternately, the values presented may also be considered as equivalent fluid with units of pounds per cubic foot (pcf).
[2]Ground acceleration obtained from the USGS Earthquake Hazards Program.
[3]Values based on assumption that wall will be formed concrete.

In the case that another material is used for backfill, MTI should be consulted for alternate lateral earth pressure values. Granular structural fill should consist of 4-inch-minus select, clean, granular soil with no more than 30 percent oversize (greater than ¾-inch) material and no more than 5 percent fines (passing the No. 200 sieve). Retaining wall and basement backfill must be placed in accordance with recommendations in the **Structural Fill** section of this report and must be properly compacted and tested.

<u>Lateral earth pressure values do not incorporate specific factors of safety, and are only applicable for non-surcharged, drained conditions.</u> Factors of safety, if applicable, should be integrated into the structural design of the wall. The preceding values are presented for idealized conditions relating to simple shallow structures. For complex structures, deep structures, or structures with significant perimeter landscaping, a soils engineer should be retained as part of the design team in developing appropriate project design parameters and construction specifications.

Retaining Wall Drainage

MTI recommends that a drainage system be incorporated into the retained soil mass. This can be accomplished by installing wall and toe drains as a part of each soil-supporting wall system. In areas where there is potential for significantly high soil moistures within the supported soil mass, installation of drains within the soil mass is recommended. Particular consideration of roof drain effluent and irrigation water must be made. <u>Further, these drainage systems must be separate from other retaining wall/foundation systems.</u> If the granular structural fill option to reduce lateral pressures is used, a compacted low permeability soil cap is recommended within the upper 2 feet of the surface to limit surface water infiltration behind the walls.

FOUNDATION AND SLAB DISCUSSION AND RECOMMENDATIONS

Various foundation types have been considered for support of the proposed structure. Two requirements must be met in the design of foundations. First, the applied bearing stress must be less than the ultimate bearing capacity of foundation soils to maintain stability. Second, total and differential settlement must not exceed an amount that will produce an adverse behavior of the superstructure. Allowable settlement is usually exceeded before bearing capacity considerations become important; thus, allowable bearing pressure is normally controlled by settlement considerations.

Considering subsurface conditions and the proposed construction, it is recommended that the structure be founded upon conventional spread footings and continuous wall footings. Total settlements should not exceed ½-inch and differential settlement should not exceed ¼-inch if the following design and construction recommendations are observed.

Foundation Design Recommendations

Based on data obtained from the site and test results from various laboratory tests performed, MTI recommends the following guidelines for the net allowable soil bearing capacity:

Soil Bearing Capacity

Foundation Depth	ASTM D1557 Subgrade Compaction	Net Allowable Soil Bearing Capacity
Footings and raft/mat slabs must bear on at least 4 feet of compacted structural fill reinforced with two layers of Tensar TX7 geogrid. Geogrid reinforced fill must bear on competent, undisturbed, native sandy silt with gravel, sandy lean clay with gravel, silty clay with gravel, or cinders. Existing sandy silt, sandy lean clay, sandy silty clay and fill materials must be completely removed from below foundation elements.[1,2] The exposed subgrade should be prepared as follows: 1. Twelve inches of structural fill (ISPWC Type 1 crushed aggregate base) must be placed over native soils and compacted to at least 95% of the maximum dry density as determined by ASTM D1557. 2. A layer of Tensar TX7 geogrid should be placed over the compacted structural fill followed by 24 inches of compacted structural fill.[3] Structural fill must be placed in maximum 12 inch thick loose lifts. 3. Another layer of Tensar TX7 geogrid should be placed over the compacted structural fill. 4. At least 12 inches of compacted structural fill should be placed over the top layer of geogrid. <u>See attached Plate 4 for graphical representation of system.</u> <u>These recommendations are applicable for raft/mat slabs and continuous/spread footings 3 to 6 feet wide.</u>	Not Required for Native Soil 95% for Structural Fill	2,500 lbs/ft^2 A ⅓ increase is allowable for short-term loading, which is defined by seismic events or designed wind speeds.

[1]<u>It will be required for MTI personnel to verify the bearing soil suitability for each structure at the time of construction.</u>
[2]<u>Depending on time of year construction takes place, the subgrade soils may be unstable because of high moisture contents. If unstable conditions are encountered, over-excavation and replacement with granular structural fill and/or use of geotextiles may be required.</u>
[3]<u>Structural fill between layers of geogrid must consist of ISPWC Type 1 crushed aggregate base.</u>
[4]<u>Geogrid must extend a minimum of 2 feet beyond the foundations on all sides and be overlapped at least 24 inches between splices.</u>

For raft or mat slabs bearing on compacted structural fill material, a modulus of subgrade reaction, k value, of 250 pci may be used. However, depending on how the slab load is applied, the value will need to be geometrically modified. The values should be adjusted for larger areas using the following expression:

Modulus of Subgrade Reaction: $k_s = k\left(\dfrac{B+1}{2B}\right)^2$

where: k_s = coefficient of vertical subgrade reaction for loaded area,
k = coefficient of vertical subgrade reaction for a 1 square foot area, and
B = effective width of area loaded, in feet.

A sliding frictional coefficient value of 0.45 should be used for foundations bearing on granular structural fill. A passive lateral earth pressure of 496 pounds per square foot per foot (psf/ft) should be used for compacted sandy gravel fill.

Footings should be proportioned to meet either the stated soil bearing capacity or the 2015 IBC minimum requirements. Total settlement should be limited to approximately 1 inch, and differential settlement should be limited to approximately ½ inch. Objectionable soil types encountered at the bottom of footing excavations should be removed and replaced with structural fill. Excessively loose or soft areas that are encountered in the footings subgrade will require over-excavation and backfilling with structural fill. To minimize the effects of slight differential movement that may occur because of variations in the character of supporting soils and seasonal moisture content, MTI recommends continuous footings be suitably reinforced to make them as rigid as possible. For frost protection, the bottom of external footings should be 36 inches below finished grade.

Floor Slab-on-Grade

Fill material was encountered across the site. MTI recommends that these fill materials be compacted in place to at least 95 percent of the maximum dry density as determined by ASTM D1557. MTI personnel must be present during excavation to identify these materials.

Organic, loose, or obviously compressive materials must be removed prior to placement of concrete floors or floor-supporting fill. In addition, the remaining subgrade should be treated in accordance with guidelines presented in the **Earthwork** section. Areas of excessive yielding should be excavated and backfilled with structural fill. Fill used to increase the elevation of the floor slab should meet requirements detailed in the **Structural Fill** section. Fill materials must be compacted to a minimum 95 percent of the maximum dry density as determined by ASTM D1557.

A free-draining granular mat (drainage fill course) should be provided below slabs-on-grade. This should be a minimum of 4 inches in thickness and properly compacted. The mat should consist of a sand and gravel mixture, complying with Idaho Standards for Public Works Construction (ISPWC) specifications for ¾-inch (Type 1) crushed aggregate. A moisture-retarder should be placed beneath floor slabs to minimize potential ground moisture effects on moisture-sensitive floor coverings.

The moisture-retarder should be at least 15-mil in thickness and have a permeance of less than 0.01 US perms as determined by ASTM E96. Placement of the moisture-retarder will require special consideration with regard to effects on the slab-on-grade and should adhere to recommendations outlined in the ACI 302.1R and ASTM E1745 publications. The granular mat should be compacted to no less than 95 percent of the maximum dry density as determined by ASTM D1557. Upon request, MTI can provide further consultation regarding installation.

CONSTRUCTION CONSIDERATIONS

Recommendations in this report are based upon structural elements of the project being founded on compacted structural fill. Structural areas should be stripped to an elevation that exposes these soil types.

Earthwork

Excessively organic soils, deleterious materials, or disturbed soils generally undergo high volume changes when subjected to loads, which is detrimental to subgrade behavior in the area of pavements, floor slabs, structural fills, and foundations. It is recommended that organic or disturbed soils, if encountered, be removed to depths of 1 foot (minimum), and wasted or stockpiled for later use. Stripping depths should be adjusted in the field to assure that the entire root zone or disturbed zone or topsoil are removed prior to placement and compaction of structural fill materials. Exact removal depths should be determined during grading operations by MTI personnel, and should be based upon subgrade soil type, composition, and firmness or soil stability. If underground storage tanks, underground utilities, wells, or septic systems are discovered during construction activities, they must be decommissioned then removed or abandoned in accordance with governing Federal, State, and local agencies. Excavations developed as the result of such removal must be backfilled with structural fill materials as defined in the **Structural Fill** section.

MTI should oversee subgrade conditions (i.e., moisture content) as well as placement and compaction of new fill (if required) after native soils are excavated to design grade. Recommendations for structural fill presented in this report can be used to minimize volume changes and differential settlements that are detrimental to the behavior of footings, pavements, and floor slabs. Sufficient density tests should be performed to properly monitor compaction. For structural fill beneath building structures, one in-place density test per lift for every 5,000 square feet is recommended. In parking and driveway areas, this can be decreased to one test per lift for every 10,000 square feet.

Dry Weather

If construction is to be conducted during dry seasonal conditions, many problems associated with soft soils may be avoided. However, some rutting of subgrade soils may be induced by shallow groundwater conditions related to springtime runoff or irrigation activities during late summer through early fall. Solutions to problems associated with soft subgrade soils are outlined in the **Soft Subgrade Soils** section. Problems may also arise because of lack of moisture in native and fill soils at time of placement. This will require the addition of water to achieve near-optimum moisture levels. Low-cohesion soils exposed in excavations may become friable, increasing chances of sloughing or caving. Measures to control excessive dust should be considered as part of the overall health and safety management plan.

Wet Weather

If construction is to be conducted during wet seasonal conditions (commonly from mid-November through May), problems associated with soft soils <u>must</u> be considered as part of the construction plan. During this time of year, fine-grained soils such as silts and clays will become unstable with increased moisture content, and eventually deform or rut. Additionally, constant low temperatures reduce the possibility of drying soils to near optimum conditions.

Soft Subgrade Soils

Shallow fine-grained subgrade soils that are high in moisture content should be expected to pump and rut under construction traffic. During periods of wet weather, construction may become very difficult if not impossible. The following recommendations and options have been included for dealing with soft subgrade conditions:

- Track-mounted vehicles should be used to strip the subgrade of root matter and other deleterious debris. Heavy rubber-tired equipment should be prohibited from operating directly on the native subgrade and areas in which structural fill materials have been placed. Construction traffic should be restricted to designated roadways that do not cross, or cross on a limited basis, proposed roadway or parking areas.
- Soft areas can be over-excavated and replaced with granular structural fill.
- Construction roadways on soft subgrade soils should consist of a minimum 2-foot thickness of large cobbles of 4 to 6 inches in diameter with sufficient sand and fines to fill voids. Construction entrances should consist of a 6-inch thickness of clean, 2-inch minimum, angular drain-rock and must be a minimum of 10 feet wide and 30 to 50 feet long. During the construction process, top dressing of the entrance may be required for maintenance.
- Scarification and aeration of subgrade soils can be employed to reduce the moisture content of wet subgrade soils. After stripping is complete, the exposed subgrade should be ripped or disked to a depth of 1½ feet and allowed to air dry for 2 to 4 weeks. Further disking should be performed on a weekly basis to aid the aeration process.
- Alternative soil stabilization methods include use of geotextiles, lime, and cement stabilization. MTI is available to provide recommendations and guidelines at your request.

Frozen Subgrade Soils

Prior to placement of structural fill materials or foundation elements, frozen subgrade soils must either be allowed to thaw or be stripped to depths that expose non-frozen soils and wasted or stockpiled for later use. Stockpiled materials must be allowed to thaw and return to near-optimal conditions prior to use as structural fill.

The onsite, shallow clayey and silty soils are susceptible to frost heave during freezing temperatures. For exterior flatwork and other structural elements, adequate drainage away from subgrades is critical. Compaction and use of structural fill will also help to mitigate the potential for frost heave. Complete removal of frost susceptible soils for the full frost depth, followed by replacement with a non-frost susceptible structural fill, can also be used to mitigate the potential for frost heave. MTI is available to provide further guidance/assistance upon request.

Structural Fill

Soils recommended for use as structural fill are those classified as GW, GP, SW, and SP in accordance with the Unified Soil Classification System (USCS) (ASTM D2487). Use of silty soils (USCS designation of GM, SM, and ML) as structural fill may be acceptable. <u>However, use of silty soils (GM, SM, and ML) as structural fill below footings is prohibited.</u> These materials require very high moisture contents for compaction and require a long time to dry out if natural moisture contents are too high and may also be susceptible to frost heave under certain conditions. Therefore, these materials can be quite difficult to work with as moisture content, lift thickness, and compactive effort becomes difficult to control. <u>If silty soil is used for structural fill, lift thicknesses should not exceed 6 inches (loose), and fill material moisture must be closely monitored at both the working elevation and the elevations of materials already placed.</u> Following placement, silty soils <u>must</u> be protected from degradation resulting from construction traffic or subsequent construction.

Recommended granular structural fill materials, those classified as GW, GP, SW, and SP, should consist of a 6-inch minus select, clean, granular soil with no more than 50 percent oversize (greater than ¾-inch) material and no more than 12 percent fines (passing No. 200 sieve). These fill materials should be placed in layers not to exceed 12 inches in loose thickness. Granular structural fill is anticipated to swell approximately 10 percent from a bank condition and shrink approximately 15 percent from a loose condition. For native clayey and silty soils, swell values ranging from 15 to 20 percent should be anticipated from a bank condition and shrink roughly 5 to 10 percent from a loose condition. It is MTI's understanding that native soils are to be used for backfill along the utility corridor.

Prior to placement of structural fill materials, surfaces must be prepared as outlined in the **Construction Considerations** section. Structural fill material should be moisture-conditioned to achieve optimum moisture content prior to compaction. For structural fill below footings, areas of compacted backfill must extend outside the perimeter of the footings for a distance equal to the thickness of fill between the bottom of foundation and underlying soils, or 5 feet, whichever is less. All fill materials must be monitored during placement and tested to confirm compaction requirements, outlined below, have been achieved.

Each layer of structural fill must be compacted, as outlined below:

- <u>Below Structures and Rigid Pavements</u>: A minimum of 95 percent of the maximum dry density as determined by ASTM D1557.
- <u>Below Flexible Pavements</u>: A minimum of 92 percent of the maximum dry density as determined by ASTM D1557 or 95 percent of the maximum dry density as determined by ASTM D698.

The ASTM D1557 test method must be used for samples containing up to 40 percent oversize (greater than ¾-inch) particles. If material contains more than 40 percent but less than 50 percent oversize particles, compaction of fill must be confirmed by proof rolling each lift with a 10-ton vibratory roller (or equivalent) until the maximum density has been achieved. Density testing must be performed after each proof rolling pass until the in-place density test results indicate a drop (or no increase) in the dry density, defined as maximum density or "break over" point. The number of required passes should be used as the requirements on the remainder of fill placement. Material should contain sufficient fines to fill void spaces, and must not contain more than 50 percent oversize particles.

Backfill of Walls

Backfill materials must conform to the requirements of structural fill, as defined in this report. For wall heights greater than 2.5 feet, the maximum material size should not exceed 4 inches in diameter. Placing oversized material against rigid surfaces interferes with proper compaction, and can induce excessive point loads on walls. Backfill shall not commence until the wall has gained sufficient strength to resist placement and compaction forces. Further, retaining walls above 2.5 feet in height shall be backfilled in a manner that will limit the potential for damage from compaction methods and/or equipment. It is recommended that only small hand-operated compaction equipment be used for compaction of backfill within a horizontal distance equal to the height of the wall, measured from the back face of the wall.

Backfill should be compacted in accordance with the specifications for structural fill, except in those areas where it is determined that future settlement is not a concern, such as planter areas. In nonstructural areas, backfill must be compacted to a firm and unyielding condition.

Excavations

Shallow excavations that do not exceed 4 feet in depth may be constructed with side slopes approaching vertical. Below this depth, it is recommended that slopes be constructed in accordance with Occupational Safety and Health Administration (OSHA) regulations, Section 1926, Subpart P. Based on these regulations, on-site soils are classified as type "C" soil, and as such, excavations within these soils should be constructed at a maximum slope of 1½ feet horizontal to 1 foot vertical (1½:1) for excavations up to 20 feet in height. Excavations in excess of 20 feet will require additional analysis. <u>Note that these slope angles are considered stable for short-term conditions only, and will not be stable for long-term conditions.</u>

During the subsurface exploration, boring sidewalls generally exhibited little indication of collapse. For deep excavations, native soils cannot be expected to remain in position. These materials are prone to failure and may collapse, thereby undermining upper soil layers. This is especially true when excavations approach depths near the water table. Care must be taken to ensure that excavations are properly backfilled in accordance with procedures outlined in this report.

Groundwater Control

Groundwater was not encountered during the investigation and is anticipated to be below the depth of most construction. Special precautions may be required for control of surface runoff and subsurface seepage. It is recommended that runoff be directed away from open excavations. Silty and clayey soils may become soft and pump if subjected to excessive traffic during time of surface runoff. Ponded water in construction areas should be drained through methods such as trenching, sloping, crowning grades, nightly smooth drum rolling, or installing a French drain system. Additionally, temporary or permanent driveway sections should be constructed if extended wet weather is forecasted.

GENERAL COMMENTS

When plans and specifications are complete, or if significant changes are made in the character or location of the proposed structure, consultation with MTI should be arranged as supplementary recommendations may be required. Suitability of subgrade soils and compaction of structural fill materials must be verified by MTI personnel prior to placement of structural elements. Additionally, monitoring and testing should be performed to verify that suitable materials are used for structural fill and that proper placement and compaction techniques are utilized.

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APPENDICES

ACRONYM LIST

AASHTO:	American Association of State Highway and Transportation Officials
ACHD:	Ada County Highway District
ACI	American Concrete Institute
ASCE	American Society of Civil Engineers
ASTM:	American Society for Testing and Materials
bgs:	below ground surface
CBR:	California Bearing Ratio
D:	natural dry unit weight, pcf
ESAL	Equivalent Single Axle Load
GS:	grab sample
IBC:	International Building Code
IDEQ	Idaho Department of Environmental Quality
ISPWC:	Idaho Standards for Public Works Construction
ITD:	Idaho Transportation Department
LL:	Liquid Limit
M:	water content
MSL:	mean sea level
N:	Standard "N" penetration: blows per foot, Standard Penetration Test
NP:	nonplastic
OSHA	Occupational Safety and Health Administration
PCCP:	Portland Cement Concrete Pavement
PERM:	vapor permeability
PI:	Plasticity Index
PID:	photoionization detector
PVC:	polyvinyl chloride
Qc:	cone penetrometer value, unconfined compressive strength, psi
Qp:	Penetrometer value, unconfined compressive strength, tsf
Qu:	Unconfined compressive strength, tsf
RMR	Rock Mass Rating
RQD	Rock Quality Designation
R-Value	Resistance Value
SPT:	Standard Penetration Test (140:pound hammer falling 30 in. on a 2:in. split spoon)
USCS:	Unified Soil Classification System
USDA:	United States Department of Agriculture
UST:	underground storage tank
V:	vane value, ultimate shearing strength, tsf

Geotechnical General Notes

Relative Density and Consistency Classification			
Coarse-Grained Soils	**SPT Blow Counts (N)**	**Fine-Grained Soils**	**SPT Blow Counts (N)**
Very Loose:	< 4	Very Soft:	< 2
Loose:	4-10	Soft:	2-4
Medium Dense:	10-30	Medium Stiff:	4-8
Dense:	30-50	Stiff:	8-15
Very Dense:	>50	Very Stiff:	15-30
		Hard:	>30

Moisture Content	
Description	**Field Test**
Dry	Absence of moisture, dusty, dry to touch
Moist	Damp but not visible moisture
Wet	Visible free water, usually soil is below water table

Cementation	
Description	**Field Test**
Weakly	Crumbles or breaks with handling or slight finger pressure
Moderately	Crumbles or beaks with considerable finger pressure
Strongly	Will not crumble or break with finger pressure

Particle Size					
Boulders:	>12 in.	Coarse-Grained Sand:	5 to 0.6 mm	Silts:	0.075 to 0.005 mm
Cobbles:	12 to 3 in.	Medium-Grained Sand:	0.6 to 0.2 mm	Clays:	<0.005 mm
Gravel:	3 in. to 5 mm	Fine-Grained Sand:	0.2 to 0.075 mm		

Unified Soil Classification System			
Major Divisions		**Symbol**	**Soil Descriptions**
Coarse-Grained Soils <50% passes No.200 sieve	Gravel & Gravelly Soils <50% coarse fraction passes No.4 sieve	GW	Well-graded gravels; gravel/sand mixtures with little or no fines
		GP	Poorly-graded gravels; gravel/sand mixtures with little or no fines
		GM	Silty gravels; poorly-graded gravel/sand/silt mixtures
		GC	Clayey gravels; poorly-graded gravel/sand/clay mixtures
	Sand & Sandy Soils >50% coarse fraction passes No.4 sieve	SW	Well-graded sands; gravelly sands with little or no fines
		SP	Poorly-graded sands; gravelly sands with little or no fines
		SM	Silty sands; poorly-graded sand/gravel/silt mixtures
		SC	Clayey sands; poorly-graded sand/gravel/clay mixtures
Fine Grained Soils >50% passes No.200 sieve	Silts & Clays LL < 50	ML	Inorganic silts; sandy, gravelly or clayey silts
		CL	Lean clays; inorganic, gravelly, sandy, or silty, low to medium-plasticity clays
		OL	Organic, low-plasticity clays and silts
	Silts & Clays LL > 50	MH	Inorganic, elastic silts; sandy, gravelly or clayey elastic silts
		CH	Fat clays; high-plasticity, inorganic clays
		OH	Organic, medium to high-plasticity clays and silts
Highly Organic Soils		PT	Peat, humus, hydric soils with high organic content

ROCK CLASSIFICATION SYSTEM

WEATHERING	
WEATHERING	**FIELD TEST**
Fresh	No sign of decomposition or discoloration. Rings under hammer impact.
Slightly Weathered	Slight discoloration inwards from open fractures, otherwise similar to Fresh.
Moderately Weathered	Discoloration throughout. Weaker minerals such as feldspar decomposed. Strength somewhat less than fresh rock but cores cannot be broken by hand or scraped with a knife. Texture preserved.
Highly Weathered	Most minerals somewhat decomposed. Specimens can be broken by hand with effort or shaved with knife. Core stones present in rock mass. Texture becoming indistinct but fabric preserved.
Completely Weathered	Minerals decomposed to soil but fabric and structure preserved. Specimens easily crumbled or penetrated.

FRACTURING	
SPACING	**DISCRIPTION**
6 ft.	Very widely
2 – 6 ft.	Widely
8 – 24 in.	Moderately
2 ½ - 8 in.	Closely
¾ - 2 ½ in.	Very Closely

ROCK QUALITY DESIGNATION (RQD)	
RQD (%)	**ROCK QUALITY**
90 – 100	Excellent
75 – 90	Good
50 – 75	Fair
25 – 50	Poor
0 - 25	Very Poor

COMPETENCY			
STRENGTH	**CLASS**	**FIELD TEST**	**APPROXIMATE RANGE OF UNCONFINED COMPRESSIVE STRENGTH (tsf)**
Extremely Strong	I	Many blows with geologic hammer required to break intact specimen.	>2000
Very Strong	II	Hand-held specimen breaks with pick end of hammer under more than one blow.	2000 - 1000
Strong	III	Cannot be scraped or peeled with knife, hand-held specimen can be broken with single moderate blow with pick end of hammer.	1000 - 500
Moderately Strong	IV	Can just be scraped or peeled with knife. Indentations 1 mm to 3 mm show in specimen with moderate blow with pick end of hammer.	500 - 250
Weak	V	Material crumbles under moderate blow with pick end of hammer and can be peeled with a knife, but is hard to hand-trim for tri-axial test specimen.	250 - 10
Friable	VI	Material crumbles in hand.	N/A

MATERIALS TESTING & INSPECTION

FIELD BORING LOG

BORING NO.: SB-1

TOTAL DEPTH: 25.0'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling Company
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger and Diamond Core Wireline
JOB NO.:	E170233g	DATES DRILLED:	15 January 2018
LOGGED BY:	Troy A. Poslo	NORTHING/EASTING:	N703741.20 E370350.47

Groundwater level | Standard Split Spoon | Modified California Sampler | Rock Core

DEPTH	SOIL/ ROCK TYPE	RUN	RECOV % (25 75)	RQD % (25 75)	SAMPLE METHOD	USCS SOIL DESCRIPTION/ ROCK DESCRIPTION	BLOWS	BLOWS/ FOOT (N60)
0						POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.	7/8/9	
						SANDY LEAN CLAY (CL): Brown, slightly moist, very stiff, with fine-grained sand.		
5						SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. --Gravel content varied throughout.	10/16/28	0 30 60
							15/17/13	
10							6/7/11	0 30 60
							12/42/50 for 6"	
15		1				BASALT: Dark gray, moderately to slightly weathered, very closely to widely fractured, moderately strong.		0 30 60
20		2						0 30 60
25						Groundwater not encountered.		

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MATERIALS TESTING & INSPECTION

FIELD BORING LOG

BORING NO.: SB-2

TOTAL DEPTH: 24.5'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling Company
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger and Diamond Core Wireline
JOB NO.:	E170233g	DATES DRILLED:	15 January 2018
LOGGED BY:	Troy A. Poslo	NORTHING/EASTING:	N703741.20 E70401.47

Groundwater level | Standard Split Spoon | Modified California Sampler | Rock Core

DEPTH	SOIL/ ROCK TYPE	RUN	RECOV % (25 75)	RQD % (25 75)	SAMPLE METHOD	USCS SOIL DESCRIPTION/ ROCK DESCRIPTION	BLOWS	BLOWS/ FOOT (N60)
0						POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.	10/19/9	
						SANDY LEAN CLAY (CL): Brown, slightly moist, very stiff, with fine-grained sand.		
5						SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. --Gravel content varied throughout.	10/29/44	0 30 60
							10/5/8	
10							11/13/13	0 30 60
							20/22/27	
15		1				BASALT: Dark gray, moderately to slightly weathered, very closely to widely fractured, moderately strong.		0 30 60
20		2						0 30 60
						Groundwater not encountered.		

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FIELD BORING LOG

MATERIALS TESTING & INSPECTION

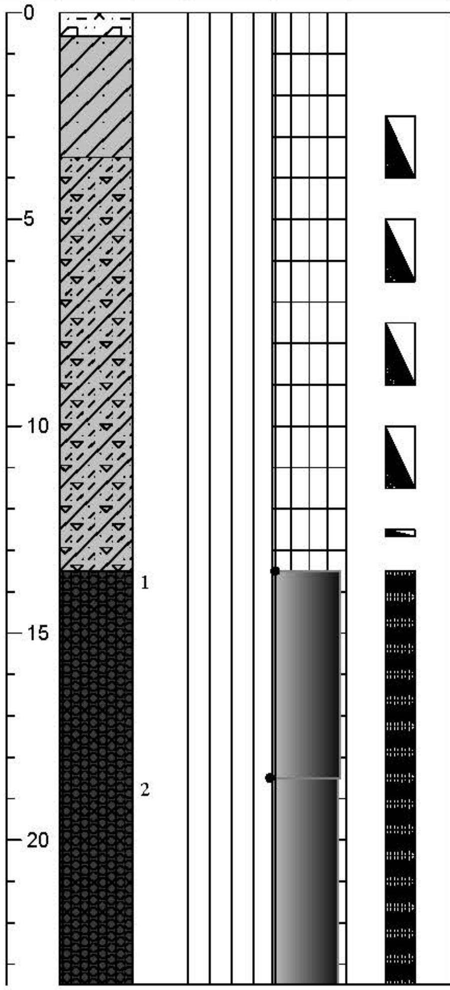
BORING NO.: **SB-3**

TOTAL DEPTH: **23.5'**

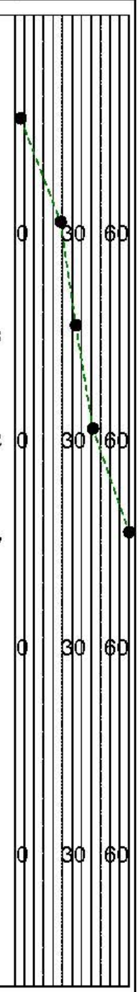
PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling Company
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger and Diamond Core Wireline
JOB NO.:	E170233g	DATES DRILLED:	15 January 2018
LOGGED BY:	Troy A. Poslo	NORTHING/EASTING:	N703711.20 E370401.47

Groundwater level — Standard Split Spoon — Modified California Sampler — Rock Core

DEPTH	SOIL/ROCK TYPE	RUN	RECOV % (25 75)	RQD % (25 75)	SAMPLE METHOD	USCS SOIL DESCRIPTION/ ROCK DESCRIPTION	BLOWS	BLOWS/ FOOT (N60)



USCS SOIL DESCRIPTION/ ROCK DESCRIPTION	BLOWS
POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.	2/1/2
SANDY LEAN CLAY (CL): Brown, slightly moist, soft, with fine-grained sand.	
SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. --Gravel content varied throughout.	11/6/18 12/19/13 13/19/22 50 for 6"
BASALT: Dark gray, moderately to slightly weathered, closely to widely fractured, moderately strong.	
Groundwater not encountered.	



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MATERIALS TESTING & INSPECTION

FIELD BORING LOG

BORING NO.: SB-4

TOTAL DEPTH: 25.0'

PROJECT INFORMATION

PROJECT: Sample Preparation Lab

LOCATION: INL Materials & Fuel Complex, Bingham County

JOB NO.: E170233g

LOGGED BY: Troy A. Poslo

DRILLING INFORMATION

DRILLING CO.: Haztech Drilling Company

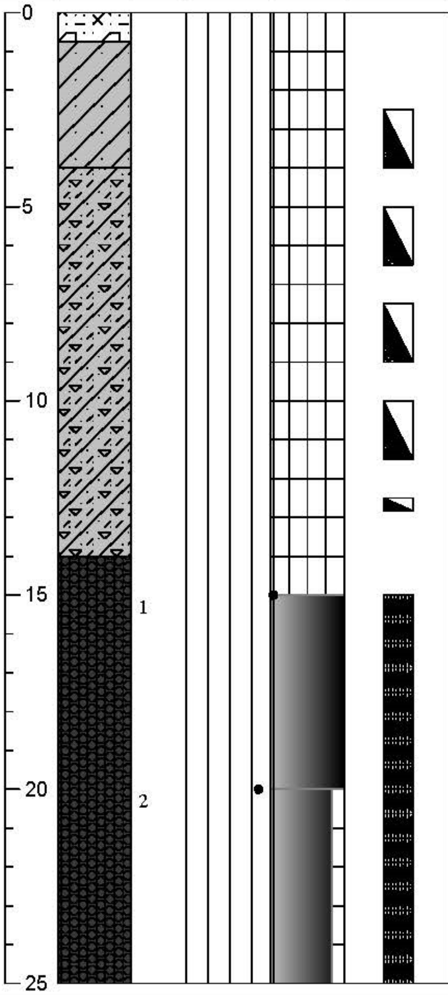
METHOD OF DRILLING: 6" Hollow Stem Auger and Diamond Core Wireline

DATES DRILLED: 15 January 2018

NORTHING/EASTING: N703690.20 E370401.47

Groundwater level | Standard Split Spoon | Modified California Sampler | Rock Core

DEPTH	SOIL/ROCK TYPE	RUN	RECOV % (25 75)	RQD % (25 75)	SAMPLE METHOD	USCS SOIL DESCRIPTION/ ROCK DESCRIPTION	BLOWS	BLOWS/ FOOT (N60)



POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.

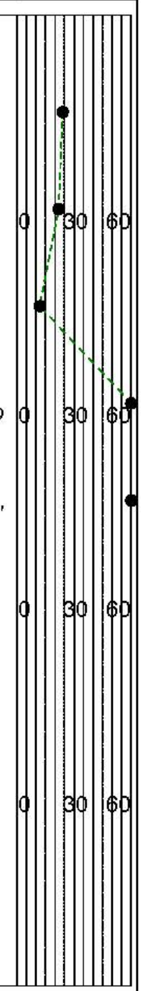
SANDY LEAN CLAY (CL): Brown, slightly moist, very stiff, with fine-grained sand.

SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel.
--Gravel content varied throughout.

BASALT: Dark gray, moderately to slightly weathered, closely to widely fractured, weak to strong.

Groundwater not encountered.

BLOWS: 7/10/14; 7/10/12; 9/7/5; 13/22/39; 50 for 4"



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

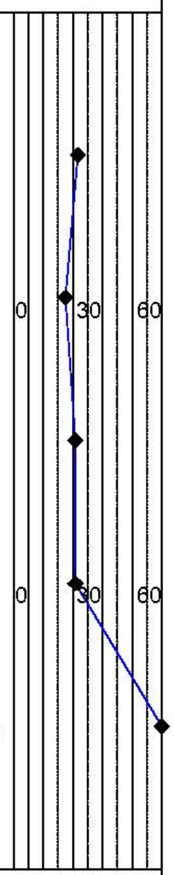
BOREHOLE NO.: **SP-1**

TOTAL DEPTH: **15.0'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	18 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703801.20 E370350.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.	17.2		99	55.9			
		SANDY LEAN CLAY (CL): Brown, slightly moist, very stiff, with fine-grained sand.						9/12/14	
		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.							
5								8/11/10	0 30 60
								18/14/11	
10								6/11/14	0 30 60
								17/35/40	
		CINDERS: Reddish brown, slightly moist, very dense.							
15		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

BOREHOLE NO.: SP-2

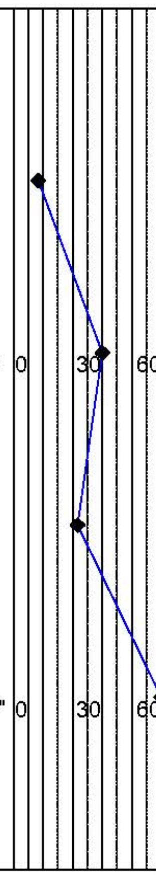
TOTAL DEPTH: 12.5'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	18 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703801.20 E370414.49

Water level during drilling · Standard Split Spoon · Shelby Tube · California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.						
		SANDY LEAN CLAY (CL): Brown, slightly moist, stiff, with fine-grained sand.					Standard Split Spoon	5/5/5
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel conent varied throughout.					Standard Split Spoon	14/16/20
							Standard Split Spoon	9/12/44
10		BASALT: Dark gray, moderately to slightly weathered, moderately strong.					Standard Split Spoon	50 for 1.5"

BLOWS PER FOOT (N)



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

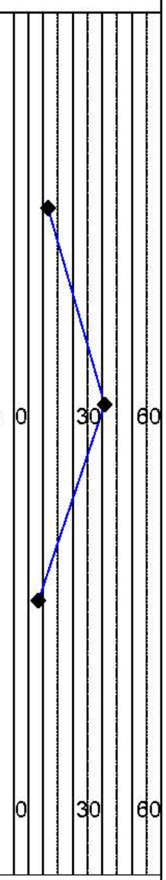
BOREHOLE NO.: SP-3

TOTAL DEPTH: 11.0'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	16 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703771.20 E370323.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SILT WITH SAND (ML): Brown, slightly moist to moist, stiff, with fine-grained sand.					Standard Split Spoon	1/2/12	
5		SILT WITH GRAVEL (ML): Brown, moist, stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.					Standard Split Spoon	12/18/19	
							Standard Split Spoon	6/6/4	
10		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

BOREHOLE NO.: **SP-4**

TOTAL DEPTH: **15.5'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	**Sample Preparation Lab**	DRILLING CO.:	**Haztech Drilling, Inc.**
LOCATION:	**INL Materials & Fuel Complex**	METHOD OF DRILLING:	**6" Hollow Stem Auger**
	Bingham County	SAMPLING METHODS:	**Split Spoon**
JOB NO.:	**E170233g**	DATES DRILLED:	**16 January 2018**
LOGGED BY:	**Troy A. Posio**	NORTHING/EASTING:	**N703771.20 E370350.47**

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY SILT (ML): Brown, slightly moist to moist, very stiff, with fine-grained sand.						20/12/14	
		SANDY SILT WITH GRAVEL (ML): Brown, moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.							
5								5/9/13	0 30 60
								7/10/9	
10								9/13/16	0 30 60
								45/50 for 2"	
		CINDERS: Reddish brown, slightly moist, very dense.							
15		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							

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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

BOREHOLE NO.: **SP-5**

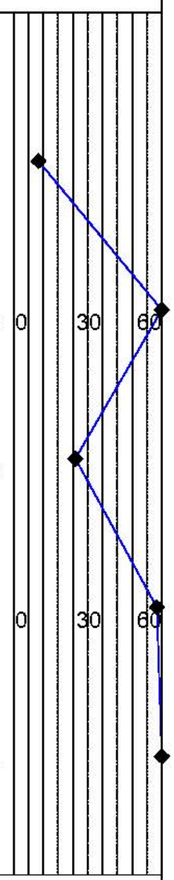
TOTAL DEPTH: **14.5'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	12 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703771.20 E370382.47

Water level during drilling | Standard Split Spoon | Shelby Tube | California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.						
		SANDY SILT (ML): Brown, slightly moist, stiff, with fine-grained sand.	12.9	NP	99	52.5		7/5/5
5		SANDY SILT WITH GRAVEL (ML): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.						11/21/50 for 5"
								10/13/12
10								8/27/31
								12/50 for 2.5"
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.						

BLOWS PER FOOT (N)



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

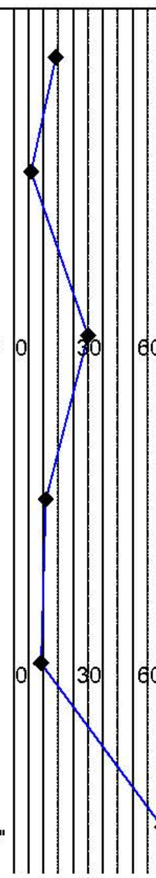
BOREHOLE NO.: **SP-6**

TOTAL DEPTH: **13.5'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	11 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703771.20 E370414.47

Water level during drilling · Standard Split Spoon · Shelby Tube · California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense, with fine to coarse-grained sand and 2-inch-minus gravel.					Standard Split Spoon	9/9/8	
		SANDY LEAN CLAY (CL): Brown, slightly moist, medium stiff to very stiff, with fine-grained sand.					Standard Split Spoon	4/3/4	
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, medium stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.					Standard Split Spoon	10/14/16	0 30 60
							Standard Split Spoon	6/6/7	
10							Standard Split Spoon	9/4/7	0 30 60
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.					Standard Split Spoon	50 for 1.5"	



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

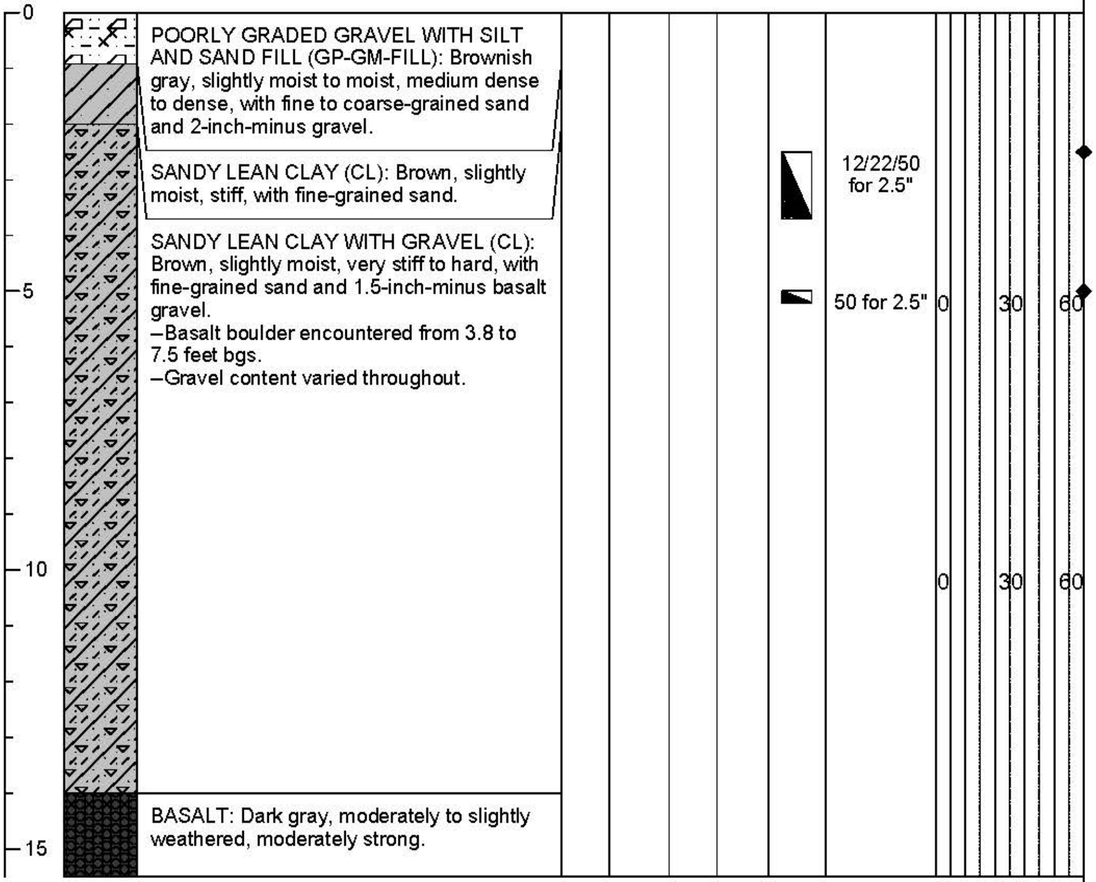
BOREHOLE NO.: **SP-7**

TOTAL DEPTH: **15.5'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	EI70233g	DATES DRILLED:	11 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703771.20 E370434.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY LEAN CLAY (CL): Brown, slightly moist, stiff, with fine-grained sand.					Standard Split Spoon	12/22/50 for 2.5"	
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Basalt boulder encountered from 3.8 to 7.5 feet bgs. –Gravel content varied throughout.					Standard Split Spoon	50 for 2.5"	0 30 60
10									0 30 60
15		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

BOREHOLE NO.: **SP-8**

TOTAL DEPTH: **13.7'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex, Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	11 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703741.20 E370414.49

Water level during drilling | Standard Split Spoon | Shelby Tube | California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY LEAN CLAY (CL): Brown, slightly moist, stiff, with fine-grained sand.					Split Spoon	4/4/5	
		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.							
5							Split Spoon	12/23/19	0 30 60
							Split Spoon	3/17/22	
10							Split Spoon	8/8/12	0 30 60
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.					Split Spoon		

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MATERIALS TESTING & INSPECTION

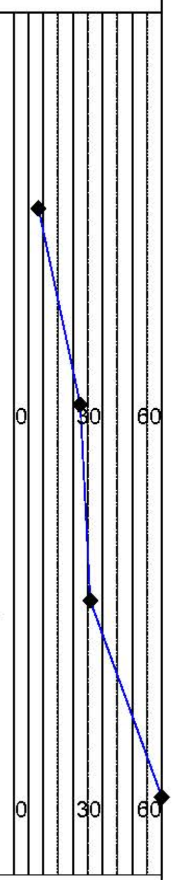
FIELD BOREHOLE LOG

BOREHOLE NO.: SP-9
TOTAL DEPTH: 11.0'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	16 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703711.20 E370323.47

Water level during drilling · Standard Split Spoon · Shelby Tube · California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SILT WITH SAND (ML): Brown, slightly moist, stiff, with fine-grained sand.					Standard Split Spoon	5/6/4	
5		SILT WITH GRAVEL (ML): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.					Standard Split Spoon	18/18/9	
							Standard Split Spoon	14/18/13	
10		BASALT: Dark gray, moderately to slightly weathered, very closely to widely fractured, moderately strong.					Standard Split Spoon	50 for 2"	



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

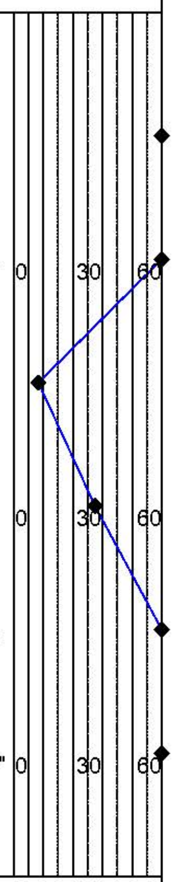
BOREHOLE NO.: **SP-10**

TOTAL DEPTH: **17.5'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	EI70233g	DATES DRILLED:	17 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703690.20 E370350.47

Water level during drilling · Standard Split Spoon · Shelby Tube · California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, very dense, with fine to coarse-grained sand and 2-inch-minus gravel.					Standard Split Spoon	50 for 5"	
		SANDY SILT (ML): Brown, slightly moist, stiff, with fine-grained sand.							
5		SANDY SILT WITH GRAVEL (ML): Brown, slightly moist, stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel.					Standard Split Spoon	14/50 for 4"	
		CINDERS: Reddish brown, slightly moist, very dense.					Standard Split Spoon	38/7/3	
10		SANDY SILT WITH GRAVEL (ML): Brown, slightly moist, stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.					Standard Split Spoon	5/17/16	
							Standard Split Spoon	13/23/50 for 5"	
15							Standard Split Spoon	50 for 3.5"	
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



MATERIALS TESTING & INSPECTION

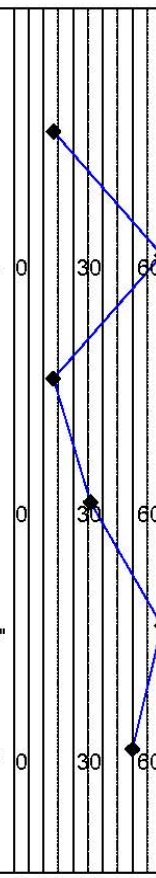
FIELD BOREHOLE LOG

BOREHOLE NO.: SP-11
TOTAL DEPTH: 17.5'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	12 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703711.20 E370382.47

Water level during drilling · Standard Split Spoon · Shelby Tube · California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY LEAN CLAY (CL): Brown, slightly moist, very stiff, with fine-grained sand.						4/6/10	
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.						16/47/15	
								6/9/7	
10								9/14/17	
								50 for 4.5"	
15								15/22/26	
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

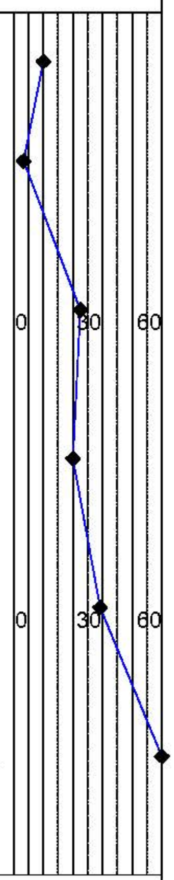
BOREHOLE NO.: **SP-12**

TOTAL DEPTH: **14.5'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuels Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	12 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703711.20 E370414.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense, with fine to coarse-grained sand and 2-inch-minus gravel.	17.2	23/8	100	64.8		8/6/6	
		SANDY LEAN CLAY (CL): Brown, slightly moist to moist, soft to stiff, with fine-grained sand.						4/2/2	
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.						9/10/17	
								8/9/15	
10								6/11/24	
								33/50 for 5.5"	
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

BOREHOLE NO.: SP-13

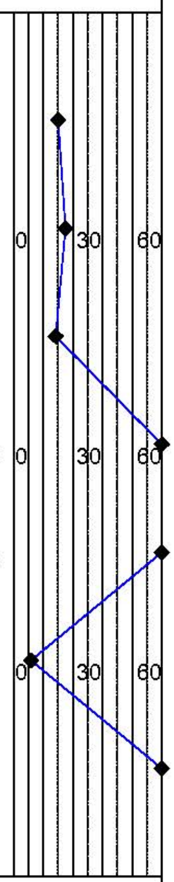
TOTAL DEPTH: 20.0'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	11 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703711.20 E370434.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS
0	POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.					Standard Split Spoon	7/9/8
	SANDY LEAN CLAY (CL): Brown, slightly moist, very stiff, with fine-grained sand.						
5	SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout. –Basalt boulder noted from 14.0 to 15.5 feet bgs.					Standard Split Spoon	10/11/11
						Standard Split Spoon	7/9/8
10						Standard Split Spoon	11/17/50 for 4"
						Standard Split Spoon	23/49/50 for 5.5"
15						Standard Split Spoon	9/4/3
	LEAN CLAY (CL): Light brown, moist, medium stiff.	23.3	31/15	100	91.5	Standard Split Spoon	1/11/50 for 5.5"
20	BASALT: Dark gray, moderately to slightly weathered, moderately strong.						

BLOWS PER FOOT (N)



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

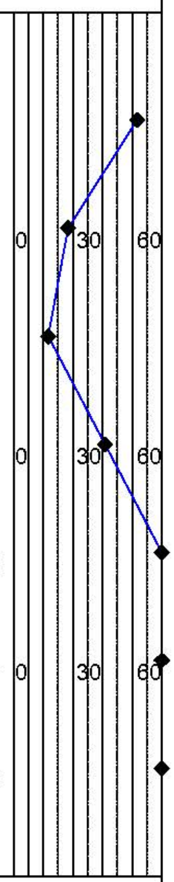
BOREHOLE NO.: SP-14

TOTAL DEPTH: 20.0'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	17 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703669.20 E370530.47

Water level during drilling | Standard Split Spoon | Shelby Tube | California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
							Split Spoon	50 for 4"	
		SILTY CLAY (CL-ML): Brown, slightly moist to moist, stiff, with fine-grained sand.							
5		SILTY CLAY WITH GRAVEL (CL-ML): Brown, slightly moist, stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Basalt boulder encountered from 1.5 to 4.0 feet bgs. –Gravel content varied throughout.					Split Spoon	7/7/15	
							Split Spoon	7/9/5	
10							Split Spoon	7/13/24	
							Split Spoon	14/32/42	
15							Split Spoon	27/50 for 5.5"	
							Split Spoon	18/45/50 for 3"	
20		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

BOREHOLE NO.: SP-15

TOTAL DEPTH: 7.75'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	17 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703669.20 E370414.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		ASPHALTIC CONCRETE: 2 inches thick.							
		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.					Standard Split Spoon	14/33/22	
5							Standard Split Spoon	8/21/50 for 4"	0 30 60
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.					Standard Split Spoon	50 for 3"	

MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

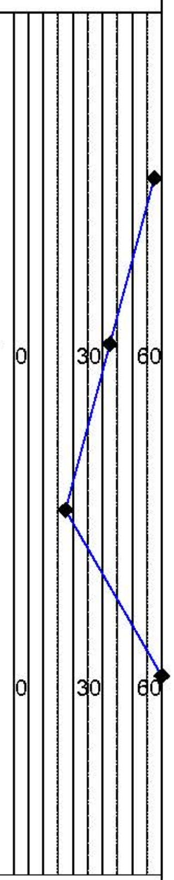
BOREHOLE NO.: SS-7

TOTAL DEPTH: 13.0'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	16 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703801.20 E370323.47

Water level during drilling | Standard Split Spoon | Shelby Tube | California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SILT WITH SAND (ML): Brown, slightly moist, hard, with fine-grained sand.					Standard Split Spoon	6/19/38	
5		SILT WITH GRAVEL (ML): Brown, slightly moist, hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Weak calcium carbonate cementation noted in top of layer. –Gravel content varied throughout.					Standard Split Spoon	14/22/17	0 30 60
							Standard Split Spoon	8/8/13	
10							Standard Split Spoon	50 for 4"	0 30 60
		BASALT: Dark gray, moderately to slightly weathered, strong.							



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

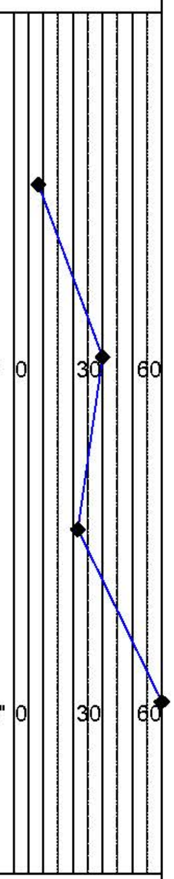
BOREHOLE NO.: SS-8

TOTAL DEPTH: 12.5'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	18 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703801.20 E370382.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY LEAN CLAY (CL): Brown, slightly moist, stiff, with fine-grained sand.					Standard Split Spoon	5/5/5	
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.					Standard Split Spoon	14/16/20	
							Standard Split Spoon	9/12/44	
10		BASALT: Dark gray, moderately to slightly weathered, moderately strong.					Standard Split Spoon	50 for 1.5"	



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

BOREHOLE NO.: SS-9
TOTAL DEPTH: 20.0'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	18 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703801.20 E370434.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.					Standard Split Spoon	13/20/17	
		SANDY LEAN CLAY (CL): Brown, slightly moist, stiff to very stiff, with fine-grained sand.							
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.					Standard Split Spoon	11/21/23	0 30 60
							Standard Split Spoon	5/9/27	
10		Basalt boulder encountered from 10.4 to 11.5 feet bgs.					Standard Split Spoon	50 for 5"	0 30 60
							Standard Split Spoon	17/23/42	
15							Standard Split Spoon	11/18/50 for 3"	0 30 60
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.					Standard Split Spoon	50 for 3"	
20									

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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

BOREHOLE NO.: **SS-10**

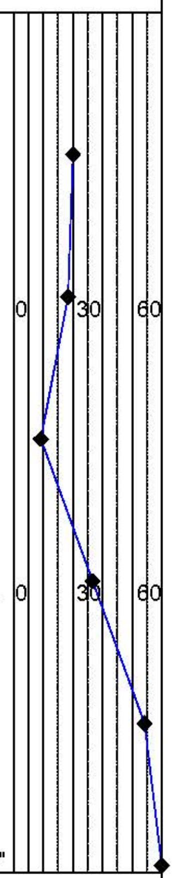
TOTAL DEPTH: **15.12'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	16 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703741.20 E370313.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.						
		SILT WITH SAND (ML): Brown, slightly moist to moist, very stiff, with fine-grained sand.	15.7	NP	99	74.8		7/10/14
5		SILT WITH GRAVEL (ML): Brown, moist, stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.						7/10/12
								5/6/5
10								11/18/14
								8/15/38
		CINDERS: Reddish brown, slightly moist, very dense.						
15		BASALT: Dark gray, moderately to slightly weathered, strong.						50 for 1.5"

BLOWS PER FOOT (N)



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

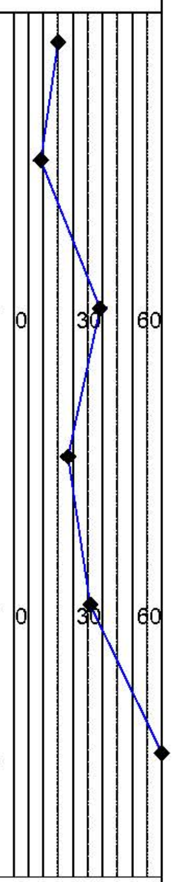
BOREHOLE NO.: **SS-11**

TOTAL DEPTH: **14.6'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	12 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703741.20 E370382.47

Water level during drilling · Standard Split Spoon · Shelby Tube · California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense, with fine to coarse-grained sand and 2-inch-minus gravel.						14/9/9	
		SANDY LEAN CLAY (CL): Brown, slightly moist, stiff to very stiff, with fine-grained sand.						6/6/5	
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.						17/18/17 11/13/9	
10								11/14/17 45/50 for 4.5"	
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

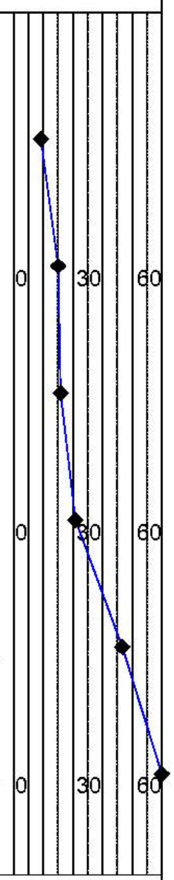
BOREHOLE NO.: **SS-12**

TOTAL DEPTH: **17.0'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	**Sample Preparation Lab**	DRILLING CO.:	**Haztech Drilling, Inc.**
LOCATION:	**INL Materials & Fuel Complex**	METHOD OF DRILLING:	**6" Hollow Stem Auger**
	Bingham County	SAMPLING METHODS:	**Split Spoon**
JOB NO.:	**E170233g**	DATES DRILLED:	**11 January 2018**
LOGGED BY:	**Troy A. Posio**	NORTHING/EASTING:	**N703741.20 E370434.47**

Water level during drilling | Standard Split Spoon | Shelby Tube | California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY LEAN CLAY (CL): Brown, slightly moist, very stiff, with fine-grained sand.					Standard Split Spoon	4/6/5	
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, very stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.					Standard Split Spoon	4/5/13	
							Standard Split Spoon	5/10/9	
10							Standard Split Spoon	7/9/16	
							Standard Split Spoon	22/21/23	
15							Standard Split Spoon	26/50 for 4.5"	
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

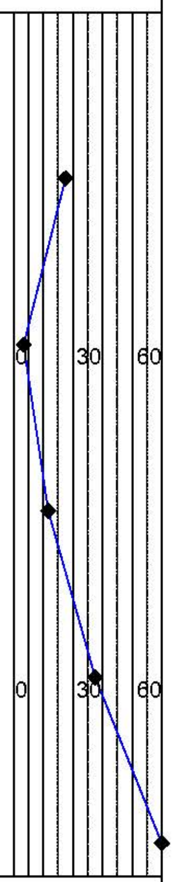
BOREHOLE NO.: SS-13

TOTAL DEPTH: 13.0'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	16 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703669.20 E370323.47

Water level during drilling | Standard Split Spoon | Shelby Tube | California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SILTY CLAY (CL-ML): Brown, slightly moist to moist, very stiff, with fine-grained sand.						3/9/12	
		SILTY CLAY WITH GRAVEL (CL-ML): Brown, moist, soft to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.							
5			29.9	29/7	99	80.7		2/1/3	0 30 60
								6/8/6	
10								5/12/21	0 30 60
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.						50 for 2"	



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

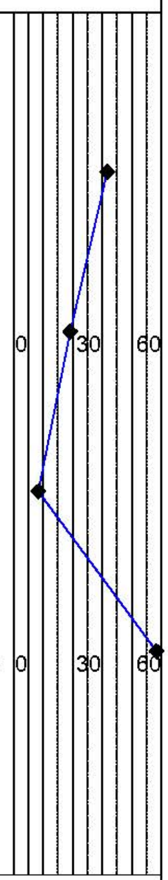
BOREHOLE NO.: SS-14

TOTAL DEPTH: 13.5'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel COmplex Bingham County	METHOD OF DRILLING:	6" Hollow Stem Auger
		SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	17 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703669.20 E370434.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY LEAN CLAY (CL): Brown, slightly moist to moist, stiff, with fine-grained sand.					Standard Split Spoon	4/22/16	
		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content noted throughout. –Some cinders noted from 7.5 to 9.0 feet bgs.							
5							Standard Split Spoon	6/10/13	
							Standard Split Spoon	8/6/4	
10							Standard Split Spoon	11/23/35	
		BASALT: Dark gray, moderately to slightly weathered, very closely to widely fractured, strong.							



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MATERIALS TESTING & INSPECTION

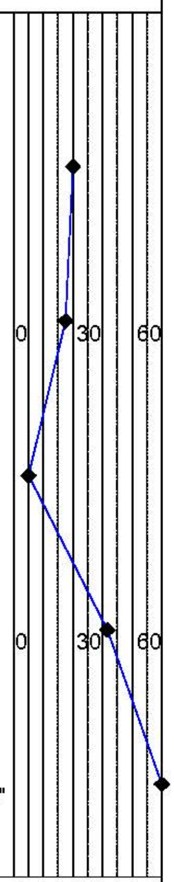
FIELD BOREHOLE LOG

BOREHOLE NO.: **SS-15**
TOTAL DEPTH: **14.0'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Sample Preparation Lab	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	17 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703669.20 E370434.47

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		POORLY GRADED GRAVEL WITH SILT AND SAND FILL (GP-GM-FILL): Brownish gray, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY LEAN CLAY (CL): Brown, slightly moist, stiff to very stiff, with fine-grained sand.					Standard Split Spoon	9/14/10	
5		SANDY LEAN CLAY WITH GRAVEL (CL): Brown, slightly moist, medium stiff to hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Gravel content varied throughout.					Standard Split Spoon	8/12/9	
							Standard Split Spoon	3/2/4	
10							Standard Split Spoon	7/12/26	
							Standard Split Spoon	50 for 4.5"	
		BASALT: Dark gray, moderately to slightly weathered, moderately strong.							



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MATERIALS TESTING & INSPECTION

FIELD BOREHOLE LOG

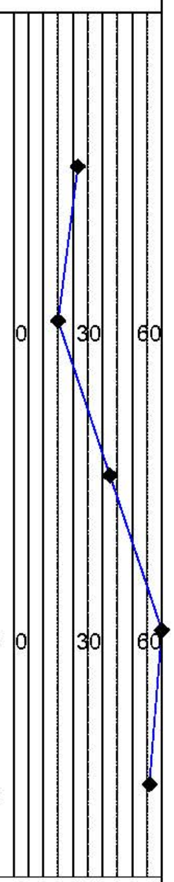
BOREHOLE NO.: PRH-3

TOTAL DEPTH: 14.0'

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Utility Corridor	DRILLING CO.:	Haztech Drilling, Inc.
LOCATION:	INL Materials & Fuel Complex	METHOD OF DRILLING:	6" Hollow Stem Auger
	Bingham County	SAMPLING METHODS:	Split Spoon
JOB NO.:	E170233g	DATES DRILLED:	19 January 2018
LOGGED BY:	Troy A. Posio	NORTHING/EASTING:	N703781.87 E369950.59

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS	BLOWS PER FOOT (N)
0		SILTY GRAVEL WITH SAND FILL (GM-FILL): Brown, slightly moist to moist, medium dense to dense, with fine to coarse-grained sand and 2-inch-minus gravel.							
		SANDY SILTY CLAY (CL-ML): Brown, slightly moist, very stiff, with fine-grained sand.					Split Spoon	9/13/13	
5			9.4	22/5	100	60.9	Split Spoon	9/8/10	0 30 60
		SANDY SILTY CLAY WITH GRAVEL (CL-ML): Brown, slightly moist, hard, with fine-grained sand and 1.5-inch-minus basalt gravel. –Basalt boulder encountered from 3.8 to 7.5 feet bgs. –Gravel content varied throughout.					Split Spoon	9/14/25	
10							Split Spoon	15/40/29	0 30 60
							Split Spoon	12/19/36	



FIELD BOREHOLE LOG

MATERIALS TESTING & INSPECTION

BOREHOLE NO.: **PRH-6**

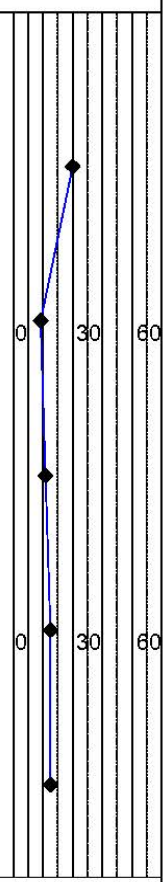
TOTAL DEPTH: **14.0'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	**Utility Corridor**	DRILLING CO.:	**Haztech Drilling, Inc.**
LOCATION:	**INL Materials & Fuel Complex**	METHOD OF DRILLING:	**6" Hollow Stem Auger**
	Bingham County	SAMPLING METHODS:	**Split Spoon**
JOB NO.:	**E170233g**	DATES DRILLED:	**18 January 2018**
LOGGED BY:	**Troy A. Posio**	NORTHING/EASTING:	**N703509.15 E369859.83**

Water level during drilling — Standard Split Spoon — Shelby Tube — California Sampler

DEPTH	SOIL TYPE	DESCRIPTION	MOISTURE (%)	LL/PI	% < #4	% < #200	SAMPLE	BLOWS
0	ML	SILT WITH SAND (ML): Brown, slightly moist, stiff to very stiff, with fine-grained sand.						
			12.8	NP	100	80.4	California Sampler	9/5/15
5							Standard Split Spoon	7/5/6
							Standard Split Spoon	3/5/8
10	CL	LEAN CLAY (CL): Brown, slightly moist, stiff to very stiff.					Standard Split Spoon	4/6/9
			20.8	34/15	100	94.8	Standard Split Spoon	4/6/9

BLOWS PER FOOT (N)



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Utility Corridor Soil Probe Depth to Bedrock

Boring	Depth to Bedrock
PRH-1	Not encountered to 14.0 feet bgs
PRH-2	13.5 feet bgs
PRH-3	Not encountered to 14.0 feet bgs
PRH-4	Not encountered to 14.0 feet bgs
PRH-5	9.0 feet bgs
PRH-6	Not encountered to 14.0 feet bgs
PRH-7	7.5 feet bgs
PRH-8	7.0 feet bgs
PRH-9	2.7 feet bgs
PRH-10	1.3 feet bgs
PRH-11	2.5 feet bgs
PRH-12	10.5 feet bgs
PRH-13	9.5 feet bgs
PRH-14	2.5 feet bgs
PRH-15	4.0 feet bgs

LABORATORY TEST RESULTS

All laboratory test results have been reviewed and approved by MTI corporate quality manager Brandon Huff to ensure that all tests were performed in accordance with applicable test standards.

Brandon Huff
Corporate Quality Manager

ROCK CORE COMPRESSIVE STRENGTH

Lab Test Location/Depth	Cylinder Diameter	Cylinder Height	Test Date	Load Failure	σ_u*	σ_u
-	(in)	(in)	-	(lbs)	(psi)	(tsf)
SB-1 17.0’	2.39	4.78	1/23/18	16,615	3,700	266.4
SB-1 24.0’	2.38	4.81	1/23/18	20,645	4,640	334.1
SB-2 15.0’	2.38	4.68	1/23/18	15,560	3,500	252.0
SB-2 16.0’	2.39	4.72	1/23/18	29,050	6,470	465.8
SB-2 24.5’	2.39	4.83	1/23/18	18,425	4,100	295.2
SB-3 13.5’	2.39	4.80	1/23/18	18,520	4,120	296.6
SB-3 23.5’	2.39	4.70	1/23/18	22,075	4,920	354.2
SB-4 15.0’	2.38	4.72	1/23/18	56,755	12,750	918.0
SB-4 20.0’	2.39	4.79	1/23/18	25,510	5,680	409.0
SB-4 25.0’	2.39	4.69	1/23/18	13,985	3,110	223.9

SIEVE AND ATTERBERG

Lab Test Location/depth	M	LL	PI	Sieve Analysis (% passing)				
-	%	-	-	#4	#10	#40	#100	#200
SB-1 2.5’	12.8	25	9	99	99	96	76	62.9
SP-1 2.0’	17.2	-	-	99	97	93	73	55.9
SP-5 2.5’	12.9	-	-	99	96	90	68	52.5
SP-12 0.8’	17.2	23	8	100	99	97	81	64.8
SP-13 17.5’	23.3	31	15	100	99	99	96	91.5
SS-10 2.5’	15.7	-	-	99	98	96	87	74.8
SS-13 5.0’	29.9	29	7	99	99	97	91	80.7
PRH-3 5.0’	9.4	22	5	100	100	97	81	60.9
PRH-6 2.5’	12.8	-	-	100	100	98	91	80.4
PRH-6 12.5’	20.8	34	15	100	100	99	98	94.8

HYDROMETER

Lab Test Location/Depth	Hydrometer (%)			
-	Sand	Silt	Clay	Colloids
PRH-3 5.0'	39.1	60.2	0.6	0.1
PRH-6 2.5'	19.6	71.2	5.0	4.2
PRH-6 5.0'	5.2	89.9	3.5	1.4

TUBE DENSITY

Lab Test Location/Depth	Dry Density
-	lbs/ft^3
PRH-3 5.0'	108.00
PRH-6 2.5'	91.77

Testing standards for the above listed laboratory tests can be found in the **Laboratory Testing Program** section of this report.

CBR Laboratory Test Data

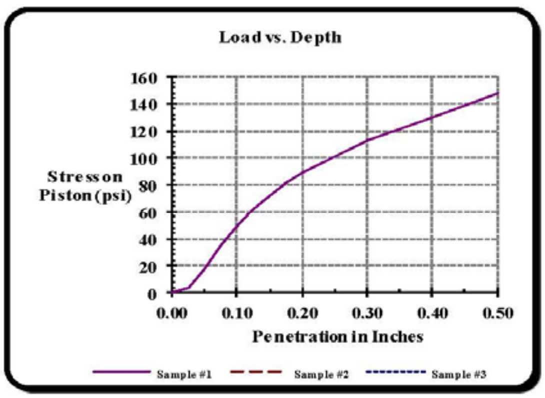
Source and Description:	SP-1:2.0' Clay. Assumed Maximum Density and Moisture.			
Date Obtained:	Janurary 24, 2018			
Sample ID:	18-7060			
Soak Period & Swell:	96 Hours and 1.0%			
Sampling and Preparation:	ASTM D75: X ASTM D421: X	AASHTO T2: AASHTO T87:		
Test Standard:	ASTM D1883: X	AASHTO T193:		
Sample Compaction:	ASTM D 698: X ASTM D 1557:	AASHTO T 99: AASHTO T 180:	**Method** A	
Sample Condition:	Soaked: X	Unsoaked:		

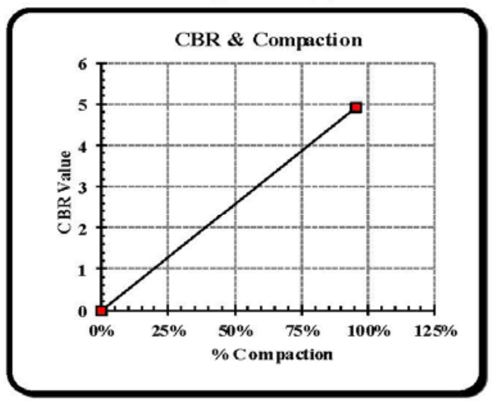
Sample #1

#1 Load	Depth Inches	#1 psi	CBR Value
0	0.000	0	
9	0.025	3	
52	0.050	17	
105	0.075	35	
147	0.100	49	5
186	0.125	62	
218	0.150	73	
245	0.175	82	
267	0.200	89	6
337	0.300	112	6
389	0.400	130	6
444	0.500	148	6

Sample #:	**1**	**2**	**3**
CBR Value:	5	0	0
After SoakDry Density:	103.8	0	0
% Compaction:	95.4%	0.0%	0.0%
Corrected CBR Value:	**5**	**0**	**0**

Before Soak Maximum Dry Density:	**108.8**
Moisture Content Before Compaction:	12.6
Moisture Content After Compaction:	12.6
Moisture Content Top 1 Inch:	24.1
% Passing 3/4":	100
Surcharge Amount (lb):	10.0





CBR Laboratory Test Data

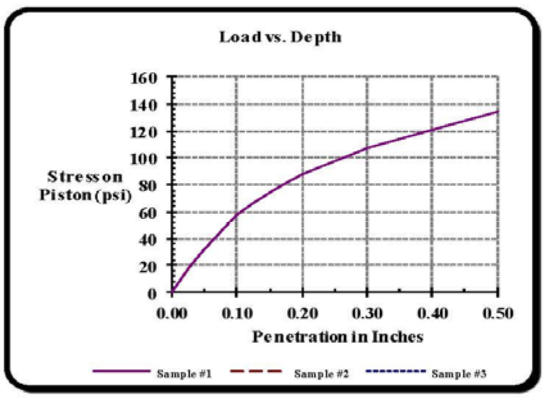
Source and Description:	SP-2:2.0' Clay. Assumed Maximum Density and Moisture.			
Date Obtained:	Janurary 24, 2018			
Sample ID:	18-7061			
Soak Period & Swell:	96 Hours and 1.1%			
Sampling and Preparation:	ASTM D75: X	AASHTO T2:		
	ASTM D421: X	AASHTO T87:		
Test Standard:	ASTM D1883: X	AASHTO T193:		
Sample Compaction:	ASTM D 698: X	AASHTO T 99:		**Method**
	ASTM D 1557:	AASHTO T 180:		A
Sample Condition:	Soaked: X	Unsoaked:		

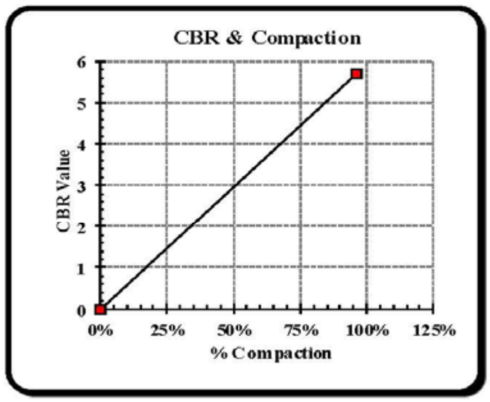
Sample #1

#1 Load	Depth Inches	#1 psi	CBR Value
0	0.000	0	
53	0.025	18	
96	0.050	32	
136	0.075	45	
171	0.100	57	6
200	0.125	67	
224	0.150	75	
245	0.175	82	
265	0.200	88	6
322	0.300	107	6
361	0.400	120	5
401	0.500	134	5

Sample #:	**1**	**2**	**3**
CBR Value:	6	0	0
After SoakDry Density:	105.5	0	0
% Compaction:	96.3%	0.0%	0.0%
Corrected CBR Value:	**6**	**0**	**0**

Before Soak Maximum Dry Density:	**109.6**
Moisture Content Before Compaction:	12.3
Moisture Content After Compaction:	12.3
Moisture Content Top 1 Inch:	22.9
% Passing 3/4":	100
Surcharge Amount (lb):	10.0



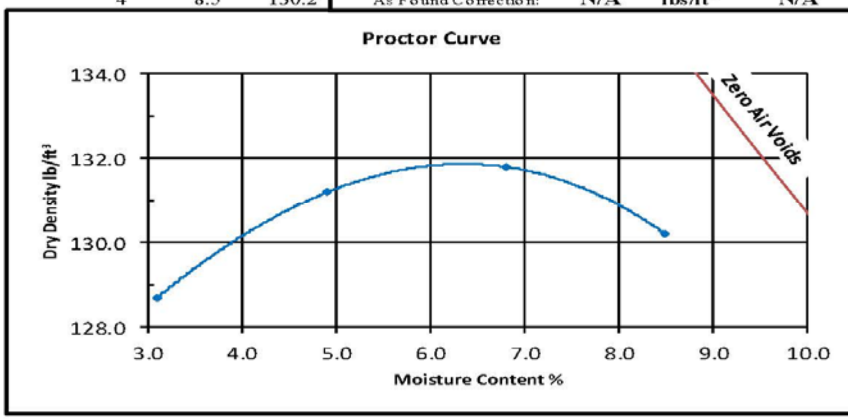


LABORATORY COMPACTION CHARACTERISTICS OF SOIL

Source and Description:	Location 1, Monroe Pit, Pit Run
Date Obtained:	January 22, 2018
Sample ID:	18-7036
Sampling and Preparation:	ASTM D75: X Moist: X Manual: Mechanical:
Test Standard:	AASHTO T99: AASHTO T180: ASTM D698: ASTM D1557: **Method** C

Assumed Sp. Gr.	Point Number	Percent Moisture	Dry Density
2.65	1	3.1	128.7
	2	4.9	131.2
	3	6.8	131.8
	4	8.5	130.2

	Maximum Dry Density		Optimum Moisture
Uncorrected:	131.9	lbs/ft³	6.3 %
ASTM D 4718 Correction:	**138.6**	**lbs/ft³**	**5.1%**
As Found Correction:	**N/A**	**lbs/ft³**	**N/A**



Sieve Size	Percent Passing
6.0"	
5.0"	
4.0"	
3.0"	**100**
2.0"	**98**
1.5"	**95**
1.0"	**86**
3/4"	**76**
1/2"	**64**
3/8"	**57**
1/4"	
#4	**40.7**
#8	**31**
#10	**28**
#16	**24**
#30	**18**
#40	**15**
#50	**11**
#100	**6**
#200	**5.0**

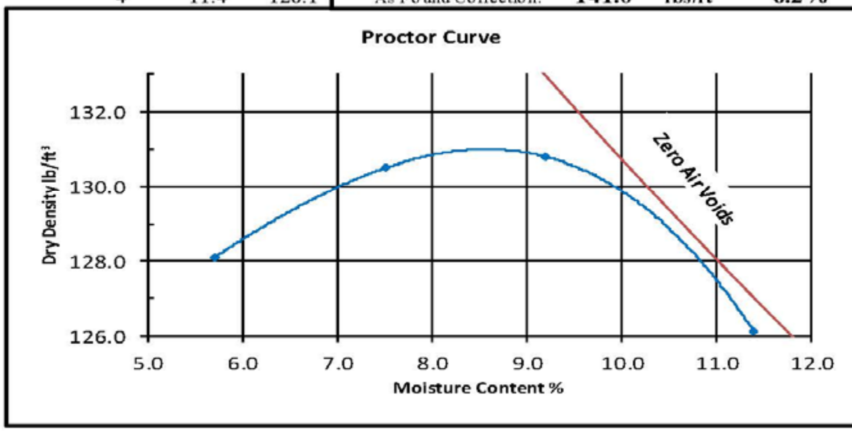
Note: ASTM D698 and D1557 valid with up to 5% Oversize Particles; correctable up to 30% via ASTM D 4718 and invalid for Oversized Particles greater than 30% retained on the ¾ inch screen.

LABORATORY COMPACTION CHARACTERISTICS OF SOIL

Source and Description:	Location 2, Monroe Pit, Pit Run
Date Obtained:	January 22, 2018
Sample ID:	18-7037
Sampling and Preparation:	ASTM D75: X Moist: X Manual: Mechanical:
Test Standard:	AASHTO T99: AASHTO T180: **Method** ASTM D698: ASTM D1557: C

Assumed Sp. Gr.	Point Number	Percent Moisture	Dry Density
2.65	1	5.7	128.1
	2	7.5	130.5
	3	9.2	130.8
	4	11.4	126.1

	Maximum Dry Density		Optimum Moisture
Uncorrected:	131.0	lbs/ft³	8.6 %
ASTM D 4718 Correction:	**Not Valid**	lbs/ft³	**Not Valid**
As Found Correction:	**141.0**	lbs/ft³	**6.2%**



Sieve Size	Percent Passing
6.0"	
5.0"	
4.0"	100
3.0"	95
2.0"	93
1.5"	87
1.0"	79
3/4"	66
1/2"	53
3/8"	45
1/4"	
#4	29.8
#8	23
#10	21
#16	20
#30	17
#40	13
#50	10
#100	3
#200	1.3

Note: ASTM D698 and D1557 valid with up to 5% Oversize Particles; correctable up to 30% via ASTM D 4718 and invalid for Oversized Particles greater than 30% retained on the ¾ inch screen.

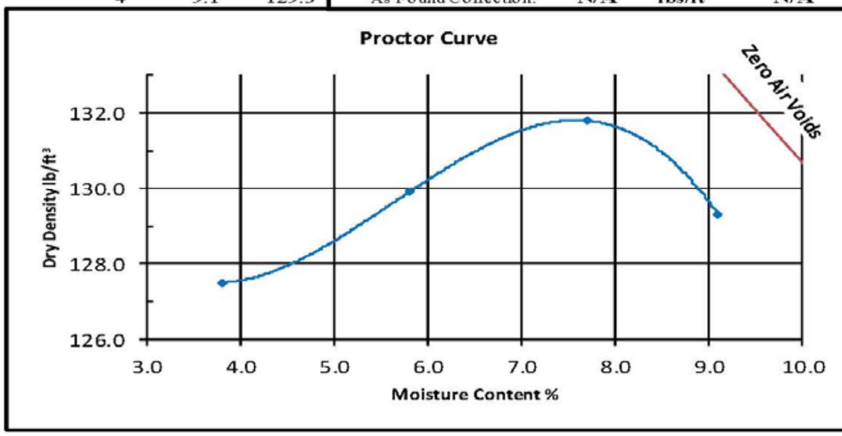
Resistivity: 15,800 ohms-cm

LABORATORY COMPACTION CHARACTERISTICS OF SOIL

Source and Description:	Location 3, Monroe Pit, Pit Run
Date Obtained:	January 22, 2018
Sample ID:	18-7038
Sampling and Preparation:	ASTM D75: X Moist: X Manual: Mechanical:
Test Standard:	AASHTO T99: AASHTO T180: **Method** ASTM D698: ASTM D1557: C

Assumed Sp. Gr.	Point Number	Percent Moisture	Dry Density
2.65	1	3.8	127.5
	2	5.8	129.9
	3	7.7	131.8
	4	9.1	129.3

	Maximum Dry Density		Optimum Moisture
Uncorrected:	131.8	lbs/ft³	7.6 %
ASTM D 4718 Correction:	137.7	lbs/ft³	6.3%
As Found Correction:	N/A	lbs/ft³	N/A



Sieve Size	Percent Passing
6.0"	
5.0"	
4.0"	
3.0"	
2.0"	100
1.5"	96
1.0"	87
3/4"	79
1/2"	67
3/8"	59
1/4"	
#4	34.0
#8	24
#10	20
#16	17
#30	11
#40	8
#50	5
#100	3
#200	1.8

Note: ASTM D698 and D1557 valid with up to 5% Oversize Particles; correctable up to 30% via ASTM D 4718 and invalid for Oversized Particles greater than 30% retained on the ¾ inch screen.

Resistivity: 15,800 ohms-cm

SETTLEMENT CALCULATIONS

Dimension Solution Software
Release Version 2.00.9, January 8, 2013

Materials Testing & Inspection

Tensar®

Project:	Sample Preparation Laboratory
Number:	E170233g
Location:	INL Materials & Fuel Complex
Designer:	Elizabeth Brown, P.E.

Footing Parameters:

Width:	3	ft
Length:	3	ft
Depth:	3	ft
Applied Bearing:	2500	psf

Geogrid Parameters:

Width:	7	ft
Length:	7	ft
Top Geogrid Distance:	1	ft
Spacing:	2	ft
Bottom Geogrid Distance:	1	ft
Fill Thickness:	4.000	ft
Number of Layers:	2	
Product Designation:	TX7	

SETTLEMENT

UNIFORM SOIL INPUT

Foundation Soil Parameters:

Elastic Modulus:	40	ksf
Unit Weight:	125	pcf
Poisson's Ratio:	0.3	

Reinforced Fill Parameters:

Elastic Modulus:	800	ksf

LAYERED SOIL INPUT, COHESIONLESS AND VARIABLE

Reinforced Fill Elastic Modulus: 800 ksf

S1 - Silts, Sandy Silts
S2 - Fine-Medium Sands
S3 - Coarse Sands
S4 - Sandy Gravel, Gravel

Variable Soils only:

Layer No.	Soil Type	Thickness ft	Unit Wgt pcf	SPT	OCR	Cc/1+e	Cr/Cc
1	S1	4	100	4	NA	NA	NA
2	S1	11	105	15	NA	NA	NA
3	S4	10	135	60	NA	NA	NA

LAYERED COHESIONLESS SOIL OUTPUT

Estimated Settlement:
Reinforced: 0.15 in
Unreinforced: 0.72 in

Percent Reduction in Settlement:
79.1 %

Layer 3 was analyzed as a sandy gravel since rock is not an input parameter in the software.

SETTLEMENT CALCULATIONS

Tensar®

Dimension Solution Software
Release Version 2.00.9; January 8, 2013

Materials Testing & Inspection

Project:	Sample Preparation Laboratory
Number:	E170233g
Location:	INL Materials & Fuel Complex
Designer:	Elizabeth Brown, P.E.

Footing Parameters:

Width:	6	ft
Length:	6	ft
Depth:	3	ft
Applied Bearing:	2500	psf

Geogrid Parameters:

Width:	10	ft
Length:	10	ft
Top Geogrid Distance:	1	ft
Spacing:	2	ft
Bottom Geogrid Distance:	1	ft
Fill Thickness:	4.000	ft
Number of Layers:	2	
Product Designation:	TX7	

SETTLEMENT

UNIFORM SOIL INPUT

Foundation Soil Parameters:

Elastic Modulus:	40	ksf
Unit Weight:	125	pcf
Poisson's Ratio:	0.3	

Reinforced Fill Parameters:

Elastic Modulus: 800 ksf

LAYERED SOIL INPUT, COHESIONLESS AND VARIABLE

Reinforced Fill Elastic Modulus: 800 ksf

S1 - Silts, Sandy Silts
S2 - Fine-Medium Sands
S3 - Coarse Sands
S4 - Sandy Gravel, Gravel

Variable Soils only:

Layer No.	Soil Type	Thickness ft	Unit Wgt pcf	SPT	OCR	Cc/1+e	Cr/Cc
1	S1	4	100	4	NA	NA	NA
2	S1	11	105	15	NA	NA	NA
3	S4	10	135	60	NA	NA	NA

LAYERED COHESIONLESS SOIL OUTPUT

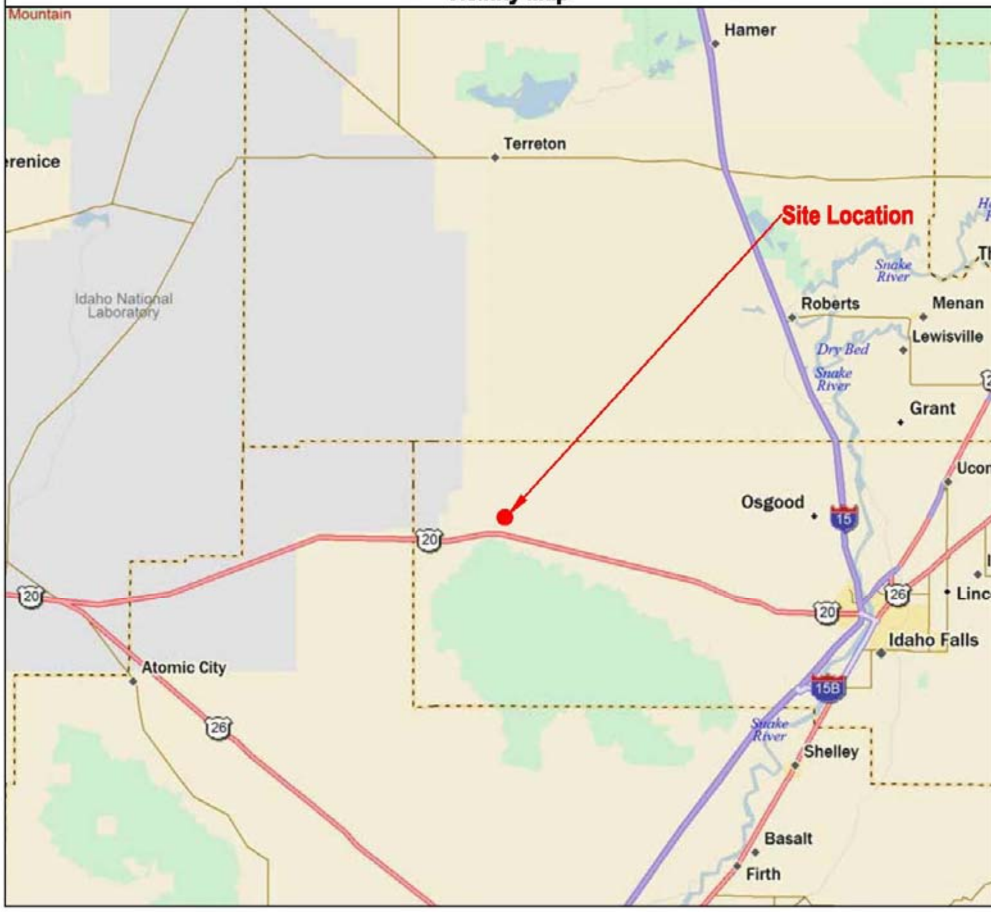
Estimated Settlement:
Reinforced: 0.26 in
Unreinforced: 1.11 in

Percent Reduction in Settlement:
76.4 %

Layer 3 was analyzed as a sandy gravel since rock is not an input parameter in the software.

Vicinity Map

Plate 1



MAP NOTES:
- Delorme Street Atlas
- Not to Scale

LEGEND

Approximate Site Location ●

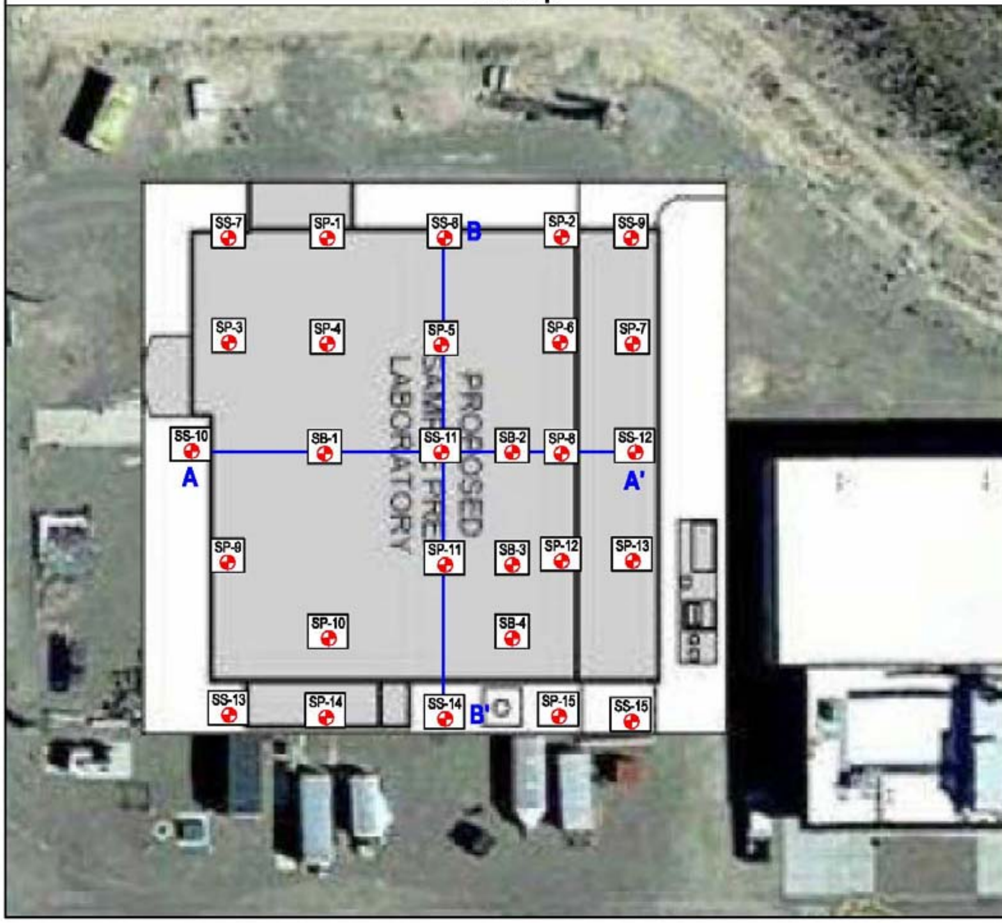
Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Modified from DeLorme by: CCW
20 February 2018
Drawing: E170233g

MATERIALS TESTING & INSPECTION

1230 North Skyline Drive #C
Idaho Falls, ID 83402
Phone: 208 529-8242
Fax: 208 529-6911
E-mail: mti@mti-id.com

Site Map Plate 2



NOTES:
- Not to Scale

LEGEND

Approximate MTI Boring Location

N

Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Modified by: CCW
20 March 2018
Drawing: E170233g

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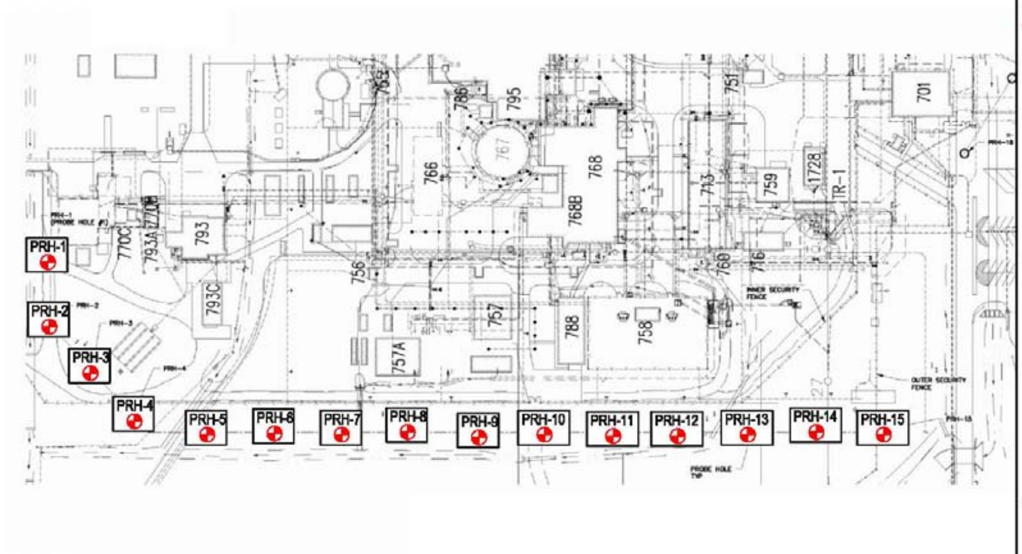
Site Map

Plate 3



NOTES:
- Not to Scale

LEGEND

Approximate MTI Boring Location

Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Modified by: CCW
20 February 2018
Drawing: E170233g

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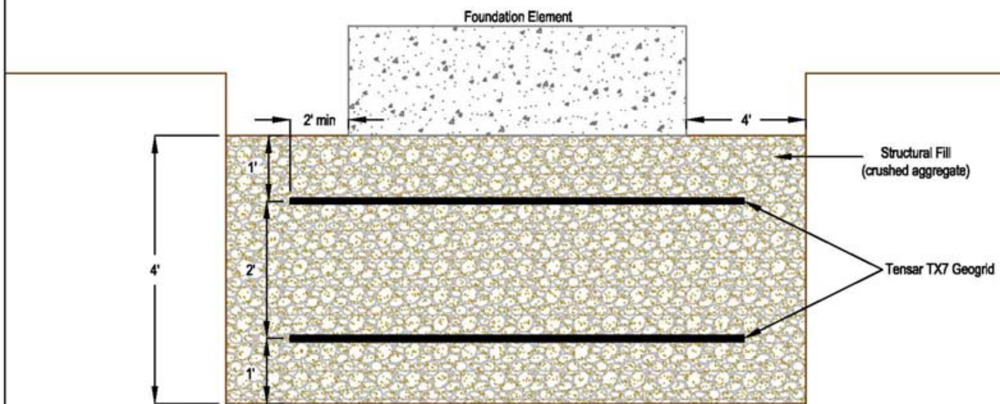
Typical Foudnation Cross Section

Plate 4

NOTES:

- These recommendations are applicable for raft/mat slabs and continuous/spread footings 3 to 6 feet wide.
- Structural fill between geogrid layers must consist of ISPWC 3/4" Type 1 crushed aggregate.
- Fill material must be compacted to at least 95% of the maximum dry density as determined by ASTM D1557.
- Geogrid to be installed in accordance with manufacturer's recommendations.



NOTES:

- Not to Scale

LEGEND

Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Drawn by: EB
23 February 2018
Drawing: E170233g

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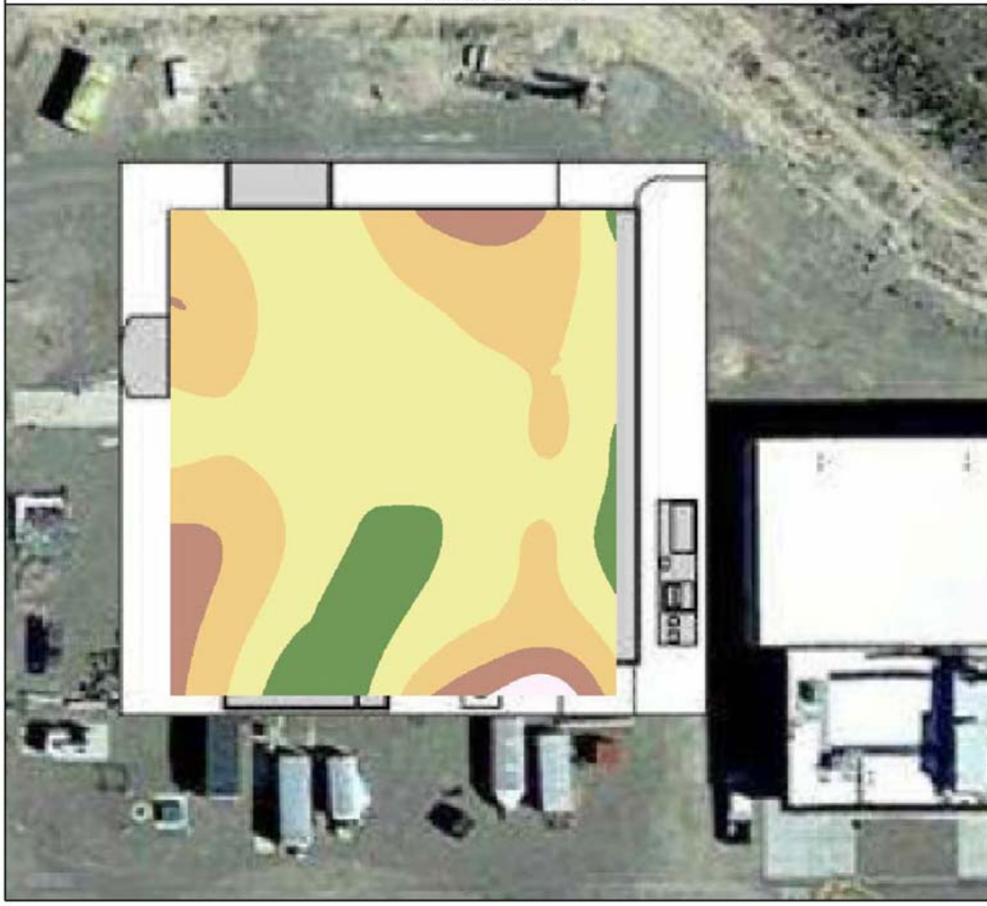
Basalt Elevation

Plate 5



NOTES:
- Not to Scale
- Basalt elevation interpolated from boring data and survey elevation using ESRI ArcMap.

LEGEND

Basalt Elevation (Feet MSL)

- 5,103 - 5,105
- 5,106 - 5,108
- 5,109 - 5,111
- 5,112 - 5,114
- 5,115 - 5,116

N

Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Modified by: CCW
23 February 2018
Drawing: E170233g

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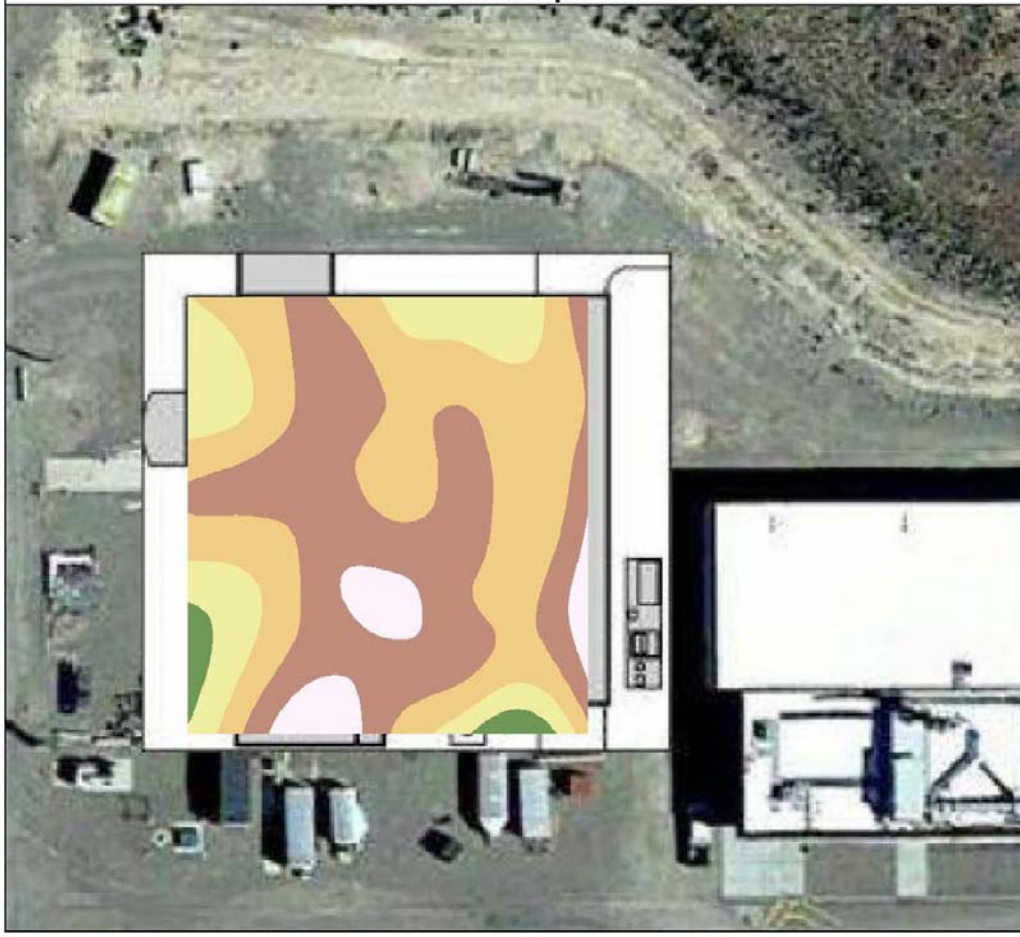
Basalt Depth

Plate 6



NOTES:
- Not to Scale
- Basalt depth interpolated from boring data using ESRI ArcMap.

LEGEND

Basalt Depth (Feet bgs)

- 5.9 - 8.52
- 8.53 - 11.1
- 11.2 - 13.8
- 13.9 - 16.4
- 16.5 - 19

Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Modified by: CCW
23 February 2018
Drawing: E170233g

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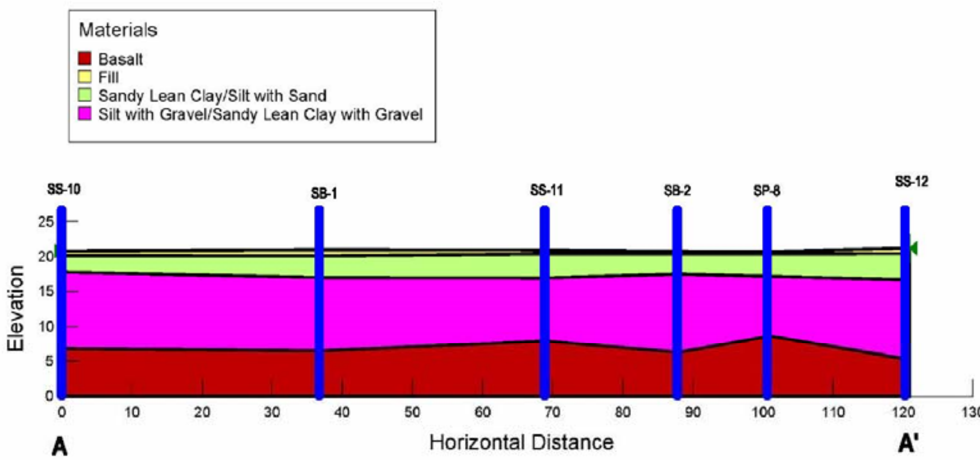
Profile A - A'

Plate 7



NOTES:

- Not to Scale
- Add 5,100 to the profile elevations to obtain site datum.

LEGEND

Basalt Depth (Feet bgs)

Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Modified by: CCW
20 March 2018
Drawing: E170233g

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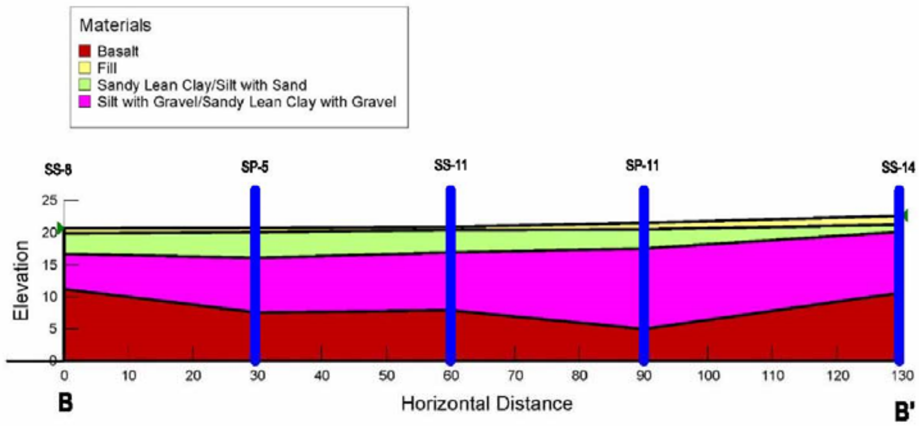
Profile B - B'

Plate 8



NOTES:

- Not to Scale
- Add 5,100 to the profile elevations to obtain site datum.

LEGEND

Basalt Depth (Feet bgs)

Sample Preparation Laboratory
INL Materials & Fuel Complex
Bingham County, ID

Modified by: CCW
20 March 2018
Drawing: E170233g

MATERIALS TESTING & INSPECTION

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Appendix C

Preliminary Design Calculations

COLLECTION SYSTEM CALCULATIONS														
From	To	Pipe Size (in)	Mannings Coeff	Area (ft^2)	P_{wet} (ft)	R_h (ft)	3/4 Full (in)	Slope (ft/ft)	$Q_{3/4full}$ (cfs)	$Q_{3/4full}$ (gpm)	Q_{full} (cfs)	V_{full} (fps)	Q_{peak} (gpm)	$Q_{3/4\ full} > Q_{peak}$?
SSMH 1	SSMH 2	7.92	0.012	0.342	2.07	0.165	5.94	0.0040	0.735	329.901	0.744	2.17	24.84	YES
SSMH 2	SSMH 3	7.92	0.012	0.342	2.07	0.165	5.94	0.0040	0.735	329.901	0.744	2.17	24.84	YES
SSMH 3	SSMH 4	7.92	0.012	0.342	2.07	0.165	5.94	0.0040	0.735	329.901	0.744	2.17	24.84	YES
SSMH 4	LS	7.92	0.012	0.342	2.07	0.165	5.94	0.0040	0.735	329.901	0.744	2.17	24.84	YES

Wetwell Design Calculations

Project Title: MFC West Campus Utility Corridor
J-U-B Project Number: 80-14-010
Design Engineer: GJA
Date and Time: 2/9/2018 15:48

Note: Enter data only in cells with bold, italics.

Design Influent Flows

Design Average Flow =	***10.0***	gpm
	14,400	gpd
Design Peak Hourly Flow =	***25.0***	gpm
	36,000	gpd

Selected Pumping Rates

Station Discharge with 1 pump running =	***120***	gpm
Station Discharge with 2 pumps running in parallel =	***180***	gpm

Wet Well Design

Calculate minimum required working volume in wet well:

Number of pumps =	***2***	
Maximum number of starts per hour per pump =	***6***	
Minimum cycle time =	5	minutes
Minimum required working volume in wet well =	150	gallons
Inside diameter of wet well =	***5***	feet
Minimum required depth of working volume =	1.02	feet
Set depth of working volume =	***1.5***	feet

Configure wet well:

Minimum required depth of submergence for pumps =	***2.00***	feet	
Wet well depth at low water level (LW) alarm) =	***1.50***	feet	
Difference in depth between LW alarm and lead pump off settings =	***0.50***	feet	
Verify adequate depth of submergence =	2.00	feet	OK
Difference in depth between lead pump on and lag pump on settings =	***1.00***	feet	
Difference in depth between lag pump on and high water level (HW) alarm settings =	***1.00***	feet	

Location	Elevation (feet)	Difference (feet)	Difference (gallons)	Rising Level	Falling Level
Top of wet well slab	***5120.50***				
		12.00	1762		
Influent pipe invert	***5108.50***				
		1.00	147		
	5107.50			HW alarm on	HW alarm off
		1.00	147		
	5106.50			Lag pump on	
		1.00	147		
	5105.50			Lead pump on	
Working volume		1.50	220		
	5104.00				Both pumps off & alt lead/lag
		0.50	73		
	5103.50			LW alarm off	LW alarm on
		1.50	220		
Floor elevation	***5102.00***				

Check cycle times and number of starts per hour:

Working volume between lead pump off and lead pump on =		220 gallons	
Cycle time with 1 pump running at design average flow =		24.0 minutes	
Cycle time with 1 pump running at peak hourly flow =		11.1 minutes	
Min cycle time occurs at Qinf = 50% of Qpump =	60 gpm	7.3 minutes	
Number of starts per hour per pump at avg daily flow =		1.2	OK
Number of starts per hour per pump at peak hourly flow =		2.7	OK
Number of starts per hour per pump at minimum cycle time =		4.1	OK
Time before surcharging at design average flow after HW alarm goes off =		14.7 minutes	

Pump-System Curve Calculations

Project Title:	***MFC West Campus Utility Corridor***
J-U-B Project Number:	***80-14-010***
Design Engineer:	***GJA***
Date and Time:	2/9/2018 15:48

Note: Enter data only in cells with bold, italics.

Force Main Data

Face Piping (from pump through valve vault)

Hazen-Williams "C" factor for new pipe	***120***	
Hazen-Williams "C" factor for old pipe	***110***	
Length from valve vault to wetwell	***8***	feet
Length of face piping in wetwell	***15***	feet
Total Force Main	23	feet
Pipe Diameter (I.D.)	***4.00***	inches
Pipe "R"	0.08	
Cross Sectional Area	0.09	sq.ft.

Force Main (from valve vault to discharge point)

Hazen-Williams "C" factor for new pipe	***140***	
Hazen-Williams "C" factor for old pipe	***120***	
Length from valve vault to discharge poin	***475***	feet
Total Force Main	475	feet (IMPORTANT: See comment note.)
Pipe Diameter (I.D.)	***4.00***	inches
Pipe "R"	0.08	
Cross Sectional Area	0.09	sq.ft.
Volume per LF	0.65	gallons
Total Volume of Force Main	310	gallons

Minor Losses

Item	**Kv**	**Number**	**Total Factor**
Face Piping (from pump through valve vault)			
ENTRANCE	***0.5***	***1***	0.5
GATE VALVE	***0.2***	***1***	0.2
GLOBE VALVE	***10.0***	***0***	0.0
90 ELBOW	***0.5***	***3***	1.5
45 ELBOW	***0.3***	***0***	0.0
CHECK VALVE	***1.7***	***1***	1.7
SWING CHECK VALVE	***2.5***	***0***	0.0
PLUG VALVE	***1.4***	***0***	0.0
		TOTAL COEF. =	3.9
Force Main (from valve vault to discharge point)			
TEE run	***0.4***	***0***	0.0
TEE branch	***1.1***	***0***	0.0
45 ELBOW	***1.0***	***4***	4.0
4x3 Reducer	***0.2***	***0***	0.0
EXIT	***1.0***	***1***	1.0
		TOTAL COEF. =	5.0

Elevation and Pump Station Data

Invert elevation of force main at discharge MH	***5116.70***	feet
Invert elevation at high point of force main	***5116.70***	feet
Elevation to use in static lift calculation	5116.70	feet
Centerline elevation of pump volutes	5102.50	feet
Min static head lift	9.20	feet
Max static head lift	14.20	feet

Hayward Gordon CHOPX 3-A Pump

(2) Parallel - Hayward Gordon CHOPX 3-A Pump

ENTER PUMP CURVES:

Hayward Gordon CHOPX 3-A Pump

With one pump running:

Pump Q Range GPM	Pump H From Curve (feet)
0	***20***
50	***19***
100	***18***
150	***16***
200	***14***
250	***12***
300	***10***
350	***8***

With two pumps running in parallel:

Pump Q Range GPM	Pump H From Curve (feet)
0	20
100	19
200	18
300	16
400	14

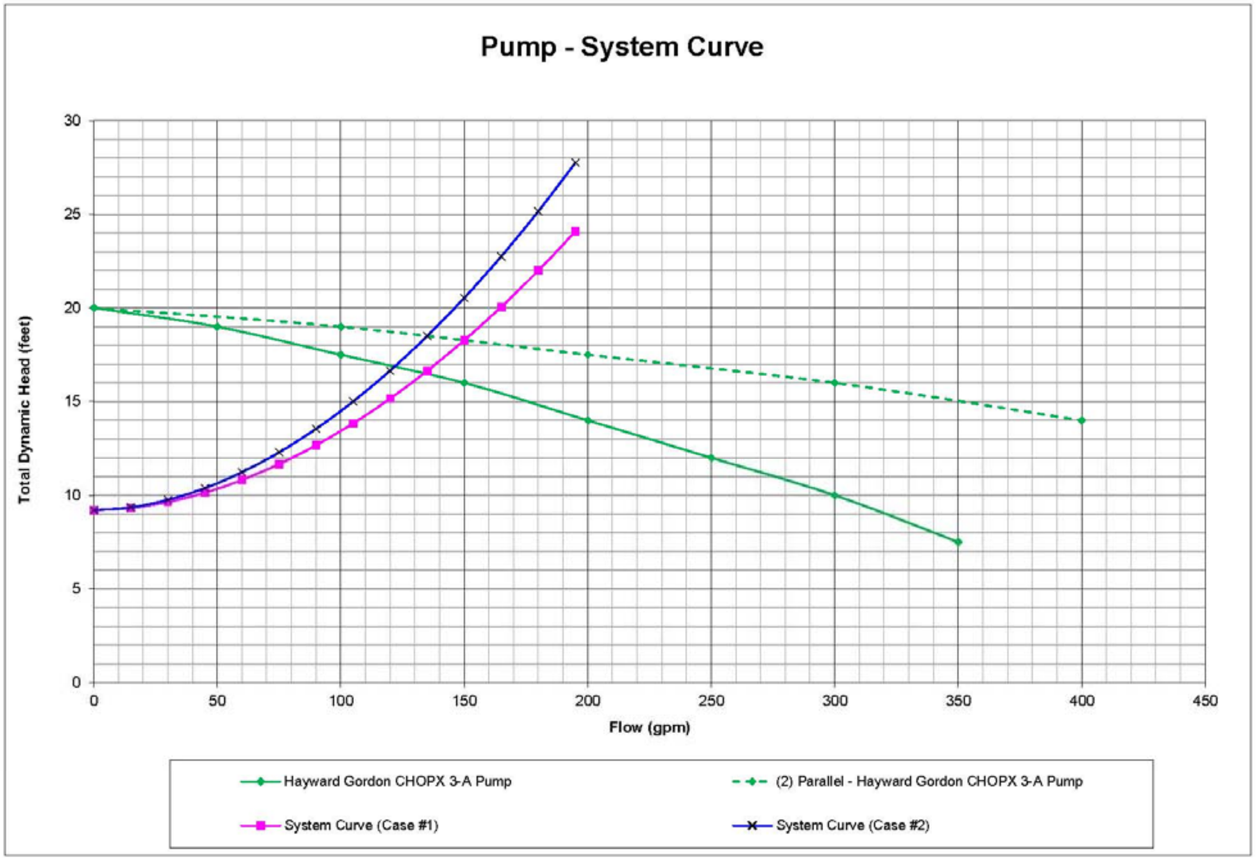
ENTER SYSTEM CURVES:

System Curve for Case #1: High wetwell level with new pipe.

Design Condition	Sys Curve Q GPM	Sys Curve Q GPD	Face Piping (from pump through valve vault) Pipe V FPS	Pipe Frict Hf (FT)	Minor Loss HL (FT)	DYNAMIC HEAD (FT)	Force Main (from valve vault to discharge point) Pipe V FPS	Pipe Frict Hf (FT)	Minor Loss HL (FT)	DYNAMIC HEAD (FT)	MIN. TDH (FT)
	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2
	15	21,600	0.4	0.0	0.0	0.0	0.4	0.1	0.0	0.1	9.3
	30	43,200	0.8	0.0	0.0	0.1	0.8	0.3	0.0	0.4	9.6
	45	64,800	1.1	0.0	0.1	0.1	1.1	0.7	0.1	0.8	10.1
	60	86,400	1.5	0.1	0.1	0.2	1.5	1.2	0.2	1.4	10.8
	75	108,000	1.9	0.1	0.2	0.3	1.9	1.8	0.3	2.1	11.7
	90	129,600	2.3	0.2	0.3	0.5	2.3	2.6	0.4	3.0	12.7
	105	151,200	2.7	0.2	0.4	0.7	2.7	3.4	0.6	4.0	13.8
Selected Pumping Rate (120 gpm)	***120***	172,800	3.1	0.3	0.6	0.9	3.1	4.4	0.7	5.1	15.2
	135	194,400	3.4	0.4	0.7	1.1	3.4	5.5	0.9	6.4	16.6
	150	216,000	3.8	0.4	0.9	1.3	3.8	6.6	1.1	7.8	18.3
	165	237,600	4.2	0.5	1.1	1.6	4.2	7.9	1.4	9.3	20.1
	180	259,200	4.6	0.6	1.3	1.9	4.6	9.3	1.6	10.9	22.0
	195	280,800	5.0	0.7	1.5	2.2	5.0	10.8	1.9	12.7	24.1

System Curve for Case #2: High wetwell level with old pipe.

Design Condition	Sys Curve Q GPM	Sys Curve Q GPD	Face Piping (from pump through valve vault) Pipe V FPS	Pipe Frict Hf (FT)	Minor Loss HL (FT)	DYNAMIC HEAD (FT)	Force Main (from valve vault to discharge point) Pipe V FPS	Pipe Frict Hf (FT)	Minor Loss HL (FT)	DYNAMIC HEAD (FT)	MAX TDH (FT)
	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2
	15	21,600	0.4	0.0	0.0	0.0	0.4	0.1	0.0	0.1	9.4
	30	43,200	0.8	0.0	0.0	0.1	0.8	0.4	0.0	0.5	9.8
	45	64,800	1.1	0.1	0.1	0.1	1.1	1.0	0.1	1.1	10.4
	60	86,400	1.5	0.1	0.1	0.2	1.5	1.6	0.2	1.8	11.2
	75	108,000	1.9	0.1	0.2	0.4	1.9	2.4	0.3	2.7	12.3
	90	129,600	2.3	0.2	0.3	0.5	2.3	3.4	0.4	3.8	13.5
	105	151,200	2.7	0.3	0.4	0.7	2.7	4.6	0.6	5.1	15.0
Selected Pumping Rate (120 gpm)	120	172,800	3.1	0.3	0.6	0.9	3.1	5.8	0.7	6.6	16.7
	135	194,400	3.4	0.4	0.7	1.1	3.4	7.3	0.9	8.2	18.5
	150	216,000	3.8	0.5	0.9	1.4	3.8	8.8	1.1	10.0	20.5
	165	237,600	4.2	0.6	1.1	1.7	4.2	10.5	1.4	11.9	22.8
	180	259,200	4.6	0.7	1.3	2.0	4.6	12.3	1.6	14.0	25.2
	195	280,800	5.0	0.8	1.5	2.3	5.0	14.3	1.9	16.2	27.8



Pump - System Curve
Total Dynamic Head (feet)
Flow (gpm)
0
5
10
15
20
25
30
0
50
100
150
200
250
300
350
400
450
Hayward Gordon CHOPX 3-A Pump
(2) Parallel - Hayward Gordon CHOPX 3-A Pump
System Curve (Case #1)
System Curve (Case #2)