VOLUME 1
BASIS OF DESIGN

Wrangell Junkyard Repository Site
Wrangell, Alaska
TDD: 17-01-0015

START IV
Region 10

June 9, 2017

Prepared for:

U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101

Prepared by:

ECOLOGY AND ENVIRONMENT, INC.
720 Third Avenue, Suite 1700
Seattle, Washington 98104

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PROFESSIONAL ENGINEER CERTIFICATION PAGE

BASIS OF DESIGN
Wrangell Junkyard Repository Site
Wrangell, Alaska
TDD: 17-01-0005

Pursuant to Alaska Administrative Code (AAC) 12 AAC 36.185(a)(3), final plans, surveys, reports, and required construction documents approved for building permit issuance for which the registrant is qualified to seal and for which the registrant claims responsibility are required to be submitted under the seal of a State of Alaska licensed professional engineer. This page provides the signature and seal to comply with the regulation.

I hereby certify that this Basis of Design report for the Wrangell Junkyard Repository Site in Wrangell, Alaska, was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Alaska. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

SIGNATURE:

REGISTRATION NUMBER: EV14234
STATE: Alaska

DATE:06-09-2017

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List of Abbreviations and Acronyms

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
Ahtna	Ahtna Engineering Services, LLC
bgs	below ground surface
BMP	best management practice
CFR	Code of Federal Regulations
E & E	Ecology and Environment, Inc.
EPA	United States Environmental Protection Agency
ERRS	Emergency and Rapid Response Services
ESA	Endangered Species Act
FML	flexible membrane liner
HASP	health and safety plan
junkyard site	Wrangell Junkyard Site
LLDPE	linear low-density polyethylene
OSHA	Occupational Safety and Health Administration
RCRA	Resource Conservation and Recovery Act
REC	recognized environmental condition
repository site	Wrangell Junkyard Repository Site
START	Superfund Technical Assessment and Response Team
TCLP	Toxicity Characteristic Leaching Procedure
TDD	Technical Direction Document

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1 Introduction

Ecology and Environment, Inc. (E & E) has been tasked by the United States Environmental Protection Agency (EPA) under Superfund Technical Assessment and Response Team (START)-IV contract number EP-S7-13-07, Technical Direction Document (TDD) 17-01-0015, to prepare the Wrangell Junkyard Repository Design. The TDD provides funding for START to develop a repository design package for a former hard rock quarry site selected by the Alaska Department of Environmental Conservation (ADEC). Upon completion, ADEC will use the repository design package to complete the removal action under separate contracts administered by ADEC.

This Basis of Design Report is composed of four sections. Section 1 presents the introduction, states the purpose for developing the report, summarizes background information about the site, and provides an overview of the existing site conditions. Section 2 presents preliminary surveys and investigations to assist in the planning of the removal action, and Section 3 discusses the proposed design and describes additional considerations for the removal action. Section 4 is a list of the references used in this report.

1.1 Site Description and Background

The Wrangell Junkyard Site (referred to herein as the "junkyard site") is located approximately 4 miles south of the city of Wrangell, on Wrangell Island, Alaska (see Figure 1-1). The junkyard site sits on the east side of Zimovia Highway and slopes toward the Zimovia Strait. It consists of approximately 2.5 acres of land (parcel number 03-006-303) which operated as a private salvage yard beginning in the 1960s. The property was foreclosed on in 2008, at which point the Borough of Wrangell assumed ownership of the property (E & E 2015).

A separate site approximately eight miles south of the junkyard site has been selected by ADEC as a permanent repository location for treated material from the former junkyard. This site, referred to herein as the Wrangell Junkyard Repository Site, or the "repository site," is a former Alaska Department of Natural Resources (ADNR) rock quarry south of Pat Creek Road, approximately 1.5 miles east of Zimovia Highway (see Figure 1-1). The repository site is surrounded on three sides by steep rock walls. The quarry floor slopes toward the quarry opening and Pat Creek Road. The existing site conditions are presented on Sheet 2 of Appendix C.

1.2 Previous Site Investigations and Cleanup Activities

Previous site investigations, sampling, reporting, and cleanup efforts have been completed at the junkyard site. These efforts are listed below; additional information is available in the cited documents.

- February 2001 Final Preliminary Assessment, Wrangell Junkyard Site (E & E 2001): E & E performed a preliminary assessment of the junkyard site, which included soil and sediment sampling performed in August 2000. Surface soil sample results indicated the presence of lead concentrations exceeding ADEC cleanup levels, and other hazardous substances were found at elevated levels in surface soil samples and sediment samples.
- June 2002 Report, Wrangell Junkyard Site Characterization and Removal Cost Estimate (E & E 2002): E & E performed fieldwork at the junkyard site, including surface and subsurface soil sampling and X-ray fluorescence analysis. Four surface soil samples were tested for toxicity characteristic leaching procedure (TCLP) lead analysis. Elevated lead concentrations were found in multiple areas, and test results indicated the presence of leachable lead.
- October 2012 Bi-valve Specimen Sampling Wrangell Junkyard Contaminated Site Zimovia Strait: ADEC collected bi-valve samples from the beach southwest of the junkyard site. Resource Conservation and Recovery Act (RCRA) metals analyses indicated lead was below the National Shellfish Sanitation Program guidance level for human consumption (ADEC 2013).
- November 2012 Wrangell Junkyard Summary of Site Conditions and Justification for Removal Action (ADEC 2012): ADEC made a recommendation for a near-term removal action at the junkyard site, with an emphasis on the northeast portion of the site.
- July 2015 Wrangell Junkyard Targeted Brownfields Assessment (E & E 2015): E & E reviewed previous sampling results and other information, and worked with stakeholders to evaluate recognized environmental conditions (RECs) at the junkyard site. The identified outstanding RECs included Lead Contaminated Soil/Debris Pile Remnants; Drum Caches; Wood Piles/Burn Areas; Overland Drainages; Areas around Former Onsite Structures (where transformer oil was applied); Downgradient Adjacent Properties; and Zimovia Strait.
- 2016 Wrangell Junkyard Site Cleanup (NRC Alaska Weekly Project Status Updates): Working under a Corrective Action Plan dated April 5, 2016, NRC Alaska and NORTECH performed excavation, treatment, and stockpiling operations at the junkyard site during the summer of 2016. Solid waste such as batteries and metal debris were shipped off site for disposal. Woody debris was brought to the Wrangell Institute where it was later burned. Soil was screened from rock and debris, and treated with ECOBOND to limit the leaching potential of the lead-contaminated soil. Approximately 18,515 cubic yards of treated soil were stockpiled at the northwest corner of the junkyard site, to remain on site until a final repository location was constructed. The

treated material was wrapped with black plastic and supported by a 6- to 16-foot-tall berm of 6-inch minus clean rock fill.

- August 2016 START Site Visit (Aug 1–2 Site Visit Findings), September 16, 2016 (E & E 2016): START met with ADEC, EPA, ADNR, the EPA Emergency and Rapid Response Services (ERRS) contractor, NRC Alaska, and other stakeholders at the junkyard site to discuss work completed to date. EPA, START, and ERRS visited potential locations for a permanent repository location. Based on previous ADEC site visits and memoranda (Proposed Monofill Site for Wrangell Junkyard Lead Contaminated Soil Memorandum, May 3, 2016 [ADEC 2016]), the ADNR rock pit on Pat Creek Road was a primary focus (NRC Alaska and Nortech 2016).
- December 2016 Proposed Wrangell Monofill Report of Findings, Wrangell, Alaska (Ahtna 2017): A hydrologic and geotechnical investigation was conducted by Ahtna Engineering Services, LLC (Ahtna) in December 2016 and summarized in the report. ADEC Division of Spill Response and Prevention Contaminated Sites Program and Division of Solid Waste used this report for selection of the repository site and design parameters. A discussion of report findings is included in Section 2.

1.3 Purpose of the Design Report

The purpose of this Basis of Design Report is to compile, for EPA Region 10 and ADEC, functional and technical requirements and provisions applicable to the removal action, which include the following:

- Design assumptions and parameters, including technical and functional restrictions based on results of previous investigations;
- Specifications for detailed equipment, procedures, and materials;
- Repository design considerations, including determination of hydrologic and slope stability characteristics;
- Construction plan set showing site layout, cover design, cover materials, locations of construction activities, and construction details; and
- Identification of the need for additional regulatory agency permits, coordination with outside agencies, site access agreements, and easements.

EPA and ADEC comments on previous work plans and conceptual design reports were incorporated into the Basis of Design Report package. START has coordinated, checked, and proofed the plans and specifications for accuracy and completeness.

This final removal design is a comprehensive set of specifications, drawings, and design report, designed to meet the cleanup objectives established for the repository site. EPA Region 10 is providing this final package to ADEC, who will contract with their chosen contractor to implement the design. These documents are considered comprehensive and complete such that bidding packages can be prepared by ADEC and provided to remediation contractors.

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ecology and environment, inc.
Global Environmental Specialists

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WRANGELL JUNKYARD
Wrangell, Alaska

Figure 1-1
SITE LOCATION MAP

Date : 4/3/2017

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2 Preliminary Surveys and Data Collection

This section details site surveys and investigations to assist in the planning of the removal action and provide compliance with certain applicable regulations.

2.1 Cultural Resources Survey

To comply with Section 106 of the National Historic Preservation Act, ADEC performed a cultural review and survey of the repository site. The Alaska State Historic Preservation Officer returned a finding of No Historic Properties Affected.

2.2 Endangered Species Act/Threatened & Endangered Species Survey

To comply with the Endangered Species Act (ESA), ADEC performed a preliminary assessment and determined that no endangered species are expected to occur at the Site. No further coordination was required with the United States Fish and Wildlife Service, Alaska Department of Fish and Game, ADNR, or National Marine Fisheries Service, a branch of National Oceanic and Atmospheric Administration, regarding the presence of sensitive plant and animal species near the repository site.

2.3 Topographic Survey

A topographic survey of the proposed repository site was conducted by R&M Engineering in November 2016 to establish topographic elevations of the existing rock quarry and access road that extends from the quarry to the intersection with Pat Creek Road. The survey provided 1-foot contours for the repository area; the extent of the survey is shown on Sheet 2 of the design drawings provided in Appendix C. The topographic survey data were used to determine the area and volume within the quarry available to construct the repository.

2.4 Hydrogeological Report

As noted above, a hydrologic and geotechnical investigation was conducted by Ahtna in December of 2016 and summarized in the report *Proposed Wrangell Monofill Report of Findings, Wrangell, Alaska* (Ahtna 2017). As part of this investigation, three exploratory borings were advanced at the repository site to characterize subsurface conditions, determine site groundwater depths, and identify baseline groundwater quality conditions at the rock quarry location that has been selected as the repository site.

The borings completed at the proposed repository site were advanced to depths ranging from 6 to approximately 34 feet below ground surface (bgs). Subsurface material consisted primarily of crushed rock overburden underlain by fractured bedrock. The thickness of the overburden material ranged from 1 to 10 feet bgs across the site (Ahtna 2017). A groundwater monitoring well or piezometer was installed at each of the three boring locations, and groundwater levels were recorded to establish a baseline. Groundwater was identified in the overburden and fractured rock at depths of approximately 2.5 to 3.2 feet bgs (Ahtna 2017); however, these elevations may not be representative of the highest groundwater elevations, as they were discrete readings and do not account for seasonal fluctuations. The hydraulic gradient was calculated as approximately 0.0077 feet per foot with the general direction of flow toward Pat Creek Road (Ahtna 2017). It should be noted that two of the borings were terminated just above bedrock due to the presence of an oily sheen observed in the groundwater. The source of the oil was not identified during the site investigation.

Analytical samples were collected from the boring advanced to 34 feet bgs to establish background concentrations in site groundwater. Despite evidence of oil in groundwater, analytical testing was limited to metals, and the primary contaminant of concern was identified as lead based on the concentrations found in the waste material consolidated at the junkyard site. The laboratory results indicated that the baseline concentrations of metal contaminants at the repository site are below the maximum contamination levels, as summarized under Title 18 Alaska Administrative Code (AAC) Section 75: Table C. These baseline groundwater concentrations can be used in post-construction monitoring to assess the effectiveness of the monofill design.

In accordance with AAC 60.217, unlined landfills must have a minimum of 10 feet of separation between the highest measured level of an aquifer and the bottom of the waste, unless the landfill is constructed 2 feet or more above the natural ground surface. Due to the shallow depth of groundwater, the construction of a foundation layer between the junkyard site waste material and the ground surface will be required at the repository site. The waste material at the junkyard site was determined to have elevated concentrations of lead, and the total volume of material requiring consolidation and capping was estimated as 18,515 cubic yards. The junkyard site waste material has been treated with a chemical binder, ECOBOND, which encapsulates lead and other metals in the soil, making them insoluble in order to reduce the leaching potential. TCLP and synthetic precipitation leaching procedure confirmation laboratory testing was conducted on the treated soil; the testing confirmed that lead does not leach from the treated soil and that the concentrations in the waste material at the junkyard site are present in non-hazardous concentrations (NRC Alaska and NORTECH 2016). Note that if consumed by humans, plants, or animals, the lead may have some bioavailability that is potentially toxic. Concentrations of lead in soil are still considered hazardous for the direct contact/ingestion human health exposure pathways.

2.5 Geotechnical Sampling

Material samples were collected by E & E in March 2017. Sample sources included Treated Waste Soil (sample numbers 17031001, 17031002, and 17031003) contained within the onsite stockpile at the Junkyard Site, locally available aggregates including three-eighths (3/8)-inch Minus Aggregate (sample number 17031004) and one (1)-inch Minus Drain Rock (sample number 17031006), and Topsoil and Clean Backfill (sample number 17031005) at a local supplier. Samples were submitted to GeoTesting Express, Inc., a geotechnical analytical laboratory.

Fine Grained Soils (Treated Waste Soil and Topsoil/Clean Backfill) were analyzed for:

- Engineering Classification for fine grained soils, to include grain size distribution; plasticity limit; liquid limit; moisture content; and USCS Classification (ASTM D2487);
- Standard Proctor (ASTM D698);
- Hydraulic Conductivity using Flexible Wall Permeameter (ASTM D5084); and
- Three-Point Direct Shear Test Series (ASTM D3080).

Granular Soils (3/8-inch Minus Aggregate and 1-inch Minus Drain Rock) were analyzed for:

- Grain Size Analysis (ASTM D422);
- Standard Proctor (ASTM D698);
- Fixed Wall Permeability (ASTM D2434); and
- Three-Point Direct Shear Test Series (ASTM D3080).

Three samples of the Treated Waste Soil were collected and each run for Engineering Classification. The Treated Waste Soil samples were then consolidated into one sample by the testing laboratory and run for the remaining parameters. The results have been used to perform slope stability, veneer stability, and repository infiltration analyses and identify the compaction requirements for the repository that are presented in Appendix A. Geotechnical results are presented within the specifications, as part of Specification Section 003132, Geotechnical Data, in Appendix B.

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3 Basis of Design

This section describes the design for the proposed removal action. The details presented below and in the accompanying appendices form the basis for implementation of the removal action.

Site controls and best management practices (BMPs) will be implemented during construction activities to protect workers, the community, and the environment from short-term construction impacts such as erosion, sedimentation, fugitive dust, and other similar potential impacts. Non-hazardous materials and wastes such as inert construction debris will be disposed of or recycled in accordance with appropriate solid waste disposal or recycling requirements.

3.1 Design Criteria

3.1.1 Design Objectives

The objective of this repository design is to isolate and stabilize the treated lead-impacted soil from the junkyard site in a manner that protects human health and environment receptors. The design is intended to satisfy pertinent requirements of 18 AAC Chapter 60, Solid Waste Management.

3.1.2 Basis of Design

General requirements for issuance of a permit by the ADEC allowing construction and operation of a solid waste facility are described in 18 AAC 60.200. However, a permit is not required for disposal that is governed by an approved contaminated site cleanup plan under 18 AAC 75 or 18 AAC 78.

Descriptions of the calculations for the repository design are provided in the Design Memoranda in Appendix A. The memoranda describe the objectives, criteria, and methodology and/or software and models used in the engineering calculations. The memoranda list pertinent assumptions, cite references, and summarize pertinent results. Site-specific data or information is used for calculations where possible; however, when site-specific data are not available, then literature-based values are used. As detailed in Section 2, additional geotechnical soil and rock samples have been analyzed, and the results have been included in calculations incorporated in this Design Report.

Appendix A-1 describes basin hydrology for the repository site location and has been used to design run-on and run-off control features. Appendix A-2 includes a slope stability analysis in which slope failure modes are modeled for the repository design under the load of cover materials. Results are used to assess stable slope angles with appropriate safety factors. Appendix A-3 describes the repository cover design and materials. Appendix A-4 includes calculations that assess the cover veneer stability. Appendix A-5 discusses the hydraulic design of on-site channels and underdrain.

3.2 Design Drawings

A complete design drawing set for the repository is provided in Appendix C. Following review, this set will be sealed and made ready for construction.

3.3 Project Technical Specification

In general, the design scope of work for the removal action includes:

- Preparing the repository site with a base layer;
- Transporting the stabilized soil (waste material) from the junkyard site to the repository site;
- Grading and stabilizing the emplaced waste material to elevations specified in the design drawings;
- Constructing a repository cover system as specified in the design drawings; and
- Planting and stabilizing the repository cap.

Technical project specifications are included as Appendix B. The project specifications conform to the 2016 Construction Specifications Institute MasterFormat organizational standard and include the following elements:

- Division 0, Procurement and Contracting Requirements, are not included in the design package (with the exception of the Engineering Seal Page, Table of Contents, and List of Drawings). Procurement and contracting language may be added by the State of Alaska.
- Division 1, General Requirements, not including Price and Payment Procedures but including Summary of Work, Work Restrictions, Project Submittals, Temporary Facilities and Controls, and Project Record Requirements.
- Division 2, Existing Conditions, includes sections such as Maintenance of Existing Conditions, Site Surveys, Waste Containment Geomembrane, Excavation and Handling of Contaminated Material, and Cover Materials.
- Division 31, Earthwork, includes Geotextile Fabric, Clearing and Grubbing, and Backfill and Compaction.
- Division 32, Exterior Improvements, includes Gates and Bollards.
- Division 33, Utilities, includes Subdrainage Piping.

A complete specifications table of contents is presented within the specifications as part of Specification Section 001110, Table of Contents, in Appendix B.

3.4 Removal Assumptions

Based on information available at the time of design, the proposed removal action discussed herein is limited to work performed at the repository site, with the exception of transporting waste material from its current location at the junkyard site. Restoration of the junkyard site is not covered in this design. ADEC has coordinated with ADNR for use of the quarry location. The construction contractor will be responsible for contacting ADNR and the City of Wrangell to obtain the right-of-entry prior to conducting field activity at both the junkyard and repository sites. The following removal assumptions have been made in developing this design.

Substantive Requirement Goals

Under the Alaska Pollutant Discharge Elimination System, Construction General Permit, ADEC has the authority to require actions when stormwater discharges related to a project may occur. This requirement applies to disturbed sites greater than 1 acre. Based on the plans, the total disturbed area at the repository site, including site access and staging areas, is greater than 1 acre. Therefore, it is anticipated that a General Permit for Discharges from Large and Small Construction Activities will be necessary.

Requirements for the construction of repositories are determined by the Solid Waste Program. Discussion between the Engineer, EPA, ADEC, and the Solid Waste Program has indicated that this repository will be considered an industrial solid waste landfill, the plan for which is to be approved by the Contaminated Sites Program with input provided by the Solid Waste Program. Specific construction requirements are discussed in Appendix A-3.

Areas Targeted for Construction

The details presented below and on the drawings in Appendix C, which show the design for the repository construction, will be used as a basis for conducting the removal action. As stated previously, the project will include transportation of stabilized lead-contaminated soil from the junkyard site to the repository site. The presented construction documents do not address activities at the junkyard site other than those related to transportation, which is discussed in this section along with other removal action operations.

Volume of Waste

The volume of treated waste to be removed from the junkyard site is understood to be 18,515 cubic yards (NRC Alaska and NORTECH 2016). This entire volume of material has been treated with ECOBOND and is stockpiled at the junkyard site. During sampling, conversations with the NRC Alaska project manager and observations from collection of three waste samples resulted in an estimation that up to 10 percent of the waste material may contain rock up to 6 inches in size. In addition, 4- to 6-inch rock was used to construct a perimeter berm at the junkyard site for the treated waste stockpile. The volume of the berm rock is estimated at 1,200 cubic yards (Ginter 2017). It is anticipated this material will be used in the repository construction as described below.

3.5 Site Preparation

As part of site preparation, equipment and material staging areas and temporary facilities will be constructed as required to conduct removal activities. The junkyard site currently has a stabilized rock construction entrance, and the repository access road has been regularly used as a haul road for the quarry. Therefore, no construction entrance work is anticipated prior to construction, such as widening or increasing curve radius. Repairs and maintenance will be required throughout and following construction.

Construction Site Layout

The actual locations of the temporary staging areas, temporary construction facilities (office trailer, temporary utilities, etc.), and vehicle loading zones will be finalized in the field prior to commencement of the removal action. For the purposes of this design, it is assumed that the areas within the quarry (see Appendix C drawings) will be used for staging. To the extent practicable, temporary staging and vehicle loading areas will not be established in locations that may interfere with construction operations or necessary traffic flow. An ADNR land use permit will be required for facilities that remain on the repository site for a period of more than 14 days.

Site Control and Access

Site access will be achieved by utilizing Zimovia Highway and Pat Creek Road. It is expected that the existing entrance roads to both the quarry and junkyard site are sufficient for hauling in their current state. Access utilized for construction will be maintained to allow for uninterrupted access to public roadways. The construction contractor will be responsible for controlling access to the repository site and the junkyard site.

Traffic Control

Publicly owned and operated vehicles (i.e., those not related to site activities) will generally not be allowed on site. Traffic detours and disruption that may result from the removal action will be coordinated with local agencies and in accordance with a Traffic Control Plan, to be completed by the selected construction contractor. The movement of equipment and personnel during on-site operations (e.g., construction equipment staging, waste and fill hauling, and personnel access to the repository site) will be controlled.

Utility Locate and Services

Prior to initiating work at the repository site, it is expected that the selected contractor will coordinate with local utility companies to obtain service for any temporary on-site facilities that will be utilized during the removal action (i.e., temporary construction trailers, etc.). It will be the responsibility of the selected contractor to locate and protect aboveground or subgrade utilities existing at the repository site.

Safety and Contingency Planning

Each contractor and subcontractor working on site is responsible for preparing a site-specific health and safety plan (HASP) to govern their activities in relation to their scope of work and the specifications. The HASP is required in accordance with Occupational Safety and Health Administration (OSHA) Standards and Regulations contained in 29 Code of Federal Regulations (CFR) 1910 and 29 CFR 1926. Each plan should specifically identify the person with authority to stop work at the site. The OSHA citations listed below are a few of the regulations that will be observed throughout the construction process and are not comprehensive. While START is not responsible for the safety of the selected contractor(s), the regulations are listed here to serve as a reminder of the most common OSHA violations and to keep employees focused on safety.

Proper hoisting and lifting operations will be important to worker safety and are regulated under 29 CFR 1926.550–556. Hoisting and lifting operations are anticipated to take place on many occasions throughout this project, including during loading and unloading of materials and equipment.

Use of ladders or scaffolding is not anticipated. OSHA regulates the use of ladders in 29 CFR 1926.1050–1060 and the use of scaffolds in 29 CFR 1926.450–454. Fall protection standards are specified in 29 CFR 1926.500–503. Fall protection is required for anyone working at a level 6 feet or more above a lower level. For heights greater than 6 feet, employers have the choice of using either a guardrail system, safety net system, or personal fall arrest system to protect workers.

It is the responsibility of the selected contractor(s) to follow these and other regulations and maintain a site-specific HASP on site at all times.

3.6 Removal Action Operations

Clearing and Grubbing

Throughout the removal action, activities will be restricted in an effort to preserve existing vegetation. Specifications will include the requirements for clearing of trees within the quarry site. Cleared trees will be removed from site and burned in accordance with City of Wrangell regulations.

Construction Runoff

Current conditions at the repository site allow runoff to sheet flow to the north, out of the quarry. This is not expected to change during or after construction. A hydrologic analysis has been performed for the repository site and is presented in Appendix A-2. This analysis presents anticipated flow rates during peak storms for the proposed conditions. As previously discussed, an Alaska Pollutant Discharge Elimination System stormwater permit as required under 18 AAC 70, Construction General Permit (AKR1000000) will be obtained by the selected contractor.

Waste Loading
The stockpiled waste material will be removed from the junkyard site with excavators and/or loaders, and loaded into haul trucks for transport to the repository site. It is understood that the stabilized waste has been screened, and debris has been removed.

Waste Transport
The selected contractor will take care to transport waste material properly from the stockpile location to the repository site. A plastic liner should be placed within the haul truck bed such that transported soil will not contact the truck bed and potential liquid will not leak during transport. To limit exposing the existing stockpile and placed repository soil to the elements, only areas to be hauled that day or required to be uncovered for soil placement should be exposed. During rain, it will be required that the contractor make every effort to keep the waste material dry. In accordance with 18 AAC 60.015 and AS 46.06.080, the waste material shall be covered or otherwise prevented from blowing out of the truck during transport to the repository.

Repository Construction
Appendix C presents design plans for the repository. Appendix A further discusses the design methodology for the engineered cap. The proposed design is described below.

The quarry floor beneath the repository will be filled to a depth of 2 feet with clean shot rock obtained from within the quarry. Some of this shot rock is piled on the ground, while additional rock may need to be shot from the quarry walls during the removal action to produce adequate volume. This rock will provide separation between the treated waste and the groundwater table. Smaller rock, such as D-1 material (1-inch minus aggregate), will be placed on the shot rock and covered with a non-woven geotextile fabric as a base for waste soil (monofill material). Monofill material will be placed above the base in 6- to 12-inch lifts and compacted. Compaction specifications are included in the design documents. Concurrent with placement of monofill material, a 3-foot wide chimney drain made of 6-inch minus rock will be constructed along the outer rim of the repository. The chimney drain will facilitate drainage from potential run-on and from off the final cover. A non-woven geotextile fabric will be placed as a barrier between the chimney drain and emplaced waste material. Based on the proposed design, monofill material will be placed up to a peak height of 38 feet with the front of the repository at a 4:1 horizontal to vertical slope (equivalent to a 25% grade). The slope will progress to the top of the monofill material for a distance of approximately 200 feet, at which point the grade will be 1%. In addition, the top surface of the monofill material will maintain a crown toward the chimney drains.

An engineered cover will be placed above the monofill of treated waste soil, following the grade discussed above. The cover will consist of the following layers listed from bottom to top:

Layer 1: 4 inches of 3/8-inch minus aggregate to protect the flexible membrane liner (FML);

Layer 2: 40-mil linear low-density polyethylene (LLDPE) FML as an infiltration barrier;

Layer 3: 6 inches of 3/8-inch minus aggregate to protect the FML;

Layer 4: 12 inches of D-1 (1-inch minus) drain rock to provide a drainage layer to perforated plastic pipe that is placed within the 3/8-inch aggregate and sloped to drain;

Layer 5: 18 inches of clean cover soil separated from the drain rock by a nonwoven geotextile fabric; and

Layer 6: 6 inches of vegetated topsoil.

Cover Vegetation
Following cleanup activities, disturbed areas will be restored to provide a stable surface. Topsoil sources will be located by the selected contractor prior to beginning work, specifications will require the source to be sampled and analyzed for contaminants to reduce the potential for bringing additional contaminants to the site. At the conclusion of the removal action, the areas disturbed during construction, as well as the repository cap will be seeded and mulched in a manner appropriate for the area. The sequence of the work and phasing of excavations will be coordinated to move expeditiously and prevent excessive erosion from bare soil. Local seeding requirements have been obtained from the ADNR, Division of Agriculture Plant Materials Center.

3.7 General Construction Site Guidelines
BMPs will be employed throughout construction for control of erosion, sedimentation, and fugitive dust generation in order to avoid adverse impacts on wildlife and their habitats. The design drawings call for several measures. A water truck will be at the repository throughout construction to keep the staging area and access drive moist enough to limit fugitive dust. Runoff from and erosion around the staging area will be controlled with silt fence, brush barriers, or straw wattles. These will be placed around the perimeter of the staging area to slow water and settle out sediment prior to runoff continuing down gradient. A riprap apron will be installed at the downstream end of each drainage ditch to dissipate energy of runoff from the repository. This apron will be installed prior to construction of the cap, and will be maintained throughout construction. At construction completion, the riprap apron will be cleaned of accumulated sediment and remain in place as an energy dissipation feature for the channel outlets.

3.8 Site Monitoring and Inspections

Field Screening and Excavation Extent

Due to the treated nature of the waste to be placed into the repository, it is not anticipated that field screening or analytical testing will be required.

Air Monitoring

While air monitoring may not be necessary for this site, visual monitoring should be performed. Fugitive dust due to construction equipment and/or wind should be kept to a minimum by employing a water truck at both sites at all times. Dust control shall also be maintained during transport of waste material to the repository site. As previously stated, this will be accomplished by covering the waste material on each truckload.

Best Management Practice Monitoring and Inspections

Appropriate and practicable greener cleanup BMPs will be implemented during cleanup activities, including, but not limited to, minimizing energy consumption, generation and transport of fugitive dust, waste generation through reuse and recycling, impacts to water resources, areas requiring activity or use limitation, unnecessary soil and habitat disturbance, and lighting and noise disturbance. The objective of BMP monitoring and inspections is to protect the community, workers, and environment throughout the duration of the removal action. The repository site will be inspected daily to assess mitigation efforts and BMP placement.

3.9 Roles and Responsibilities

The site removal action will be performed by a contractor to be selected by ADEC.

Construction Monitoring

It is recommended that ADEC secure an engineer to perform construction monitoring. The engineer should be responsible for tracking the project's progress and completion according to the approved design documents.

4 References

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A Design Memoranda

Appendix A-1	Slope Stability Analysis
Appendix A-2	Hydrologic Analysis
Appendix A-3	Cover system evaluation/HELP model
Appendix A-4	Hydraulic Design Methodology and Analysis
Appendix A-5	Veneer Slope Stability Analysis

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Appendix A-1 Slope Stability Analysis

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ecology and environment, inc.

Design Memorandum

Date:	6/9/2017
To:	Design File
From:	Jennifer Jenkins
Reviewer:	Tom Campbell, P.E.
Subject:	**Wrangell Junkyard Repository Site Slope Stability Analysis**

PROFESSIONAL ENGINEER CERTIFICATION PAGE

Wrangell Junkyard Repository Site Slope Stability Analysis
Wrangell Junkyard Repository Site
Wrangell, Alaska
TDD: 17-01-0005

Pursuant to Alaska Administrative Code (AAC) 12 AAC 36.185(a)(3), only final plans, surveys, reports, and required construction documents approved for building permit issuance for which the registrant is qualified to seal and for which the registrant claims responsibility are required to be submitted under the seal of a State of Alaska licensed professional engineer. This page provides the signature and seal to comply with the regulation.

I hereby certify that this Slope Stability Analysis for the Wrangell Junkyard Repository Site in Wrangell, Alaska, was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Alaska. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

SIGNATURE:

REGISTRATION NUMBER: EV14234
STATE: Alaska

DATE: 06-09-2017

STATE OF ALASKA
49 TH
Thomas C. Campbell
06-09-17
No. EV14234
REGISTERED PROFESSIONAL ENGINEER

OBJECTIVE

This memorandum describes the slope stability analysis that was performed to evaluate the performance of the design for the Wrangell Junkyard Repository Site monofill. The calculations herein are intended to provide the designers with an awareness of potential slope issues but are not intended as guidance for constructability or construction. Additionally, it is recommended that site-specific testing of material be conducted, as soil mechanic properties can be highly variable.

CRITERIA

Slope stability analyses are routinely performed in order to assess the safety and functional design of excavated, natural, or graded slopes (Abramson 2002). A Factor of Safety (FOS) was used as the criteria to evaluate the adequate performance of the conceptual slopes. Technically, the FOS represents the relationship between the average shear strength of the soil (T_f) and the average shear stress developed along potential failure surfaces (T_d)(Das 2010):

$$FOS = \frac{\mathrm{Tf}}{\mathrm{Td}}$$

When the FOS is equal to 1 or less, the slope is in a state of impending failure. The *Slope Stability Engineer Manual* (USACE 2003) recommends using a minimum FOS of 1.5 for normal long-term loading conditions for embankments.

An additional evaluation of the slope failure during a seismic event was also conducted; the recommended minimum FOS of 1.4 for pseudo-static (seismic) conditions was used to evaluate the conceptual design.

METHOD OF ANALYSIS

An initial evaluation of site conditions determined that the critical mode of failure for the site is a surface slide which would occur along the slope (translational failure) with small depth to length ratio. This is typical in cohesionless (granular) soils and is more prevalent in slopes containing geosynthetics when compared to rotational failures. XSTABL© Version 5.2 by Interactive Software Designs, Inc. was used to develop the slope geometry and perform the slope analysis. The program allows for a search of the most critical surface and returns a corresponding FOS using two-dimensional limit equilibrium analysis by the simplified Bishop and Janbu methods.

Stability analyses of earth slopes during earthquake shaking are analyzed using the pseudo-static method; the first known documentation of pseudo-static analysis in the technical literature was by Terzhagi (1950). This method assumes a planar slip surface in a slope resulting from a permanent, unidirectional body force. This results in an extremely conservative evaluation of the actual failure stresses that likely occur under a seismic event (intermittent and multidirectional forces) for dry, cohesionless material. Pseudo-static analysis models the seismic shaking as a permanent body force that is added to the force-body diagram of a conventional static limit-equilibrium analysis; normally, only the horizontal component of earthquake shaking is modeled because the effects of vertical forces tend to average out to near zero. For a planar slip surface in a slope consisting of dry, cohesionless material, the pseudo-static FOS equation is:

$$\mathrm{FOS} = [(W\cos\alpha - kW\sin\alpha)\tan\varphi]/(W\sin\alpha + kW\cos\alpha)$$

where FOS is the pseudo-static factor of safety, W is the weight per unit length of slope, α is the slope angle, φ is the friction angle of the slope material, and k is the pseudo-static coefficient, defined as:

$$k = ah/g$$

where ah is the horizontal ground acceleration and g is the acceleration of Earth's gravity. There are several recommendations for selecting a pseudo-static coefficient that are presented in Table 1 of the report "Methods for assessing the stability of slopes during earthquakes- A retrospective" (Jibson 2011). Table 1 within this report lists several recommendations for selecting a pseudo-static coefficient, two of which recommend using the estimate of 0.50 X PGA/g where PGA is representative of the peak ground acceleration, which is a value that can be obtained from USGS seismic maps. This methodology was used to determine the pseudo-static coefficient for the Wrangell Site, as peak ground acceleration maps are readily available for the site area.

ASSUMPTIONS

The geology of Wrangell Island reveals that bedrock is fairly shallow and consists of a combination of sedimentary and intrusive rocks from the Cretaceous age. The principal surficial materials found on Wrangell Island are beach, alluvial and glacial deposits. Typical beach deposits consist of layers of gravel and sand that are reworked from glacial deposits resulting from wave action and tidal currents. Alluvial deposits in the same area include stratified silt, sand and gravel. These deposits can extend from 5 to 15 feet in thickness and are concentrated within the floodplains of large streams and rivers in areas further inland. The majority of the island surficial geology is comprised of glacial deposits of unconsolidated silt, sand, gravel and boulders. The topsoil that has developed above the well-drained surficial materials have been characterized by an organic rich layer that is approximately 5 to 12 centimeters thick. Wrangell Island is free of permafrost (Hogan 1995).

A former hard rock quarry located on property owned and managed by the Alaska Department of Natural Resources has been selected to contain the waste material generated at the Wrangell Junkyard Site. Approximately 18,515 CY of soil is impacted with high levels of lead. Lead contaminated soil currently consolidated at the Wrangell Junkyard Site has been treated with ECOBOND to reduce lead solubility and leaching potential (Ahtna, 2017). Although contaminant testing was conducted on the Wrangell waste material, geotechnical or engineering soil analysis has not been performed to determine geophysical properties. Geophysical testing was conducted in March 2017, a table summarizing those results are in Attachment A (the complete testing results are included in the Specification Package, Section 003132, Geotechnical Data).

In January 2017, a hydrogeological investigation was performed for the Alaska Department of Environmental Conservation by Ahtna Engineering Services, LLC at the quarry selected for the repository site. Three exploratory borings were advanced to characterize subsurface soils and groundwater elevations within the quarry. Borings were advanced to depths ranging from approximately 6 feet below ground surface (bgs) to 34 feet bgs. The borings revealed that the subsurface is comprised of crushed rock overburden underlain by shallow fractured bedrock. The thickness of the overburden was measured as approximately 1 to 10 feet bgs, and groundwater was observed within the overburden and fractured rock. Groundwater was encountered at all three boring locations at depths of approximately 2.5 to 3.2 feet bgs. (Ahtna 2016)

The design criteria and assumptions used in this assessment include the following:

[1] Slope stability was evaluated using a 4:1 (horizontal: vertical) grade for the face of the monofill. Design Drawing C-5 shows the cross section detail of the monofill including the maximum waste thickness and cover design.

[2] Maximum height of finished slope is estimated at 43.83 feet above ground surface, with a waste material thickness of 38 feet. The total length of the pile slope is approximately 175 feet. The top of the pile was estimated to extend approximately 140 feet and tie into the existing quarry grade with a minimum slope of 3% for drainage.

[3] Geotechnical testing was conducted on the Clean Backfill material, the D-1 1-inch Drain Rock, the 3/8-inch Minus Aggregate, and the Wrangell stockpile waste material. Geotechnical parameters used in the XSTABLE© slope stability analysis are provided in Table 1 and summarized in Attachment A. The complete testing results are included in the Specification Package, Section 003132, Geotechnical Data.

[4] Groundwater was located at a minimum depth of approximately 2.5 feet below ground surface (Ahtna Engineering Services, LLC January 2017). In accordance with AAC 60.217, unlined landfills or repositories must have at least 10 feet of separation between the highest measured level of an aquifer of resource value and the bottom of the contaminated material unless the landfill is constructed two feet or more above the natural ground surface. Since there is not a 10 foot separation from groundwater, the repository is being constructed 2 feet above the natural ground surface of the quarry using a 2-foot foundation layer of native shot-rock. Geotechnical testing was not conducted on the foundation material; therefore the a generic soil classification of USCS GW was assigned to this layer and typical soil parameters were assumed based on typical values found in literature resources and compared to the geotechnical results from the Clean Backfill and waste piles sources, which had similar characteristics.

[5] It is assumed that seepage will not be present in the estimated potential failure zone. This is due to the installation of chimney drains around the repository perimeter. Seepage failure is evaluated in the Veneer Stability analysis (E & E 2017).

[6] Native base soils include gravely coarse sandy loam at both locations based on the Ahtna soil boring logs (see Specification Section 332900, Well Abandonment) and the area soil maps provided by USGS (see Attachment B). The Ahtna boring logs show the overburden layer from 1 to 10 feet (Ahtna 2017) below ground surface (bgs). To simplify the XSTABL© model, a native base of the overburden material was averaged and assumed to have a thickness of 5.5’ and is represented as very gravelly coarse sandy loam material (see above). A USCS soil type GM was used to represent the base native material at the monofill location and compared to the Clean Backfill and waste material geotechnical properties since the materials were similar. Geophysical parameters used as inputs into the XSTABL© model are summarized in Table 1, below. These values have been assumed based on typical values found in literature resources or from laboratory results (summarized in Attachment A).

[7] Based on the Ahtna borings, a fractured bedrock layer was observed at depths from 1 to 10 feet bgs (Ahtna 2017). Ahtna boring logs are included in Specification Section 332900, Well Abandonment. A bedrock layer was modeled in XSTABLE to provide a limiting depth for the toe failure calculations.

[8] Once the Wrangell waste material is placed and compacted within the Monofill site it will be capped with a linear low density polyethylene (LLDPE) FML geomembrane liner, 6-inch 3/8” Minus Aggregate cushion layer, a 1 foot D-1, 1” Minus Drain Rock layer, a 1.5 foot layer of Clean Backfill , and then covered with a 6-inch layer of vegetative cover soil. Due to the remoteness of the site, the only viable source for topsoil for the vegetative cover is the Clean Backfill. A summary of the assumed physical soil properties are listed in Table 1 below. The slope stability focused on the stability of the monofill waste material; therefore, to simplify the

analysis the cover was modeled in XSTABLE as a uniformly distributed force along the entire length of face of the slope of the waste material and top of pile. A force of 440 pounds per square foot (lbs/sf) was used in the model to represent the summation of the saturated unit weights of all the cover layers based on their proposed thickness.

[9] The seismic coefficient (k) is assumed to be 0.035 based on the Peak Ground Acceleration of 7%g as identified on the contour map for the event with a 10% chance of exceedance in 50 years (see Attachment C) to evaluate the potential earthquake impacts.

Table 1: Input Parameters for XSTABL© Simulation – Wrangell Repository

Soil Layers	Thickness ft	Density_{dry} lb/ft^3	Density_{sat} lb/ft^3	Cohesion lb/ft^2	Friction Angle
Bedrock*	10	140	140	0	65
Monofill Native Base (GM)*	5.5	120	125	0	34
Shot-Rock Foundation (GW)*	10	125	135	0	36
Treated Waste (GM)	38	100.5	120.3	30.6	38.8
3/8- inch Minus Aggregate Cushion	0.33	135	145.9	77.13	46.6
LLDPE FML	0.1	58	58	0	34
3/8-inch Minus Aggregate	0.5	135	145.9	77.13	46.6
Drainage Rock (D-1) Cap (GW)	1.0	125.4	130.5	47.5	53.1
Clean Backfill	1.5	100	117.6	76.9	39.9
Vegetated Top Soil Cap (OL)	0.5	100	117.6	76.9	39.9

Geotechnical parameters of bedrock, native base soil and shot-rock foundation estimated using values from: http://www.geotechdata.info/parameter/parameter.html

Geotechnical parameters of geomembrane liner estimated using values from: https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=35522.wba and

http://mining.solutions/heapleach/2013/wp-content/uploads/2013/10/Jose-Ale-Trends-of-large-scale-direct-shear-strength-results-rev-C.pdf

CONCLUSIONS

The FOS results of the XSTABL© simulation for the design at Wrangell for both non-seismic and seismic conditions are presented below in Table 2 and were evaluated under Bishop and Janbu methods. XSTABL© results for the Bishop, Janbu, and Seismic analysis are provided in Attachment D.

Table 2: Stability Results	
Scenario	Minimum FOS
4:1 no seismic	3.83
4:1 Seismic	3.35

This slope meets the recommended criteria of a 1.5 FOS under static conditions and 1.4 FOS for seismic loads.

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Attachment A

Geotechnical Summary

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Material	Thickness	Dry Density	Sat Density	Moisture Conent	Friction Angle	Cohesion	
	FT	lbs/ft^3	lbs/ft^3	%	degrees	lbs/ft^2	kPA
Waste Pile	38	100.5	120.3	19.7	38.8	30.6	1.47
Cover							
Topsoil	0.5	100.0	117.6	17.6	39.9	76.9	3.68
Common Fill	1.5	100.0	117.6	17.6	39.9	76.9	3.68
1" minus	1	125.4	130.5	4.1	53.1	47.5	2.27
3/8" minus	0.5	135.0	145.9	8.1	46.6	77.13	3.69
Total Force			**438.7**	lb/ft^2			

30-mil LLDPE FML*		
Interface Friction Angle	34	degrees
Adhesion	0	kPA

*assumes LLDPE FML and 3/8" (granular) interface

Reference: Interface Shear: Towards understanding significance in Geotechnical Structures, SRK Consulting, (Howel and Kirsten) and MicroSpike Textured Geomembrane Info Sheet (Agru America)

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Attachment B

USGS Soil Surveys and Geotechnical Summary

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United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for
Stikine Area, Alaska

March 1, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


132° 18' 47" W
132° 18' 38" W
56° 21' 14" N
56° 21' 8" N
666020
666040
666060
666080
666100
666120
666140
666160
6248720
6248700
6248680
6248660
6248640
6248620
6248600
6248580
6248560
6248540
16D
Soil Map may not be valid at this scale.
Map Scale: 1:958 if printed on A portrait (8.5" x 11") sheet.
Meters
0 10 20 40 60
Feet
0 45 90 180 270
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 8N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:31,700.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Stikine Area, Alaska
Survey Area Data: Version 10, Sep 27, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Stikine Area, Alaska (AK645)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
16D	Kupreanof-Mosman complex, 35 to 75 percent slopes	1.9	100.0%
Totals for Area of Interest		**1.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Stikine Area, Alaska

16D—Kupreanof-Mosman complex, 35 to 75 percent slopes

Map Unit Setting

National map unit symbol: 1ngq
Elevation: 0 to 3,000 feet
Mean annual precipitation: 21 to 220 inches
Mean annual air temperature: 39 to 48 degrees F
Frost-free period: 90 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Kupreanof and similar soils: 45 percent
Mosman and similar soils: 45 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kupreanof

Setting

Landform: Mountains
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Colluvium and/or glaciofluvial deposits

Typical profile

H1 - 0 to 1 inches: silt loam
H2 - 1 to 8 inches: gravelly sandy loam
H3 - 8 to 25 inches: very gravelly coarse sandy loam
H4 - 25 to 60 inches: very gravelly sandy loam

Properties and qualities

Slope: 35 to 75 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Hydric soil rating: No

Description of Mosman

Setting

Landform: Mountains
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Colluvium derived from granodiorite and/or residuum weathered from granodiorite

Typical profile

H1 - 0 to 1 inches: very gravelly loam
H2 - 1 to 11 inches: very gravelly loam
H3 - 11 to 15 inches: unweathered bedrock

Properties and qualities

Slope: 35 to 75 percent
Depth to restrictive feature: 3 to 14 inches to lithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 1.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Mcgilvery

Percent of map unit: 4 percent
Landform: Mountains
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Mitkof

Percent of map unit: 3 percent
Landform: Mountains, till plains
Down-slope shape: Linear
Across-slope shape: Concave
Hydric soil rating: No

Wadleigh

Percent of map unit: 3 percent
Landform: Depressions on hills
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Particle Size and Coarse Fragments (Monofill Location)

This table shows estimates of particle size distribution and coarse fragment content of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Total fragments is the content of fragments of rock and other materials larger than 2 millimeters in diameter on volumetric basis of the whole soil.

Fragments 2-74 mm refers to the content of coarse fragments in the 2 to 74 millimeter size fraction.

Fragments 75-249 mm refers to the content of coarse fragments in teh 75 to 249 millimeter size fraction.

Fragments 250-599 mm refers to the content of coarse fragments in the 250 to 599 millimeter size fraction.

Fragments >=600 mm refers to the content of coarse fragments in the greater than or equal to 600 millimeter size fraction.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Particle Size and Coarse Fragments–Stikine Area, Alaska										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
16D—Kupreanof-Mosman complex, 35 to 75 percent slopes										
Kupreanof	H1	0-1	-37-	-58-	0- 5- 10	14	12	2	—	—
	H2	1-8	-64-	-31-	0- 5- 10	27	24	3	—	—
	H3	8-25	-65-	-30-	0- 5- 10	38	29	9	—	—
	H4	25-60	-64-	-31-	0- 5- 10	46	29	17	—	—
Mosman	H1	0-1	-47-	-45-	5- 8- 10	34	31	3	—	—
	H2	1-11	-49-	-46-	0- 5- 10	40	30	10	—	—
	H3	11-15	—	—	—	—	—	—	—	—
McGilvery	Oi	0-8	—	—	—	2	—	2	—	—
	2C	8-9	-37-	-58-	0- 5- 10	44	32	12	—	—
	R	9-13	—	—	—	—	—	—	—	—
Mitkof	H1	0-1	-69-	-24-	5- 8- 10	13	8	5	—	—
	H2	1-11	-38-	-60-	0- 3- 5	35	28	7	—	—
	H3	11-60	-50-	-48-	0- 3- 5	33	20	13	—	—
Wadleigh	H1	0-2	-38-	-60-	0- 3- 5	20	18	2	—	—
	H2	2-11	-38-	-60-	0- 3- 5	40	37	3	—	—
	H3	11-60	-37-	-58-	0- 5- 10	42	39	3	—	—

Engineering Properties (Monofill Location)

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Percentage of rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties–Stikine Area, Alaska														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
16D—Kupreanof-Mosman complex, 35 to 75 percent slopes														
Kupreanof	45	C	0-1	Silt loam	ML	A-4	0- 0- 0	0- 3- 5	85-93-100	75-88-100	65-80-95	55-65-75	—	NP
			1-8	Gravelly sandy loam, gravelly silt loam, sandy loam	SM, ML, GM	A-4, A-2, A-1	0- 0- 0	0- 5- 10	65-80-95	55-70-85	40-58-75	20-40-60	—	NP
			8-25	Very gravelly coarse sandy loam, very cobbly sandy loam	SM, GM	A-4, A-2, A-1	0- 0- 0	0-15- 30	50-60-70	40-50-60	20-35-50	15-28-40	—	NP
			25-60	Very gravelly sandy loam, extremely cobbly coarse sandy loam	SM, GP-GM, GM, SP-SM	A-1	0- 0- 0	5-30- 55	45-58-70	35-45-55	15-28-40	10-15-20	—	NP
Mosman	45	D	0-1	Very gravelly loam	GM, SM	A-2, A-1	0- 0- 0	0- 5- 10	55-63-70	35-45-55	30-40-50	20-28-35	35-40-45	NP-3 -5
			1-11	Very gravelly loam, extremely gravelly silt loam	GM, SM	A-2, A-1	0- 0- 0	10-18-25	55-63-70	25-40-55	20-35-50	15-25-35	35-40-45	NP-3 -5
			11-15	Unweathered bedrock	—	—	—	—	0- 0- 0	0- 0- 0	—	—	—	—
Mcgilvery	4	D	0-8	Peat	PT	A-8	0- 0- 0	0- 3- 5	0- 0- 0	0- 0- 0	—	—	—	—
			8-9	Extremely gravelly loam, very gravelly silt loam	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	15-20-25	50-55-60	20-28-35	15-23-30	10-15-20	—	NP

Engineering Properties–Stikine Area, Alaska														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
			9-13	Unweathered bedrock	—	—	—	—	0- 0- 0	0- 0- 0	—	—	—	—
Mitkof	3	C	0-1	Sandy loam	ML, SM	A-5	0- 0- 0	0- 8- 15	90-95-100	85-93-100	65-80-95	45-53-60	40-45-50	NP-3 -5
			1-11	Gravelly silt loam, very gravelly sandy loam, very cobbly loam	GM, SM	A-1, A-2	0- 0- 0	5-13- 20	60-65-70	35-48-60	25-40-55	15-23-30	40-45-50	NP-3 -5
			11-60	Very gravelly loam, very cobbly sandy loam, very gravelly coarse sandy loam	SM	A-1	0- 0- 0	15-23-30	70-73-75	45-48-50	30-38-45	15-20-25	20-25-30	NP-3 -5
Wadleigh	3	D	0-2	Silt loam	ML, SM	A-4	0- 0- 0	0- 3- 5	80-90-100	60-78-95	55-73-90	40-55-70	—	NP
			2-11	Very gravelly silt loam, very gravelly sandy loam	GM, SM	A-2, A-1	0- 0- 0	0- 5- 10	40-55-70	30-40-50	25-35-45	15-25-35	—	NP
			11-60	Extremely gravelly silt loam, very gravelly sandy loam, very gravelly loam	GC-GM, GM, GP-GM	A-2, A-1	0- 0- 0	0- 5- 10	40-50-60	20-35-50	15-28-40	10-23-35	15-18-20	NP-3 -5

Particle Size and Coarse Fragments (Monofill Location)

This table shows estimates of particle size distribution and coarse fragment content of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Total fragments is the content of fragments of rock and other materials larger than 2 millimeters in diameter on volumetric basis of the whole soil.

Fragments 2-74 mm refers to the content of coarse fragments in the 2 to 74 millimeter size fraction.

Fragments 75-249 mm refers to the content of coarse fragments in teh 75 to 249 millimeter size fraction.

Fragments 250-599 mm refers to the content of coarse fragments in the 250 to 599 millimeter size fraction.

Fragments >=600 mm refers to the content of coarse fragments in the greater than or equal to 600 millimeter size fraction.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Particle Size and Coarse Fragments–Stikine Area, Alaska										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
16D—Kupreanof-Mosman complex, 35 to 75 percent slopes										
Kupreanof	H1	0-1	-37-	-58-	0- 5- 10	14	12	2	—	—
	H2	1-8	-64-	-31-	0- 5- 10	27	24	3	—	—
	H3	8-25	-65-	-30-	0- 5- 10	38	29	9	—	—
	H4	25-60	-64-	-31-	0- 5- 10	46	29	17	—	—
Mosman	H1	0-1	-47-	-45-	5- 8- 10	34	31	3	—	—
	H2	1-11	-49-	-46-	0- 5- 10	40	30	10	—	—
	H3	11-15	—	—	—	—	—	—	—	—
McGilvery	Oi	0-8	—	—	—	2	—	2	—	—
	2C	8-9	-37-	-58-	0- 5- 10	44	32	12	—	—
	R	9-13	—	—	—	—	—	—	—	—
Mitkof	H1	0-1	-69-	-24-	5- 8- 10	13	8	5	—	—
	H2	1-11	-38-	-60-	0- 3- 5	35	28	7	—	—
	H3	11-60	-50-	-48-	0- 3- 5	33	20	13	—	—
Wadleigh	H1	0-2	-38-	-60-	0- 3- 5	20	18	2	—	—
	H2	2-11	-38-	-60-	0- 3- 5	40	37	3	—	—
	H3	11-60	-37-	-58-	0- 5- 10	42	39	3	—	—

Physical Soil Properties (Monofill Location)

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Physical Soil Properties–Stikine Area, Alaska														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
16D—Kupreanof-Mosman complex, 35 to 75 percent slopes														
Kupreanof	0-1	-37-	-58-	0- 5- 10	1.10-1.15-1.20	4.23-9.17-14.11	0.19-0.20-0.21	0.0- 1.5- 2.9	4.0- 6.0-8.0	.24	.28	5	2	134
	1-8	-64-	-31-	0- 5- 10	1.10-1.15-1.20	4.23-9.17-14.11	0.12-0.14-0.15	0.0- 1.5- 2.9	6.0-8.0-10.0	.17	.28			
	8-25	-65-	-30-	0- 5- 10	1.30-1.35-1.40	14.11-28.23-42.34	0.06-0.08-0.10	0.0- 1.5- 2.9	4.0- 6.0-8.0	.15	.43			
	25-60	-64-	-31-	0- 5- 10	1.30-1.35-1.40	14.11-28.23-42.34	0.04-0.05-0.06	0.0- 1.5- 2.9	1.0- 2.0-3.0	.10	.43			
Mosman	0-1	-47-	-45-	5- 8- 10	1.10-1.15-1.20	4.23-9.17-14.11	0.10-0.11-0.12	0.0- 1.5- 2.9	8.0-10.0-12.0	.15	.32	1	5	56
	1-11	-49-	-46-	0- 5- 10	1.10-1.15-1.20	4.23-9.17-14.11	0.10-0.11-0.12	0.0- 1.5- 2.9	10.0-12.0-14.0	.15	.55			
	11-15	—	—	—	—	—	—	—	—					
Mcgilvery	0-8	—	—	—	0.05-0.08-0.10	42.34-91.74-141.14	0.23-0.24-0.25	0.0- 1.5- 2.9	0.8- 0.9-1.0	.05	.05	1	8	0
	8-9	-37-	-58-	0- 5- 10	1.50-1.55-1.60	42.34-91.74-141.14	0.06-0.09-0.12	0.0- 1.5- 2.9	1.0- 2.0-3.0	.10	.55			
	9-13	—	—	—	—	—	—	—	—					
Mitkof	0-1	-69-	-24-	5- 8- 10	0.90-1.00-1.10	4.23-9.17-14.11	0.21-0.22-0.23	0.0- 1.5- 2.9	12.0-13.5-15.0	.37	.37	5	3	86
	1-11	-38-	-60-	0- 3- 5	1.20-1.25-1.30	4.23-9.17-14.11	0.10-0.11-0.12	0.0- 1.5- 2.9	6.0- 7.0-8.0	.15	.43			
	11-60	-50-	-48-	0- 3- 5	1.30-1.35-1.40	4.23-9.17-14.11	0.06-0.07-0.08	0.0- 1.5- 2.9	1.0- 2.0-3.0	.10	.37			

Physical Soil Properties–Stikine Area, Alaska														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
Wadleigh	0-2	-38-	-60-	0- 3- 5	1.10-1.15-1.20	4.23-9.17-14.11	0.18-0.19-0.20	0.0- 1.5- 2.9	3.0- 4.5-6.0	.43	.55	1	8	0
	2-11	-38-	-60-	0- 3- 5	1.40-1.50-1.60	4.23-9.17-14.11	0.08-0.09-0.10	0.0- 1.5- 2.9	8.0-9.0-10.0	.28	.64			
	11-60	-37-	-58-	0- 5- 10	1.80-1.95-2.10	0.00-0.21-0.42	0.00-0.00-0.00	0.0- 1.5- 2.9	0.5- 1.0-5.0	.10	.37			

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Attachment C

USGS Seismic Map

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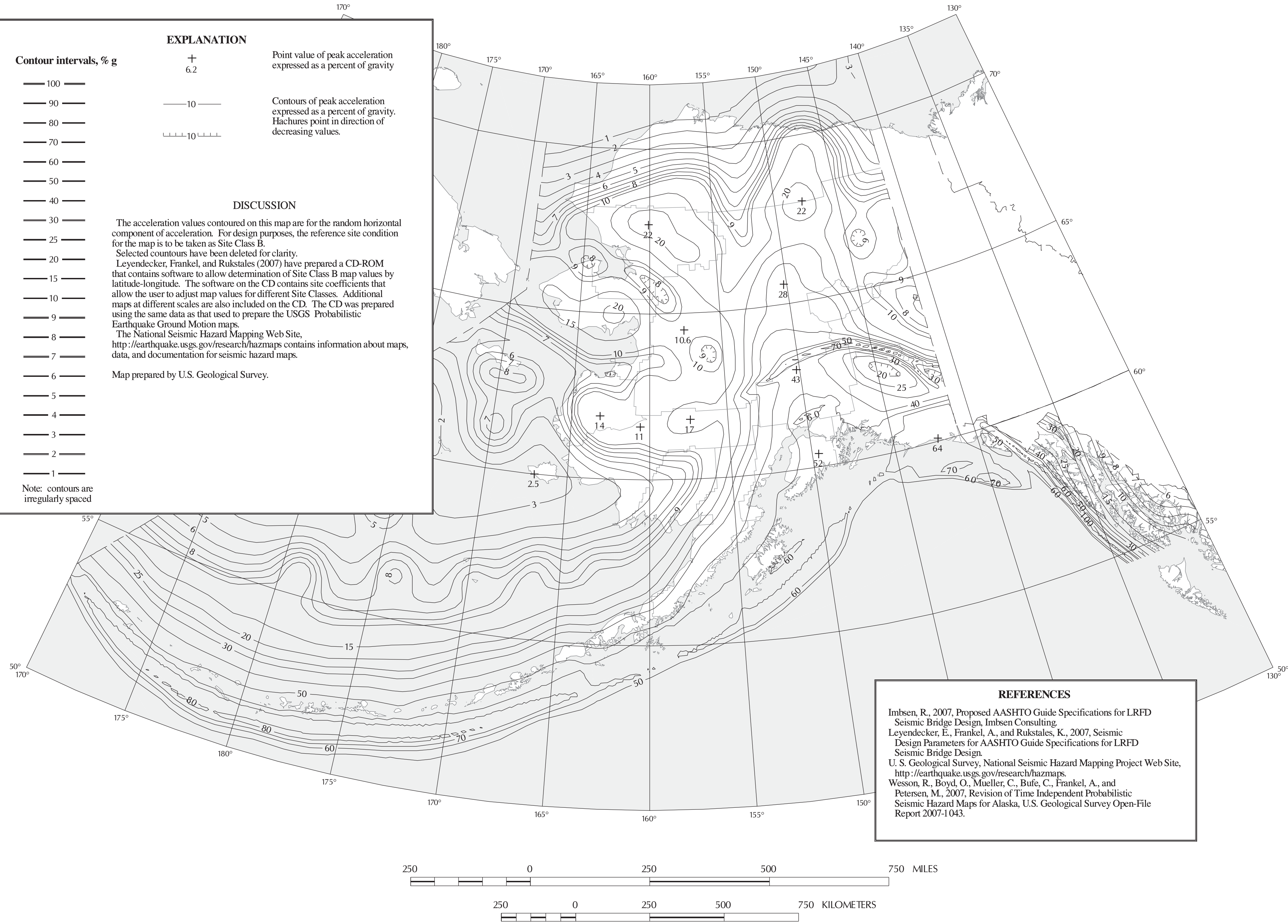
PEAK HORIZONTAL ACCELERATION FOR ALASKA
WITH 7 PERCENT PROBABILITY OF EXCEEDANCE IN 75 YEARS



EXPLANATION

Contour intervals, % g

100
90
80
70
60
50
40
30
25
20
15
10
9
8
7
6
5
4
3
2
1

Note: contours are irregularly spaced

+ 6.2 — Point value of peak acceleration expressed as a percent of gravity

10 — Contours of peak acceleration expressed as a percent of gravity. Hachures point in direction of decreasing values.

DISCUSSION

The acceleration values contoured on this map are for the random horizontal component of acceleration. For design purposes, the reference site condition for the map is to be taken as Site Class B.

Selected countours have been deleted for clarity.

Leyendecker, Frankel, and Rukstales (2007) have prepared a CD-ROM that contains software to allow determination of Site Class B map values by latitude-longitude. The software on the CD contains site coefficients that allow the user to adjust map values for different Site Classes. Additional maps at different scales are also included on the CD. The CD was prepared using the same data as that used to prepare the USGS Probabilistic Earthquake Ground Motion maps.

The National Seismic Hazard Mapping Web Site, http://earthquake.usgs.gov/research/hazmaps contains information about maps, data, and documentation for seismic hazard maps.

Map prepared by U.S. Geological Survey.

REFERENCES

Imbsen, R., 2007, Proposed AASHTO Guide Specifications for LRFD Seismic Bridge Design, Imbsen Consulting.

Leyendecker, E., Frankel, A., and Rukstales, K., 2007, Seismic Design Parameters for AASHTO Guide Specifications for LRFD Seismic Bridge Design.

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Attachment D

Slope Stability XSTABL© Run Output

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XSTABL RESULTS WRANGELL MONOFILL

XSTABL File: WRANGEL1   5-23-17   15:45

```
*******************************************
*              X S T A B L                *
*                                         *
*        Slope Stability Analysis         *
*               using the                 *
*            Method of Slices             *
*                                         *
*        Copyright (C) 1992 - 2015        *
*   Interactive Software Designs, Inc.    *
*        Moscow, ID 83843, U.S.A.         *
*                                         *
*          All Rights Reserved            *
*                                         *
*  Ver. 5.209                96 - 2099    *
*******************************************
```

Problem Description : WRANGLE4:1

SEGMENT BOUNDARY COORDINATES
----

5 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	15.5	15.0	15.5	3
2	15.0	15.5	23.0	17.5	2
3	23.0	17.5	33.0	17.5	2
4	33.0	17.5	185.0	57.5	1
5	185.0	57.5	335.0	62.3	1

3 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	33.0	17.5	335.0	17.5	2
2	15.0	15.5	335.0	15.5	3
3	.0	10.0	335.0	10.0	4

ISOTROPIC Soil Parameters

----

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	100.5	120.3	.0	38.80	.000	.0	0
2	125.0	135.0	.0	36.00	.000	.0	0
3	120.0	125.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	65.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****

PHREATIC SURFACE,

****

Point No.	x-water (ft)	y-water (ft)
1	.00	13.00
2	335.00	13.00

BOUNDARY LOADS

----

2 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	33.0	185.0	440.0	14.0
2	185.0	335.0	440.0	1.7

NOTE - Intensity is specified as a uniformly distributed
force acting on a HORIZONTALLY projected surface.

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 1 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	.0	10.0	335.0	10.0

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

1000 trial surfaces will be generated and analyzed.

100 Surfaces initiate from each of 10 points equally spaced along the ground surface between x = 1.0 ft
and x = 180.0 ft

Each surface terminates between x = 180.0 ft
and x = 250.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

4.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * *   SIMPLIFIED BISHOP METHOD   * * * * *

The most critical circular failure surface
is specified by 52 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	1.00	15.50
2	4.91	14.67
3	8.84	13.91
4	12.78	13.21
5	16.73	12.58
6	20.69	12.03
7	24.66	11.53
8	28.64	11.11
9	32.62	10.76
10	36.61	10.47
11	40.61	10.25
12	44.60	10.11
13	48.60	10.03
14	52.60	10.02
15	56.60	10.07
16	60.60	10.20
17	64.59	10.40
18	68.59	10.66
19	72.57	10.99
20	76.55	11.40
21	80.52	11.86
22	84.49	12.40
23	88.44	13.01
24	92.38	13.68
25	96.31	14.43
26	100.23	15.23
27	104.13	16.11
28	108.02	17.05
29	111.89	18.06
30	115.74	19.14
31	119.58	20.28
32	123.39	21.49
33	127.18	22.77
34	130.95	24.11
35	134.70	25.51
36	138.42	26.98
37	142.11	28.51
38	145.78	30.10
39	149.42	31.76
40	153.03	33.48

41	156.61	35.26
42	160.16	37.11
43	163.68	39.01
44	167.17	40.98
45	170.62	43.00
46	174.03	45.08
47	177.41	47.22
48	180.75	49.42
49	184.05	51.68
50	187.32	53.99
51	190.54	56.36
52	192.34	57.73

**** Simplified BISHOP FOS = 3.836 ****

```
********************************************************************
          **                                                      **
          **  Out of the   1000 surfaces generated and analyzed by XSTABL,  **
          **      103 surfaces were found to have MISLEADING FOS values.   **
          **                                                      **
********************************************************************
```

The following is a summary of the TEN most critical surfaces

Problem Description : WRANGLE4:1

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	3.836	51.22	242.56	232.55	1.00	192.34	5.538E+07
2.	3.840	52.03	250.16	240.15	1.00	195.84	5.955E+07
3.	3.845	51.66	249.92	239.83	1.00	195.24	5.888E+07
4.	3.856	50.75	248.50	238.25	1.00	193.52	5.693E+07

	5.	3.857	51.17	252.06	241.82	1.00	195.21
5.896E+07							
	6.	3.863	52.12	259.43	249.23	1.00	198.80
6.338E+07							
	7.	3.864	52.96	262.78	252.68	1.00	201.00
6.612E+07							
	8.	3.865	49.28	230.26	220.12	1.00	185.71
4.800E+07							
	9.	3.866	50.26	249.20	238.83	1.00	193.05
5.645E+07							
	10.	3.877	52.53	265.91	255.65	1.00	201.32
6.670E+07							

* * * END OF FILE * * *

XSTABL File: WRANGEL1   5-23-17   16:14

```
 ******************************************
 *             X S T A B L                *
 *                                        *
 *       Slope Stability Analysis         *
 *              using the                 *
 *           Method of Slices             *
 *                                        *
 *       Copyright (C) 1992 - 2015        *
 *   Interactive Software Designs, Inc.   *
 *       Moscow, ID 83843, U.S.A.         *
 *                                        *
 *          All Rights Reserved           *
 *                                        *
 *  Ver. 5.209                96 - 2099   *
 ******************************************
```

Problem Description : WRANGLE4:1

SEGMENT BOUNDARY COORDINATES

5 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	15.5	15.0	15.5	3
2	15.0	15.5	23.0	17.5	2
3	23.0	17.5	33.0	17.5	2
4	33.0	17.5	185.0	57.5	1
5	185.0	57.5	335.0	62.3	1

3 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	33.0	17.5	335.0	17.5	2
2	15.0	15.5	335.0	15.5	3
3	.0	10.0	335.0	10.0	4

ISOTROPIC Soil Parameters

----

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	100.5	120.3	.0	38.80	.000	.0	0
2	125.0	135.0	.0	36.00	.000	.0	0
3	120.0	125.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	65.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water =   62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	.00	13.00
2	335.00	13.00

BOUNDARY LOADS
----

2 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	33.0	185.0	440.0	14.0
2	185.0	335.0	440.0	1.7

```
NOTE - Intensity is specified as a uniformly distributed
       force acting on a HORIZONTALLY projected surface.


-------------------------------------------------------------
BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED
-------------------------------------------------------------

  LOWER limiting boundary of  1 segments:

Segment      x-left     y-left    x-right    y-right
   No.        (ft)       (ft)       (ft)       (ft)

    1           .0       10.0      335.0       10.0



A critical failure surface searching method, using a random
technique for generating CIRCULAR surfaces has been specified.


 1000 trial surfaces will be generated and analyzed.


 100 Surfaces initiate from each of  10 points equally spaced
along the ground surface between  x =      1.0 ft
                             and  x =    180.0 ft


Each surface terminates between   x =    180.0 ft
                            and   x =    250.0 ft


Unless further limitations were imposed, the minimum elevation
at which a surface extends is  y =       .0 ft


    4.0 ft line segments define each trial failure surface.



---------------------
ANGULAR RESTRICTIONS
---------------------

  The first segment of each failure surface will be inclined
  within the angular range defined by :

          Lower angular limit :=   -45.0 degrees
          Upper angular limit :=  (slope angle - 5.0) degrees
```

```
*******************************************************************
          **
**
          **  Out of the   1000 surfaces generated and analyzed by
XSTABL,  **
          **      105 surfaces were found to have MISLEADING FOS values.
**
          **
**

*******************************************************************
```

The following is a summary of the TEN most critical surfaces

Problem Description : WRANGLE4:1

	Modified JANBU FOS	Correction Factor	Initial x-coord (ft)	Terminal x-coord (ft)	Available Strength (lb)
1.	3.842	1.029	1.00	192.34	2.378E+05
2.	3.846	1.029	1.00	195.84	2.476E+05
3.	3.851	1.029	1.00	195.24	2.452E+05
4.	3.860	1.033	20.89	193.79	2.552E+05
5.	3.863	1.028	1.00	193.52	2.386E+05
6.	3.864	1.028	1.00	195.21	2.435E+05
7.	3.864	1.033	20.89	196.80	2.642E+05
8.	3.868	1.032	20.89	196.96	2.642E+05
9.	3.870	1.028	1.00	198.80	2.540E+05
10.	3.871	1.028	1.00	201.00	2.613E+05

* * * END OF FILE * * *

XSTABL File: WRANGEL1   5-23-17   16:17

```
****************************************
*            X S T A B L               *
*                                      *
*       Slope Stability Analysis       *
*              using the               *
*           Method of Slices           *
*                                      *
*       Copyright (C) 1992 - 2015      *
*   Interactive Software Designs, Inc. *
*       Moscow, ID 83843, U.S.A.       *
*                                      *
*          All Rights Reserved         *
*                                      *
*  Ver. 5.209               96 - 2099  *
****************************************
```

Problem Description : WRANGLE4:1

SEGMENT BOUNDARY COORDINATES
----

5 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	15.5	15.0	15.5	3
2	15.0	15.5	23.0	17.5	2
3	23.0	17.5	33.0	17.5	2
4	33.0	17.5	185.0	57.5	1
5	185.0	57.5	335.0	62.3	1

3 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	33.0	17.5	335.0	17.5	2
2	15.0	15.5	335.0	15.5	3
3	.0	10.0	335.0	10.0	4

ISOTROPIC Soil Parameters

----

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	100.5	120.3	.0	38.80	.000	.0	0
2	125.0	135.0	.0	36.00	.000	.0	0
3	120.0	125.0	.0	34.00	.000	.0	1
4	140.0	140.0	.0	65.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	.00	13.00
2	335.00	13.00

A horizontal earthquake loading coefficient
of .035 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

BOUNDARY LOADS
----

2 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	33.0	185.0	440.0	14.0
2	185.0	335.0	440.0	1.7

NOTE - Intensity is specified as a uniformly distributed force acting on a HORIZONTALLY projected surface.

BOUNDARIES THAT LIMIT SURFACE GENERATION HAVE BEEN SPECIFIED

LOWER limiting boundary of 1 segments:

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)
1	.0	10.0	335.0	10.0

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

1000 trial surfaces will be generated and analyzed.

100 Surfaces initiate from each of 10 points equally spaced along the ground surface between x = 1.0 ft
and x = 180.0 ft

Each surface terminates between x = 180.0 ft
and x = 250.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

4.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****
**
**
** Out of the 1000 surfaces generated and analyzed by XSTABL, **
** 89 surfaces were found to have MISLEADING FOS values. **
**
**
****

The following is a summary of the TEN most critical surfaces

Problem Description : WRANGLE4:1

	Modified JANBU FOS	Correction Factor	Initial x-coord (ft)	Terminal x-coord (ft)	Available Strength (lb)
1.	3.353	1.029	1.00	192.34	2.360E+05
2.	3.354	1.029	1.00	195.84	2.458E+05
3.	3.359	1.029	1.00	195.24	2.433E+05
4.	3.369	1.033	20.89	193.79	2.533E+05
5.	3.370	1.033	20.89	196.80	2.622E+05
6.	3.372	1.028	1.00	195.21	2.416E+05
7.	3.372	1.028	1.00	193.52	2.368E+05
8.	3.372	1.028	1.00	201.00	2.594E+05
9.	3.373	1.032	20.89	196.96	2.621E+05

```
          10.     3.374          1.028        1.00      198.80
2.521E+05
```

* * * END OF FILE * * *

Appendix A-2 Hydrologic Analysis

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ecology and environment, inc.

Design Memorandum

Date:	6/9/2017
To:	Design File
From:	Maren Fulton
Reviewer:	Thomas C. Campbell, P.E.
Subject:	Wrangell Junkyard Repository Site Stormwater Runoff and Hydrology Analysis

---

PROFESSIONAL ENGINEER CERTIFICATION PAGE

Wrangell Junkyard Repository Site Stormwater Runoff and Hydrology Analysis
Wrangell Junkyard Repository Site
Wrangell, Alaska
TDD: 17-01-0005

Pursuant to Alaska Administrative Code (AAC) 12 AAC 36.185(a)(3), only final plans, surveys, reports, and required construction documents approved for building permit issuance for which the registrant is qualified to seal and for which the registrant claims responsibility are required to be submitted under the seal of a State of Alaska licensed professional engineer. This page provides the signature and seal to comply with the regulation.

I hereby certify that this Stormwater Runoff and Hydrology Analysis for the Wrangell Junkyard Repository Site in Wrangell, Alaska, was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Alaska. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

SIGNATURE:

REGISTRATION NUMBER: EV14234
STATE: Alaska

DATE: 06-09-2017

STATE OF ALASKA
49 TH
Thomas C. Campbell
06-09-17
No. EV14234
REGISTERED PROFESSIONAL ENGINEER

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OBJECTIVE

This memorandum describes the hydrologic analysis that was performed to predict stormwater runoff from the contributing watersheds to the Wrangell Junkyard Repository Site (referred to herein as the "repository site"). The estimated flow rates will be used in the design of stormwater conveyances for the engineered cover and stormwater run-on management.

CRITERIA

According to 18 AAC 60.225. Surface water requirements:

(b)(2): If the department determines that a control system for stormwater run-off is necessary to prevent the landfill from contributing to siltation or flooding problems in nearby surface water bodies, the owner or operator of a landfill shall construct and maintain a control system capable of containing and controlling the run-off from a 24-hour, 25-year storm.

(c): The owner or operator of a solid waste disposal facility shall construct and maintain a control system that will prevent run-on from flowing onto the active portion of the facility. The control system must be capable of handling the peak discharge from a 25-year storm.

METHOD OF ANALYSIS

Calculations for peak discharge (Q) are based on the Rational Method. It is not as sophisticated as the Natural Resources Conservation Service (NRCS) Technical Release 55 (TR-55) method, but it is the simplest way to determine peak discharges in smaller/less complex watersheds in which the runoff is predominantly unconfined flow over land, such as the one considered in this analysis. The Rational equation is:

$$Q = CiA, \text{ where}$$

Q is the peak discharge in cubic feet per second, C is the weighted Rational runoff coefficient (c) for the drainage basin (dimensionless), i is the rainfall intensity in inches per hour, and A is the drainage basin area in acres.

ASSUMPTIONS

The drainage basin was delineated using topographic contours obtained from the survey conducted by R&M Engineering on November 17, 2016 (RM 2016), using the ridgelines surrounding the rock pit as a guide, as well as the estimated design for the repository cover from the Design Memorandum *Wrangell Junkyard Repository Site Cover Analysis - 30% Design* (E & E 2017). The majority of upgradient areas drain away from the rock pit, creating minimal run-on onto the repository site, with the majority of stormwater generated within the rock pit area. The drainage basin area (A) was estimated based on this delineation. Attachment A contains a figure showing the delineated drainage basin.

Rainfall intensity (i) used to predict peak flows were estimated using 24-hour National Oceanic and Atmospheric Administration (NOAA) Point Precipitation Frequency Estimates (NOAA Atlas 14, Volume 2, Version 7; NOAA 2014) for the site latitude and longitude. Attachment B contains the point precipitation frequency estimates for the repository site (Latitude 56.2447 degrees, Longitude -132.2987 degrees).

The Rational Method runoff coefficients (c) within the drainage basin were based on assumed watershed characteristics of the basin (soil type, land cover, watershed slope) and obtained from Tables 3-1 and 3-2 of the Alaska Storm Water Guide (ADEC 2011). For each stormwater drainage area, the predominant hydrologic soil groups were obtained from either the NRCS soil survey (see Attachment C; NRCS n.d.) or current site conditions (e.g., use as a quarry). Land cover was evaluated based on current aerials for each of the drainage basins. Slope was obtained from the topographic survey in Attachment A or from the proposed surface slope of the repository cover. Selected c coefficients included 0.22 to represent the repository vegetated cover, 0.60 to represent the quarry walls and floor, and 0.13 to represent the forested area surrounding the quarry. These coefficients were weighted to obtain the Rational runoff coefficient, C. Runoff coefficients are shown in Attachment D.

CONCLUSIONS

The peak flow rates obtained will be used for design of the constructed stormwater controls for the engineered cover and on the repository site. The majority of runoff will be concentrated as channelized flow in engineered drainage paths prior to discharging from the site. Peak discharge calculations are included in Attachment E. Table E1 shows the peak discharge calculations for the existing conditions; Table E2 shows the peak discharge calculations for potential stormwater run-on onto and runoff from the engineered cover; and Table E3 shows the peak discharge calculations for all stormwater generated on the repository site following repository construction.

REFERENCES

ADEC (Alaska Department of Environmental Conservation); Division of Water. December 2011. *Alaska Storm Water Guide. Chapter 3 Storm Water Design Considerations and Methods.*

Ecology and Environment, April 2017, *Wrangell Junkyard Repository Site Cover Analysis - 30% Design*.

R&M Engineering, November 2016, *A Topographic Survey Plan of ADEC Contaminated Soil Repository within the City and Borough of Wrangell, Alaska Sitka Recording District*. R&M/PDC Project No. 16416JN.10

USDA, Natural Resources Conservation Service Soils, Web Soil Survey, March 13, 2017, https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/.

NOAA (National Oceanographic and Atmospheric Administration) Atlas 14, Volume 2, Version 7, March 28, 2017, http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

Attachment A

Drainage Basin Map

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ecology and environment, inc.
Global Environmental Specialists
Seattle, Washington

0' 15' 30' 60' 120'
CONTOUR INTERVAL = 2 FOOT

WRANGELL JUNKYARD
Wrangell, Alaska

Attachment A
DRAINAGE BASIN MAP

Date:	Drawn by:	
4/6/17		10:START IV\17010015\fig

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Attachment B

Point Precipitation Frequency Estimates

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NOAA Atlas 14, Volume 7, Version 2
Location name: Wrangell, Alaska, USA*
Latitude: 56.2447°, Longitude: -132.2987°
Elevation: 654.38 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Douglas Kane, Sarah Dietz, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Svetlana Stuefer, Amy Tidwell, Carl Trypaluk, Dale Unruh, Michael Yekta, Erica Betts, Geoffrey Bonnin, Sarah Heim, Lillian Hiner, Elizabeth Lilly, Jayashree Narayanan, Fenglin Yan, Tan Zhao

NOAA, National Weather Service, Silver Spring, Maryland
and
University of Alaska Fairbanks, Water and Environmental Research Center

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

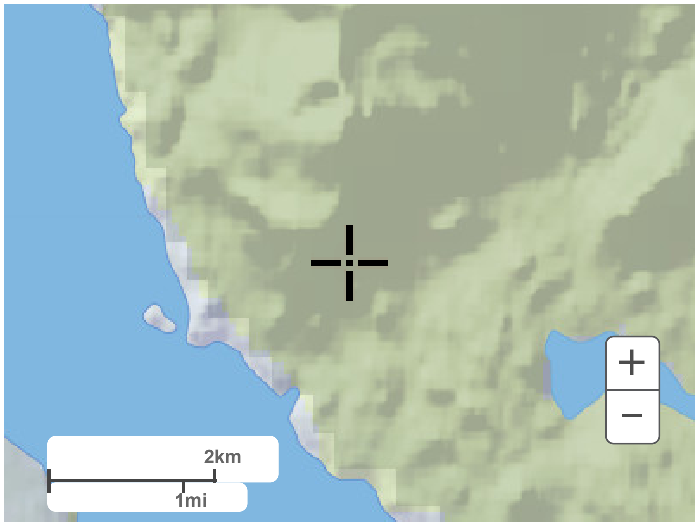
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	1.79 (1.49-2.27)	2.10 (1.73-2.69)	2.50 (2.00-3.26)	2.82 (2.23-3.76)	3.26 (2.52-4.44)	3.61 (2.75-5.00)	3.95 (2.95-5.56)	4.31 (3.17-6.17)	4.78 (3.44-6.98)	5.14 (3.65-7.63)
10-min	1.21 (1.00-1.53)	1.41 (1.16-1.81)	1.67 (1.34-2.19)	1.89 (1.49-2.51)	2.19 (1.69-2.98)	2.42 (1.84-3.35)	2.65 (1.99-3.73)	2.89 (2.13-4.14)	3.21 (2.32-4.70)	3.45 (2.45-5.13)
15-min	0.940 (0.780-1.19)	1.10 (0.904-1.42)	1.31 (1.05-1.71)	1.48 (1.17-1.96)	1.71 (1.32-2.32)	1.89 (1.44-2.61)	2.07 (1.55-2.92)	2.26 (1.66-3.23)	2.50 (1.81-3.66)	2.69 (1.91-4.00)
30-min	0.624 (0.518-0.790)	0.732 (0.600-0.938)	0.868 (0.698-1.14)	0.980 (0.776-1.30)	1.13 (0.878-1.54)	1.25 (0.954-1.74)	1.37 (1.03-1.93)	1.50 (1.10-2.14)	1.66 (1.20-2.43)	1.79 (1.27-2.65)
60-min	0.427 (0.355-0.541)	0.501 (0.411-0.643)	0.594 (0.478-0.778)	0.671 (0.531-0.893)	0.777 (0.601-1.06)	0.859 (0.654-1.19)	0.941 (0.705-1.32)	1.03 (0.756-1.47)	1.14 (0.821-1.67)	1.22 (0.868-1.82)
2-hr	0.322 (0.268-0.408)	0.379 (0.311-0.486)	0.449 (0.361-0.588)	0.507 (0.401-0.675)	0.588 (0.454-0.800)	0.650 (0.494-0.900)	0.712 (0.533-1.00)	0.776 (0.572-1.11)	0.860 (0.620-1.26)	0.925 (0.657-1.38)
3-hr	0.287 (0.238-0.363)	0.337 (0.276-0.432)	0.399 (0.320-0.522)	0.451 (0.356-0.600)	0.522 (0.404-0.710)	0.577 (0.439-0.799)	0.632 (0.474-0.890)	0.690 (0.508-0.987)	0.765 (0.552-1.12)	0.823 (0.584-1.22)
6-hr	0.234 (0.194-0.296)	0.275 (0.225-0.352)	0.326 (0.262-0.426)	0.368 (0.291-0.490)	0.426 (0.330-0.580)	0.471 (0.358-0.652)	0.516 (0.386-0.726)	0.562 (0.414-0.805)	0.624 (0.450-0.913)	0.671 (0.476-0.997)
12-hr	0.175 (0.146-0.222)	0.206 (0.169-0.265)	0.247 (0.198-0.323)	0.279 (0.220-0.371)	0.322 (0.249-0.438)	0.356 (0.271-0.493)	0.390 (0.292-0.548)	0.425 (0.313-0.608)	0.471 (0.340-0.689)	0.506 (0.360-0.753)
24-hr	0.128 (0.112-0.147)	0.150 (0.130-0.175)	0.180 (0.153-0.214)	0.203 (0.170-0.246)	0.234 (0.191-0.290)	0.258 (0.207-0.325)	0.282 (0.222-0.361)	0.307 (0.238-0.399)	0.340 (0.258-0.452)	0.365 (0.273-0.493)
2-day	0.088 (0.077-0.101)	0.102 (0.088-0.119)	0.121 (0.102-0.144)	0.135 (0.112-0.163)	0.153 (0.125-0.190)	0.167 (0.134-0.211)	0.182 (0.143-0.232)	0.196 (0.152-0.255)	0.215 (0.163-0.286)	0.230 (0.172-0.310)
3-day	0.070 (0.062-0.081)	0.081 (0.070-0.094)	0.094 (0.080-0.112)	0.105 (0.087-0.126)	0.118 (0.096-0.146)	0.128 (0.103-0.161)	0.138 (0.109-0.177)	0.149 (0.115-0.194)	0.162 (0.123-0.216)	0.173 (0.129-0.233)
4-day	0.060 (0.053-0.069)	0.069 (0.060-0.080)	0.080 (0.068-0.095)	0.088 (0.074-0.107)	0.099 (0.081-0.123)	0.107 (0.086-0.135)	0.115 (0.091-0.148)	0.124 (0.096-0.161)	0.134 (0.102-0.179)	0.142 (0.106-0.192)
7-day	0.046 (0.041-0.053)	0.053 (0.046-0.062)	0.061 (0.052-0.073)	0.068 (0.056-0.082)	0.075 (0.061-0.093)	0.081 (0.065-0.102)	0.086 (0.068-0.110)	0.092 (0.071-0.119)	0.099 (0.075-0.131)	0.104 (0.078-0.140)
10-day	0.039 (0.035-0.045)	0.045 (0.039-0.053)	0.052 (0.045-0.062)	0.057 (0.048-0.070)	0.064 (0.052-0.079)	0.068 (0.055-0.086)	0.072 (0.057-0.093)	0.076 (0.059-0.099)	0.082 (0.062-0.109)	0.086 (0.064-0.116)
20-day	0.031 (0.027-0.035)	0.035 (0.031-0.041)	0.041 (0.034-0.048)	0.044 (0.037-0.053)	0.048 (0.039-0.060)	0.051 (0.041-0.064)	0.054 (0.043-0.069)	0.057 (0.044-0.074)	0.060 (0.046-0.080)	0.063 (0.047-0.085)
30-day	0.027 (0.024-0.032)	0.031 (0.027-0.037)	0.036 (0.031-0.043)	0.039 (0.033-0.047)	0.042 (0.035-0.053)	0.045 (0.036-0.057)	0.047 (0.037-0.061)	0.049 (0.038-0.064)	0.052 (0.040-0.069)	0.054 (0.041-0.073)
45-day	0.025 (0.022-0.028)	0.028 (0.024-0.033)	0.032 (0.027-0.038)	0.034 (0.029-0.042)	0.037 (0.030-0.046)	0.039 (0.031-0.049)	0.041 (0.033-0.053)	0.043 (0.033-0.056)	0.045 (0.034-0.060)	0.047 (0.035-0.063)
60-day	0.022 (0.019-0.025)	0.025 (0.022-0.029)	0.028 (0.024-0.034)	0.030 (0.025-0.037)	0.033 (0.027-0.040)	0.034 (0.028-0.043)	0.036 (0.028-0.046)	0.037 (0.029-0.049)	0.039 (0.030-0.052)	0.041 (0.030-0.055)

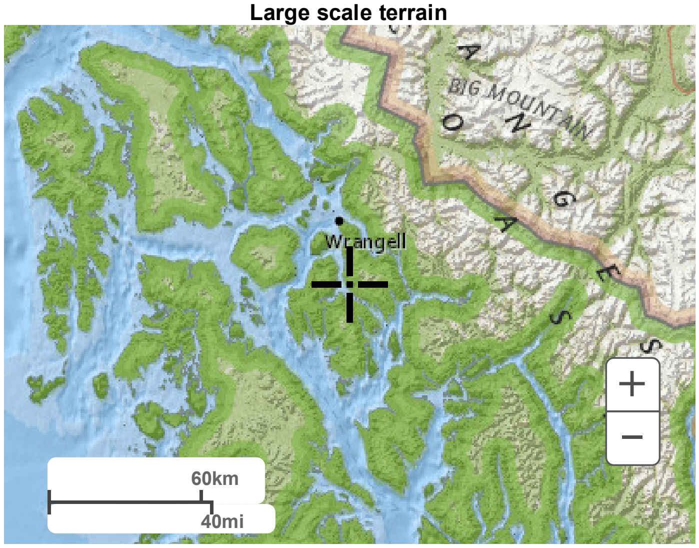
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

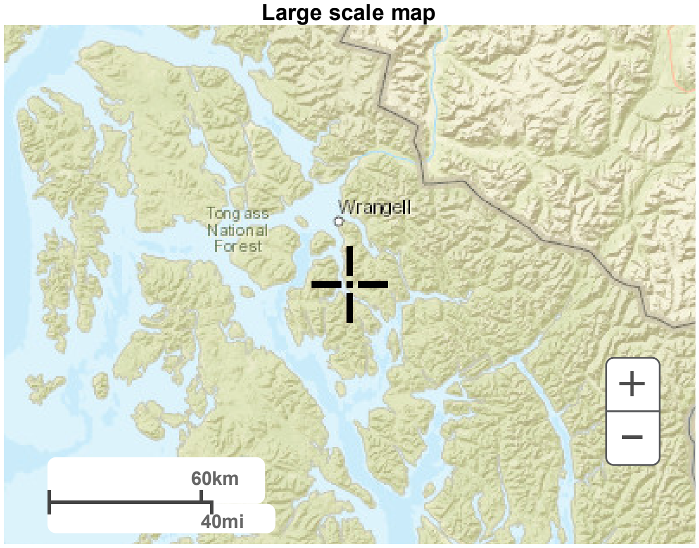
Please refer to NOAA Atlas 14 document for more information.



Large scale terrain



Large scale map



Large scale aerial

Attachment C

Natural Resources Conservation Service, Web Soil Survey

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United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Stikine Area, Alaska

March 1, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

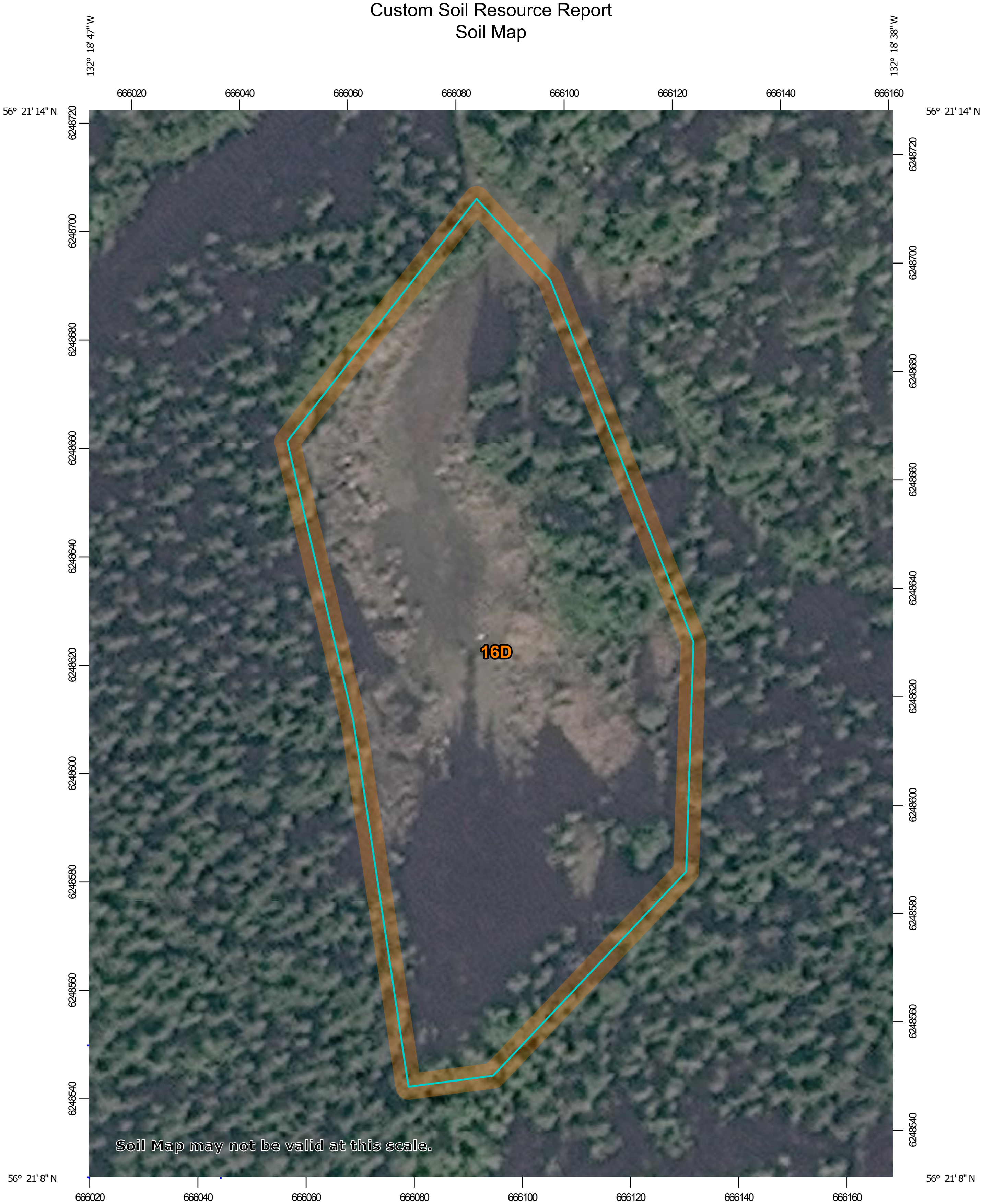
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

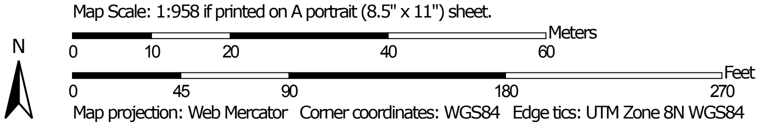
Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:958 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 8N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:31,700.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Stikine Area, Alaska
Survey Area Data: Version 10, Sep 27, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Stikine Area, Alaska (AK645)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
16D	Kupreanof-Mosman complex, 35 to 75 percent slopes	1.9	100.0%
Totals for Area of Interest		**1.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Stikine Area, Alaska

16D—Kupreanof-Mosman complex, 35 to 75 percent slopes

Map Unit Setting

National map unit symbol: 1ngq
Elevation: 0 to 3,000 feet
Mean annual precipitation: 21 to 220 inches
Mean annual air temperature: 39 to 48 degrees F
Frost-free period: 90 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Kupreanof and similar soils: 45 percent
Mosman and similar soils: 45 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kupreanof

Setting

Landform: Mountains
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Colluvium and/or glaciofluvial deposits

Typical profile

H1 - 0 to 1 inches: silt loam
H2 - 1 to 8 inches: gravelly sandy loam
H3 - 8 to 25 inches: very gravelly coarse sandy loam
H4 - 25 to 60 inches: very gravelly sandy loam

Properties and qualities

Slope: 35 to 75 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Hydric soil rating: No

Description of Mosman

Setting

Landform: Mountains
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Colluvium derived from granodiorite and/or residuum weathered from granodiorite

Typical profile

H1 - 0 to 1 inches: very gravelly loam
H2 - 1 to 11 inches: very gravelly loam
H3 - 11 to 15 inches: unweathered bedrock

Properties and qualities

Slope: 35 to 75 percent
Depth to restrictive feature: 3 to 14 inches to lithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 1.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Mcgilvery

Percent of map unit: 4 percent
Landform: Mountains
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Mitkof

Percent of map unit: 3 percent
Landform: Mountains, till plains
Down-slope shape: Linear
Across-slope shape: Concave
Hydric soil rating: No

Wadleigh

Percent of map unit: 3 percent
Landform: Depressions on hills
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Particle Size and Coarse Fragments (Monofill Location)

This table shows estimates of particle size distribution and coarse fragment content of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Total fragments is the content of fragments of rock and other materials larger than 2 millimeters in diameter on volumetric basis of the whole soil.

Fragments 2-74 mm refers to the content of coarse fragments in the 2 to 74 millimeter size fraction.

Fragments 75-249 mm refers to the content of coarse fragments in teh 75 to 249 millimeter size fraction.

Fragments 250-599 mm refers to the content of coarse fragments in the 250 to 599 millimeter size fraction.

Fragments >=600 mm refers to the content of coarse fragments in the greater than or equal to 600 millimeter size fraction.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Particle Size and Coarse Fragments–Stikine Area, Alaska										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
16D—Kupreanof-Mosman complex, 35 to 75 percent slopes										
Kupreanof	H1	0-1	-37-	-58-	0- 5- 10	14	12	2	—	—
	H2	1-8	-64-	-31-	0- 5- 10	27	24	3	—	—
	H3	8-25	-65-	-30-	0- 5- 10	38	29	9	—	—
	H4	25-60	-64-	-31-	0- 5- 10	46	29	17	—	—
Mosman	H1	0-1	-47-	-45-	5- 8- 10	34	31	3	—	—
	H2	1-11	-49-	-46-	0- 5- 10	40	30	10	—	—
	H3	11-15	—	—	—	—	—	—	—	—
McGilvery	Oi	0-8	—	—	—	2	—	2	—	—
	2C	8-9	-37-	-58-	0- 5- 10	44	32	12	—	—
	R	9-13	—	—	—	—	—	—	—	—
Mitkof	H1	0-1	-69-	-24-	5- 8- 10	13	8	5	—	—
	H2	1-11	-38-	-60-	0- 3- 5	35	28	7	—	—
	H3	11-60	-50-	-48-	0- 3- 5	33	20	13	—	—
Wadleigh	H1	0-2	-38-	-60-	0- 3- 5	20	18	2	—	—
	H2	2-11	-38-	-60-	0- 3- 5	40	37	3	—	—
	H3	11-60	-37-	-58-	0- 5- 10	42	39	3	—	—

Engineering Properties (Monofill Location)

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Percentage of rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties–Stikine Area, Alaska														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
16D—Kupreanof-Mosman complex, 35 to 75 percent slopes														
Kupreanof	45	C	0-1	Silt loam	ML	A-4	0- 0- 0	0- 3- 5	85-93-100	75-88-100	65-80-95	55-65-75	—	NP
			1-8	Gravelly sandy loam, gravelly silt loam, sandy loam	SM, ML, GM	A-4, A-2, A-1	0- 0- 0	0- 5- 10	65-80-95	55-70-85	40-58-75	20-40-60	—	NP
			8-25	Very gravelly coarse sandy loam, very cobbly sandy loam	SM, GM	A-4, A-2, A-1	0- 0- 0	0-15- 30	50-60-70	40-50-60	20-35-50	15-28-40	—	NP
			25-60	Very gravelly sandy loam, extremely cobbly coarse sandy loam	SM, GP-GM, GM, SP-SM	A-1	0- 0- 0	5-30- 55	45-58-70	35-45-55	15-28-40	10-15-20	—	NP
Mosman	45	D	0-1	Very gravelly loam	GM, SM	A-2, A-1	0- 0- 0	0- 5- 10	55-63-70	35-45-55	30-40-50	20-28-35	35-40-45	NP-3 -5
			1-11	Very gravelly loam, extremely gravelly silt loam	GM, SM	A-2, A-1	0- 0- 0	10-18-25	55-63-70	25-40-55	20-35-50	15-25-35	35-40-45	NP-3 -5
			11-15	Unweathered bedrock	—	—	—	—	0- 0- 0	0- 0- 0	—	—	—	—
Mcgilvery	4	D	0-8	Peat	PT	A-8	0- 0- 0	0- 3- 5	0- 0- 0	0- 0- 0	—	—	—	—
			8-9	Extremely gravelly loam, very gravelly silt loam	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	15-20-25	50-55-60	20-28-35	15-23-30	10-15-20	—	NP

Engineering Properties–Stikine Area, Alaska														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
			9-13	Unweathered bedrock	—	—	—	—	0- 0- 0	0- 0- 0	—	—	—	—
Mitkof	3	C	0-1	Sandy loam	ML, SM	A-5	0- 0- 0	0- 8- 15	90-95-100	85-93-100	65-80-95	45-53-60	40-45-50	NP-3 -5
			1-11	Gravelly silt loam, very gravelly sandy loam, very cobbly loam	GM, SM	A-1, A-2	0- 0- 0	5-13- 20	60-65-70	35-48-60	25-40-55	15-23-30	40-45-50	NP-3 -5
			11-60	Very gravelly loam, very cobbly sandy loam, very gravelly coarse sandy loam	SM	A-1	0- 0- 0	15-23-30	70-73-75	45-48-50	30-38-45	15-20-25	20-25-30	NP-3 -5
Wadleigh	3	D	0-2	Silt loam	ML, SM	A-4	0- 0- 0	0- 3- 5	80-90-100	60-78-95	55-73-90	40-55-70	—	NP
			2-11	Very gravelly silt loam, very gravelly sandy loam	GM, SM	A-2, A-1	0- 0- 0	0- 5- 10	40-55-70	30-40-50	25-35-45	15-25-35	—	NP
			11-60	Extremely gravelly silt loam, very gravelly sandy loam, very gravelly loam	GC-GM, GM, GP-GM	A-2, A-1	0- 0- 0	0- 5- 10	40-50-60	20-35-50	15-28-40	10-23-35	15-18-20	NP-3 -5

Particle Size and Coarse Fragments (Monofill Location)

This table shows estimates of particle size distribution and coarse fragment content of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Total fragments is the content of fragments of rock and other materials larger than 2 millimeters in diameter on volumetric basis of the whole soil.

Fragments 2-74 mm refers to the content of coarse fragments in the 2 to 74 millimeter size fraction.

Fragments 75-249 mm refers to the content of coarse fragments in teh 75 to 249 millimeter size fraction.

Fragments 250-599 mm refers to the content of coarse fragments in the 250 to 599 millimeter size fraction.

Fragments >=600 mm refers to the content of coarse fragments in the greater than or equal to 600 millimeter size fraction.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Particle Size and Coarse Fragments–Stikine Area, Alaska										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
16D—Kupreanof-Mosman complex, 35 to 75 percent slopes										
Kupreanof	H1	0-1	-37-	-58-	0- 5- 10	14	12	2	—	—
	H2	1-8	-64-	-31-	0- 5- 10	27	24	3	—	—
	H3	8-25	-65-	-30-	0- 5- 10	38	29	9	—	—
	H4	25-60	-64-	-31-	0- 5- 10	46	29	17	—	—
Mosman	H1	0-1	-47-	-45-	5- 8- 10	34	31	3	—	—
	H2	1-11	-49-	-46-	0- 5- 10	40	30	10	—	—
	H3	11-15	—	—	—	—	—	—	—	—
McGilvery	Oi	0-8	—	—	—	2	—	2	—	—
	2C	8-9	-37-	-58-	0- 5- 10	44	32	12	—	—
	R	9-13	—	—	—	—	—	—	—	—
Mitkof	H1	0-1	-69-	-24-	5- 8- 10	13	8	5	—	—
	H2	1-11	-38-	-60-	0- 3- 5	35	28	7	—	—
	H3	11-60	-50-	-48-	0- 3- 5	33	20	13	—	—
Wadleigh	H1	0-2	-38-	-60-	0- 3- 5	20	18	2	—	—
	H2	2-11	-38-	-60-	0- 3- 5	40	37	3	—	—
	H3	11-60	-37-	-58-	0- 5- 10	42	39	3	—	—

Physical Soil Properties (Monofill Location)

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Physical Soil Properties–Stikine Area, Alaska														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
16D—Kupreanof-Mosman complex, 35 to 75 percent slopes														
Kupreanof	0-1	-37-	-58-	0- 5- 10	1.10-1.15-1.20	4.23-9.17-14.11	0.19-0.20-0.21	0.0- 1.5- 2.9	4.0- 6.0-8.0	.24	.28	5	2	134
	1-8	-64-	-31-	0- 5- 10	1.10-1.15-1.20	4.23-9.17-14.11	0.12-0.14-0.15	0.0- 1.5- 2.9	6.0-8.0-10.0	.17	.28			
	8-25	-65-	-30-	0- 5- 10	1.30-1.35-1.40	14.11-28.23-42.34	0.06-0.08-0.10	0.0- 1.5- 2.9	4.0- 6.0-8.0	.15	.43			
	25-60	-64-	-31-	0- 5- 10	1.30-1.35-1.40	14.11-28.23-42.34	0.04-0.05-0.06	0.0- 1.5- 2.9	1.0- 2.0-3.0	.10	.43			
Mosman	0-1	-47-	-45-	5- 8- 10	1.10-1.15-1.20	4.23-9.17-14.11	0.10-0.11-0.12	0.0- 1.5- 2.9	8.0-10.0-12.0	.15	.32	1	5	56
	1-11	-49-	-46-	0- 5- 10	1.10-1.15-1.20	4.23-9.17-14.11	0.10-0.11-0.12	0.0- 1.5- 2.9	10.0-12.0-14.0	.15	.55			
	11-15	—	—	—	—	—	—	—	—					
Mcgilvery	0-8	—	—	—	0.05-0.08-0.10	42.34-91.74-141.14	0.23-0.24-0.25	0.0- 1.5- 2.9	0.8- 0.9-1.0	.05	.05	1	8	0
	8-9	-37-	-58-	0- 5- 10	1.50-1.55-1.60	42.34-91.74-141.14	0.06-0.09-0.12	0.0- 1.5- 2.9	1.0- 2.0-3.0	.10	.55			
	9-13	—	—	—	—	—	—	—	—					
Mitkof	0-1	-69-	-24-	5- 8- 10	0.90-1.00-1.10	4.23-9.17-14.11	0.21-0.22-0.23	0.0- 1.5- 2.9	12.0-13.5-15.0	.37	.37	5	3	86
	1-11	-38-	-60-	0- 3- 5	1.20-1.25-1.30	4.23-9.17-14.11	0.10-0.11-0.12	0.0- 1.5- 2.9	6.0- 7.0-8.0	.15	.43			
	11-60	-50-	-48-	0- 3- 5	1.30-1.35-1.40	4.23-9.17-14.11	0.06-0.07-0.08	0.0- 1.5- 2.9	1.0- 2.0-3.0	.10	.37			

Physical Soil Properties–Stikine Area, Alaska														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
Wadleigh	0-2	-38-	-60-	0- 3- 5	1.10-1.15-1.20	4.23-9.17-14.11	0.18-0.19-0.20	0.0- 1.5- 2.9	3.0- 4.5-6.0	.43	.55	1	8	0
	2-11	-38-	-60-	0- 3- 5	1.40-1.50-1.60	4.23-9.17-14.11	0.08-0.09-0.10	0.0- 1.5- 2.9	8.0-9.0-10.0	.28	.64			
	11-60	-37-	-58-	0- 5- 10	1.80-1.95-2.10	0.00-0.21-0.42	0.00-0.00-0.00	0.0- 1.5- 2.9	0.5- 1.0-5.0	.10	.37			

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Attachment D

Rational Runoff Coefficients

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Table 3-1. Correlation of soil texture with soil infiltration rate and HSG

Soil texture	Infiltration rate (if not measured directly) inches per hour[a]	Hydrologic Soil Group	General soil infiltration classification
Coarse sand (or coarser)	3.6	A	High
Loamy coarse sand	3.6	A	High
Sand	3.6	A	High
Loamy Sand	1.63	A	High
Sandy Loam	0.5	A	High
Loam	0.24	B	Moderate
Silt loam	0.13	B	Moderate
Sandy clay loam	0.11	$\boxed{\text{C}}$	Moderate
Clay loam	0.09	D	Low
Silty clay loam	0.06[b]	D	Low
Sandy clay	0.05	D	Low
Silty clay	0.04	D	Low
Clay	0.02	D	Low

a. Infiltration rates represent the lowest value for each textural class presented in Table 2 of Rawls et al, 1998.

b. Generalized values provide in Brakensiek and Rawls, (1983).

Table 3-2. Rational formula coefficients for various HSGs

		HYDROLOGIC SOIL GROUP											
		A soil			B soil			C soil			D soil		
Slope		0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%
Landcover													
Forest, brush	a*	0.05	0.08	0.11	0.08	0.11	0.14	0.10	$\boxed{0.13}$	0.16	0.12	0.16	0.20
	b*	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Wetland	a							0.12	0.16	0.20	0.12	0.16	0.20
Parkland	a	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
	b	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Cultivated	a	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
	b	0.08	0.14	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Pasture	a	0.12	0.20	0.30	0.18	0.28	0.37	0.24	0.34	0.44	0.30	0.40	0.50
	b	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Lawn	a	0.17	0.22	0.35	0.17	0.22	0.35	0.17	$\boxed{0.22}$	0.35	0.17	0.22	0.35
Barren	a	0.25	0.30	0.35	0.25	0.30	0.35	0.50	0.55	0.60	$\boxed{0.50}$	0.55	$\boxed{0.60}$
Graded slope													
Gravel	a	0.25	0.30	0.35	0.25	0.30	0.35	0.50	0.55	0.60	0.50	0.55	0.60
Earthen	a	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Drives, walks	a	0.75	0.80	0.85	0.75	0.80	0.85	0.75	0.80	0.85	0.75	0.80	0.85
Streets													
Gravel	a	0.50	0.55	0.60	0.50	0.55	0.60	0.50	0.55	0.60	0.50	0.55	0.60
Paved	a	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
	b	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97
Impervious	a	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
	b	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

* - a, ≤ 25-year, 24-hour event; b, >25-year, 24-hour event

Modified from: Rawls et al. 1981; WSDOT 2005.

Attachment E

Peak Discharge Calculations

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Runoff Calculations, Rational Method - Wrangell Repository Site, Wrangell, Alaska

Q = CiA

c (surrounding forest) = 0.13
c (quarry walls, earth) = 0.6
c (vegetated repository cover) = 0.22
c (quarry floor, barren) = 0.5
Total Area (A) (sf) = 66,245
A (repository cover) (sf) = 33,100
A (upgradient forested area) (sf) = 1,895

A (upgradient surrounding area) (sf) = 17,057
A (downgradient area in drainage) (sf) = 14,193

NOTE: Rational formula '*c'* values were obtained from Table 3-1 and Table 3-2 in Chapter 3, Storm Water Design Considerations and Methods, of the December 2011 Alaska Storm Water Guide.

Table E1. Runoff Calculations for Upgradient Land Prior to Repository Construction		
A (sf) =	52,052	
$c_{weighted}$, *C (dimensionless) =*	0.52	
Storm Intensity	***i* (in/hr)**	***Q* (cfs)**
2-year / 6 hour	0.275	0.171
2-year / 24 hour	0.15	0.093
5-year / 24 hour	0.18	0.112
10-year / 24 hour	0.203	0.126
25-year / 15 min	1.71	1.061
25-year / 30 min	1.13	0.701
25-year / 60 min	0.777	0.482
25-year / 2 hour	0.588	0.365
25-year / 3 hour	0.522	0.324
25-year / 6 hour	0.426	0.264
25-year / 12 hour	0.322	0.200
25-year / 24 hour	0.234	0.145
50-year / 24 hour	0.258	0.160
100-year / 24 hour	0.282	0.175

Table E2. Runoff Calculations for Engineered Cover and Upgradient Land Only		
A (sf) =	52,052	
c *weighted* , *C (dimensionless)* =	0.34	
Storm Intensity	***i* (in/hr)**	***Q* (cfs)**
2-year / 6 hour	0.275	0.112
2-year / 24 hour	0.15	0.061
5-year / 24 hour	0.18	0.073
10-year / 24 hour	0.203	0.083
25-year / 15 min	1.71	0.697
25-year / 30 min	1.13	0.461
25-year / 60 min	0.777	0.317
25-year / 2 hour	0.588	0.240
25-year / 3 hour	0.522	0.213
25-year / 6 hour	0.426	0.174
25-year / 12 hour	0.322	0.131
25-year / 24 hour	0.234	0.095
50-year / 24 hour	0.258	0.105
100-year / 24 hour	0.282	0.115

Table E3. Runoff Calculations for Entire Rock Pit Area		
A (sf) =	66,245	
c *weighted* , *C (dimensionless)* =	0.38	
Storm Intensity	***i* (in/hr)**	***Q* (cfs)**
2-year / 6 hour	0.275	0.157
2-year / 24 hour	0.15	0.086
5-year / 24 hour	0.18	0.103
10-year / 24 hour	0.203	0.116
25-year / 15 min	1.71	0.976
25-year / 30 min	1.13	0.645
25-year / 60 min	0.777	0.443
25-year / 2 hour	0.588	0.336
25-year / 3 hour	0.522	0.298
25-year / 6 hour	0.426	0.243
25-year / 12 hour	0.322	0.184
25-year / 24 hour	0.234	0.134
50-year / 24 hour	0.258	0.147
100-year / 24 hour	0.282	0.161

Appendix A-3 Cover system evaluation/HELP model

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ecology and environment, inc.

Design Memorandum

Date:	6/9/2017
To:	Design File
From:	Jeff Guerrero
Reviewer:	Thomas C. Campbell, P.E.
Subject:	Wrangell Junkyard Repository Site Cover Analysis

PROFESSIONAL ENGINEER CERTIFICATION PAGE

Wrangell Junkyard Repository Site Cover Analysis
Wrangell Junkyard Repository Site
Wrangell, Alaska
TDD: 17-01-0005

Pursuant to Alaska Administrative Code (AAC) 12 AAC 36.185(a)(3), only final plans, surveys, reports, and required construction documents approved for building permit issuance for which the registrant is qualified to seal and for which the registrant claims responsibility are required to be submitted under the seal of a State of Alaska licensed professional engineer. This page provides the signature and seal to comply with the regulation.

I hereby certify that this Cover Analysis for the Wrangell Junkyard Repository Site in Wrangell, Alaska, was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Alaska. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

SIGNATURE:

REGISTRATION NUMBER: EV14234
STATE: Alaska

DATE: 06-09-2017

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OBJECTIVE

This memorandum describes the preliminary repository cover design for a proposed monofill waste repository to contain waste soils that originated from the Wrangell Junkyard Site. The intent of this information is to provide an understanding of the proposed final cover for the waste material and to assist in evaluation of various performance criteria, including slope stability and hydrology, described in other memoranda.

CRITERIA

Alaska Department of Conservation (ADEC) requirements and performance characteristics that were considered in this design include separation from groundwater, cover material, runoff drainage, impedance of biological impacts, erosion, and final vegetation.

The Alaska Administrative Code 18 AAC 60.217 identifies ADEC requirements for landfill separation from groundwater. The code requires unlined landfills or repositories to have at least 10 feet of separation between the highest measured aquifer level and the bottom of the waste material unless the landfill is constructed 2 feet or more above the natural ground surface.

18 AAC 60.485 requires a cover design that minimizes infiltration through the waste material. A permeability of $1x10^{-5}$ centimeters per second (cm/sec) or less is required.

To provide drainage for stormwater infiltrating through the cover while also considering biological impacts, a 1-foot layer of drainage rock has been considered at a slope of no steeper than 3:1, in accordance with 18 AAC 60.

The topsoil material layer should be sufficient to support vegetation while promoting drainage away from the monofill such that erosion is minimized. To minimize erosion, 18 AAC 60.485(d)(2) requires a minimum of 6 inches of earthen material capable of sustaining native plant growth.

METHOD OF ANALYSIS

Analysis of slope stability for the preliminary design is documented in the memorandum *Wrangell Junkyard Repository Slope Stability Analysis*, and site hydrology is presented in the technical memorandum *Wrangell Junkyard Repository Hydrologic Analysis.* Analysis of infiltration through the cover system has been performed based on the proposed cover design discussed herein. The U.S. Environmental Protection Agency (EPA) and U.S. Army Corps of Engineers Hydrologic Evaluation of Landfill Performance (HELP) model, Version 3 was used to analyze infiltration. Results are discussed below, while Attachment A presents the HELP model output.

ASSUMPTIONS

An initial conversation between the EPA, ADEC, and Ecology and Environment, Inc. (E & E) on March 2, 2017, addressed a preliminary cover design for the proposed monofill. The first consideration was a suitable base material below the waste to ensure that the requirements of 18 AAC 60.217 were met. Doug Buteyn (ADEC Solid Waste Program) confirmed that 2 feet of clean material placed above existing grade would provide the required separation of emplaced waste from groundwater.

Figure 1 presents the proposed repository footprint and waste placement extents. The final design will require 2 feet of shot rock on top of existing grade in order to meet the requirements of AAC 60.485. The shot rock is available on site across the quarry floor; however, no volume estimate has been generated. Additional rock can be shot off the quarry walls to create the volume necessary for 2 feet of separation above existing grade. It is anticipated that the shot rock material will have considerable void space. Therefore, smaller aggregates such as 6-inch minus rock and 1-inch minus aggregate should be used to fill the void space via vibratory compaction. In addition, a non-woven geotextile fabric will be placed above the 2-foot base and smaller aggregate to limit the potential for waste material to migrate below the intended bottom elevation. The proposed repository layering is presented in Figure 2.

Waste material (ECOBOND-treated soil) will be placed above the 2-foot base. It is assumed that this material will be transported from the current stockpile at the Wrangell Junkyard Site to the proposed repository site (herein referred to as "the repository site") in a manner that ensures it remains dry until final cover installation. Waste material should be compacted and have a smooth top surface. The waste volume to be placed in the repository is 18,515 cubic yards (NRC Alaska). A flexible membrane liner (FML) will act as a barrier layer against infiltration. The FML will easily meet the $1x10^{-5}$ cm/sec requirement for a cover system under 18 AAC 60.485. A 4-inch layer of 3/8-inch minus gravel will be placed directly above the treated waste soil to protect the liner from puncture.

When choosing an FML, material performance must be considered. Three common FML materials were analyzed for the repository hydraulic barrier layer: high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), and polyvinyl chloride (PVC). While many comparison factors exist, several factors that should be considered are highlighted here and summarized in Table 1. Given the size of the area that will receive a liner, the ease of installation should be considered. PVC and LLDPE can be assembled by welding the seams in a factory setting prior to shipping to the repository site. The size of preassembled LLDPE panels can be over 25,000 square feet, depending on thickness. Factory welding may also help to limit potentially poor field welds that may lead to high stress points and eventual cracks. HDPE liner welds must be performed in the field utilizing 23-foot width (typical) rolls. For optimal seams, folds and wrinkles must be limited (Contain Enviro Services 2017).

Flexibility is a factor that impacts ease of installation, as well as other performance characteristics. Flexibility is particularly important for this design since up to 45 feet of fill is being placed, which will likely encounter some level of settling. In general, HDPE is the most rigid of the considered materials, and becomes more rigid at lower temperatures. PVC is typically flexible, while LLDPE is very flexible. Uni-axial and multi-axial elongation are standard measures of FML materials that assess the material's ability to withstand directional stretching. Overall, LLDPE has the best elongation performance, while HDPE is weak in response to multi-axial elongation (Sadlier 1997). A related factor is the capacity for elongation prior to failure, which measures the percent elongation that can occur before breaking. HDPE is limited to 18%, PVC is less than 500%, and LLDPE exceeds 800% elongation (GSE Environmental 2017).

Environmental stress cracks can develop in certain FMLs for various reasons, including extreme temperature swings, poor contact at the seams, and contact with incompatible material. PVC is the most resistant to stress cracks. HDPE has been known to produce these cracks, while they occur in LLDPE less often (Sadlier 1997).

Due to the limited analyses performed on the waste material, chemical resistance may be a prudent characteristic to consider. While resistance to a wide range of specific compounds is detailed for each FML type, this discussion is limited to the general ability to withstand chemical exposure. HDPE is considered excellent, while PVC is fair. LLDPE is considered good with regard to general chemical exposure (Sadlier 1997).

Based on the stated FMP performance characteristics, LLDPE has been selected. This is based on several criteria, including the relative ease of installation, flexibility, and elongation performance. The ability to have panels factory assembled makes LLDPE a better choice than HDPE. The ease of field seaming and repair makes it a better choice than PVC. Flexibility is the greatest differentiator between LLDPE and either HDPE or PVC.

Table 1 FML Performance Characteristics

Performance Criteria	HDPE	LLDPE	PVC
Ease of installation	Field welds, multiple rolls	Can be factory-assembled	Can be factory-assembled
Flexibility	Somewhat rigid	Very Flexible	Flexible
Uni-axial elongation performance	Excellent	Excellent	Good
Multi-axial elongation performance	Poor	Excellent	Excellent
Environmental stress cracks	Occurs	Occurs less than HDPE	Does not occur
General chemical exposure	Excellent	Good	Fair

Above the FML layer, a drainage layer consisting of 6 inches of 3/8-inch minus gravel will be placed as a bedding material for 12 inches of drain rock (1-inch minus aggregate). The 3/8-inch minus gravel will help prevent drain rock from tearing the FML and will provide a base for perforated drainpipe. An upper portion of the 12-inch drainage layer may be replaced with larger cobble or stone available from the quarry or current waste material stockpile area as a means of limiting burrowing animals. However, research has not indicated that this is a concern for the repository site (ADFG 2017). Above the drain rock layer, 18 inches of clean cover soil is planned to underlie 6 inches of topsoil that will be planted. A geotextile fabric will separate the cover soil layer from the drainage layer.

As mentioned above, the HELP model was used to estimate the infiltration potential of the proposed cover. Modeling an FML requires consideration of manufacturing and installation defects. Based on HELP guidance, one pinhole (1 millimeter in diameter) per acre was assumed for manufacturing defects, and four installation defects per acre (1 square centimeter in area) were used, which is considered a good installation with minimized wrinkling (Schroeder). Therefore, it is anticipated that some level of infiltration will occur when using an FML as a hydraulic barrier. The HELP model has been developed based on assumed soil characteristics consistent with soils found on Wrangell Island. In late March 2017, E & E collected samples from the treated waste, local quarry aggregates, and a potential cover soil and has used geotechnical analysis data in the HELP calculations.

A topographic survey of the repository site was used to generate a grading plan based on the known volume of waste. A section view of the proposed repository is shown in Figure 3. The design for the southern half of the repository, which has a flatter slope and the thickest placement of waste material (see Figure 4), was used in the HELP model calculations. Based on geotechnical soil property data, the HELP model calculates a peak daily value of 780 gallons per acre of water infiltration through the bottom layer. The calculated average annual infiltration through the bottom layer over 30 years is 72,200 gallons per acre per year. HELP output data are presented in Attachment A.

CONCLUSIONS

Based on the March 2 conversation with ADEC and EPA, E & E recommends constructing the monofill on a 2-foot layer of on-site rock material. Based on E & E's site visit in 2016, it is understood that some rock is available at the repository site already as shot rock. It is not known whether the quantity is sufficient to construct the entire monofill base.

A non-woven geotextile fabric will be placed above the 2-foot base layer. The treated waste material will be placed next and compacted in 6- to 12-inch lifts. The material must remain protected from rainfall during transportation from the stockpile site to the monofill location. In accordance with 18 AAC 60, the top of this layer will maintain a crown to promote stormwater runoff to the sides of the repository. Along the back and sides of the repository, drainage ditches will collect stormwater runoff. At the repository sides, a 3-foot wide chimney drain will be installed to collect water within the repository and potential water from the adjacent quarry walls. It is recommended that the chimneys be constructed of 6-inch minus rock. A 4:1 (H:V) slope is proposed toward the front of the repository such that the front of the cover will tie into the emplaced 2-foot base layer. Based on topographic survey and a waste material volume of 18,515 cubic yards, the waste material will be placed up to a thickness of 38 feet at the back of the repository, which corresponds with the 293.5-foot contour. As Figure 2 shows, the cover layers will extend another 3.5 feet above the waste, to an elevation of 297. The engineered cap will extend 314 feet to the north before tying into existing grade of the quarry (see Figure 4).

Above the waste fill, a 4-inch layer of 3/8-inch minus aggregate will be placed as FML protection against large material within the waste. Next, a textured 40-mil LLDPE FML layer is proposed as the infiltration barrier for stormwater. Immediately above the liner, 6 inches of 3/8-inch minus aggregate will be placed as FML protection against puncture from the drain rock above, and as bedding for perforated drainpipe.

Above the bedding material, a 12-inch drainage layer composed of D-1 (1-inch minus) drain rock will be placed. A final 18-inch layer of clean fill soil will be placed next, followed by 6 inches of topsoil appropriate for native seeding.

REFERENCES

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Sadlier, M., Frobel, R., 1997. GeoEnvironmental Conference 1997, Presentation. Accessed at www.geosynthetica.net as published on August 17, 2004: A Flexible Membrane Liner Comparison.

Schroeder, P. R., Aziz, N. M., Lloyd, C. M. and Zappi, P. A., 1994. The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3, EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

Figures

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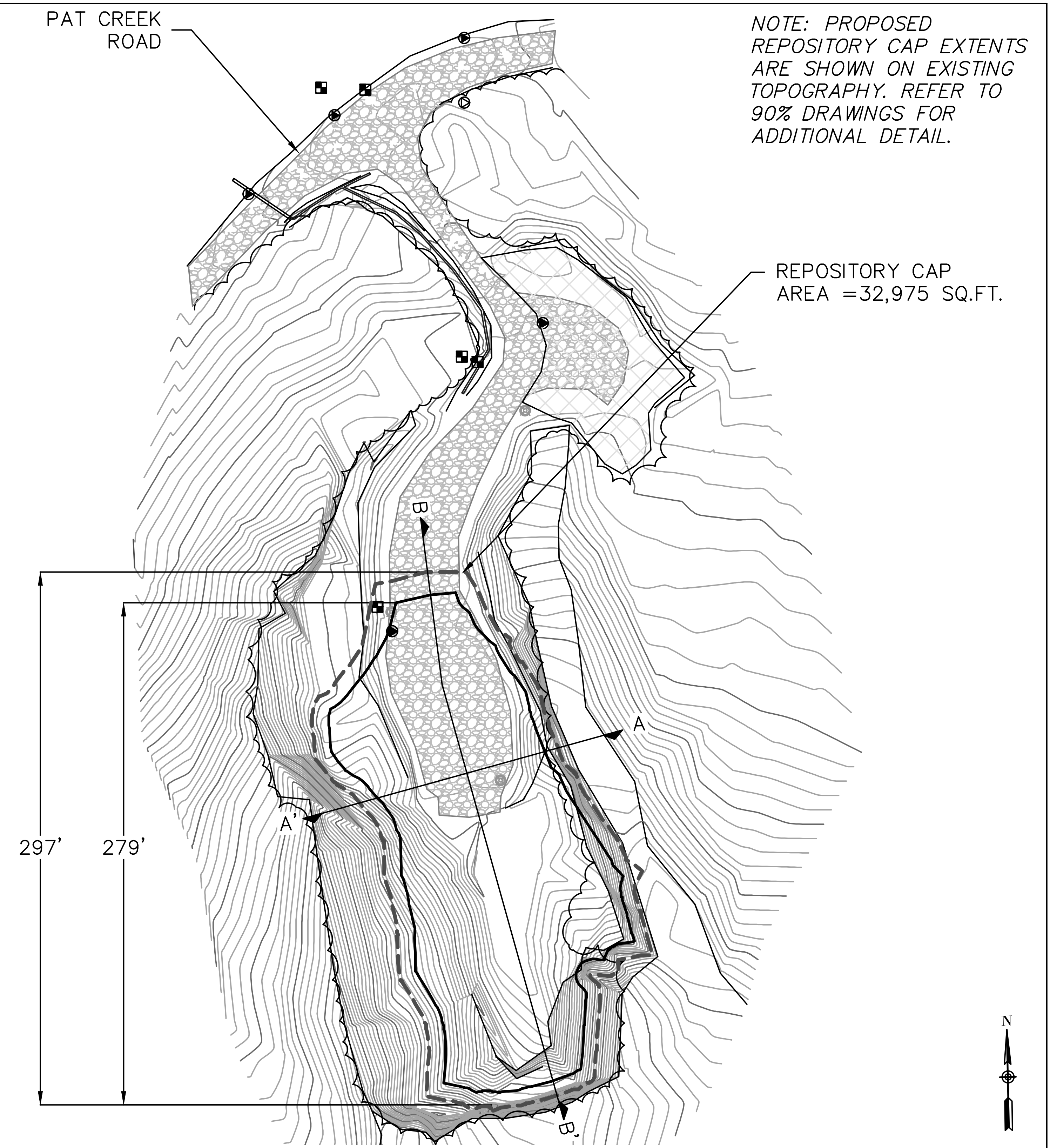

LEGEND

EXISTING GROUND SURFACE (GRAVEL)

LIMITS OF REPOSITORY CAP

LIMITS OF WASTE MATERIAL

0 75 150 Feet

FIGURE 1
LIMITS OF PROPOSED REPOSITORY
WRANGELL JUNKYARD REPOSITORY
CITY AND BOROUGH OF WRANGELL, ALASKA

ecology and environment, inc.
Global Environmental Specialists

DATE ISSUED	05/25/2017
C.A.D. FILE NO.	90%DESIGNDRAWINGS.DWG

*NOTE: ON–SITE SHOT ROCK MAY BE USED FOR 2' BASE LAYER. VOID SPACE MUST BE FILLED WITH 1" MINUS OR OTHER ADEQUATE MATERIAL TO CREATE A SMOOTH BASE SUITABLE FOR NON–WOVEN GEOTEXTILE FABRIC AND WASTE MATERIAL PLACEMENT.

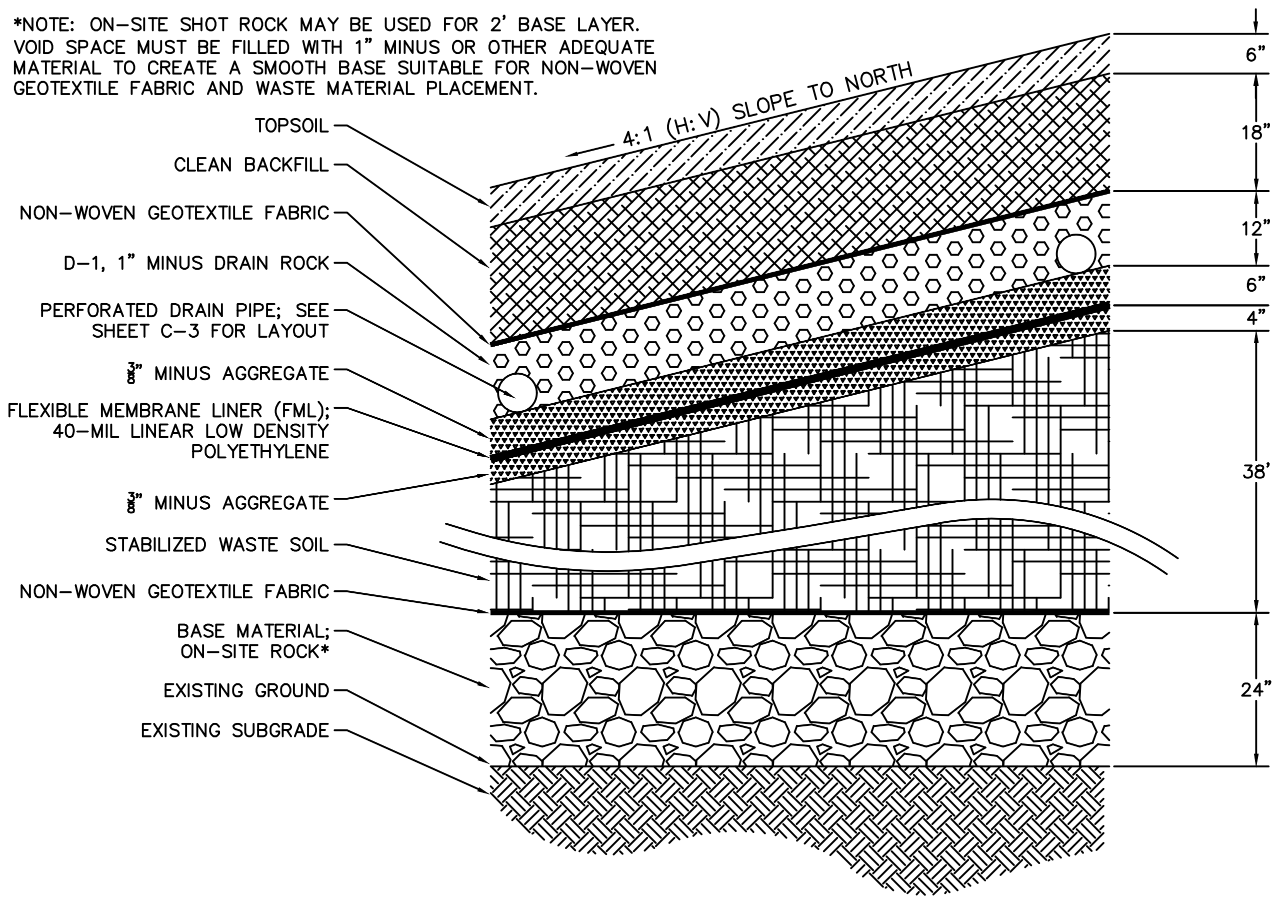

FIGURE 2
PROPOSED REPOSITORY COVER SECTION
WRANGELL JUNKYARD REPOSITORY
CITY AND BOROUGH OF WRANGELL, ALASKA

ecology and environment, inc.
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05/25/2017

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90%DESIGNDRAWINGS.DWG

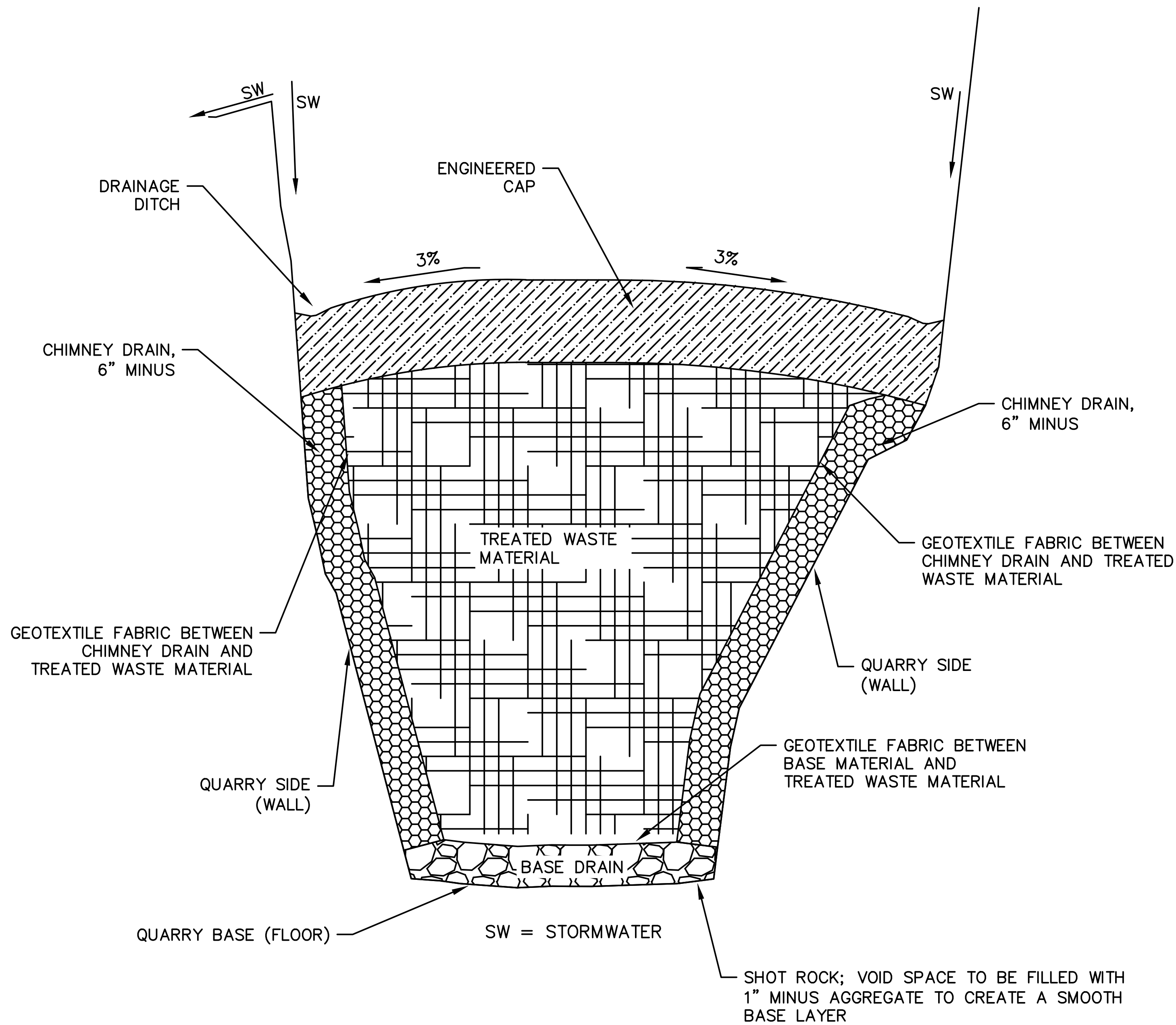

FIGURE 3
CROSS SECTION A–A'
WRANGELL JUNKYARD REPOSITORY
CITY AND BOROUGH OF WRANGELL, ALASKA

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05/25/2017

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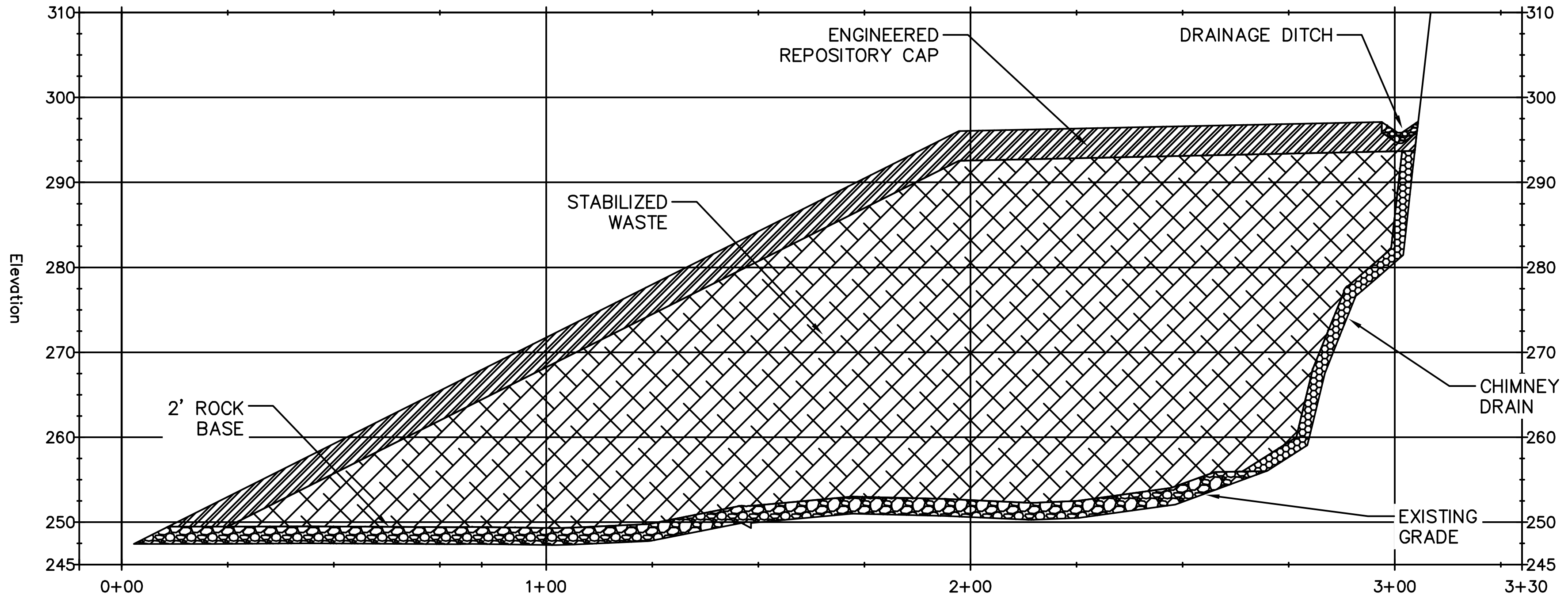

FIGURE 4
CROSS SECTION B–B'
WRANGELL JUNKYARD REPOSITORY
CITY AND BOROUGH OF WRANGELL, ALASKA

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05/25/2017

C.A.D. FILE NO.
90%DESIGNDRAWINGS.DWG

Attachment A

HELP Model Output

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```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************
```

```
PRECIPITATION DATA FILE:    C:\HELP3\Wrang.D4
TEMPERATURE DATA FILE:      C:\HELP3\Wrang.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\Wrang.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\Wrang.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\Wrang.D10
OUTPUT DATA FILE:           C:\HELP3\Wrang.OUT
```

TIME: 12:50   DATE: 5/24/2017

```
******************************************************************************

     TITLE:  Wrangell

******************************************************************************
```

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

```
             MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      6.00   INCHES
POROSITY                     =      0.4170 VOL/VOL
FIELD CAPACITY               =      0.0450 VOL/VOL
WILTING POINT                =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2731 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.340000006000E-04 CM/SEC


                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     18.00   INCHES
POROSITY                     =      0.4170 VOL/VOL
FIELD CAPACITY               =      0.0450 VOL/VOL
WILTING POINT                =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3199 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.340000006000E-04 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3420 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1149 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999991000E-01 CM/SEC


                        LAYER  4
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      6.00   INCHES
POROSITY                     =      0.2650 VOL/VOL
```

```
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0896 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.659999996000E-01 CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =     50.0    FEET


                     LAYER  5
                     --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                     LAYER  6
                     --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      4.00   INCHES
POROSITY                    =      0.2650 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0571 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.659999996000E-01 CM/SEC


                     LAYER  7
                     --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
```

```
THICKNESS                   =    456.00   INCHES
POROSITY                    =      0.4570 VOL/VOL
FIELD CAPACITY              =      0.1310 VOL/VOL
WILTING POINT               =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1359 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.369999998000E-05 CM/SEC
```

```
                      LAYER  8
                      --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC
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          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
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 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF   50. FEET.

SCS RUNOFF CURVE NUMBER             =     50.50
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      0.760  ACRES
EVAPORATIVE ZONE DEPTH              =      8.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      2.214  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      3.336  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.144  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     72.295  INCHES
TOTAL INITIAL WATER                 =     72.295  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
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EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ANNETTE ALASKA

STATION LATITUDE	=	56.47 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	160
END OF GROWING SEASON (JULIAN DATE)	=	262
EVAPORATIVE ZONE DEPTH	=	8.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	76.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	76.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	80.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	80.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR OLYMPIA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
8.01	6.13	6.09	4.94	4.79	4.29
5.36	6.99	11.49	13.91	10.01	9.20

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
32.80	36.50	38.00	42.90	48.90	54.00
57.80	56.30	54.10	46.90	39.70	35.60

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA
AND STATION LATITUDE = 56.47 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	5.66	4.72	2.74	4.11	10.16	2.17
	6.17	13.42	7.21	11.87	12.67	12.46
RUNOFF	0.487	0.072	0.001	0.273	2.173	0.138
	0.579	6.612	4.012	3.095	3.143	3.768
EVAPOTRANSPIRATION	0.706	1.007	1.517	2.211	3.155	2.191
	2.489	2.507	1.841	1.276	1.058	0.692
LATERAL DRAINAGE COLLECTED	5.0967	3.4065	1.9978	2.4330	1.3837	3.5917
FROM LAYER 4	0.8953	4.9891	0.9135	5.0269	8.4637	6.9858
PERCOLATION/LEAKAGE THROUGH	0.3475	0.2530	0.1685	0.1929	0.1268	0.2561
LAYER 5	0.0903	0.3388	0.0933	0.3294	0.5250	0.4535
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0001	0.0003	0.0004	0.0004
LAYER 8	0.0004	0.0007	0.0003	0.0008	0.0009	0.0007

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.733	0.542	0.287	0.362	0.199	0.534
TOP OF LAYER 5	0.129	0.718	0.136	0.723	1.258	1.005
STD. DEVIATION OF DAILY	0.569	0.257	0.187	0.284	0.135	0.564
HEAD ON TOP OF LAYER 5	0.086	0.608	0.065	0.702	0.673	0.563

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	93.36	257561.609	100.00
RUNOFF	24.352	67181.352	26.08
EVAPOTRANSPIRATION	20.650	56968.969	22.12
DRAINAGE COLLECTED FROM LAYER 4	45.1839	124653.234	48.40
PERC./LEAKAGE THROUGH LAYER 5	3.175225	8759.810	3.40
AVG. HEAD ON TOP OF LAYER 5	0.5520		
PERC./LEAKAGE THROUGH LAYER 8	0.005025	13.863	0.01
CHANGE IN WATER STORAGE	3.170	8744.170	3.39
SOIL WATER AT START OF YEAR	72.487	199978.078	
SOIL WATER AT END OF YEAR	75.657	208722.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.013	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	9.26	9.15	8.05	5.03	3.08	3.35
	11.98	6.24	3.43	19.44	12.51	6.15

RUNOFF	0.706	10.437	3.248	0.490	0.041	0.482
	6.577	0.892	0.618	7.965	1.814	0.264
EVAPOTRANSPIRATION	0.605	0.237	0.691	2.110	2.684	1.990
	3.367	2.527	1.319	1.169	0.913	0.561
LATERAL DRAINAGE COLLECTED	6.4446	1.0641	1.7179	4.3834	1.6115	0.6043
FROM LAYER 4	2.1834	3.2529	1.0517	5.5440	9.3055	4.9647
PERCOLATION/LEAKAGE THROUGH	0.4250	0.1026	0.1298	0.3047	0.1433	0.0686
LAYER 5	0.1763	0.2415	0.1038	0.3482	0.5722	0.3432
PERCOLATION/LEAKAGE THROUGH	0.0016	0.0025	0.3550	0.3950	0.2098	0.2183
LAYER 8	0.2391	0.2261	0.1613	0.1149	0.2290	0.1584

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.927	0.169	0.247	0.651	0.232	0.090
TOP OF LAYER 5	0.314	0.468	0.156	0.797	1.383	0.714
STD. DEVIATION OF DAILY	0.526	0.097	0.453	0.514	0.143	0.029
HEAD ON TOP OF LAYER 5	0.259	0.444	0.062	0.931	0.493	0.476

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	97.67	269452.000	100.00
RUNOFF	33.535	92515.148	34.33
EVAPOTRANSPIRATION	18.173	50136.512	18.61
DRAINAGE COLLECTED FROM LAYER 4	42.1280	116222.711	43.13
PERC./LEAKAGE THROUGH LAYER 5	2.959201	8163.844	3.03

AVG. HEAD ON TOP OF LAYER 5	0.5124		
PERC./LEAKAGE THROUGH LAYER 8	2.311018	6375.636	2.37
CHANGE IN WATER STORAGE	1.523	4202.012	1.56
SOIL WATER AT START OF YEAR	75.657	208722.250	
SOIL WATER AT END OF YEAR	75.928	209471.453	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.252	3452.810	1.28
ANNUAL WATER BUDGET BALANCE	0.0000	-0.042	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	9.38	8.20	5.50	7.62	1.57	2.38
	7.76	7.09	4.50	14.21	10.99	12.47
RUNOFF	2.008	0.020	0.391	1.106	0.000	0.000
	2.476	3.749	0.893	4.883	1.748	4.386
EVAPOTRANSPIRATION	0.640	0.939	1.389	2.484	2.146	1.787
	2.921	0.986	1.803	1.182	0.910	0.333
LATERAL DRAINAGE COLLECTED	7.0867	6.4896	5.7830	2.1035	2.4582	0.4845
FROM LAYER 4	2.0176	1.1124	2.5642	3.5134	8.2733	6.6329
PERCOLATION/LEAKAGE THROUGH	0.4576	0.4207	0.3885	0.1765	0.1989	0.0573
LAYER 5	0.1703	0.1097	0.1955	0.2575	0.5174	0.4339
PERCOLATION/LEAKAGE THROUGH	0.2632	0.3240	0.3839	0.4494	0.4501	0.3145
LAYER 8	0.3338	0.2468	0.1634	0.1895	0.1694	0.1463

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	1.019	1.033	0.832	0.313	0.354	0.072
TOP OF LAYER 5	0.290	0.160	0.381	0.505	1.230	0.954
STD. DEVIATION OF DAILY	0.586	0.465	0.489	0.156	0.230	0.030
HEAD ON TOP OF LAYER 5	0.184	0.067	0.371	0.417	0.625	0.574

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	91.67	252899.234	100.00
RUNOFF	21.660	59755.926	23.63
EVAPOTRANSPIRATION	17.519	48332.652	19.11
DRAINAGE COLLECTED FROM LAYER 4	48.5193	133855.109	52.93
PERC./LEAKAGE THROUGH LAYER 5	3.383718	9335.000	3.69
AVG. HEAD ON TOP OF LAYER 5	0.5952		
PERC./LEAKAGE THROUGH LAYER 8	3.434172	9474.192	3.75
CHANGE IN WATER STORAGE	0.537	1481.315	0.59
SOIL WATER AT START OF YEAR	75.928	209471.453	
SOIL WATER AT END OF YEAR	75.536	208387.547	
SNOW WATER AT START OF YEAR	1.252	3452.810	1.37
SNOW WATER AT END OF YEAR	2.181	6018.032	2.38
ANNUAL WATER BUDGET BALANCE	0.0000	0.036	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	9.30	3.52	5.77	4.89	3.07	2.23
	5.47	3.96	23.04	13.97	11.85	7.58
RUNOFF	6.070	3.069	0.858	0.001	0.000	0.000
	2.029	0.954	14.324	5.319	3.412	1.456
EVAPOTRANSPIRATION	0.249	0.084	1.322	2.469	2.759	1.853
	3.189	1.976	1.532	1.212	0.965	0.683
LATERAL DRAINAGE COLLECTED	5.3602	0.6717	1.7547	4.0105	1.6180	0.6353
FROM LAYER 4	0.3510	0.4860	3.1432	8.3191	6.3956	4.5275
PERCOLATION/LEAKAGE THROUGH	0.3652	0.0737	0.1480	0.2899	0.1443	0.0711
LAYER 5	0.0435	0.0581	0.2130	0.5217	0.4127	0.3230
PERCOLATION/LEAKAGE THROUGH	0.1844	0.3154	0.4636	0.3579	0.1789	0.1789
LAYER 8	0.2288	0.2284	0.1942	0.1952	0.1466	0.1235

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.771	0.103	0.252	0.596	0.233	0.094
TOP OF LAYER 5	0.050	0.070	0.467	1.196	0.950	0.651
STD. DEVIATION OF DAILY	0.517	0.037	0.200	0.354	0.133	0.034
HEAD ON TOP OF LAYER 5	0.035	0.024	0.703	0.616	0.745	0.334

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	94.65	261120.359	100.00
RUNOFF	37.492	103432.828	39.61
EVAPOTRANSPIRATION	18.293	50466.508	19.33
DRAINAGE COLLECTED FROM LAYER 4	37.2726	102827.781	39.38
PERC./LEAKAGE THROUGH LAYER 5	2.664148	7349.851	2.81
AVG. HEAD ON TOP OF LAYER 5	0.4529		
PERC./LEAKAGE THROUGH LAYER 8	2.795805	7713.068	2.95
CHANGE IN WATER STORAGE	-1.203	-3319.766	-1.27
SOIL WATER AT START OF YEAR	75.536	208387.547	
SOIL WATER AT END OF YEAR	76.514	211085.812	
SNOW WATER AT START OF YEAR	2.181	6018.032	2.30
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.068	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 5

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

PRECIPITATION	3.88	9.47	5.40	6.55	1.94	3.86
	0.82	9.00	8.69	21.24	10.83	8.96
RUNOFF	1.945	8.941	4.106	1.091	0.000	0.059
	0.000	3.419	4.296	7.810	2.547	1.707
EVAPOTRANSPIRATION	0.593	0.286	0.808	2.250	2.208	2.217
	1.400	1.634	2.127	1.165	1.064	0.809
LATERAL DRAINAGE COLLECTED	3.1402	0.4628	0.2734	2.8417	1.3156	1.1181
FROM LAYER 4	0.8709	0.3943	3.8277	8.1426	7.9726	4.8729
PERCOLATION/LEAKAGE THROUGH	0.2326	0.0552	0.0369	0.2206	0.1225	0.1035
LAYER 5	0.0906	0.0490	0.2730	0.4974	0.4907	0.3402
PERCOLATION/LEAKAGE THROUGH	0.1945	0.2643	0.3603	0.3034	0.2554	0.1205
LAYER 8	0.1503	0.1401	0.1214	0.1721	0.1502	0.1145

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.452	0.074	0.039	0.422	0.189	0.166
TOP OF LAYER 5	0.125	0.057	0.569	1.171	1.185	0.701
STD. DEVIATION OF DAILY	0.481	0.020	0.025	0.270	0.123	0.148
HEAD ON TOP OF LAYER 5	0.055	0.024	0.424	0.881	0.870	0.404

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	90.64	250057.625	100.00
RUNOFF	35.922	99101.211	39.63
EVAPOTRANSPIRATION	16.561	45687.133	18.27
DRAINAGE COLLECTED FROM LAYER 4	35.2328	97200.227	38.87

PERC./LEAKAGE THROUGH LAYER 5	2.512472	6931.407	2.77
AVG. HEAD ON TOP OF LAYER 5	0.4291		
PERC./LEAKAGE THROUGH LAYER 8	2.346923	6474.691	2.59
CHANGE IN WATER STORAGE	0.578	1594.321	0.64
SOIL WATER AT START OF YEAR	76.514	211085.812	
SOIL WATER AT END OF YEAR	77.092	212680.125	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.039	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 6

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	7.20	7.71	4.92	7.89	5.24	2.74
	0.67	1.32	4.10	13.14	7.80	6.10
RUNOFF	1.029	8.926	0.845	1.400	0.064	0.049
	0.000	0.021	0.498	4.380	1.512	0.316
EVAPOTRANSPIRATION	0.515	0.092	1.314	2.665	3.781	2.486
	0.838	1.608	1.484	1.156	0.858	0.647
LATERAL DRAINAGE COLLECTED	5.6903	0.7333	2.3714	3.1579	2.4014	0.7600
FROM LAYER 4	0.5531	0.5141	0.2931	3.9202	5.3829	4.5686
PERCOLATION/LEAKAGE THROUGH	0.3843	0.0779	0.1829	0.2419	0.1987	0.0816
LAYER 5	0.0629	0.0607	0.0392	0.2580	0.3612	0.3242

PERCOLATION/LEAKAGE THROUGH	0.2414	0.3285	0.4422	0.3182	0.2330	0.1729
LAYER 8	0.2166	0.2401	0.1953	0.1715	0.1888	0.1325

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.818	0.117	0.341	0.469	0.345	0.113
TOP OF LAYER 5	0.080	0.074	0.044	0.564	0.800	0.657
STD. DEVIATION OF DAILY	0.515	0.048	0.327	0.242	0.125	0.038
HEAD ON TOP OF LAYER 5	0.044	0.027	0.016	0.710	0.576	0.377

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	68.83	189888.250	100.00
RUNOFF	19.040	52526.613	27.66
EVAPOTRANSPIRATION	17.445	48128.605	25.35
DRAINAGE COLLECTED FROM LAYER 4	30.3462	83719.203	44.09
PERC./LEAKAGE THROUGH LAYER 5	2.273575	6272.338	3.30
AVG. HEAD ON TOP OF LAYER 5	0.3685		
PERC./LEAKAGE THROUGH LAYER 8	2.880794	7947.533	4.19
CHANGE IN WATER STORAGE	-0.882	-2433.752	-1.28
SOIL WATER AT START OF YEAR	77.092	212680.125	
SOIL WATER AT END OF YEAR	75.886	209355.562	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.323	890.818	0.47
ANNUAL WATER BUDGET BALANCE	0.0000	0.041	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 7

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	8.37	3.71	8.36	6.63	4.05	2.50
	11.54	3.36	8.11	10.45	6.40	13.31
RUNOFF	1.733	0.088	1.222	0.059	1.167	0.000
	5.660	2.098	4.454	4.196	0.741	2.367
EVAPOTRANSPIRATION	0.657	0.827	1.627	2.409	3.057	1.399
	2.847	1.937	0.382	1.204	0.917	0.699
LATERAL DRAINAGE COLLECTED	6.5489	3.2305	3.0549	5.6071	1.8650	0.5668
FROM LAYER 4	0.9275	2.8399	0.6059	3.8357	5.2617	6.5777
PERCOLATION/LEAKAGE THROUGH	0.4315	0.2439	0.2365	0.3794	0.1617	0.0653
LAYER 5	0.0902	0.2196	0.0687	0.2742	0.3613	0.4326
PERCOLATION/LEAKAGE THROUGH	0.0969	0.1030	0.2287	0.3276	0.2587	0.3134
LAYER 8	0.3352	0.3043	0.1749	0.1427	0.1982	0.1285

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.942	0.514	0.439	0.833	0.268	0.084
TOP OF LAYER 5	0.133	0.408	0.090	0.552	0.782	0.946
STD. DEVIATION OF DAILY	0.478	0.223	0.224	0.423	0.142	0.027
HEAD ON TOP OF LAYER 5	0.181	0.347	0.030	0.414	0.403	0.460

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	86.79	239436.297	100.00
RUNOFF	23.785	65617.219	27.40
EVAPOTRANSPIRATION	17.962	49552.605	20.70
DRAINAGE COLLECTED FROM LAYER 4	40.9215	112894.289	47.15
PERC./LEAKAGE THROUGH LAYER 5	2.964827	8179.365	3.42
AVG. HEAD ON TOP OF LAYER 5	0.4994		
PERC./LEAKAGE THROUGH LAYER 8	2.612142	7206.376	3.01
CHANGE IN WATER STORAGE	1.510	4165.744	1.74
SOIL WATER AT START OF YEAR	75.886	209355.562	
SOIL WATER AT END OF YEAR	76.818	211925.578	
SNOW WATER AT START OF YEAR	0.323	890.818	0.37
SNOW WATER AT END OF YEAR	0.901	2486.541	1.04
ANNUAL WATER BUDGET BALANCE	0.0000	0.058	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 8

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	8.82	8.55	7.14	3.11	6.16	5.52
	2.46	1.34	4.41	19.40	8.40	9.05
RUNOFF	1.694	0.384	0.854	0.002	1.595	0.689
	1.201	0.028	0.376	9.825	2.182	4.819
EVAPOTRANSPIRATION	1.064	0.834	1.270	1.872	2.725	2.141
	2.038	0.699	1.244	1.316	0.954	0.399
LATERAL DRAINAGE COLLECTED	7.2529	7.9923	3.9804	3.8332	1.2719	1.1314
FROM LAYER 4	1.7498	0.7100	0.3308	6.4021	4.3281	4.1535
PERCOLATION/LEAKAGE THROUGH	0.4671	0.5014	0.2896	0.2817	0.1197	0.1099
LAYER 5	0.1556	0.0778	0.0377	0.4049	0.3037	0.3031
PERCOLATION/LEAKAGE THROUGH	0.1177	0.2240	0.4170	0.4833	0.3783	0.3734
LAYER 8	0.2903	0.2307	0.1741	0.1945	0.2243	0.1191

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	1.043	1.229	0.572	0.570	0.183	0.168
TOP OF LAYER 5	0.252	0.102	0.049	0.921	0.643	0.597
STD. DEVIATION OF DAILY	0.584	0.557	0.355	0.272	0.108	0.063
HEAD ON TOP OF LAYER 5	0.091	0.041	0.077	0.847	0.457	0.276

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	84.36	232732.359	100.00
RUNOFF	23.650	65246.504	28.03

EVAPOTRANSPIRATION	16.555	45671.621	19.62
DRAINAGE COLLECTED FROM LAYER 4	43.1365	119004.852	51.13
PERC./LEAKAGE THROUGH LAYER 5	3.052238	8420.514	3.62
AVG. HEAD ON TOP OF LAYER 5	0.5274		
PERC./LEAKAGE THROUGH LAYER 8	3.226813	8902.133	3.83
CHANGE IN WATER STORAGE	-2.208	-6092.679	-2.62
SOIL WATER AT START OF YEAR	76.818	211925.578	
SOIL WATER AT END OF YEAR	74.766	206263.312	
SNOW WATER AT START OF YEAR	0.901	2486.541	1.07
SNOW WATER AT END OF YEAR	0.745	2056.124	0.88
ANNUAL WATER BUDGET BALANCE	0.0000	-0.070	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	7.53	8.98	5.01	6.31	7.03	3.58
	2.97	1.60	12.16	12.33	12.48	11.61
RUNOFF	6.722	7.693	6.277	0.734	0.812	0.099
	0.679	0.027	6.477	3.351	2.264	4.857
EVAPOTRANSPIRATION	0.383	0.220	0.867	2.469	3.097	2.638
	1.388	2.343	1.012	1.292	0.911	0.336
LATERAL DRAINAGE COLLECTED	0.8101	0.2707	0.1656	1.9848	3.7561	1.7481
FROM LAYER 4	0.6074	0.3555	0.8885	7.4702	5.1897	7.8881

PERCOLATION/LEAKAGE THROUGH	0.0859	0.0368	0.0251	0.1685	0.2712	0.1537
LAYER 5	0.0684	0.0449	0.0829	0.4748	0.3552	0.5002
PERCOLATION/LEAKAGE THROUGH	0.1004	0.1997	0.2818	0.2366	0.2309	0.1584
LAYER 8	0.0970	0.0850	0.1397	0.1827	0.1734	0.1026

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.117	0.043	0.024	0.295	0.540	0.260
TOP OF LAYER 5	0.087	0.051	0.132	1.074	0.771	1.134
STD. DEVIATION OF DAILY	0.053	0.008	0.010	0.140	0.445	0.111
HEAD ON TOP OF LAYER 5	0.038	0.026	0.245	0.683	0.459	0.621

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	91.59	252678.437	100.00
RUNOFF	39.995	110337.234	43.67
EVAPOTRANSPIRATION	16.956	46779.160	18.51
DRAINAGE COLLECTED FROM LAYER 4	31.1349	85894.867	33.99
PERC./LEAKAGE THROUGH LAYER 5	2.267598	6255.850	2.48
AVG. HEAD ON TOP OF LAYER 5	0.3774		
PERC./LEAKAGE THROUGH LAYER 8	1.988106	5484.788	2.17
CHANGE IN WATER STORAGE	1.516	4182.455	1.66
SOIL WATER AT START OF YEAR	74.766	206263.312	
SOIL WATER AT END OF YEAR	74.939	206742.562	

SNOW WATER AT START OF YEAR	0.745	2056.124	0.81
SNOW WATER AT END OF YEAR	2.088	5759.337	2.28
ANNUAL WATER BUDGET BALANCE	0.0000	-0.083	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	5.54	7.24	6.63	5.09	3.80	8.75
	0.00	6.84	7.30	19.27	6.62	6.92
RUNOFF	2.241	0.457	0.156	0.071	0.743	1.281
	0.000	4.295	1.460	7.656	0.228	0.002
EVAPOTRANSPIRATION	0.737	0.749	1.701	2.372	1.883	2.937
	0.587	1.891	1.952	1.213	0.784	0.479
LATERAL DRAINAGE COLLECTED	2.7630	6.1405	5.5222	3.3527	1.6113	3.4764
FROM LAYER 4	1.6973	0.5280	0.8512	8.0851	5.5447	4.5236
PERCOLATION/LEAKAGE THROUGH	0.2182	0.3967	0.3734	0.2526	0.1438	0.2476
LAYER 5	0.1508	0.0603	0.0830	0.5013	0.3731	0.3216
PERCOLATION/LEAKAGE THROUGH	0.1002	0.2943	0.3505	0.3060	0.4013	0.3237
LAYER 8	0.3143	0.2136	0.2402	0.2547	0.2115	0.1191

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.397	0.978	0.794	0.498	0.232	0.517
TOP OF LAYER 5	0.244	0.076	0.127	1.163	0.824	0.651

STD. DEVIATION OF DAILY	0.218	0.669	0.500	0.261	0.128	0.562
HEAD ON TOP OF LAYER 5	0.138	0.044	0.164	0.817	0.483	0.360

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	84.00	231739.281	100.00
RUNOFF	18.591	51288.547	22.13
EVAPOTRANSPIRATION	17.285	47685.371	20.58
DRAINAGE COLLECTED FROM LAYER 4	44.0957	121651.352	52.49
PERC./LEAKAGE THROUGH LAYER 5	3.122409	8614.102	3.72
AVG. HEAD ON TOP OF LAYER 5	0.5416		
PERC./LEAKAGE THROUGH LAYER 8	3.129402	8633.395	3.73
CHANGE IN WATER STORAGE	0.899	2480.575	1.07
SOIL WATER AT START OF YEAR	74.939	206742.562	
SOIL WATER AT END OF YEAR	74.840	206468.406	
SNOW WATER AT START OF YEAR	2.088	5759.337	2.49
SNOW WATER AT END OF YEAR	3.086	8514.062	3.67
ANNUAL WATER BUDGET BALANCE	0.0000	0.039	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 11

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	5.18	7.58	4.05	3.54	2.77	5.62
	7.59	5.09	5.02	7.13	4.10	8.39
RUNOFF	2.372	1.334	0.045	0.000	0.001	0.830
	1.765	3.079	0.611	3.415	0.256	1.580
EVAPOTRANSPIRATION	0.860	0.715	1.824	2.732	2.730	3.448
	2.876	2.828	1.924	1.096	0.957	0.658
LATERAL DRAINAGE COLLECTED	4.1380	4.9070	2.8455	1.7565	0.7066	0.6281
FROM LAYER 4	1.7599	1.2807	1.1114	2.4051	0.9940	5.7431
PERCOLATION/LEAKAGE THROUGH	0.2902	0.3350	0.2217	0.1549	0.0774	0.0668
LAYER 5	0.1559	0.1217	0.1055	0.1900	0.0982	0.3860
PERCOLATION/LEAKAGE THROUGH	0.2057	0.2846	0.2969	0.3130	0.3244	0.2907
LAYER 8	0.2599	0.2055	0.1394	0.1310	0.1507	0.0974

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.595	0.781	0.409	0.261	0.102	0.093
TOP OF LAYER 5	0.253	0.184	0.165	0.346	0.148	0.826
STD. DEVIATION OF DAILY	0.540	0.444	0.294	0.102	0.036	0.087
HEAD ON TOP OF LAYER 5	0.099	0.080	0.104	0.320	0.079	0.488

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ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	66.06	182246.297	100.00

RUNOFF	15.289	42178.445	23.14
EVAPOTRANSPIRATION	22.648	62480.488	34.28
DRAINAGE COLLECTED FROM LAYER 4	28.2760	78007.734	42.80
PERC./LEAKAGE THROUGH LAYER 5	2.203228	6078.265	3.34
AVG. HEAD ON TOP OF LAYER 5	0.3470		
PERC./LEAKAGE THROUGH LAYER 8	2.699269	7446.743	4.09
CHANGE IN WATER STORAGE	-2.852	-7867.093	-4.32
SOIL WATER AT START OF YEAR	74.840	206468.406	
SOIL WATER AT END OF YEAR	74.206	204720.687	
SNOW WATER AT START OF YEAR	3.086	8514.062	4.67
SNOW WATER AT END OF YEAR	0.868	2394.688	1.31
ANNUAL WATER BUDGET BALANCE	0.0000	-0.023	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 12

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	10.86	8.73	0.75	6.73	2.97	4.86
	4.17	4.79	7.07	25.69	11.83	13.86
RUNOFF	5.455	11.393	0.424	1.423	0.000	0.319
	1.837	1.161	2.279	13.679	3.635	0.856
EVAPOTRANSPIRATION	0.384	0.398	0.663	2.555	3.154	2.684
	2.026	2.083	1.837	1.021	1.050	0.806

LATERAL DRAINAGE COLLECTED	2.4962	0.5028	0.2399	1.6896	1.1866	0.8020
FROM LAYER 4	1.0374	1.7873	2.3018	6.8796	8.6212	4.8242
PERCOLATION/LEAKAGE THROUGH	0.2021	0.0592	0.0337	0.1454	0.1150	0.0838
LAYER 5	0.1044	0.1562	0.1823	0.4348	0.5352	0.3421
PERCOLATION/LEAKAGE THROUGH	0.1531	0.1025	0.1481	0.2372	0.2309	0.1542
LAYER 8	0.1204	0.1268	0.1300	0.1140	0.1139	0.1075

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.359	0.077	0.035	0.251	0.171	0.119
TOP OF LAYER 5	0.149	0.257	0.342	0.989	1.281	0.694
STD. DEVIATION OF DAILY	0.213	0.023	0.013	0.171	0.069	0.053
HEAD ON TOP OF LAYER 5	0.045	0.135	0.300	0.818	0.586	0.257

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ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	102.31	282252.781	100.00
RUNOFF	42.460	117139.227	41.50
EVAPOTRANSPIRATION	18.662	51484.129	18.24
DRAINAGE COLLECTED FROM LAYER 4	32.3688	89298.992	31.64
PERC./LEAKAGE THROUGH LAYER 5	2.394260	6605.285	2.34
AVG. HEAD ON TOP OF LAYER 5	0.3937		
PERC./LEAKAGE THROUGH LAYER 8	1.738600	4796.450	1.70
CHANGE IN WATER STORAGE	7.081	19534.020	6.92

SOIL WATER AT START OF YEAR	74.206	204720.687	
SOIL WATER AT END OF YEAR	74.973	206835.516	
SNOW WATER AT START OF YEAR	0.868	2394.688	0.85
SNOW WATER AT END OF YEAR	7.182	19813.891	7.02
ANNUAL WATER BUDGET BALANCE	0.0000	-0.055	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 13

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.10	7.26	6.60	7.06	3.38	1.37
	7.83	8.70	18.67	11.70	11.60	6.84
RUNOFF	0.285	8.052	6.025	1.571	1.017	0.000
	5.279	4.103	10.421	2.399	6.778	2.206
EVAPOTRANSPIRATION	0.269	0.286	0.634	2.376	1.986	1.000
	2.689	3.183	2.227	1.230	0.831	0.656
LATERAL DRAINAGE COLLECTED	5.3279	2.7732	0.4959	2.9523	1.2786	0.5993
FROM LAYER 4	0.3397	0.7627	2.4878	6.1755	5.7803	2.4208
PERCOLATION/LEAKAGE THROUGH	0.3672	0.2087	0.0585	0.2226	0.1198	0.0685
LAYER 5	0.0436	0.0782	0.1904	0.4108	0.3766	0.1985
PERCOLATION/LEAKAGE THROUGH	0.2385	0.3099	0.3882	0.3791	0.3141	0.1583
LAYER 8	0.2088	0.1989	0.1886	0.1779	0.1320	0.0989

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.766	0.442	0.071	0.439	0.184	0.089
	0.049	0.110	0.370	0.888	0.859	0.348
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.396	0.392	0.031	0.370	0.118	0.021
	0.026	0.088	0.437	0.502	0.781	0.170

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ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	94.11	259630.625	100.00
RUNOFF	48.134	132792.578	51.15
EVAPOTRANSPIRATION	17.368	47915.199	18.46
DRAINAGE COLLECTED FROM LAYER 4	31.3940	86609.734	33.36
PERC./LEAKAGE THROUGH LAYER 5	2.343310	6464.724	2.49
AVG. HEAD ON TOP OF LAYER 5	0.3845		
PERC./LEAKAGE THROUGH LAYER 8	2.793170	7705.796	2.97
CHANGE IN WATER STORAGE	-5.579	-15392.681	-5.93
SOIL WATER AT START OF YEAR	74.973	206835.516	
SOIL WATER AT END OF YEAR	76.576	211256.719	
SNOW WATER AT START OF YEAR	7.182	19813.891	7.63
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.019	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 14

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	9.74	6.64	6.40	4.85	2.80	1.83
	1.46	6.10	3.89	4.90	8.69	5.37
RUNOFF	0.233	11.924	2.507	0.384	0.001	0.000
	0.115	2.135	0.841	0.271	0.658	0.094
EVAPOTRANSPIRATION	0.712	0.140	0.887	2.477	2.533	2.219
	1.303	2.569	1.619	1.115	0.601	0.849
LATERAL DRAINAGE COLLECTED	4.8855	0.5644	1.2127	3.0103	1.6569	0.5768
FROM LAYER 4	0.3539	0.7442	0.8803	1.2540	6.3386	4.5163
PERCOLATION/LEAKAGE THROUGH	0.3377	0.0641	0.1003	0.2275	0.1450	0.0666
LAYER 5	0.0462	0.0721	0.0879	0.1155	0.4133	0.3225
PERCOLATION/LEAKAGE THROUGH	0.1424	0.1696	0.3107	0.3222	0.1870	0.1468
LAYER 8	0.1850	0.1859	0.1925	0.1559	0.1080	0.1433

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.703	0.090	0.174	0.447	0.238	0.086
TOP OF LAYER 5	0.051	0.107	0.131	0.180	0.942	0.650
STD. DEVIATION OF DAILY	0.482	0.029	0.309	0.346	0.163	0.017
HEAD ON TOP OF LAYER 5	0.010	0.127	0.093	0.151	0.581	0.324

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ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	62.67	172893.937	100.00
RUNOFF	19.161	52861.898	30.57
EVAPOTRANSPIRATION	17.024	46966.055	27.16
DRAINAGE COLLECTED FROM LAYER 4	25.9938	71711.680	41.48
PERC./LEAKAGE THROUGH LAYER 5	1.998709	5514.039	3.19
AVG. HEAD ON TOP OF LAYER 5	0.3166		
PERC./LEAKAGE THROUGH LAYER 8	2.249192	6205.071	3.59
CHANGE IN WATER STORAGE	-1.758	-4850.690	-2.81
SOIL WATER AT START OF YEAR	76.576	211256.719	
SOIL WATER AT END OF YEAR	74.088	204393.578	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.729	2012.443	1.16
ANNUAL WATER BUDGET BALANCE	0.0000	-0.080	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 15

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	8.90	4.79	6.91	5.01	9.84	1.37
	4.29	4.95	8.53	20.22	7.55	12.67
RUNOFF	7.090	4.466	3.078	0.141	3.699	0.004
	1.082	1.200	4.032	9.043	1.964	2.582

EVAPOTRANSPIRATION	0.460	0.164	0.927	2.682	2.043	1.813
	2.767	3.028	1.929	1.047	0.932	0.809
LATERAL DRAINAGE COLLECTED	1.7545	0.5319	0.5982	4.3831	1.4358	2.9761
FROM LAYER 4	0.5264	0.3764	2.7836	4.6150	6.9387	7.5291
PERCOLATION/LEAKAGE THROUGH	0.1556	0.0613	0.0595	0.3136	0.1315	0.2255
LAYER 5	0.0616	0.0477	0.2048	0.3177	0.4461	0.4831
PERCOLATION/LEAKAGE THROUGH	0.1010	0.0491	0.1697	0.2653	0.1984	0.1298
LAYER 8	0.1410	0.1632	0.1934	0.2072	0.1761	0.1132

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.252	0.085	0.086	0.651	0.206	0.442
TOP OF LAYER 5	0.076	0.054	0.414	0.664	1.031	1.083
STD. DEVIATION OF DAILY	0.096	0.026	0.196	0.297	0.134	0.353
HEAD ON TOP OF LAYER 5	0.028	0.021	0.430	0.541	0.643	0.523

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ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	95.03	262168.719	100.00
RUNOFF	38.381	105884.141	40.39
EVAPOTRANSPIRATION	18.601	51316.449	19.57
DRAINAGE COLLECTED FROM LAYER 4	34.4486	95036.859	36.25
PERC./LEAKAGE THROUGH LAYER 5	2.507976	6919.003	2.64
AVG. HEAD ON TOP OF LAYER 5	0.4204		
PERC./LEAKAGE THROUGH LAYER 8	1.907463	5262.309	2.01

CHANGE IN WATER STORAGE	1.692	4668.898	1.78
SOIL WATER AT START OF YEAR	74.088	204393.578	
SOIL WATER AT END OF YEAR	76.510	211074.922	
SNOW WATER AT START OF YEAR	0.729	2012.443	0.77
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.047	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 16

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	11.66	3.76	5.80	4.67	4.77	2.64
	1.04	1.64	4.49	12.18	6.65	9.12
RUNOFF	1.680	1.375	0.982	0.270	1.170	0.000
	0.067	0.000	1.629	4.270	0.651	1.190
EVAPOTRANSPIRATION	0.632	0.692	1.744	2.845	2.637	1.201
	1.497	1.772	1.289	1.174	0.882	0.648
LATERAL DRAINAGE COLLECTED	6.7046	5.0694	3.6285	2.0624	1.3106	0.9110
FROM LAYER 4	0.4086	0.4509	0.4897	3.5874	5.6519	4.9868
PERCOLATION/LEAKAGE THROUGH	0.4387	0.3408	0.2662	0.1693	0.1211	0.0944
LAYER 5	0.0487	0.0536	0.0579	0.2560	0.3820	0.3417
PERCOLATION/LEAKAGE THROUGH	0.1137	0.3392	0.4698	0.3652	0.3338	0.3083
LAYER 8	0.2453	0.2190	0.1929	0.1640	0.1747	0.1350

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.964	0.779	0.522	0.307	0.188	0.135
TOP OF LAYER 5	0.059	0.065	0.073	0.516	0.840	0.717
STD. DEVIATION OF DAILY	0.493	0.605	0.414	0.237	0.126	0.028
HEAD ON TOP OF LAYER 5	0.041	0.037	0.029	0.419	0.401	0.552

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ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	68.42	188757.094	100.00
RUNOFF	13.283	36646.273	19.41
EVAPOTRANSPIRATION	17.013	46936.426	24.87
DRAINAGE COLLECTED FROM LAYER 4	35.2618	97280.227	51.54
PERC./LEAKAGE THROUGH LAYER 5	2.570337	7091.046	3.76
AVG. HEAD ON TOP OF LAYER 5	0.4304		
PERC./LEAKAGE THROUGH LAYER 8	3.060857	8444.293	4.47
CHANGE IN WATER STORAGE	-0.199	-550.089	-0.29
SOIL WATER AT START OF YEAR	76.510	211074.922	
SOIL WATER AT END OF YEAR	76.310	210524.844	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.046	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 17

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	10.46	7.94	7.91	9.41	2.61	2.13
	15.12	3.70	9.14	13.49	20.60	9.53
RUNOFF	0.168	12.750	4.707	1.222	0.000	0.707
	6.882	0.852	3.336	3.723	6.659	2.233
EVAPOTRANSPIRATION	0.697	0.185	1.398	2.493	2.243	1.215
	3.538	1.832	2.071	1.345	0.580	0.498
LATERAL DRAINAGE COLLECTED	5.2970	1.0463	2.0300	4.1063	2.4498	0.8910
FROM LAYER 4	3.2242	1.2454	1.8951	5.7570	9.7366	9.3547
PERCOLATION/LEAKAGE THROUGH	0.3643	0.1013	0.1568	0.2819	0.2005	0.0921
LAYER 5	0.2207	0.1180	0.1617	0.3849	0.5915	0.5751
PERCOLATION/LEAKAGE THROUGH	0.0999	0.0943	0.2433	0.3346	0.2293	0.1468
LAYER 8	0.2067	0.2718	0.1503	0.2303	0.1656	0.1515

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.762	0.167	0.292	0.610	0.352	0.132
TOP OF LAYER 5	0.464	0.179	0.282	0.828	1.447	1.345
STD. DEVIATION OF DAILY	0.437	0.093	0.367	0.620	0.172	0.047
HEAD ON TOP OF LAYER 5	0.632	0.097	0.162	0.569	0.618	0.662

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ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	112.04	309095.969	100.00
RUNOFF	43.239	119286.898	38.59
EVAPOTRANSPIRATION	18.095	49920.223	16.15
DRAINAGE COLLECTED FROM LAYER 4	47.0333	129755.430	41.98
PERC./LEAKAGE THROUGH LAYER 5	3.249028	8963.419	2.90
AVG. HEAD ON TOP OF LAYER 5	0.5717		
PERC./LEAKAGE THROUGH LAYER 8	2.324378	6412.494	2.07
CHANGE IN WATER STORAGE	1.349	3720.970	1.20
SOIL WATER AT START OF YEAR	76.310	210524.844	
SOIL WATER AT END OF YEAR	77.023	212490.734	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.636	1755.068	0.57
ANNUAL WATER BUDGET BALANCE	0.0000	-0.054	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 18

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	5.54	1.44	6.72	6.13	2.16	6.17
	0.00	2.84	15.90	9.48	18.32	10.50

RUNOFF	0.226	0.000	0.347	0.242	0.000	1.220
	0.000	1.513	8.619	3.043	8.060	3.459
EVAPOTRANSPIRATION	0.466	0.632	1.445	2.156	1.562	3.696
	0.610	1.188	1.851	1.339	1.057	0.711
LATERAL DRAINAGE COLLECTED	5.8648	2.2211	2.1908	3.7471	3.3245	0.7915
FROM LAYER 4	1.2590	0.5417	1.9531	3.2175	9.1913	5.6839
PERCOLATION/LEAKAGE THROUGH	0.3905	0.1809	0.1787	0.2715	0.2474	0.0825
LAYER 5	0.1204	0.0634	0.1515	0.2453	0.5614	0.3835
PERCOLATION/LEAKAGE THROUGH	0.3452	0.4643	0.4811	0.3586	0.2614	0.1994
LAYER 8	0.3189	0.2423	0.1923	0.2216	0.1771	0.1424

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.843	0.354	0.315	0.557	0.478	0.118
TOP OF LAYER 5	0.181	0.078	0.290	0.463	1.366	0.817
STD. DEVIATION OF DAILY	0.536	0.191	0.226	0.414	0.390	0.075
HEAD ON TOP OF LAYER 5	0.084	0.029	0.355	0.267	0.708	0.535

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ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	85.20	235049.734	100.00
RUNOFF	26.727	73735.367	31.37
EVAPOTRANSPIRATION	16.710	46100.117	19.61
DRAINAGE COLLECTED FROM LAYER 4	39.9862	110313.852	46.93
PERC./LEAKAGE THROUGH LAYER 5	2.877034	7937.161	3.38

AVG. HEAD ON TOP OF LAYER 5	0.4883		
PERC./LEAKAGE THROUGH LAYER 8	3.404715	9392.929	4.00
CHANGE IN WATER STORAGE	-1.628	-4492.483	-1.91
SOIL WATER AT START OF YEAR	77.023	212490.734	
SOIL WATER AT END OF YEAR	76.031	209753.328	
SNOW WATER AT START OF YEAR	0.636	1755.068	0.75
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.056	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 19

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	9.29	7.45	4.74	5.52	7.62	6.67
	9.57	2.57	15.27	12.41	9.66	6.59
RUNOFF	1.909	1.273	0.019	0.047	1.602	0.673
	5.275	0.150	6.800	3.822	2.093	1.952
EVAPOTRANSPIRATION	0.515	0.629	1.503	2.728	2.161	3.846
	2.414	1.794	1.992	1.164	0.853	0.683
LATERAL DRAINAGE COLLECTED	5.3042	5.4414	5.2883	1.1784	2.5673	5.2261
FROM LAYER 4	2.6617	1.0028	2.4351	7.1834	4.9287	6.3133
PERCOLATION/LEAKAGE THROUGH	0.3594	0.3574	0.3669	0.1138	0.2009	0.3410
LAYER 5	0.2052	0.1005	0.1858	0.4561	0.3423	0.4142
PERCOLATION/LEAKAGE THROUGH	0.1367	0.2614	0.3736	0.3288	0.4289	0.3274
LAYER 8	0.2091	0.2697	0.2219	0.3258	0.1538	0.1770

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.763	0.866	0.761	0.175	0.369	0.777
TOP OF LAYER 5	0.383	0.144	0.362	1.033	0.732	0.908
STD. DEVIATION OF DAILY	0.510	0.655	0.307	0.071	0.315	0.787
HEAD ON TOP OF LAYER 5	0.365	0.064	0.358	0.732	0.358	0.626

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ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	97.36	268596.781	100.00
RUNOFF	25.615	70666.570	26.31
EVAPOTRANSPIRATION	20.282	55952.617	20.83
DRAINAGE COLLECTED FROM LAYER 4	49.5308	136645.594	50.87
PERC./LEAKAGE THROUGH LAYER 5	3.443478	9499.866	3.54
AVG. HEAD ON TOP OF LAYER 5	0.6061		
PERC./LEAKAGE THROUGH LAYER 8	3.214113	8867.096	3.30
CHANGE IN WATER STORAGE	-1.281	-3535.102	-1.32
SOIL WATER AT START OF YEAR	76.031	209753.328	
SOIL WATER AT END OF YEAR	74.717	206130.312	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.032	87.906	0.03
ANNUAL WATER BUDGET BALANCE	0.0000	-0.020	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	7.63	7.20	7.09	4.72	8.68	2.16
	0.60	9.84	19.26	12.07	9.64	11.43
RUNOFF	1.484	0.403	1.344	0.166	0.340	0.000
	0.000	3.354	11.605	1.829	2.912	3.587
EVAPOTRANSPIRATION	0.517	0.996	1.202	2.670	3.501	2.654
	1.285	2.205	2.053	1.258	0.818	0.888
LATERAL DRAINAGE COLLECTED	3.9051	6.1498	2.6340	4.5316	2.7534	2.3335
FROM LAYER 4	0.5225	2.5148	2.7471	9.3773	4.7758	5.7837
PERCOLATION/LEAKAGE THROUGH	0.2769	0.4061	0.2121	0.3177	0.2072	0.1896
LAYER 5	0.0614	0.1895	0.2154	0.5783	0.3239	0.3844
PERCOLATION/LEAKAGE THROUGH	0.2544	0.4014	0.2638	0.3849	0.3207	0.3444
LAYER 8	0.2415	0.2822	0.2692	0.2061	0.1704	0.1570

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.562	0.945	0.379	0.673	0.396	0.347
TOP OF LAYER 5	0.075	0.362	0.408	1.349	0.710	0.832
STD. DEVIATION OF DAILY	0.521	0.470	0.180	0.459	0.459	0.215
HEAD ON TOP OF LAYER 5	0.029	0.391	0.247	0.555	0.599	0.609

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ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	100.32	276762.844	100.00
RUNOFF	27.022	74549.195	26.94
EVAPOTRANSPIRATION	20.046	55302.133	19.98
DRAINAGE COLLECTED FROM LAYER 4	48.0287	132501.656	47.88
PERC./LEAKAGE THROUGH LAYER 5	3.362508	9276.485	3.35
AVG. HEAD ON TOP OF LAYER 5	0.5864		
PERC./LEAKAGE THROUGH LAYER 8	3.296225	9093.625	3.29
CHANGE IN WATER STORAGE	1.927	5316.224	1.92
SOIL WATER AT START OF YEAR	74.717	206130.312	
SOIL WATER AT END OF YEAR	76.676	211534.453	
SNOW WATER AT START OF YEAR	0.032	87.906	0.03
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 21

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

PRECIPITATION	10.41	7.87	2.04	3.87	7.67	4.49
	3.06	14.21	21.52	14.28	8.76	8.77
RUNOFF	1.936	0.474	0.009	0.000	0.362	0.020
	0.194	8.508	13.495	6.406	0.324	1.916
EVAPOTRANSPIRATION	0.946	0.229	1.860	2.025	3.434	3.228
	2.976	2.315	2.241	1.317	1.012	0.643
LATERAL DRAINAGE COLLECTED	7.2704	5.0404	4.4193	0.7570	3.3171	1.2638
FROM LAYER 4	1.3451	0.9109	6.1425	4.3705	7.2106	5.5898
PERCOLATION/LEAKAGE THROUGH	0.4702	0.3361	0.3009	0.0815	0.2369	0.1192
LAYER 5	0.1253	0.0934	0.3951	0.3073	0.4633	0.3809
PERCOLATION/LEAKAGE THROUGH	0.3256	0.3294	0.3986	0.4700	0.4278	0.2703
LAYER 8	0.2173	0.1897	0.2178	0.1835	0.1411	0.1630

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	1.046	0.803	0.636	0.112	0.477	0.188
TOP OF LAYER 5	0.193	0.131	0.913	0.629	1.072	0.804
STD. DEVIATION OF DAILY	0.511	0.627	0.678	0.033	0.504	0.085
HEAD ON TOP OF LAYER 5	0.106	0.064	0.739	0.556	0.569	0.401

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ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	106.95	295053.687	100.00
RUNOFF	33.643	92814.125	31.46
EVAPOTRANSPIRATION	22.227	61319.098	20.78
DRAINAGE COLLECTED FROM LAYER 4	47.6375	131422.391	44.54

PERC./LEAKAGE THROUGH LAYER 5	3.310193	9132.160	3.10
AVG. HEAD ON TOP OF LAYER 5	0.5835		
PERC./LEAKAGE THROUGH LAYER 8	3.334131	9198.200	3.12
CHANGE IN WATER STORAGE	0.109	299.849	0.10
SOIL WATER AT START OF YEAR	76.676	211534.453	
SOIL WATER AT END OF YEAR	76.785	211834.297	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 22

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	6.56	7.94	11.57	6.49	7.20	2.83
	9.89	3.72	10.45	11.97	8.59	6.39
RUNOFF	0.846	1.976	1.492	0.816	0.931	0.002
	4.172	1.363	4.813	3.684	1.478	1.230
EVAPOTRANSPIRATION	0.868	0.818	1.545	2.609	2.356	3.334
	2.678	2.243	1.841	1.286	0.886	0.710
LATERAL DRAINAGE COLLECTED	5.0951	4.8029	7.9380	4.7163	1.7231	2.7074
FROM LAYER 4	0.7434	1.6584	2.1522	5.2150	5.8751	3.1068
PERCOLATION/LEAKAGE THROUGH	0.3524	0.3255	0.5037	0.3337	0.1521	0.2078
LAYER 5	0.0802	0.1478	0.1721	0.3459	0.3939	0.2379

PERCOLATION/LEAKAGE THROUGH	0.2937	0.3683	0.3557	0.3046	0.4552	0.4317
LAYER 8	0.2937	0.3286	0.2198	0.2149	0.1712	0.1322

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.733	0.765	1.142	0.701	0.248	0.402
TOP OF LAYER 5	0.107	0.239	0.320	0.750	0.873	0.447
STD. DEVIATION OF DAILY	0.437	0.541	0.561	0.267	0.128	0.372
HEAD ON TOP OF LAYER 5	0.042	0.118	0.279	0.749	0.460	0.292

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ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	93.60	258223.625	100.00
RUNOFF	22.803	62908.633	24.36
EVAPOTRANSPIRATION	21.174	58415.172	22.62
DRAINAGE COLLECTED FROM LAYER 4	45.7340	126170.844	48.86
PERC./LEAKAGE THROUGH LAYER 5	3.253070	8974.570	3.48
AVG. HEAD ON TOP OF LAYER 5	0.5605		
PERC./LEAKAGE THROUGH LAYER 8	3.569693	9848.070	3.81
CHANGE IN WATER STORAGE	0.319	880.997	0.34
SOIL WATER AT START OF YEAR	76.785	211834.297	
SOIL WATER AT END OF YEAR	75.660	208730.812	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	1.444	3984.479	1.54
ANNUAL WATER BUDGET BALANCE	0.0000	-0.094	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 23

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	5.70	5.54	7.46	3.43	6.78	5.35
	10.00	4.66	20.61	22.69	8.93	5.51
RUNOFF	1.815	1.255	0.126	0.011	1.578	0.004
	4.407	1.742	11.803	12.900	2.455	0.074
EVAPOTRANSPIRATION	0.847	1.046	1.686	2.218	3.644	3.470
	2.432	3.141	2.029	1.277	0.982	0.858
LATERAL DRAINAGE COLLECTED	5.5764	2.1135	4.7394	3.0805	1.8525	0.6684
FROM LAYER 4	2.1196	1.9786	3.3087	9.0583	5.5161	3.3323
PERCOLATION/LEAKAGE THROUGH	0.3829	0.1742	0.3294	0.2336	0.1604	0.0744
LAYER 5	0.1739	0.1669	0.2371	0.5564	0.3702	0.2564
PERCOLATION/LEAKAGE THROUGH	0.2259	0.2171	0.3347	0.3007	0.2524	0.2798
LAYER 8	0.3198	0.2470	0.1407	0.2055	0.1747	0.1475

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.802	0.337	0.682	0.458	0.266	0.099
TOP OF LAYER 5	0.305	0.285	0.492	1.303	0.820	0.479
STD. DEVIATION OF DAILY	0.318	0.161	0.498	0.344	0.142	0.021
HEAD ON TOP OF LAYER 5	0.238	0.189	0.523	0.776	0.597	0.159

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ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	106.66	294253.562	100.00
RUNOFF	38.170	105304.250	35.79
EVAPOTRANSPIRATION	23.631	65192.125	22.16
DRAINAGE COLLECTED FROM LAYER 4	43.3443	119578.266	40.64
PERC./LEAKAGE THROUGH LAYER 5	3.115743	8595.712	2.92
AVG. HEAD ON TOP OF LAYER 5	0.5272		
PERC./LEAKAGE THROUGH LAYER 8	2.845670	7850.634	2.67
CHANGE IN WATER STORAGE	-1.331	-3671.664	-1.25
SOIL WATER AT START OF YEAR	75.660	208730.812	
SOIL WATER AT END OF YEAR	75.773	209043.625	
SNOW WATER AT START OF YEAR	1.444	3984.479	1.35
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.042	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 24

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.86	5.13	5.21	7.61	7.62	5.02
	4.78	7.76	6.51	13.39	5.05	8.31
RUNOFF	0.006	4.978	2.888	0.583	0.282	0.286
	1.987	2.332	1.817	5.469	0.844	2.496
EVAPOTRANSPIRATION	0.673	0.201	0.917	2.113	3.720	3.513
	2.554	3.182	1.408	1.142	0.791	0.654
LATERAL DRAINAGE COLLECTED	3.0721	0.8816	0.6899	3.5431	4.3934	3.2986
FROM LAYER 4	0.6439	0.9661	1.2659	5.3098	3.0639	7.0971
PERCOLATION/LEAKAGE THROUGH	0.2406	0.0900	0.0710	0.2599	0.3156	0.2472
LAYER 5	0.0709	0.0961	0.1175	0.3552	0.2281	0.4549
PERCOLATION/LEAKAGE THROUGH	0.3686	0.3099	0.3302	0.3236	0.2212	0.1548
LAYER 8	0.1222	0.2323	0.2641	0.2140	0.1921	0.1114

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.442	0.136	0.099	0.527	0.632	0.490
TOP OF LAYER 5	0.093	0.139	0.188	0.764	0.455	1.021
STD. DEVIATION OF DAILY	0.160	0.066	0.110	0.354	0.301	0.338
HEAD ON TOP OF LAYER 5	0.050	0.080	0.149	0.665	0.422	0.667

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ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	80.25	221393.656	100.00
RUNOFF	23.969	66124.375	29.87

EVAPOTRANSPIRATION	20.868	57569.691	26.00
DRAINAGE COLLECTED FROM LAYER 4	34.2254	94421.086	42.65
PERC./LEAKAGE THROUGH LAYER 5	2.546974	7026.592	3.17
AVG. HEAD ON TOP OF LAYER 5	0.4154		
PERC./LEAKAGE THROUGH LAYER 8	2.844350	7846.994	3.54
CHANGE IN WATER STORAGE	-1.656	-4568.462	-2.06
SOIL WATER AT START OF YEAR	75.773	209043.625	
SOIL WATER AT END OF YEAR	74.117	204475.172	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.036	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	6.22	8.08	5.44	8.28	1.24	3.25
	0.00	7.88	10.60	4.53	7.84	8.62
RUNOFF	0.007	3.204	0.071	0.423	0.004	0.000
	0.000	3.914	5.744	0.876	1.953	2.796
EVAPOTRANSPIRATION	0.750	0.441	1.476	2.381	2.042	2.211
	0.480	2.318	1.374	0.832	0.948	0.425
LATERAL DRAINAGE COLLECTED	3.1660	2.9060	5.5529	5.6330	1.5708	0.5934
FROM LAYER 4	0.6507	0.4422	2.3990	1.5449	2.6649	3.4105

PERCOLATION/LEAKAGE THROUGH	0.2349	0.2226	0.3731	0.3783	0.1433	0.0672
LAYER 5	0.0725	0.0534	0.1807	0.1385	0.2103	0.2603
PERCOLATION/LEAKAGE THROUGH	0.1552	0.2278	0.3006	0.2504	0.2868	0.3573
LAYER 8	0.3245	0.2817	0.1983	0.2135	0.1246	0.1254

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.455	0.463	0.799	0.837	0.226	0.088
TOP OF LAYER 5	0.094	0.064	0.357	0.222	0.396	0.490
STD. DEVIATION OF DAILY	0.413	0.251	0.615	0.491	0.090	0.033
HEAD ON TOP OF LAYER 5	0.041	0.030	0.441	0.155	0.224	0.200

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ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	71.98	198578.437	100.00
RUNOFF	18.992	52393.785	26.38
EVAPOTRANSPIRATION	15.678	43252.477	21.78
DRAINAGE COLLECTED FROM LAYER 4	30.5342	84237.797	42.42
PERC./LEAKAGE THROUGH LAYER 5	2.335016	6441.843	3.24
AVG. HEAD ON TOP OF LAYER 5	0.3742		
PERC./LEAKAGE THROUGH LAYER 8	2.846004	7851.556	3.95
CHANGE IN WATER STORAGE	3.930	10842.799	5.46
SOIL WATER AT START OF YEAR	74.117	204475.172	
SOIL WATER AT END OF YEAR	74.592	205783.844	

SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	3.456	9534.120	4.80
ANNUAL WATER BUDGET BALANCE	0.0000	0.015	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 26

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	10.82	2.72	6.32	3.53	3.06	3.14
	7.37	9.14	14.54	20.11	15.87	6.90
RUNOFF	6.075	10.108	0.616	0.153	0.000	0.000
	3.092	2.856	6.100	6.855	5.798	0.682
EVAPOTRANSPIRATION	0.386	0.148	1.674	2.126	2.245	2.552
	2.728	2.757	1.730	1.275	0.918	0.654
LATERAL DRAINAGE COLLECTED	0.9447	0.2921	4.2805	0.9146	1.3416	0.8142
FROM LAYER 4	1.6593	2.5026	4.2440	9.8767	10.2120	4.0445
PERCOLATION/LEAKAGE THROUGH	0.0962	0.0390	0.2883	0.0930	0.1225	0.0851
LAYER 5	0.1452	0.1936	0.2854	0.5985	0.6164	0.2953
PERCOLATION/LEAKAGE THROUGH	0.1096	0.0697	0.1494	0.2376	0.1100	0.1782
LAYER 8	0.1347	0.1844	0.1472	0.1125	0.1352	0.1955

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.136	0.047	0.616	0.136	0.193	0.121
TOP OF LAYER 5	0.239	0.360	0.631	1.420	1.518	0.582

STD. DEVIATION OF DAILY	0.071	0.008	0.651	0.069	0.130	0.051
HEAD ON TOP OF LAYER 5	0.172	0.355	0.741	0.736	0.591	0.299

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ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	103.52	285590.844	100.00
RUNOFF	42.337	116799.281	40.90
EVAPOTRANSPIRATION	19.192	52947.891	18.54
DRAINAGE COLLECTED FROM LAYER 4	41.1268	113460.711	39.73
PERC./LEAKAGE THROUGH LAYER 5	2.858386	7885.715	2.76
AVG. HEAD ON TOP OF LAYER 5	0.4997		
PERC./LEAKAGE THROUGH LAYER 8	1.763914	4866.285	1.70
CHANGE IN WATER STORAGE	-0.900	-2483.155	-0.87
SOIL WATER AT START OF YEAR	74.592	205783.844	
SOIL WATER AT END OF YEAR	77.148	212834.812	
SNOW WATER AT START OF YEAR	3.456	9534.120	3.34
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.162	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 27

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	6.76	4.93	6.89	3.32	3.77	0.92
	3.87	2.61	4.45	15.04	6.33	9.39
RUNOFF	0.178	0.188	1.494	0.044	0.311	0.002
	0.626	0.408	0.827	5.819	1.058	0.811
EVAPOTRANSPIRATION	1.126	0.518	1.285	2.487	2.931	0.863
	1.830	2.495	0.880	1.170	0.865	1.048
LATERAL DRAINAGE COLLECTED	5.7662	4.5789	2.0523	4.4043	0.6586	0.4566
FROM LAYER 4	0.5417	0.8538	0.7443	4.4860	6.9673	5.7035
PERCOLATION/LEAKAGE THROUGH	0.3902	0.3156	0.1699	0.3070	0.0732	0.0544
LAYER 5	0.0623	0.0872	0.0793	0.3103	0.4453	0.3785
PERCOLATION/LEAKAGE THROUGH	0.5201	0.3575	0.3764	0.4037	0.2804	0.3187
LAYER 8	0.3017	0.2302	0.1846	0.1402	0.1579	0.1119

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.829	0.729	0.295	0.655	0.095	0.068
TOP OF LAYER 5	0.078	0.123	0.111	0.645	1.035	0.820
STD. DEVIATION OF DAILY	0.431	0.456	0.239	0.523	0.039	0.029
HEAD ON TOP OF LAYER 5	0.043	0.075	0.055	0.463	0.714	0.596

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ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	68.28	188370.875	100.00

RUNOFF	11.765	32458.607	17.23
EVAPOTRANSPIRATION	17.496	48267.863	25.62
DRAINAGE COLLECTED FROM LAYER 4	37.2135	102664.469	54.50
PERC./LEAKAGE THROUGH LAYER 5	2.673253	7374.970	3.92
AVG. HEAD ON TOP OF LAYER 5	0.4569		
PERC./LEAKAGE THROUGH LAYER 8	3.383230	9333.654	4.95
CHANGE IN WATER STORAGE	-1.578	-4353.710	-2.31
SOIL WATER AT START OF YEAR	77.148	212834.812	
SOIL WATER AT END OF YEAR	75.569	208481.109	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	11.10	6.81	3.47	6.87	4.44	6.15
	0.00	3.08	14.63	8.50	6.73	9.40
RUNOFF	2.944	0.179	0.441	6.353	0.963	2.452
	0.000	0.559	9.249	3.468	0.578	1.903
EVAPOTRANSPIRATION	0.727	0.986	0.767	0.421	2.637	2.961
	0.423	0.232	2.266	1.110	0.834	0.568

LATERAL DRAINAGE COLLECTED	6.9928	5.3726	2.8339	0.8270	1.2119	1.3356
FROM LAYER 4	0.7915	0.4070	1.9596	3.3603	4.2051	5.7165
PERCOLATION/LEAKAGE THROUGH	0.4531	0.3620	0.2217	0.0869	0.1155	0.1233
LAYER 5	0.0843	0.0513	0.1620	0.2479	0.2997	0.3862
PERCOLATION/LEAKAGE THROUGH	0.1134	0.1286	0.3526	0.3973	0.3899	0.2850
LAYER 8	0.2389	0.1647	0.1592	0.1825	0.1504	0.1062

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	1.006	0.826	0.408	0.123	0.174	0.198
TOP OF LAYER 5	0.114	0.059	0.291	0.483	0.625	0.822
STD. DEVIATION OF DAILY	0.527	0.502	0.259	0.049	0.083	0.112
HEAD ON TOP OF LAYER 5	0.046	0.015	0.208	0.408	0.423	0.465

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ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	81.18	223959.312	100.00
RUNOFF	29.089	80249.953	35.83
EVAPOTRANSPIRATION	13.933	38437.008	17.16
DRAINAGE COLLECTED FROM LAYER 4	35.0138	96595.937	43.13
PERC./LEAKAGE THROUGH LAYER 5	2.593813	7155.811	3.20
AVG. HEAD ON TOP OF LAYER 5	0.4274		
PERC./LEAKAGE THROUGH LAYER 8	2.668741	7362.521	3.29
CHANGE IN WATER STORAGE	0.476	1313.920	0.59

SOIL WATER AT START OF YEAR	75.569	208481.109	
SOIL WATER AT END OF YEAR	76.046	209795.016	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.032	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 29

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	6.40	6.50	7.31	7.33	2.37	5.12
	0.12	4.53	15.26	6.48	6.28	11.88
RUNOFF	0.000	8.732	3.887	0.231	0.000	0.406
	0.000	1.032	9.786	3.536	0.706	1.835
EVAPOTRANSPIRATION	0.736	0.158	0.984	2.334	1.867	3.050
	0.767	1.683	1.530	1.240	0.819	0.397
LATERAL DRAINAGE COLLECTED	3.8390	0.9479	0.6468	6.5526	1.5545	1.2363
FROM LAYER 4	0.6703	0.4690	0.7157	3.4649	3.3869	7.4754
PERCOLATION/LEAKAGE THROUGH	0.2815	0.0945	0.0684	0.4288	0.1418	0.1175
LAYER 5	0.0723	0.0561	0.0781	0.2578	0.2551	0.4764
PERCOLATION/LEAKAGE THROUGH	0.1040	0.1000	0.3160	0.3246	0.2344	0.1214
LAYER 8	0.2413	0.2102	0.2072	0.2126	0.1517	0.1249

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.552	0.151	0.093	0.974	0.224	0.184
TOP OF LAYER 5	0.096	0.067	0.106	0.498	0.503	1.075
STD. DEVIATION OF DAILY	0.318	0.070	0.099	0.515	0.090	0.081
HEAD ON TOP OF LAYER 5	0.057	0.028	0.030	0.341	0.256	0.641

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ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	79.58	219545.312	100.00
RUNOFF	30.152	83184.125	37.89
EVAPOTRANSPIRATION	15.563	42936.223	19.56
DRAINAGE COLLECTED FROM LAYER 4	30.9593	85410.500	38.90
PERC./LEAKAGE THROUGH LAYER 5	2.328357	6423.471	2.93
AVG. HEAD ON TOP OF LAYER 5	0.3770		
PERC./LEAKAGE THROUGH LAYER 8	2.348326	6478.563	2.95
CHANGE IN WATER STORAGE	0.557	1535.882	0.70
SOIL WATER AT START OF YEAR	76.046	209795.016	
SOIL WATER AT END OF YEAR	75.561	208458.031	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	1.041	2872.870	1.31
ANNUAL WATER BUDGET BALANCE	0.0000	0.012	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	7.55	4.68	7.03	4.48	8.14	5.01
	4.95	2.38	9.38	9.53	10.85	11.94
RUNOFF	2.766	0.382	0.000	0.231	0.233	0.735
	2.118	0.370	4.883	3.009	3.590	3.280
EVAPOTRANSPIRATION	0.533	0.616	1.697	2.397	3.466	2.933
	2.095	0.924	2.414	0.992	0.882	0.817
LATERAL DRAINAGE COLLECTED	5.2195	2.6753	5.9502	2.9174	3.1761	3.0877
FROM LAYER 4	0.7336	0.8882	1.8383	3.0461	5.2320	6.6282
PERCOLATION/LEAKAGE THROUGH	0.3524	0.2049	0.4031	0.2280	0.2400	0.2382
LAYER 5	0.0795	0.0912	0.1483	0.2198	0.3568	0.4315
PERCOLATION/LEAKAGE THROUGH	0.1203	0.0869	0.3288	0.2333	0.3488	0.2950
LAYER 8	0.2696	0.2982	0.2563	0.2492	0.1576	0.1482

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.751	0.426	0.856	0.434	0.457	0.459
TOP OF LAYER 5	0.106	0.128	0.273	0.438	0.778	0.953
STD. DEVIATION OF DAILY	0.637	0.313	0.339	0.193	0.344	0.217
HEAD ON TOP OF LAYER 5	0.041	0.065	0.271	0.569	0.491	0.596

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ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	85.92	237036.125	100.00
RUNOFF	21.597	59583.137	25.14
EVAPOTRANSPIRATION	19.767	54533.129	23.01
DRAINAGE COLLECTED FROM LAYER 4	41.3926	114193.883	48.18
PERC./LEAKAGE THROUGH LAYER 5	2.993621	8258.801	3.48
AVG. HEAD ON TOP OF LAYER 5	0.5047		
PERC./LEAKAGE THROUGH LAYER 8	2.792178	7703.061	3.25
CHANGE IN WATER STORAGE	0.371	1022.821	0.43
SOIL WATER AT START OF YEAR	75.561	208458.031	
SOIL WATER AT END OF YEAR	76.170	210138.234	
SNOW WATER AT START OF YEAR	1.041	2872.870	1.21
SNOW WATER AT END OF YEAR	0.803	2215.495	0.93
ANNUAL WATER BUDGET BALANCE	0.0000	0.092	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	7.76	6.47	5.97	5.67	4.87	3.77
	4.85	5.48	10.60	13.70	9.81	9.20
STD. DEVIATIONS	2.35	2.09	2.07	1.67	2.59	1.87

	4.22	3.37	5.90	5.29	3.73	2.50

RUNOFF

TOTALS	2.070	4.151	1.615	0.651	0.636	0.349
	1.937	2.091	5.203	5.200	2.401	2.023
STD. DEVIATIONS	2.113	4.413	1.840	1.182	0.853	0.550
	2.207	2.023	4.222	3.162	2.047	1.391

EVAPOTRANSPIRATION

TOTALS	0.642	0.509	1.287	2.338	2.679	2.451
	2.034	2.063	1.707	1.187	0.894	0.654
STD. DEVIATIONS	0.213	0.326	0.381	0.430	0.617	0.827
	0.937	0.743	0.455	0.113	0.114	0.172

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	4.7604	2.9760	2.8963	3.2157	1.9587	1.5105
	1.1282	1.2322	1.9442	5.3481	6.1136	5.4985
STD. DEVIATIONS	1.8242	2.3071	2.0606	1.4826	0.9105	1.2310
	0.7512	1.0679	1.3269	2.3284	2.2056	1.5683

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.3284	0.2147	0.2121	0.2386	0.1633	0.1287
	0.1044	0.1099	0.1530	0.3531	0.3994	0.3722
STD. DEVIATIONS	0.1062	0.1392	0.1290	0.0891	0.0570	0.0773
	0.0510	0.0698	0.0812	0.1288	0.1202	0.0843

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.1809	0.2242	0.3224	0.3237	0.2811	0.2358
	0.2269	0.2149	0.1810	0.1827	0.1590	0.1278
STD. DEVIATIONS	0.1119	0.1252	0.1057	0.0903	0.1030	0.0987
	0.0811	0.0674	0.0517	0.0571	0.0416	0.0336

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.6846	0.4690	0.4165	0.4779	0.2817	0.2245
	0.1623	0.1772	0.2889	0.7692	0.9086	0.7908
STD. DEVIATIONS	0.2624	0.3611	0.2963	0.2203	0.1309	0.1829
	0.1080	0.1536	0.1972	0.3349	0.3278	0.2255

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	88.17	(13.166)	243234.2	100.00
RUNOFF	28.328	(9.7869)	78152.12	32.130
EVAPOTRANSPIRATION	18.446	(2.2268)	50888.45	20.922
LATERAL DRAINAGE COLLECTED FROM LAYER 4	38.58249	(6.79752)	106441.383	43.76086
PERCOLATION/LEAKAGE THROUGH LAYER 5	2.77779	(0.41370)	7663.367	3.15061
AVERAGE HEAD ON TOP OF LAYER 5	0.471	(0.083)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	2.66048	(0.71678)	7339.733	3.01756
CHANGE IN WATER STORAGE	0.150	(2.3050)	412.52	0.170

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)

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PRECIPITATION	8.90	24553.318
RUNOFF	8.020	22125.7168
DRAINAGE COLLECTED FROM LAYER 4	0.72095	1988.96606
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.038454	106.08619
AVERAGE HEAD ON TOP OF LAYER 5	3.214	
MAXIMUM HEAD ON TOP OF LAYER 5	4.438	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	15.4 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.028824	79.51992
SNOW WATER	8.54	23564.3867

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4170
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0180

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	1.8762	0.3127

2	6.0231	0.3346
3	1.1605	0.0967
4	0.4170	0.0695
5	0.0000	0.0000
6	0.2243	0.0561
7	64.9047	0.1423
8	1.3724	0.0572
SNOW WATER	0.803	

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Appendix A-4 Hydraulic Design Methodology and Analysis

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ecology and environment, inc.

Design Memorandum

Date: 6/9/2017

To: Design File

From: Jeff Guerrero

Reviewer: Thomas C. Campbell, P.E.

Subject: **Drainage Channel and Perforated Pipe Hydraulic Design**

PROFESSIONAL ENGINEER CERTIFICATION PAGE

Drainage Channel and Perforated Pipe Hydraulic Design
Wrangell Junkyard Repository Site
Wrangell, Alaska
TDD: 17-01-0005

Pursuant to Alaska Administrative Code (AAC) 12 AAC 36.185(a)(3), only final plans, surveys, reports, and required construction documents approved for building permit issuance for which the registrant is qualified to seal and for which the registrant claims responsibility are required to be submitted under the seal of a State of Alaska licensed professional engineer. This page provides the signature and seal to comply with the regulation.

I hereby certify that this Drainage Channel and Perforated Pipe Hydraulic Design for the Wrangell Junkyard Repository Site in Wrangell, Alaska, was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Alaska. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

SIGNATURE: Thomas C. Campbell

REGISTRATION NUMBER: EV14234
STATE: Alaska

DATE: 06-09-2017

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OBJECTIVE

This memo describes the hydraulic design methodology that was used to design the drainage channel geometry and underdrain pipe requirements to handle discharges from the Wrangell Repository.

The drainage channel will be sized to handle runoff from the repository cover and run-on from adjacent tributary area outside the cover limits. Adequate sizing of the drainage channel around the repository will promote drainage away from the designed cover system.

The underdrain will be located and sized to collect and discharge infiltrating stormwater from the engineered cover in order to protect the cover from veneer slide conditions and to minimize the potential for infiltration through the flexible membrane liner (FML) and into the treated waste soil. Water collected within the underdrain will be discharged to the drainage ditch.

CRITERIA

From 18 AAC 60.225 (ADEC 2013). Surface water requirements:

(b)(2): If the department determines that a control system for stormwater run-off is necessary to prevent the landfill from contributing to siltation or flooding problems in nearby surface water bodies, [the owner or operator of a landfill shall] construct and maintain a control system capable of containing and controlling the run-off from a 24-hour, 25-year storm.

(c): The owner or operator of a solid waste disposal facility shall construct and maintain a control system that will prevent run-on from flowing onto the active portion of the facility. The control system must be capable of handling the peak discharge from a 25-year storm.

METHOD OF ANALYSIS

The drainage channels around the repository have been sized according to Manning's Equation, which is appropriate for open channel flow calculations in uniform flow situations. The upstream end of both channels is at the back (south end) of the repository, and the channels will slope toward the front along both sides of the cover. To apply Manning's Equation, a peak flow from the tributary area was calculated using the HydroCAD software (v. 10.00-19). The tributary area to the western half of the repository was used for a peak discharge as it is the largest contributing area, and will therefore produce the most conservative channel sizing requirements. The 25-year, 24-hr storm event of 5.26 inches (NOAA 2017) was used as the design rain event as required by 18 AAC 60.225. Based on the proposed land cover, HydroCAD calculated that the SCS Type I storm would generate 2.33 cfs as a peak runoff rate to the western drainage ditch. Both drainage ditches were sized to this runoff rate. Trapezoidal channels with 3:1 (H:V) slopes were tested to determine which geometry would pass this storm event while also providing 1 foot of freeboard. A trapezoidal channel with a depth of 1.25 feet, bottom width of 1 foot, and 3:1 (H:V) side slopes was determined to be appropriate for the site. Based on the design peak flow, the calculated peak velocity is 5.42 ft/s with a flow depth of 0.24 feet. The HydroCAD output is included as Attachment A.

Appropriate drainage channel rock size was calculated based on the USACE Steep Slope Riprap Design method, as outlined in NEH Technical Supplement 14C – Stone Sizing Criteria. Further application notes for the method are available in the USACE Hydraulic Design of Flood Control Channels, EM 1110-2-1601 manual (USACE 1991). The steep slope method is appropriate for slopes between 2 and 20%. The steepest slope of the proposed channel is approximately 16%. The method also requires side slopes of 1:2.5 (V:H) or flatter, which is met by the proposed channel. The following equation calculates a D_{30} rock size for such channels:

$$D_{30} = \frac{1.95S^{0.555}(Cq)^{\frac{2}{3}}}{g^{\frac{1}{3}}}$$

where: D_{30} = rock size in feet; 30% of rock shall be smaller than this size
S = channel slope in feet/feet
C = flow concentration factor (usually 1.25; higher if skewed approach)
q = unit discharge (q = Q/b, where b = bottom width of channel and Q is total flow)
g = gravitational constant (feet/second/second)

Based on the design peak flow, the D30 is calculated as 0.45 feet, or 5.4 inches. Guidance in EM 1110-2-1601 suggests a unit weight of 165 pounds per cubic foot should be used to determine an appropriate gradation from the calculated D30 value. Based on Table 3-1 in EM 1110-2-1601, a D90 of 0.70 feet (8.4 inches), and a D100 of 12 inches are appropriate. Table 3-1 in EM 1110-2-1601 further defines gradation based on limits of stone weight (pounds). This data has been summarized in Table 1 below for a D30 of 0.48 feet.

Table 1. Limits of Stone Weight, lb, for Percent Lighter by Weight

	100		50		15	
D_{30} (feet)	Max	Min	Max	Min	Max	Min
0.48	86	35	26	17	13	5

The underdrain layout for the repository was established by first determining maximum pipe catchment areas. Manning's equation was used to develop flowing full capacities of various pipe sizes and slopes that would fit the site. For each flowing full capacity, a maximum pipe catchment area could be calculated as follows:

$$A = \frac{Q_{in}}{k}$$

where: Q_{in} = rate of flow to the drainage pipe (cubic feet/second)
A = contributing drainage area (square feet)
k = hydraulic conductivity of cover soils (feet/second)

To calculate the conservative contributing drainage ara, the rate of flow to the drainage pipes is equal to the flowing full capacity of the pipe. A hydraulic conductivity of $1.12\text{x}10^{-6}$ ft/s ($3.40\text{x}10^{-5}$ cm/s) was used, which is based on permeability tests conducted on common fill material collected at the site.

Based on this calculation, a 4-inch underdrain installed at a 3% grade can drain over 7 acres of upstream tributary area. Thus, just one underdrain per side (left and right of the centerline) of the repository is required for this site. The upstream side of the underdrains has been set approximately 20 feet south of the planned repository northern limit. The 4-inch underdrain pipes have been set at a 3% grade, and will discharge to the drainage ditch. The peak flow of these underdrains is 0.36 cfs from each. In addition to the peak runoff rate of 2.33 cfs, the potential peak discharge to the drainage ditch is 2.69 cfs. The drainage ditch described above has a maximum capacity of 82 cfs.

ASSUMPTIONS

The following assumptions were made based on engineering judgment and project considerations:

- Cross sections, slopes, and roughness along the drainage ditch will be uniform throughout;
- The slope profile for the drainage ditch was calculated at two points based on the repository cover design. The cover calls for a 3% longitudinal slope section, and a 25% longitudinal slope section. Drainage ditch slopes were calculated based on ditch length and total elevation drop within each of these two sections;
- The ditch will constructed of rip rap for stability and erosion control; and
- The channel will include 1 foot of freeboard for a Factor of Safety.

CONCLUSIONS

The design event, a 25-year 24-hour rain, will produce runoff that will be contained within the drainage ditch with 1 foot of additional freeboard. Additionally, the drainage ditch will provide capacity for underdrain pipes installed within the engineered cover. Based on the anticipated velocities within the drainage ditch, it was calculated for riprap with a D30 of 6 inches, and a D100 of 12 inches. To fully embed the larger stone, the drainage ditch would need a rock thickness of 1.5 times the D100, or 18 inches. This channel bottom is made of 1-inch Minus Drain Rock and 3/8-inch Minus Aggregate with an equivalent permeability of 165 ft/day. For this reason, most water will not travel through the ditch but instead will infiltrate into the chimney drain. For this reason, the rock size represented in the design drawings and specifications for the drainage ditches has been selected to match the chimney drain rock size of 6-inch Minus Rock.

REFERENCES

Alaska Department of Environmental Conservation; 18 AAC 60, Solid Waste Management; As amended through April 12, 2013.

Ecology and Environment, Inc., Design Memorandum: Wrangell Junkyard Repository Site Stormwater Runoff and Hydrology Analysis – 30% Design.

National Oceanic and Atmospheric Administration (NOAA), National Weather Service, Office of Water Prediction (OWP), NOAA Atlas 14 Point Precipitation Frequency Estimates: AK. http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html. Accessed 4/24/17.

United States Department of Agriculture (USDA), National Engineering Handbook Technical Supplement 14C – Stone Sizing Criteria, 210-VI-NEH, August 2007.

United States Army Corps of Engineers (USACE) Hydraulic Design of Flood Control Channels, EM 1110-2-1601, July 1, 1991.

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Attachment A

HydroCAD Report

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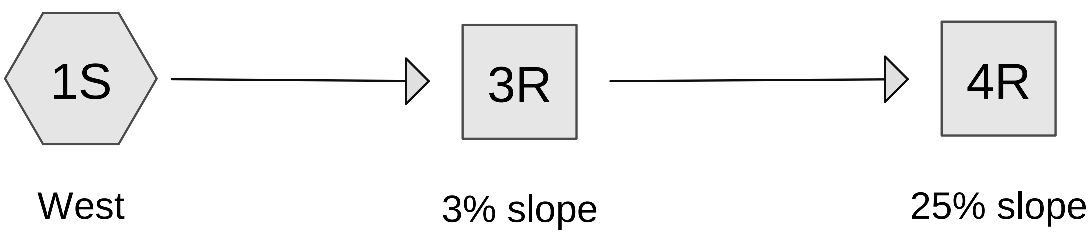
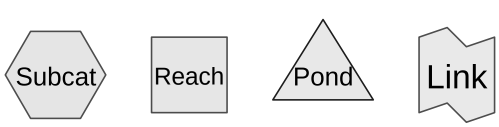




Routing Diagram for Hydraulics

Prepared by Ecology and Environment, Inc., Printed 4/28/2017

HydroCAD® 10.00-19 s/n 09519 © 2016 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.336	74	>75% Grass cover, Good, HSG C (1S)
0.064	96	Gravel surface, HSG C (1S)
0.394	89	Quarry (1S)
0.795	**83**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.400	HSG C	1S
0.000	HSG D	
0.394	Other	1S
0.795		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.336	0.000	0.000	0.336	>75% Grass cover, Good	1S
0.000	0.000	0.064	0.000	0.000	0.064	Gravel surface	1S
0.000	0.000	0.000	0.000	0.394	0.394	Quarry	1S
0.000	**0.000**	**0.400**	**0.000**	**0.394**	**0.795**	**TOTAL AREA**	

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: West Runoff Area=34,609 sf 0.00% Impervious Runoff Depth=3.41"
Flow Length=467' Tc=3.7 min CN=83 Runoff=2.33 cfs 0.226 af

Reach 3R: 3% slope Avg. Flow Depth=0.36' Max Vel=3.13 fps Inflow=2.33 cfs 0.226 af
n=0.033 L=143.0' S=0.0350 '/' Capacity=38.15 cfs Outflow=2.27 cfs 0.226 af

Reach 4R: 25% slope Avg. Flow Depth=0.24' Max Vel=5.42 fps Inflow=2.27 cfs 0.226 af
n=0.033 L=256.0' S=0.1602 '/' Capacity=81.66 cfs Outflow=2.20 cfs 0.226 af

Total Runoff Area = 0.795 ac Runoff Volume = 0.226 af Average Runoff Depth = 3.41"
100.00% Pervious = 0.795 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: West

CN for quarry (89) based on
https://www.mwrd.org/pv_obj_cache/pv_obj_id_320E5F671969B15D338ADD94432009CA15225900/filename/Appendi

Table A.2 Modified Curve Number Generation for Calumet-sag Watershed, HSG C

[49] Hint: Tc<2dt may require smaller dt

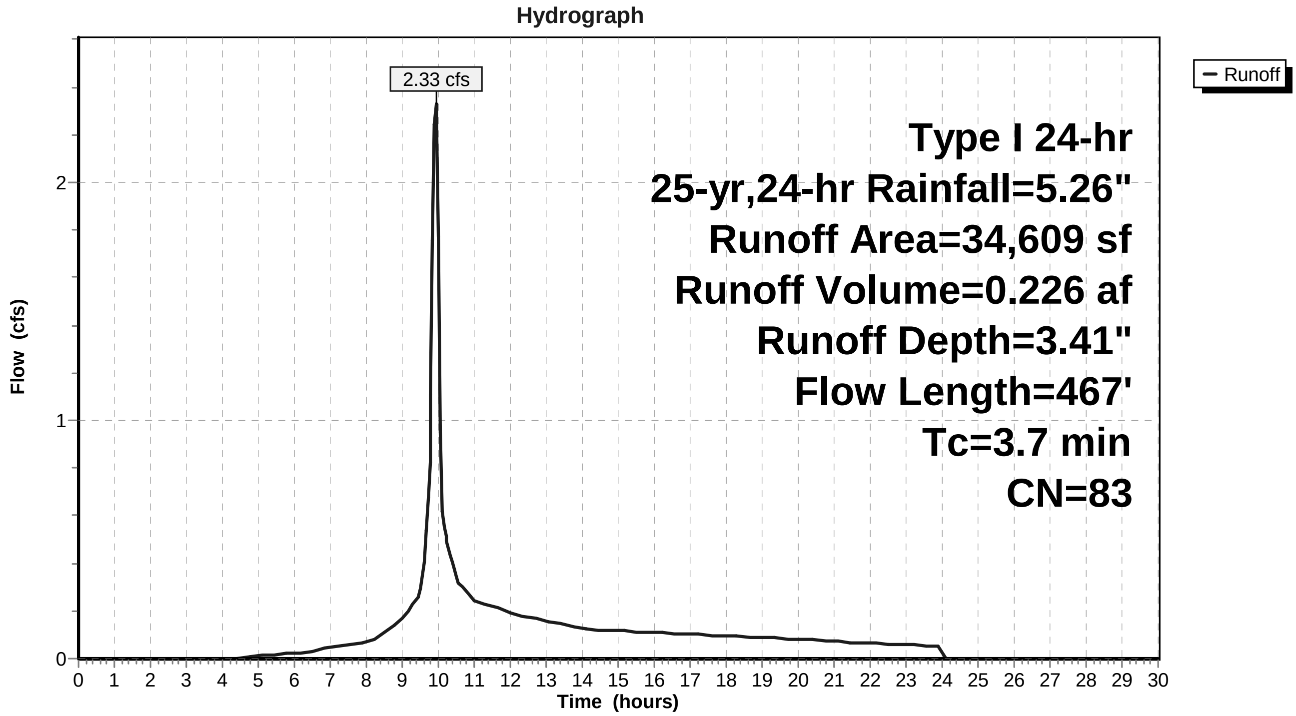
Runoff = 2.33 cfs @ 9.93 hrs, Volume= 0.226 af, Depth= 3.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 25-yr,24-hr Rainfall=5.26"

	Area (sf)	CN	Description
	14,644	74	>75% Grass cover, Good, HSG C
*	17,172	89	Quarry
	2,793	96	Gravel surface, HSG C
	34,609	83	Weighted Average
	34,609		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	68	0.7400	5.54		**Sheet Flow, overland** Smooth surfaces n= 0.011 P2= 3.37"
2.1	143	0.0200	1.14	0.09	**Trap/Vee/Rect Channel Flow, upstream end** Bot.W=0.00' D=0.16' Z= 3.0 '/' Top.W=0.96' n= 0.033
1.4	256	0.2500	2.95	0.09	**Trap/Vee/Rect Channel Flow, downstream** Bot.W=0.00' D=0.10' Z= 3.0 '/' Top.W=0.60' n= 0.033
3.7	467	Total			

Subcatchment 1S: West



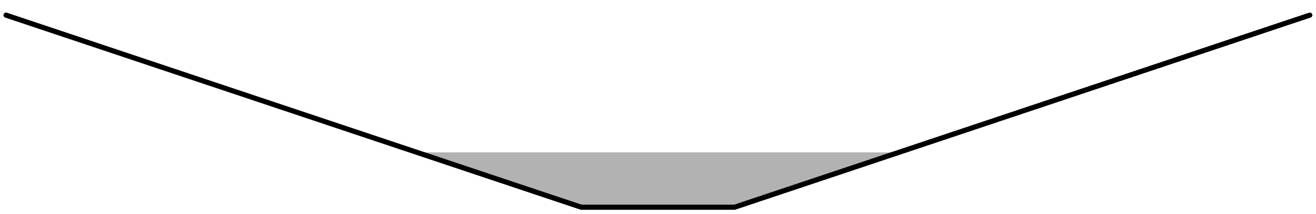
Summary for Reach 3R: 3% slope

Inflow Area = 0.795 ac, 0.00% Impervious, Inflow Depth = 3.41" for 25-yr,24-hr event
Inflow = 2.33 cfs @ 9.93 hrs, Volume= 0.226 af
Outflow = 2.27 cfs @ 9.95 hrs, Volume= 0.226 af, Atten= 3%, Lag= 1.2 min

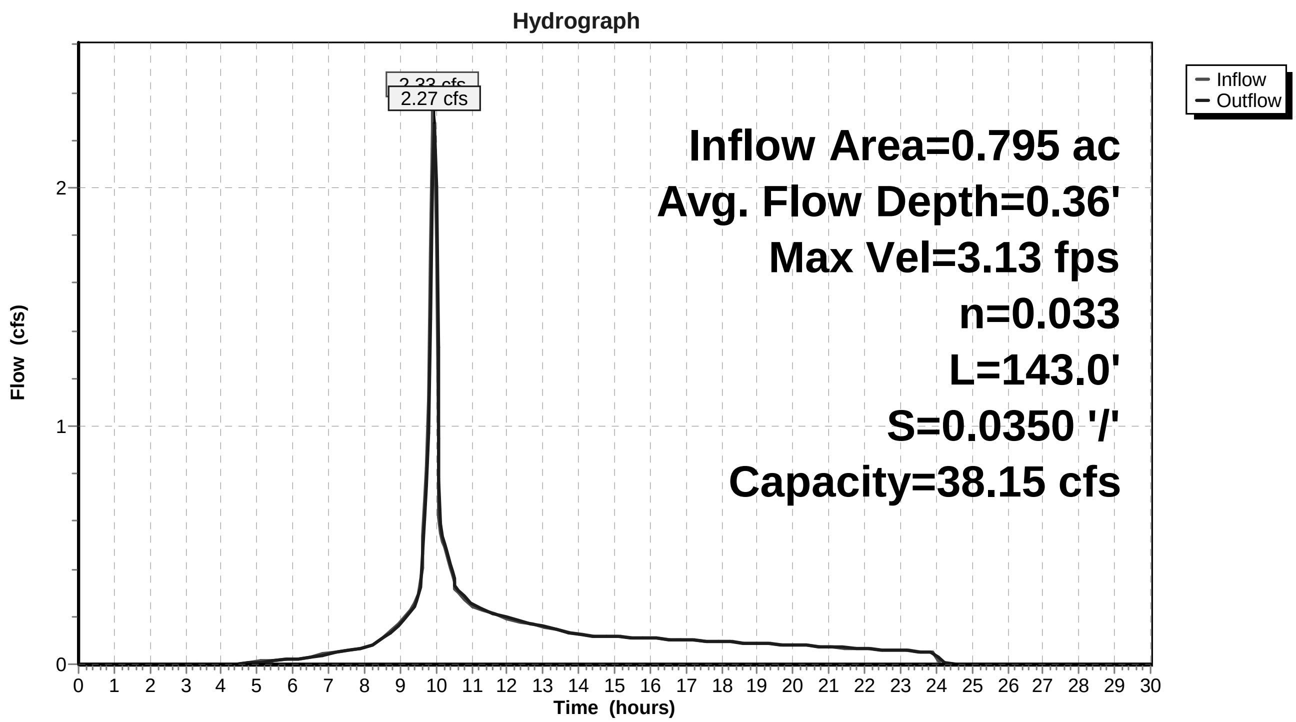
Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.13 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 1.21 fps, Avg. Travel Time= 2.0 min

Peak Storage= 106 cf @ 9.94 hrs
Average Depth at Peak Storage= 0.36'
Bank-Full Depth= 1.25' Flow Area= 5.9 sf, Capacity= 38.15 cfs

1.00' x 1.25' deep channel, n= 0.033
Side Slope Z-value= 3.0 '/' Top Width= 8.50'
Length= 143.0' Slope= 0.0350 '/'
Inlet Invert= 294.00', Outlet Invert= 289.00'



Reach 3R: 3% slope



Summary for Reach 4R: 25% slope

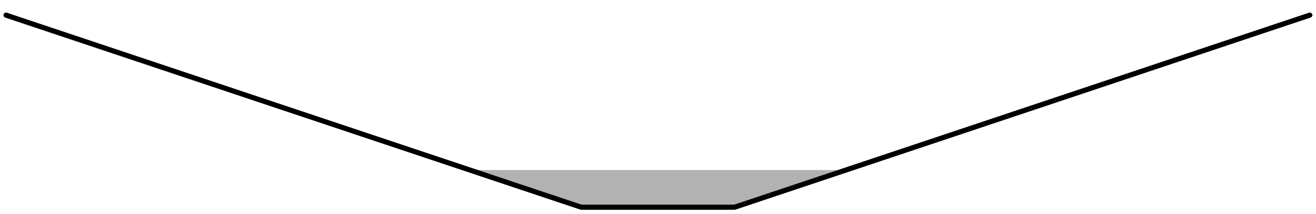
[61] Hint: Exceeded Reach 3R outlet invert by 0.24' @ 9.95 hrs

Inflow Area =	0.795 ac,	0.00% Impervious,	Inflow Depth = 3.41"	for 25-yr,24-hr event	
Inflow =	2.27 cfs @	9.95 hrs,	Volume=	0.226 af	
Outflow =	2.20 cfs @	9.97 hrs,	Volume=	0.226 af,	Atten= 3%, Lag= 1.3 min

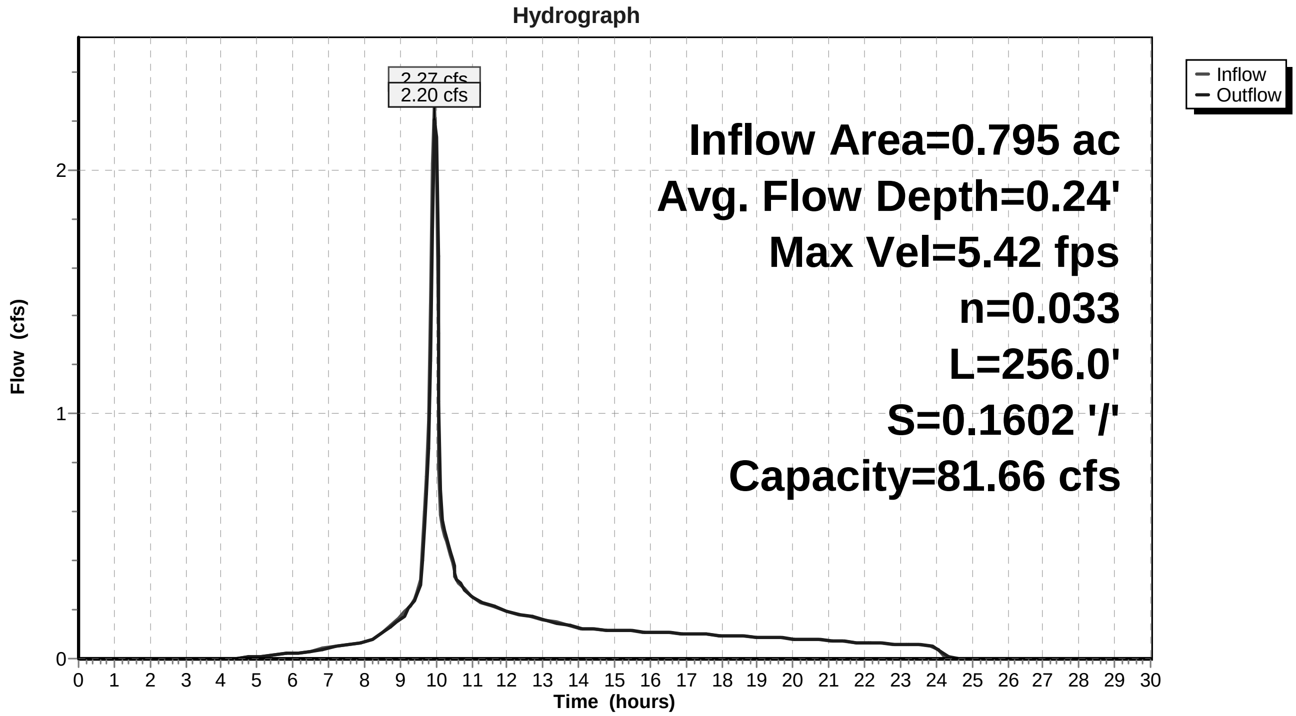
Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.42 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 2.02 fps, Avg. Travel Time= 2.1 min

Peak Storage= 107 cf @ 9.96 hrs
Average Depth at Peak Storage= 0.24'
Bank-Full Depth= 1.25' Flow Area= 5.9 sf, Capacity= 81.66 cfs

1.00' x 1.25' deep channel, n= 0.033
Side Slope Z-value= 3.0 '/' Top Width= 8.50'
Length= 256.0' Slope= 0.1602 '/'
Inlet Invert= 289.00', Outlet Invert= 248.00'



Reach 4R: 25% slope



Attachment B

Underdrain Sizing

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Date: 4/25/2017
To: Design File
From: Jeff Guerrero
Reviewer: Tom Campbell, P.E.
Subject: Wrangell Repository - Underdrain Sizing

Underdrain Pipe Capacity (Pipe-Full Capacity)
Manning's equation is used to calculate the pipe-full flow rate:

$Q_{full} = 1.49/n * A * R^{2/3} * S^{1/2}$, where:

Q_{full}	= pipe-full flow rate, ft^3/sec (unknown)		
D	= pipe diameter, ft	0.33	ft
n	= Manning's "n", dimensionless	0.012	
A	= cross-sectional area of pipe flowing full, ft^2	0.087	ft^2
R	= hydraulic radius = D/4, ft	0.083	ft
S	= longitudinal slope of pipe, ft/ft	0.01	ft/ft

Q_{full} = 0.21 ft3/sec

Maximum Pipe Catchment Area
The maximum drainage area to any single 4" underdrain is governed by the equation:

$Q_{in} = A * k$, where:

Q_{in} = rate of flow to drainage pipe (ft^3/sec)
= Q_{full} when determining maximum allowable drainage area
= 0.21 ft3/sec (calculated above)
A = contributing drainage area, ft^2 (unknown)
k = hydraulic conductivity of cover soils, 0.000034 cm/s (0.0000011152 ft/sec)

A =	185,373	ft^2	feet in upslope height
A =	4.26	acres	
	3,707.45	feet	distance between each perf pipe

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Attachment C

Stone Sizing

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Stone Sizing The USACE Steep Slope Riprap Design method (described also in EM 1110-2-1601)
Appropriate for steep slopes (2-20 percent) and side slopes of 1V:2.5H or flatter
Typical application is a rock-lined chute.
(this spreadsheet is based on NEH Technical Supplement 14C - Stone Sizing Criteria)

Channel slope, S =	0.1602	ft/ft	
Total flow, Q =	2.33	cfs	
Bottom width, b =	1	ft/ft	
Unit discharge, q =	2.33		
Flow concentration factor, C =	1.25		
Gravity, g =	32.2		
D_{30} =	0.452	ft	(refer to Table 3-1, next page)
D_{30} =	5.429	inches	
D_{90} =	8.4	in	(0.7 feet)
D_{100} =	12	in	

$$D_{30} = \frac{1.95 S^{0.555} (Cq)^{\frac{2}{3}}}{g^{\frac{1}{3}}} \qquad \text{(eq. TS14C–12)}$$

where:

D_{30} = stone size; m percent finer by weight
S = channel slope
q = unit discharge (q = Q/b, where b = bottom width of chute and Q is total flow)
C = flow concentration factor (usually 1.25, but can be higher if the approach is skewed)
g = gravitational constant

This equation is applicable to thickness = 1.5 D_{100}, angular rock unit weight of 167 pounds per cubic foot, D_{85}/D_{15} from 1.7 to 2.7, slopes from 2 to 20 percent, and uniform flow on a downslope with no tailwater. This equation typically predicts conservative sizes.

From page TS14C-7 of NEH Tech Supp 14C

Table 3-1
Gradations for Riprap Placement in the Dry, Low-Turbulence Zones

Limits of Stone Weight, lb[1], for Percent Lighter by Weight

D_{100}(max)	100		50		15		D_{30}(min)	D_{90}(min)
in.	Max	Min	Max[2]	Min	Max[2]	Min	ft	ft
Specific Weight = 155 pcf								
9	34	14	10	7	5	2	0.37	0.53
12	81	32	24	16	12	5	0.48	0.70
15	159	63	47	32	23	10	0.61	0.88
18	274	110	81	55	41	17	0.73	1.06
21	435	174	129	87	64	27	0.85	1.23
24	649	260	192	130	96	41	0.97	1.40
27	924	370	274	185	137	58	1.10	1.59
30	1,268	507	376	254	188	79	1.22	1.77
33	1,688	675	500	338	250	105	1.34	1.94
36	2,191	877	649	438	325	137	1.46	2.11
42	3,480	1,392	1,031	696	516	217	1.70	2.47
48	5,194	2,078	1,539	1,039	769	325	1.95	2.82
54	7,396	2,958	2,191	1,479	1,096	462	2.19	3.17
Specific Weight = 165 pcf								
9	36	15	11	7	5	2	0.37	0.53
12	86	35	26	17	13	5	0.48	0.70
15	169	67	50	34	25	11	0.61	0.88
18	292	117	86	58	43	18	0.73	1.06
21	463	185	137	93	69	29	0.85	1.23
24	691	276	205	138	102	43	0.97	1.40
27	984	394	292	197	146	62	1.10	1.59
30	1,350	540	400	270	200	84	1.22	1.77
33	1,797	719	532	359	266	112	1.34	1.96
36	2,331	933	691	467	346	146	1.46	2.11
42	3,704	1,482	1,098	741	549	232	1.70	2.47
48	5,529	2,212	1,638	1,106	819	346	1.95	2.82
54	7,873	3,149	2,335	1,575	1,168	492	2.19	3.17
Specific Weight = 175 pcf								
9	39	15	11	8	6	2	0.37	0.53
12	92	37	27	18	14	5	0.48	0.70
15	179	72	53	36	27	11	0.61	0.88
18	309	124	92	62	46	19	0.73	1.06
21	491	196	146	98	73	31	0.85	1.23
24	733	293	217	147	109	46	0.97	1.40
27	1,044	417	309	209	155	65	1.10	1.59
30	1,432	573	424	286	212	89	1.22	1.77
33	1,906	762	565	381	282	119	1.34	1.94
36	2,474	990	733	495	367	155	1.46	2.11
42	3,929	1,571	1,164	786	582	246	1.70	2.47
48	5,864	2,346	1,738	1,173	869	367	1.95	2.82
54	8,350	3,340	2,474	1,670	1,237	522	2.19	3.17

Notes:
1. Stone weight limit data from ETL 1110-2-120 (HQUSACE, 1971 (14 May), "Additional Guidance for Riprap Channel Protection, Ch 1," US Government Printing Office, Washington, DC). Relationship between diameter and weight is based on the shape of a sphere.
2. The maximum limits at the W_{50} and W_{15} sizes can be increased as in the Lower Mississippi Valley Division Standardized Gradations shown in Appendix F.

From page 3-3 of EM 1110-2-1601

Appendix A-5 Veneer Slope Stability Analysis

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ecology and environment, inc.

Design Memorandum

Date: 6/9/2017

To: Design File

From: Jen Jenkins

Reviewer: Thomas C. Campbell, P.E.

Subject: **Veneer Stability Analysis**

PROFESSIONAL ENGINEER CERTIFICATION PAGE

Veneer Stability Analysis
Wrangell Junkyard Repository Site
Wrangell, Alaska
TDD: 17-01-0005

Pursuant to Alaska Administrative Code (AAC) 12 AAC 36.185(a)(3), only final plans, surveys, reports, and required construction documents approved for building permit issuance for which the registrant is qualified to seal and for which the registrant claims responsibility are required to be submitted under the seal of a State of Alaska licensed professional engineer. This page provides the signature and seal to comply with the regulation.

I hereby certify that this Veneer Stability Analysis for the Wrangell Junkyard Repository Site in Wrangell, Alaska, was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Alaska. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

SIGNATURE:

REGISTRATION NUMBER: EV14234
STATE: Alaska

DATE: 06-09-2017

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OBJECTIVE

Evaluate the veneer stability of the Linear Low Density Polyethylene (LLDPE) Flexible Membrane Line (FML) cover system under fully drained conditions using peak and residual shear strengths without construction equipment. This memorandum describes the veneer stability analysis that was performed to evaluate the performance of the cover design for the Wrangell Junkyard Repository Site (referred to herein as the "repository site"). The calculations herein are intended to provide the designers with an awareness of potential slope issues that may affect the cover's constructability or long-term stability.

CRITERIA

The sliding of thin layers of cover soil (called veneer sliding) above FMLs and natural soil layers was described in detail in the paper published by Robert Koerner and Te-Yang Soong for the 1998 Sixth International Conference on Geosynthetics. A global factor of safety (FOS) was used as the criteria to evaluate the adequacy of the performance of the conceptual cover. Technically, the FOS represents the relationship between the sum of the resisting forces and the driving or mobilizing forces (Koerner and Soong 1998). The FOS becomes the ration of tangents of the internal friction angle of the cover soil against the upper surface of the FML (d) and the slope angle of the soil beneath the FML (β).

$$FOS = \frac{\tan\delta}{\tan\beta}$$

When the FOS is equal to 1.0 or less, the cover is in a state of impending failure. The recommended minimum FOS for non-critical, permanent cover systems with non-hazardous waste is 1.5 (Koerner and Soong 1998) for normal long-term loading conditions.

An additional evaluation of slope failure during a seismic event was also conducted. The recommended minimum FOS under pseudo-static (seismic) conditions is 1.0; however, as with the non-seismic analysis, due to the repository site's remoteness, the use of literature-derived FML values, and limitations of veneer stability not analyzed in this memorandum, this analysis used a FOS of 1.1 for pseudo-static conditions.

METHOD OF ANALYSIS

There are a number of situations that can destabilize slopes, including normal uniform gravitational forces (i.e., the weight of the cover soils), seepage, and seismic forces. These forces have been defined and detailed below. The analysis below follows the methodology provided by the paper *"Analysis and Design of Veneer Cover Soils"* (Koerner and Soong 1998). The FOS can be derived under each of these scenarios by balancing horizontal and vertical forces that act on the active and passive wedges of the cover soils above the geomembrane layer as identified in the figure below:

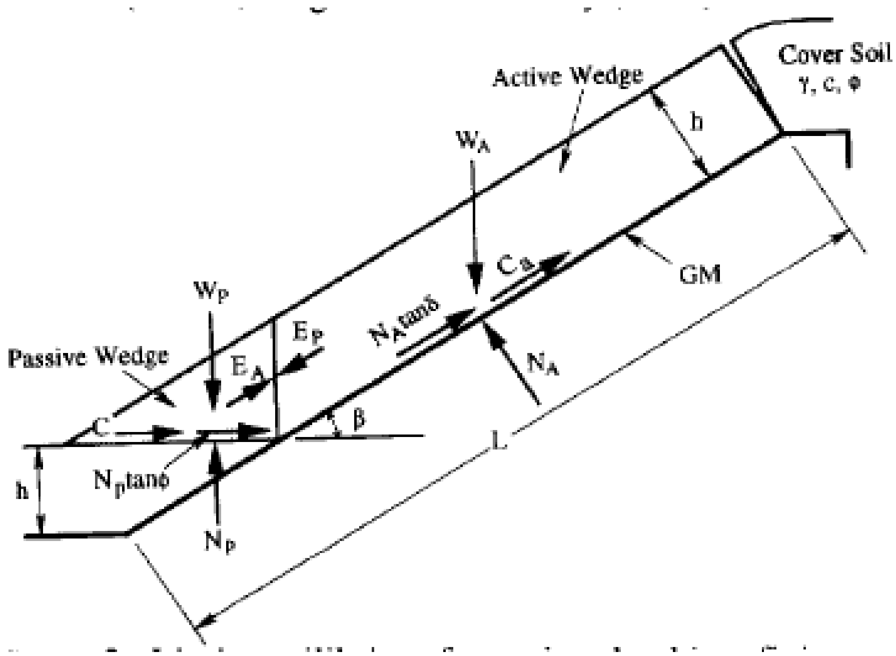

Figure 1: Limit Equilibrium forces on a soil cover for a finite length veneer slope analysis of uniform thickness (Koerner and Soong 1998)

where:
W_A – total weight of active wedge
W_p – Total weight of passive wedge
N_A – effective force normal to the failure plane of the active wedget
N_p – effective force normal to the the failure plan of the passive wedge
γ – unit weight of cover soil
h – thickness of the cover soil
L – length of slope measured along the geomembrane
β – soil slope angle beneath geomembrane
ϕ – friction angle of the cover soil
δ – interface friction angle between cover soil and geomembrane
C_a – adhesive force between cover soil of the active wedge and the geomembrane
c_a – adhesion between cover soil of active wedge and geomembrane
C – cohesive force along the failure plane of the passive wedge
c – cohesion of cover soil
FS – Factor of safety against cover soil sliding on geomembrane

Under **Uniform Gravitational Forces** the factor of safety is derived through the quadratic equation (see Attachment B for calculations for Wrangell Repository site):

$$FS = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

where:

$a = (W_A - N_A{*}\cos\beta){*}\cos\beta$
$b = -[(W_A - N_A{*}\cos\beta) * \sin\beta{*}\tan\phi + (N_A{*}\tan\delta + C_a){*}\sin\beta{*}\cos\beta + \sin\beta(C + W_P{*}\tan\phi)]$
$c = (N_A * \tan\delta + C_a){*}\sin^2\beta{*}\tan\phi$

Additional forces that lead to planar failure of slopes include phreatic soil pressure as the cover soil becomes saturated. Although it is assumed that adequate drainage of the cover has been provided in the form of underdrains, cover grading, and the perimeter chimney drain, seepage induced slope instability is possible. Seepage build up in the cover soils can occur in two ways: horizontal build up from the toe upward or parallel-to-slope buildup outward from the geomembrane. To simplify the analysis, it is assumed that the gomembrane acts as a impervious barrier layer and any infiltration into the cap is captured above the FML LLDPE liner.

Similar to the uniform gravitational forces failure scenario the **<u>Horizontal Seepage Build Up</u>** conditions can be solved by quadratic equation, above. Horizontal seepage buildup occurs when toe blockages, due to inadequate outlet cpacity or physical obstructions such as ice or debris, impede drainage of the cover soils. The FOS can be derived using the following passive and active wedge relationships as illustrated in Figure 2 (see Attachment B for calculations prepared for theWrangell Repository site):

a $= W_A * \sin\beta * \cos\beta - U_h \cos^2\beta + U_h$
b $= -W_A * \sin^2\beta * \tan\phi \; U_h * \sin\beta * \cos\beta * \tan\phi - N_A * \cos\beta * \tan\delta - (W_p - U_v) * \tan\phi$
c $= N_A * \sin\beta * \tan\delta + * \tan\phi$

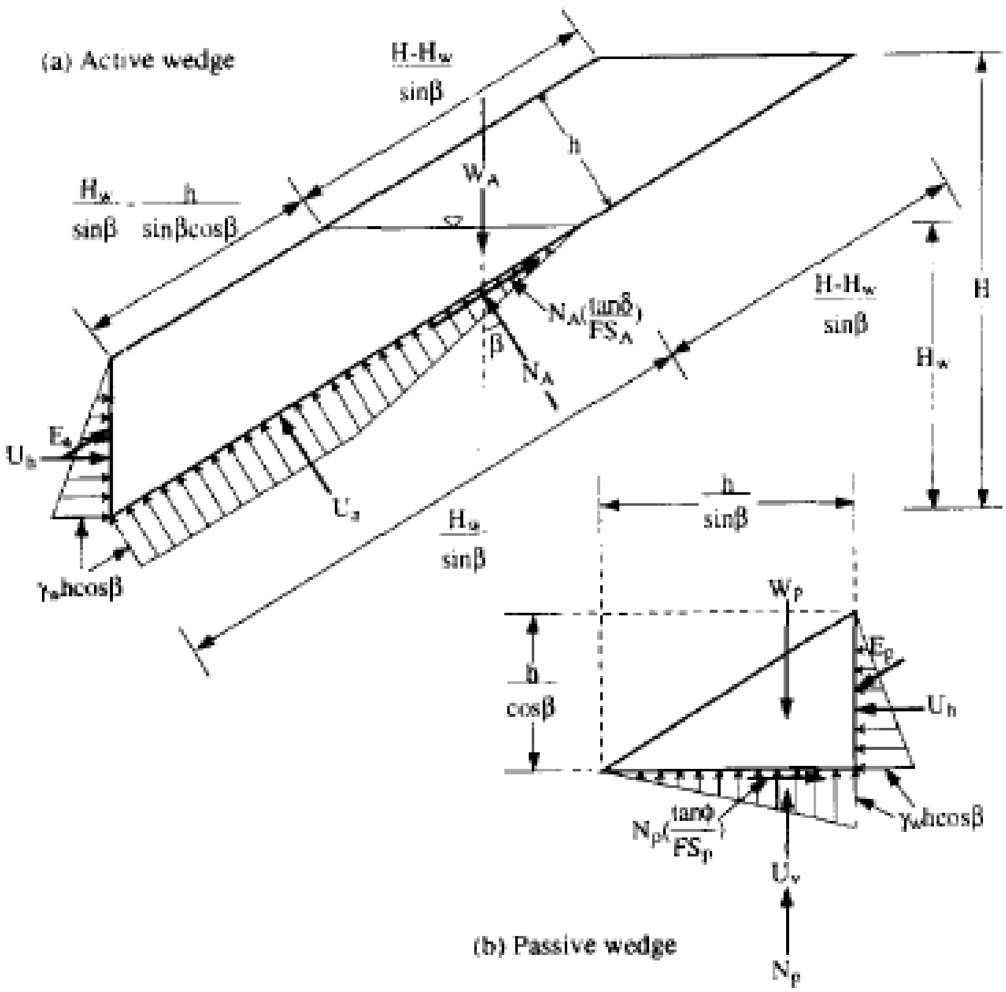

Figure 2: Saturated Cover definitions, parameters and as sumptions for Horizontal Seep (Koerner and Soong 1998)

where
γ_{sat} – saturated unit weight of cover soil
γ_t – total (moist) unti weight of cover soil
γ_w – unit weight of water
H - vertical height of slope measured from the toe
H_w – vertical height of the free water surface measured from the toe
U_n – resultant of the pore pressures acting perpendicular to the slope
U_v – resultant of the vertical pore pressures activing on the passive wedget

The **Parallel to Slope Seepage Build Up** conditions are also solved by the quadratic equation, above. Parallel seepage occurs when soils placed above the geomembrane have hydraulic conductivities that are too low. This results in clogging from overlying soils which does not have appropriate filtering of fine materials. The repository cover will have a non-woven geomembrane fabric installed below the Clean Backfill layer to help filter out fine materials and allow for proper infiltration through the 1-inch Minus Drain Rock and 3/8-inch Minus Aggregate drainage layers installed above the FML LLDPE liner. However, this analysis has assumed there is not filter fabric in order to be conservative and evaluate the failure potential of cover materials under the worst case scenario. The FOS can be derived using the following passive and active wedge relationships, as illustrated in Figure 3:

$a = W_A * \sin\beta * \cos\beta - U_h \cos^2\beta + U_h$
$b = -W_A * \sin^2\beta * \tan\phi \; U_h * \sin\beta * \cos\beta * \tan\phi - N_A * \cos\beta * \tan\delta - (W_p - U_v) * \tan\phi$
$c = N_A * \sin\beta * \tan\delta + * \tan\phi$

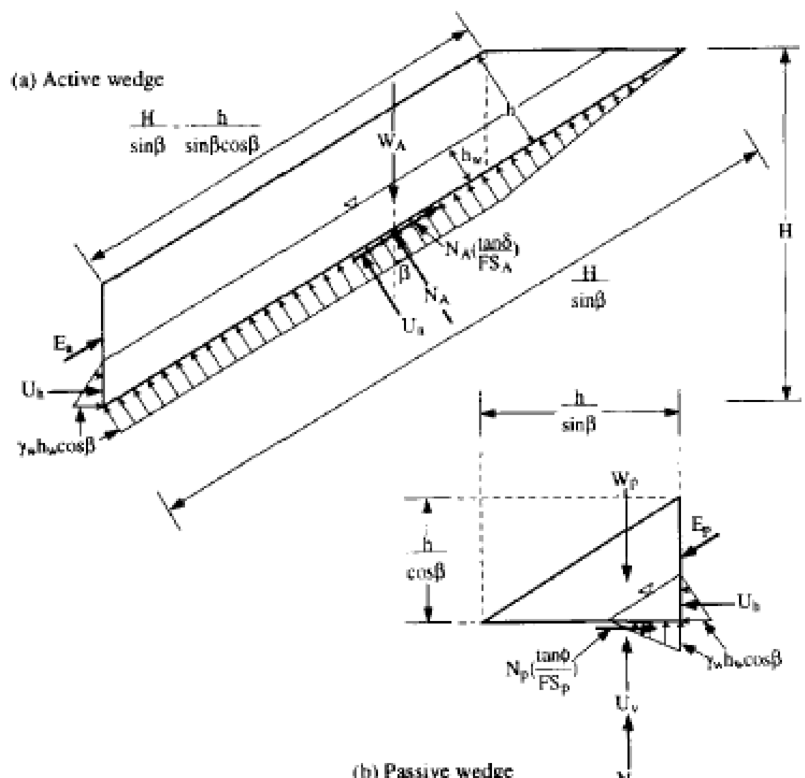

Figure 3: Saturated Cover definitions, parameters and assumptions for parallel to slope seep (Koerner and Soong 1998)

The definitions of W_A, W_p, U_h, and U_n differ slightly in the Parallel to Slope Seepage condition when compared to the Horizontal Seepage scenario, (see Attachment B).

The final slope failure scenario evaluates the cover soil under **Seismic Force** conditions. This evaluation is similar to the uniform gravitational force failure analysis except for the addition of a horizontal force representative of the seismic activity that acts on the centroid of the soil cover. This additional force is represented by an average seismic coefficient, Cs, which is determined as the ratio of the bedrock acceleration versus the gravitational acceleration. Bedrock accelerations are estimated from seismic zone maps. The C_s for Wrangell has been estimated as .035 (the seismic zone maps are provided in the *Slope Stability Memo* [E & E 2017]). Under seismic conditions the FOS can be determined from the following parameters input into the quadratic formula:

$a = (C_s*W_A - N_A*\sin\beta)*\cos\beta + C_s*W_P*\cos\beta$
$b = -[(C_s*W_A + N_A*\sin\beta) * \sin\beta*\tan\phi + (N_A*\tan\delta+C_a)* \cos^2\beta + (C+W_P*\tan\phi)*\cos\beta]$
$c = (N_A *\tan\delta+C_a)*\cos\beta*\sin\beta*\tan\phi$

The calculations for all four veneer cover failure modes are provided in Attachment B.

ASSUMPTIONS

The following assumptions were made based on engineering judgement and project considerations:

- For the uniform gravitational force scenario it is assumed that the cover is fully drained. Calculations for underdrain size and spacing are part of the Drainage Channel and Perforated Pipe Hydraulic Design memorandum (E & E 2017).
- The minimum acceptable factors of safety are 1.50 and 1.10 for peak and residual shear strength and 1.1 for pseudo-static (seismic) conditions.
- The maximum (worst-case) slope gradient is 25%, or 14.0 degrees and the maximum (worst-case) height of the monofill is 43.83 feet (including 2 foot shot rock base, 38 feet of waste and 3.5 feet of cover soil);
- The cover system consists of (from top to bottom) 6 inches of Top Soil, 18 inches of Clean Backfill, a non-woven geotextile fabric liner, a 12 inch drainage layer of D-1, 1-inch Minus Drain Rock, a 6 inch layer of 3/8-inch Minus Aggregate, a 30-mil LLDPE FML, and 4 inches of subcushion material (3/8-inch Minus Aggregate) (see Design Drawings).
- Geotechnical testing was conducted on the Clean Backfill, 1-inch Minus Drain Rock, and 3/8-inch Minus Aggregate to determine material properties including density, moisture content, permeability, shear strength, friction angle, and cohesion. A summary of geotechnical testing results are provided in Attachment A; complete testing results are included in the Specification Package, Section 003132, Geotechnical Data. The only potential source of Top Soil was the Clean Backfill due to the remoteness of the site.
- A weighted average of all cover layers was used to represent the cover soil dry density (112.3 lbs/ft^3) and saturated density (125.3 lbs/ft^3) and the result of the 3/8-inch Minus Aggregate (46.6 degrees) was used for the friction angle in the veneer failure calculations provided in Attachment B to simplify the analysis.
- Testing of the LLDPE FML liner was not conducted as the material has not been selected. It is assumed that a textured LLDPE FML will have a peak and residual interface friction angle of 34 degrees based on manufacturer material information sheets of typical products available.

CONCLUSIONS

The resulting FOS for each of the scenarios are presented in the Table below.

Summary Table of Factor of Safety for Veneer Stability Analysis of Wrangell Monofill

Veneer Failure Scenario	FS Design Criteria Peak/Residual	Calculated FOS
Uniform Gravitational Force	1.5/1.1	2.93
Horizontal Seepage Force	1.5.1.1	2.06
Parallel-to-Slope Seepage Force	1.5/1.1	1.48
Seismic	1.1/1.0	2.53

Under each scenario the cover and textured LLDPE FML meet the design criteria. Failure of the soil cover via sliding above the LLDPE FML liner is not anticiapted.

REFERENCES

Ecology and Environment, Inc., Design Drawings: Wrangell Junkyard Repository Site

Ecology and Environment, Inc., Drainage Channel and Perforated Pipe Hydraulic Design

Ecology and Environment, Inc., Slope Stability Memo

Howell, G.D and A.H. Kirsten, *Interface Shear: Towards understanding the significance in Geotechnical Structures.",* Proceedings of the first Southern African Geotechnical Conference, 2016

Koerner, Robert M. and T. Soong, "Analysis and Design of Veneer Cover Soils," *Sixth International Conference on Geosynthetics,* 1998

Attachment A

Geotechnical Summary

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Material	Thickness	Dry Density	Sat Density	Moisture Conent	Friction Angle	Cohesion	
	FT	lbs/ft^3	lbs/ft^3	%	degrees	lbs/ft^2	kPA
Waste Pile	38	100.5	120.3	19.7	38.8	30.6	1.47
Cover							
Topsoil	0.5	100.0	117.6	17.6	39.9	76.9	3.68
Common Fill	1.5	100.0	117.6	17.6	39.9	76.9	3.68
1" minus	1	125.4	130.5	4.1	53.1	47.5	2.27
3/8" minus	0.5	135.0	145.9	8.1	46.6	77.13	3.69
Total Force			**438.7**	lb/ft^2			

30-mil LLDPE FML*		
Interface Friction Angle	34	degrees
Adhesion	0	kPA

*assumes LLDPE FML and 3/8" (granular) interface
Reference: Interface Shear: Towards understanding significance in Geotechnical Structures, SRK Consulting, (Howel and Kirsten) and MicroSpike Textured Geomembrane Info Sheet (Agru America)

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Attachment B

Veneer Stability Calculation Sheets

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Limit Equilibrium Forces involved in a Finite Length Slope Analysis for a Uniformly Thick Cover Soil

Slope Inputs

γ =	17.64	kN/m3	Unit weight of the cover soil
h =	1.07	m	Thickness of the cover soil
L =	53	m	Length of slope measured along the geomembrane
B =	14.0	degrees	Soil slope angle beneath the geomembrane
Φ =	46.6	degrees	Friction angle of the cover soil
c_a =	0	kN/m2	Adhesion between the cover soil and the geomembrane
δ =	34	degrees	Interface friction angle between cover soil and geomembrane
c =	0	kN/m2	cohesion of the cover soil

Total weight of the active wedge

$W_A = \gamma * h^2 * (L/h - 1/\sin\mathrm{B} - \tan(\mathrm{B}/2))$ = 919

Effective force normal to the failure plane of the active wedge

$N_A = W_A * \cos\mathrm{B}$ = 891

Adhesive force between the cover soil of the active wedge and the geomembrane

$C_A = c_a * (L - h/\sin\mathrm{B})$ = 0

Total weight of the passive wedge

$W_P = \gamma * h^2 / \sin(2*\mathrm{B})$ = 42.7

Cohesive force along the failure plane and the passive wedge

$C_P = c * h / \sin\mathrm{B}$ = 0

Quadratic Equation to solve for FS

$$a_q(FS)^2 + b_q(FS) + c_q = 0$$

$a_q = (W_A - N_A*\cos\mathrm{B}) * \cos\mathrm{B}$ = 52

$b_q = -[(W_A - N_A*\cos B)*\sin\mathrm{B}*\tan\Phi + (N_A*\tan\delta + C_A*\sin\mathrm{B}*\cos\mathrm{B} + \sin\mathrm{B}*(C_P + W_P*\tan\Phi)]$

= -166

$c_q = (N_A * \tan\delta + C_A) * \sin^2\mathrm{B}*\tan\Phi$ = 37

Factor of safety against cover soil sliding on the geomembrane

$FS = (-b_q + sqrt(b_q\text{^}2 - 4 * a_q* c_q)) / 2 * a_q$ = $\boxed{2.93}$

Limit Equilibrium Forces involved in a Finite Length Slope Analysis
for a Uniformly Thick Cover Soil with Horizontal to Slope Seepage Buildup

Slope Inputs

γ_{sat} =	19.7	kN/m3	Saturated unit weight of the cover soil
γ =	17.64	kN/m3	Unit weight of the cover soil (engineered conditioning)
γ_w =	9.8	kN/m3	Unit weight of water
h =	1.07	m	Thickness of the cover soil
L =	53	m	Length of slope measured along the geomembrane
B =	14	degrees	Soil slope angle beneath the geomembrane
Φ =	46.6	degrees	Friction angle of the cover soil
δ =	34	degrees	Interface friction angle between cover soil and LLDPE FML

Vertical height of the slope measured from the toe

$H = L * \sin\mathrm{B}$ = 12.8 m

Vertical height of the free water surface measured from the toe

H_w = Set equal to H for worst case scenario = 12.8 m

Total weight of the active wedge

$W_A = [(\gamma sat * h * (2 * H_w * \cos\mathrm{B} - h))/\sin(2 * \mathrm{B})] + [(\gamma * h * \cos\mathrm{B} *(2* H - H_w))/\sin\mathrm{B}]$

= 2034 kN/m

Resultant of the pore pressures acting perpendicular to the slope

$U_n = (\gamma w * h * \cos\mathrm{B} * (2 * H_w * \cos\mathrm{B}- h))/\sin(2 * \mathrm{B})$

= 515 kN/m

Resultant of the pore pressures acting on the interwedge surfaces

$U_h = \gamma w * h^2 / 2$ = 5.6 kN/m

Effective force normal to the failure plane of the active wedge

$N_A = W_A * \cos\mathrm{B} + U_h * \sin\mathrm{B} - U_n$ = 1460 kN/m

Total weight of the passive wedge

$W_P = \gamma_{sat} * h^2 / \sin(2*\mathrm{B})$ = 47.8 kN/m

Resultant of the vertical pore pressures acting on the passive wedge

$U_v = U_h * \cot\mathrm{B}$ = 22.4 kN/m

Quadratic Equation to solve for FS

$$a_q(FS)^2 + b_q(FS) + c_q = 0$$

$a_q = W_A * \sin\mathrm{B} * \cos\mathrm{B} - U_h * \cos^2\mathrm{B} + U_h$ = 478 kN/m

$b_q = -W_A * \sin^2\mathrm{B} * \tan\Phi + U_h * \sin\mathrm{B} * \cos\mathrm{B} * \tan\Phi - N_A * \cos\mathrm{B} * \tan\delta - (W_P - U_V) * \tan\Phi$

= -1107 kN/m

$c_q = N_A * \sin B * \tan\delta * \tan\Phi$ = 252 kN/m

Factor of safety against cover soil sliding on the geomembrane

$FS = (-b_q + sqrt(b_q\text{^}2 - 4 * a_q * c_q)) / 2 * a_q$ = $\boxed{2.06}$

Limit Equilibrium Forces involved in a Finite Length Slope Analysis
for a Uniformly Thick Cover Soil with Parallel to Slope Seepage Buildup

Slope Inputs

γ_{sat} =	19.7	kN/m3	Saturated unit weight of the cover soil
γ =	17.64	kN/m3	Unit weight of the cover soil (engineered conditioning)
γ_w =	9.8	kN/m3	Unit weight of water
h =	1.07	m	Thickness of the cover soil
L =	53	m	Length of slope measured along the geomembrane
B =	14	degrees	Soil slope angle beneath the geomembrane
Φ =	46.6	degrees	Friction angle of the cover soil
δ =	34	degrees	Interface friction angle between cover soil and LLDPE FML

Vertical height of the slope measured from the toe

$H = L * \sin B$ = 13 m

Vertical height of the free water surface measured in the direction perpendicular to the slope

h_w = Set equal to h for worst case scenario = 1.1 m

Total weight of the active wedge

$W_A = \gamma*(h - h_w)*(2*H*\cos B - (h + h_w))/\sin(2*B) + \gamma_{sat}*h_w*(2*H*\cos B - h_w)/\sin(2*B)$

= 1066 kN/m

Resultant of the pore pressures acting perpendicular to the slope

$U_n = (\gamma w * h_w * \cos B * (2 * H * \cos B - h_w))/\sin(2 * B)$

= 515 kN/m

Resultant of the pore pressures acting on the interwedge surfaces

$U_h = \gamma w * h_w^2 / 2$ = 5.6 kN/m

Effective force normal to the failure plane of the active wedge

$N_A = W_A * \cos B + U_h * \sin B - U_n$ = 521 kN/m

Total weight of the passive wedge

$W_P = (\gamma * (h^2-h_w^2) + \gamma_{sat} * h_w^2)/ \sin(2*B)$ = 47.8 kN/m

Resultant of the vertical pore pressures acting on the passive wedge

$U_v = U_h * \cot B$ = 22.4 kN/m

Quadratic Equation to solve for FS

$a_q(FS)^2 + b_q(FS) + c_q = 0$

$a_q = W_A * \sin B * \cos B - U_h * \cos^2 B + U_h$ = 251 kN/m

$b_q = -W_A * \sin^2 B * \tan\Phi + U_h * \sin B * \cos B * \tan\Phi - N_A * \cos B * \tan\delta - (W_P - U_V) * \tan\Phi$

= -433 kN/m

$c_q = N_A * \sin B * \tan\delta * \tan\Phi$ = 90 kN/m

Factor of safety against cover soil sliding on the geomembrane

$FS = (-b_q + \text{sqrt}(b_q\text{^}2 - 4 * a_q * c_q)) / 2 * a_q$ = $\boxed{1.48}$

Limit Equilibrium Forces involved in a Finite Length Slope Analysis
for a Uniformly Thick Cover Soil under Seismic Force Conditions

Slope Inputs

γ =	17.64	kN/m3	Unit weight of the cover soil
h =	1.07	m	Thickness of the cover soil
L =	53	m	Length of slope measured along the geomembrane
B =	14.0	degrees	Soil slope angle beneath the geomembrane
Φ =	46.6	degrees	Friction angle of the cover soil
c_a =	0	kN/m2	Adhesion between the cover soil and the geomembrane
δ =	34	degrees	Interface friction angle between cover soil and geomembrane
c =	0	kN/m2	cohesion of the cover soil

Total weight of the active wedge

$W_A = \gamma * h^2 * (L/h - 1/\sin B - \tan(B/2))$ = 919

Effective force normal to the failure plane of the active wedge

$N_A = W_A * \cos B$ = 891

Adhesive force between the cover soil of the active wedge and the geomembrane

$C_A = c_a * (L - h/\sin B)$ = 0

Total weight of the passive wedge

$W_P = \gamma * h^2 / \sin(2*B)$ = 42.7

Cohesive force along the failure plane and the passive wedge

$C_P = c * h / \sin B$ = 0

Seismic Coefficient

Cs = 0.035

Quadratic Equation to solve for FS

$a_q(FS)^2 + b_q(FS) + c_q = 0$

$a_q = (CsW_A - N_A*\sin B) * \cos B + CsW_P* \cos B$ = 242

$b_q = -[Cs(W_A - N_A*\sin B)*\sin B*\tan\Phi + (N_A*\tan\delta + C_A)\cos^2 B+(C_P+W_P*\tan\Phi)\cos B]$

= -672

$c_q = (N_A * \tan\delta + C_A) * \sin B*\cos B*\tan\Phi$ = 150

Factor of safety against cover soil sliding on the geomembrane

$FS = (-b_q + \mathrm{sqrt}(b_q\text{^}2 - 4 * a_q* c_q)) / 2 * a_q$ = $\boxed{2.53}$

VOLUME 2
DESIGN PACKAGE

Wrangell Junkyard Repository Site
Wrangell, Alaska
TDD: 17-01-0015

START IV
Region 10

June 9, 2017

Prepared for:

U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101

Prepared by:

ECOLOGY AND ENVIRONMENT, INC.
720 Third Avenue, Suite 1700
Seattle, Washington 98104

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PROFESSIONAL ENGINEER CERTIFICATION PAGE

DESIGN PACKAGE
Wrangell Junkyard Repository Site
Wrangell, Alaska
TDD: 17-01-0005

Pursuant to Alaska Administrative Code (AAC) 12 AAC 36.185(a)(3), final plans, surveys, reports, and required construction documents approved for building permit issuance for which the registrant is qualified to seal and for which the registrant claims responsibility are required to be submitted under the seal of a State of Alaska licensed professional engineer. This page provides the signature and seal to comply with the regulation.

I hereby certify that this Design Package for the Wrangell Junkyard Repository Site in Wrangell, Alaska, was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Alaska. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

SIGNATURE: Thomas Campbell

REGISTRATION NUMBER: EV14234
STATE: Alaska

DATE: 06-09-2017

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B Technical Specifications

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DIVISION 00
PROCUREMENT AND CONTRACTING REQUIREMENTS

Section 000107	-	Seals Page
Section 000110	-	Table of Contents
Section 000115	-	List of Drawings
Section 003126	-	Existing Hazardous Material Information
Section 003132	-	Geotechnical Data
Section 007100	-	Abbreviations-Definitions

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SECTION 000107
SEALS PAGE

1.0 GENERAL

PROFESSIONAL ENGINEER CERTIFICATION PAGE

Design Package
Wrangell Junkyard Repository Site
Wrangell, Alaska

Pursuant to Alaska Administrative Code (AAC) 12 AAC 36.185(a)(3), only final plans, surveys, reports, and required construction documents approved for building permit issuance for which the registrant is qualified to seal and for which the registrant claims responsibility are required to be submitted under the seal of a State of Alaska licensed professional engineer. This page provides the signature and seal to comply with the regulation.

I hereby certify that the Design Package for the Wrangell Junkyard Repository Site in Wrangell, Alaska, consisting of Design Drawings as listed in Section 000115 and Specifications as listed in Section 000110, was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Alaska. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

SIGNATURE:

REGISTRATION NUMBER: EV14234
STATE: Alaska

DATE: 06-09-2017

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

[Not used.]

*** END OF SECTION ***

1.0 GENERAL

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Section 000110, Table of Contents ....2 Pages

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Section 003126, Existing Hazardous Material Information.....................2 Pages

Section 003132, Geotechnical Data ....34 Pages

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Section 015000, Temporary Facilities and Controls...............................4 Pages

Section 015700, Environmental Protection Procedures..........................6 Pages

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DIVISION 32 - EXTERIOR IMPROVEMENTS

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Section 329000, Topsoil and Seeding..6 Pages

DIVISION 33 - UTILITIES

Section 332900, Well Abandonment ....16 Pages

Section 334616, Subdrainage Piping ....2 Pages

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

[Not used.]

*** END OF SECTION ***

1.0 GENERAL

1.1 QUALITY ASSURANCE

A. Inform the Agency of any discrepancies, errors, or omissions discovered on drawings.

1.2 PROJECT CONDITIONS

A. Where there are minor differences as determined by the Agency between details and dimensions shown on drawings and details and dimensions of existing features at the site, use details and dimensions of existing features at the site.

1.3 COPIES OF DRAWINGS

A. An electronic copy of the Contract files will be provided by the Agency. The Contractor is responsible for furnishing their own hardcopy set(s) as needed to perform the Work.

1.4 LIST OF CONTRACT DRAWINGS

C-1 – VICINITY MAP, SITE LOCATION, AND SHEET INDEX

C-2 – EXISTING CONDITIONS SURVEY 2016

C-3 – SITE FEATURES AND GRADING PLAN

C-4 – PROFILE AND SECTION VIEWS

C-5 – CONSTRUCTION DETAILS

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

[Not used.]

*** END OF SECTION ***

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1.0 SUMMARY

A. Previous site investigations, sampling, and reporting have been completed at the Junkyard Site and the Repository Site. To date, cleanup efforts have been completed at the Junkyard Site resulting in a treated waste soil stockpile at the northwest corner of the Site. These efforts are listed below; additional information is available in the cited documents.

B. The studies listed herein are for the Contractor's information only. Any conclusions or interpretations contained in those studies were made by the individuals preparing the studies and may or may not have been included in the design of the Work covered in this Contract. Any conclusions or interpretations made by the Contractor are his/hers alone.

C. Previous studies may be reviewed through a request to the Agency.

1.1 PREVIOUS STUDIES AND REPORTS – JUNKYARD SITE

A. February 2001 Final Preliminary Assessment, Wrangell Junkyard Site (E & E 2001): E & E performed a preliminary assessment of the Junkyard Site, which included soil and sediment sampling performed in August 2000. Surface soil sample results indicated the presence of lead concentrations exceeding ADEC cleanup levels, and other hazardous substances were found at elevated levels in surface soil and sediment samples.

B. June 2002 Report, Wrangell Junkyard Site Characterization and Removal Cost Estimate (E & E 2002): E & E performed fieldwork at the Junkyard Site, including surface and subsurface soil sampling and X-ray fluorescence analysis. Four surface soil samples were tested for toxicity characteristic leaching procedure (TCLP) lead analysis. Elevated lead concentrations were found in multiple areas, and test results indicated the presence of leachable lead.

C. October 2012 Bi-valve Specimen Sampling Wrangell Junkyard Contaminated Site Zimovia Strait: ADEC collected bi-valve samples from the beach southwest of the Junkyard Site. Resource Conservation and Recovery Act (RCRA) metals analyses indicated lead was below the National Shellfish Sanitation Program guidance level for human consumption (ADEC 2013).

D. November 2012 Wrangell Junkyard Summary of Site Conditions and Justification for Removal Action (ADEC 2012): ADEC made a recommendation for a near-term removal action at the Junkyard Site, with an emphasis on the northeast portion of the site.

E. July 2015 Wrangell Junkyard Targeted Brownfields Assessment (E & E 2015): E & E reviewed previous sampling results and other information, and worked with stakeholders to evaluate recognized environmental conditions (RECs) at the Junkyard Site. The identified outstanding RECs included Lead Contaminated Soil/Debris Pile Remnants; Drum Caches; Wood Piles/Burn Areas; Overland Drainages; Areas around

Former Onsite Structures (where transformer oil was applied); Downgradient Adjacent Properties; and Zimovia Strait.

F. 2016 Wrangell Junkyard Site Cleanup (NRC Alaska Weekly Project Status Updates): Working under a Corrective Action Plan dated April 5, 2016, NRC Alaska and NORTECH performed excavation, treatment, and stockpiling operations at the Junkyard Site during the summer of 2016. Solid waste such as batteries and metal debris were shipped off site for disposal. Woody debris was brought to the Wrangell Institute where it was later burned. Soil was screened from rock and debris, and treated with ECOBOND to limit the leaching potential of the lead-contaminated soil. Approximately 18,515 cubic yards of treated waste soil were stockpiled at the northwest corner of the Junkyard Site, to remain on site until a final repository location was constructed. The treated material was wrapped with black plastic and supported by a 6- to 16-foot-tall berm of 6-inch minus clean rock fill.

1.2 PREVIOUS STUDIES AND REPORTS – REPOSITORY SITE

A. August 2016 START Site Visit (Aug 1–2 Site Visit Findings, September 16, 2016 [E & E 2016]; Proposed Monofill Site for Wrangell Junkyard Lead Contaminated Soil Memorandum, May 3, 2016 [ADEC 2016]): START met with ADEC, EPA, ADNR, the EPA Emergency and Rapid Response Services (ERRS) contractor, NRC Alaska, and other stakeholders at the Junkyard Site to discuss work completed to date. EPA, START, and ERRS visited potential locations for a permanent repository location. Based on previous ADEC site visits, the ADNR rock pit on Pat Creek Road was a primary focus (NRC Alaska and Nortech 2016).

B. December 2016 Proposed Wrangell Monofill Report of Findings, Wrangell, Alaska (Ahtna 2017): A hydrologic and geotechnical investigation was conducted by Ahtna Engineering Services, LLC (Ahtna) in December 2016 and summarized in the report. ADEC Division of Spill Response and Prevention Contaminated Sites Program and Division of Solid Waste used this report for selection of the repository site and design parameters. A discussion of report findings is included in Section 011100, SUMMARY OF WORK.

2.0 PRODUCTS

[Not Used]

3.0 EXECUTION

[Not Used]

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. The Geotechnical results presented herein are for informational purposes only. Materials used in construction of the repository should be verified against the results presented here, and in accordance with Section 310513, SELECT FILL AND TOPSOIL, to ensure that design assumptions are upheld.

1.2 BACKGROUND

A. Material samples were collected by E & E in March 2017. Sample sources included Treated Waste Soil (sample numbers 17031001, 17031002, and 17031003) contained within the onsite stockpile at the Junkyard Site, locally available aggregates including three-eighths (3/8)-inch Minus Aggregate (sample number 17031004) and one (1)-inch Minus Drain Rock (sample number 17031006), and Topsoil and Clean Backfill (sample number 17031005) at a local supplier. Samples were submitted to GeoTesting Express, Inc., a geotechnical analytical laboratory. Samples have been analyzed for:

1. Fine Grained Soils (Treated Waste Soil and Topsoil/Clean Backfill):

    a. Engineering Classification for fine grained soils, to include grain size distribution; plasticity limit; liquid limit; moisture content; and USCS Classification (ASTM D2487);
    b. Standard Proctor (ASTM D698);
    c. Hydraulic Conductivity using Flexible Wall Permeameter (ASTM D5084);
    d. Three-Point Direct Shear Test Series (ASTM D3080).

2. Granular Soils (3/8-inch Minus Aggregate and 1-inch Minus Drain Rock):

    a. Grain Size Analysis (ASTM D422);
    b. Standard Proctor (ASTM D698);
    c. Fixed Wall Permeability (ASTM D2434);
    d. Three-Point Direct Shear Test Series (ASTM D3080).

B. Three samples of the Treated Waste Soil were collected and each run according to Paragraph 1.2.A.1.a., above. The Treated Waste Soil samples were then consolidated into one sample by the testing laboratory and run for the remaining parameters.

C. Geotechnical testing results are included as Attachments 003132-A, Treated Waste Soil; 003132-B, 3/8-inch Minus Aggregate; 003132-C, Topsoil and Clean Backfill; and 003132-D, 1-inch Minus Drain Rock.

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

[Not used.]

*** END OF SECTION ***

ATTACHMENT 003132-A
Treated Waste Soil

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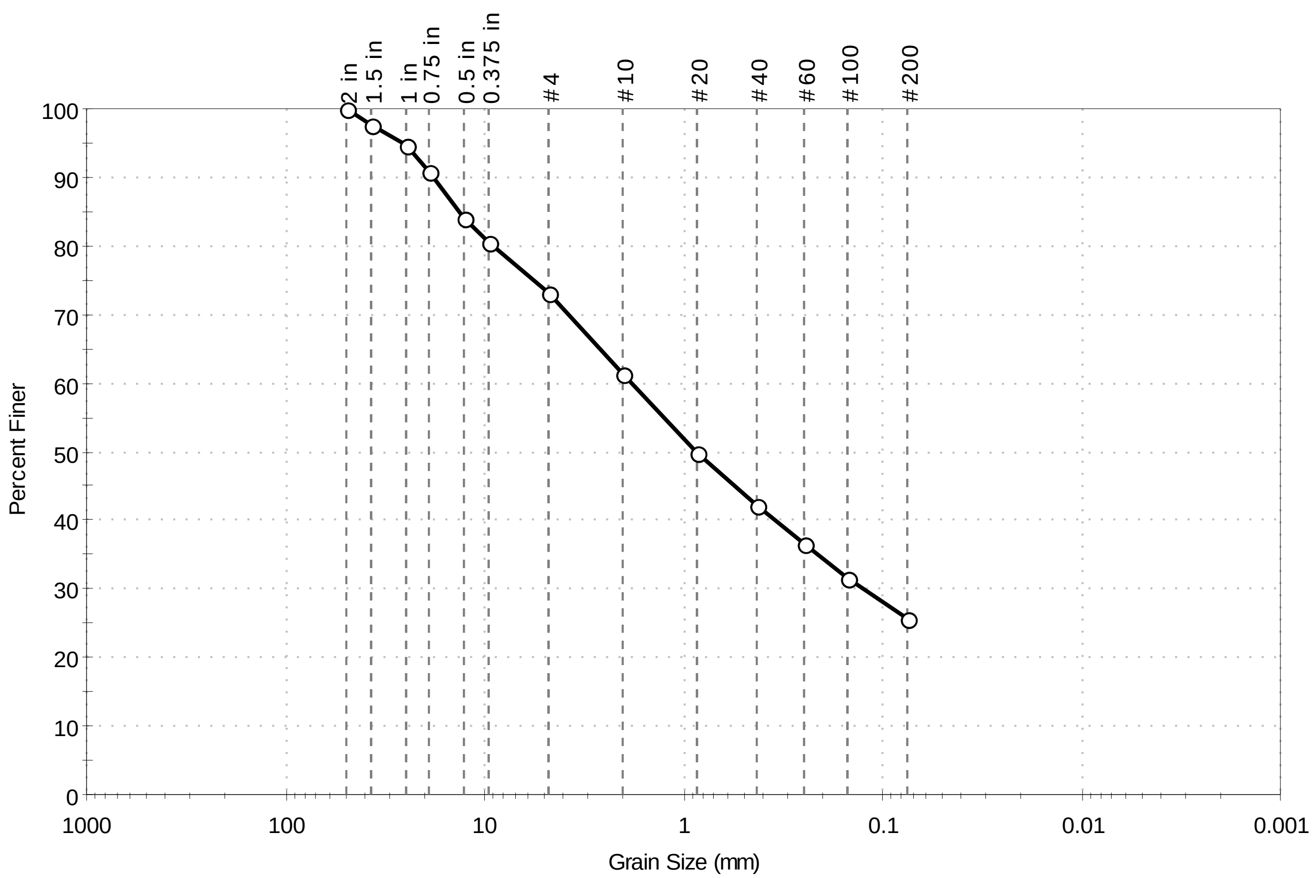
Client:	Test America		
Project:	Wrangell Junkyard		
Location:	---	Project No:	GTX-306247
Boring ID: ---	Sample Type: bucket	Tested By:	jbr
Sample ID: 17031001	Test Date: 04/10/17	Checked By:	emm
Depth : ---	Test Id: 407949		

Test Comment: ---

Visual Description: Moist, very dark gray silty sand with gravel and organic fines

Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	26.9	47.5	25.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	98		
1 in	25.00	95		
0.75 in	19.00	91		
0.5 in	12.70	84		
0.375 in	9.50	81		
#4	4.75	73		
#10	2.00	61		
#20	0.85	50		
#40	0.42	42		
#60	0.25	37		
#100	0.15	32		
#200	0.075	26		

Coefficients

D_{85} = 13.4395 mm | D_{30} = 0.1249 mm

D_{60} = 1.7990 mm | D_{15} = N/A

D_{50} = 0.8647 mm | D_{10} = N/A

C_u = N/A | C_c = N/A

Classification

ASTM Silty sand with gravel and organic fines (SM)

AASHTO Clayey Gravel and Sand (A-2-7 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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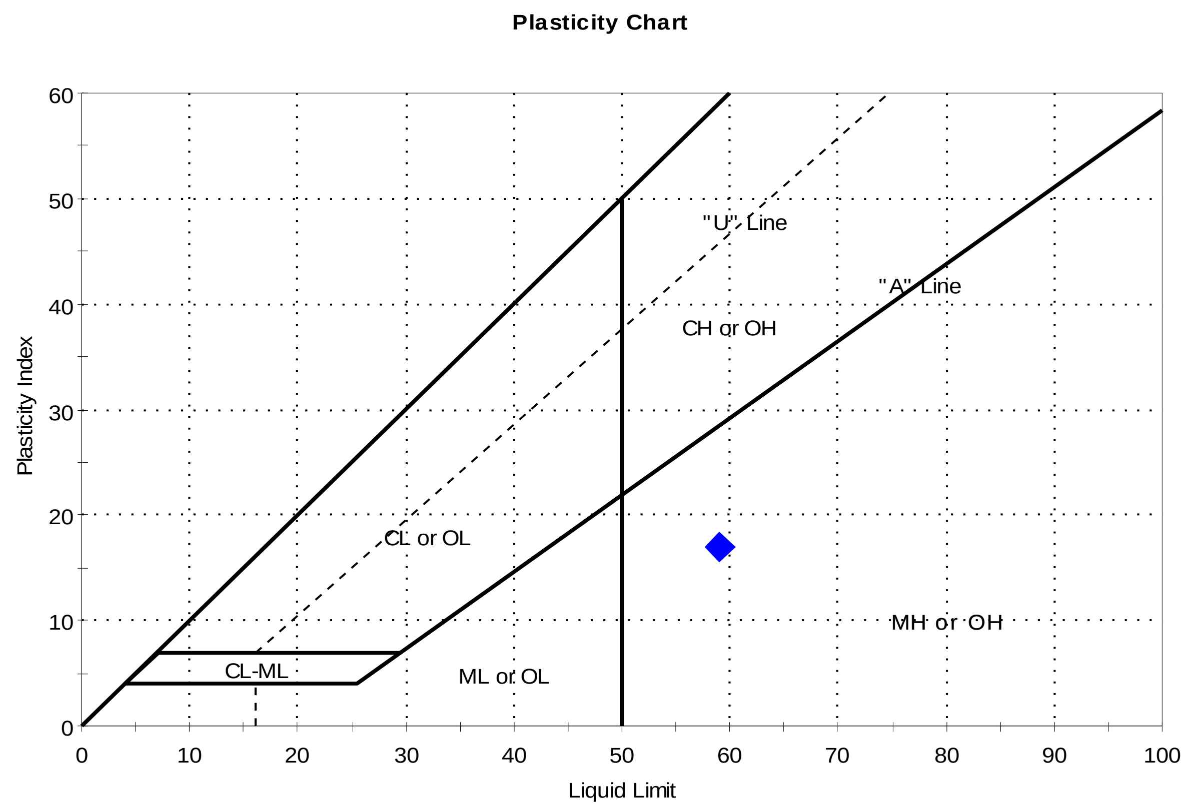
Client:	Test America				
Project:	Wrangell Junkyard				
Location:	---			Project No:	GTX-306247
Boring ID:	---	Sample Type:	bucket	Tested By:	cam
Sample ID:	17031001	Test Date:	04/10/17	Checked By:	emm
Depth :	---	Test Id:	407955		

Test Comment: ---

Visual Description: Moist, very dark gray silty sand with gravel and organic fines

Sample Comment: ---

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	17031001	---	---	31	59	42	17	-0.6	Silty sand with gravel and organic fines (SM)

Sample Prepared using the WET method

58% Retained on #40 Sieve

Dry Strength: HIGH

Dilatancy: SLOW

Toughness: LOW

In order to properly describe the soil an Oven Dried Liquid Limit test was performed.
The Oven Dried Liquid Limit was determined to be non-plastic.

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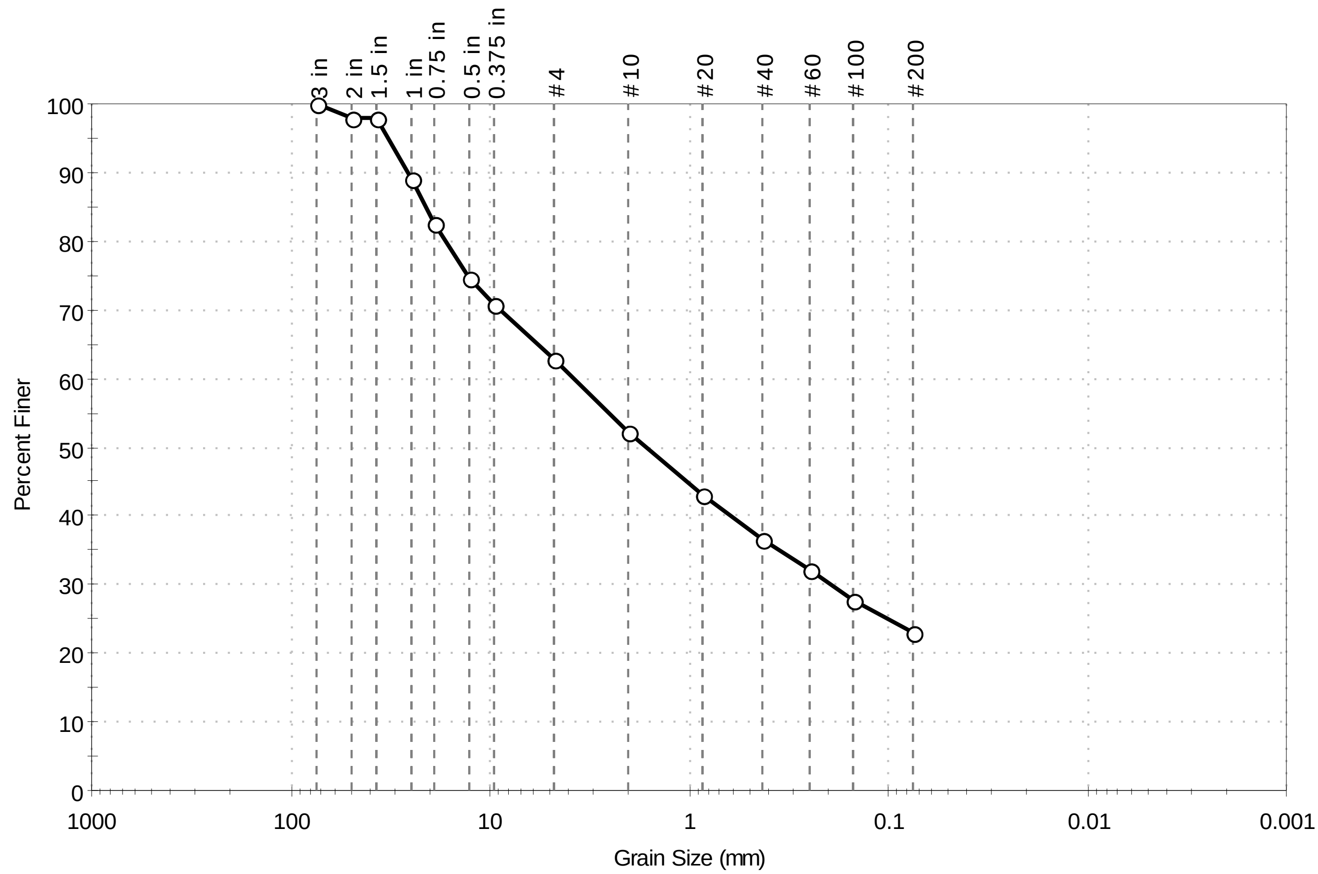
Client: Test America			
Project: Wrangell Junkyard			
Location: ---		Project No:	GTX-306247
Boring ID: ---	Sample Type: bucket	Tested By:	jbr
Sample ID: 17031002	Test Date: 04/10/17	Checked By:	emm
Depth : ---	Test Id: 407950		
Test Comment: ---			
Visual Description: Moist, very dark gray silty sand with gravel and organic fines			
Sample Comment: ---			

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	37.2	39.8	23.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3 in	75.00	100		
2 in	50.00	98		
1.5 in	37.50	98		
1 in	25.00	89		
0.75 in	19.00	83		
0.5 in	12.70	75		
0.375 in	9.50	71		
#4	4.75	63		
#10	2.00	52		
#20	0.85	43		
#40	0.42	37		
#60	0.25	32		
#100	0.15	28		
#200	0.075	23		

Coefficients

D_{85} = 20.9653 mm | D_{30} = 0.1954 mm

D_{60} = 3.7901 mm | D_{15} = N/A

D_{50} = 1.6420 mm | D_{10} = N/A

C_u = N/A | C_c = N/A

Classification

ASTM: Silty sand with gravel and organic fines (SM)

AASHTO: Clayey Gravel and Sand (A-2-7 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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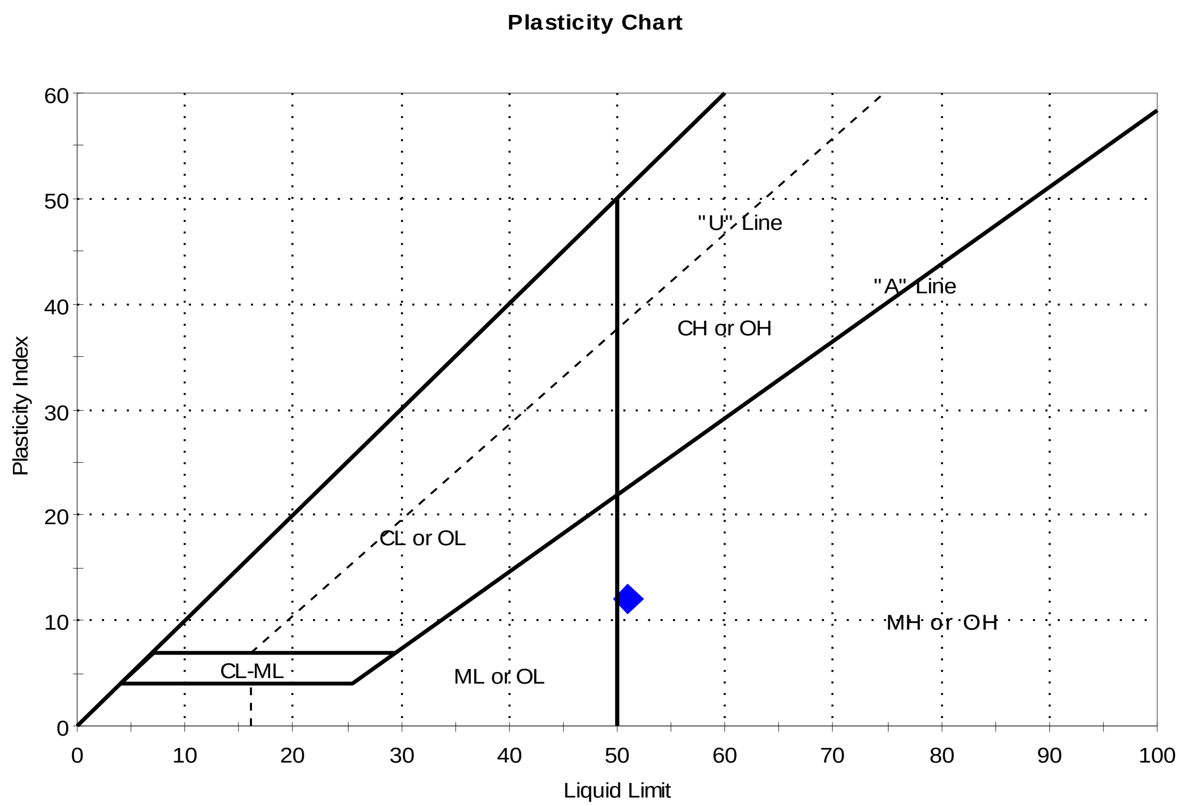
Client:	Test America				
Project:	Wrangell Junkyard				
Location:	---			Project No:	GTX-306247
Boring ID:	---	Sample Type:	bucket	Tested By:	cam
Sample ID:	17031002	Test Date:	04/10/17	Checked By:	emm
Depth :	---	Test Id:	407956		
Test Comment:	---				
Visual Description:	Moist, very dark gray silty sand with gravel and organic fines				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	17031002	---	---	26	51	39	12	-1.1	Silty sand with gravel and organic fines (SM)

Sample Prepared using the WET method

63% Retained on #40 Sieve

Dry Strength: HIGH

Dilatancy: SLOW

Toughness: LOW

In order to properly describe the soil an Oven Dried Liquid Limit test was performed.
The Oven Dried Liquid Limit was determined to be non-plastic.

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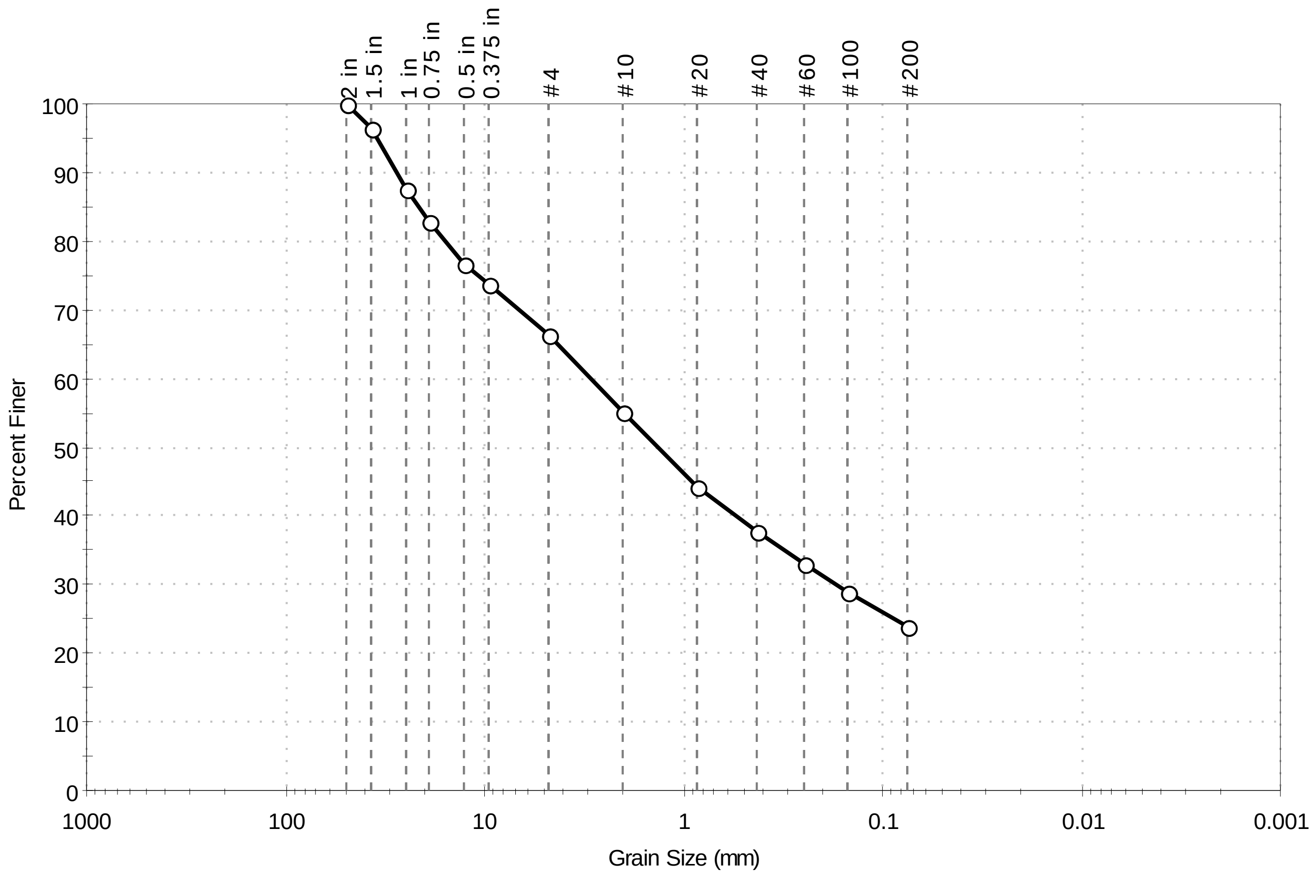
GeoTesting EXPRESS

Client:	Test America				
Project:	Wrangell Junkyard				
Location:	---			Project No:	GTX-306247
Boring ID:	---	Sample Type:	bucket	Tested By:	jbr
Sample ID:	17031003	Test Date:	04/10/17	Checked By:	emm
Depth :	---	Test Id:	407951		
Test Comment:	---				
Visual Description:	Moist, very dark gray silty sand with gravel and organic fines				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	33.8	42.3	23.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	96		
1 in	25.00	88		
0.75 in	19.00	83		
0.5 in	12.70	77		
0.375 in	9.50	74		
#4	4.75	66		
#10	2.00	55		
#20	0.85	44		
#40	0.42	38		
#60	0.25	33		
#100	0.15	29		
#200	0.075	24		

Coefficients

D_{85} = 21.3259 mm | D_{30} = 0.1707 mm
D_{60} = 2.9022 mm | D_{15} = N/A
D_{50} = 1.3340 mm | D_{10} = N/A
C_u = N/A | C_c = N/A

Classification

ASTM: Silty sand with gravel and organic fines (SM)

AASHTO: Clayey Gravel and Sand (A-2-7 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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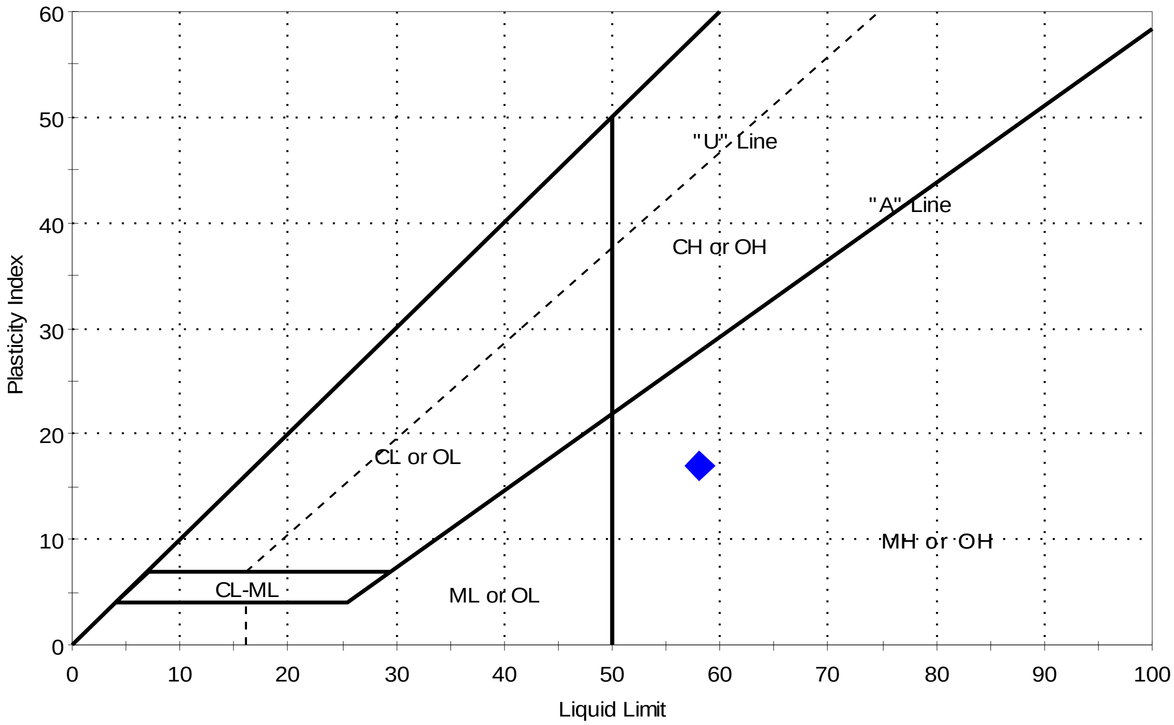
Client: Test America			
Project: Wrangell Junkyard			
Location: ---		Project No:	GTX-306247
Boring ID: ---	Sample Type: bucket	Tested By:	cam
Sample ID: 17031003	Test Date: 04/10/17	Checked By:	emm
Depth : ---	Test Id: 407957		
Test Comment: ---			
Visual Description: Moist, very dark gray silty sand with gravel and organic fines			
Sample Comment: ---			

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	17031003	---	---	35	58	41	17	-0.4	Silty sand with gravel and organic fines (SM)

Sample Prepared using the WET method

62% Retained on #40 Sieve

Dry Strength: HIGH

Dilatancy: SLOW

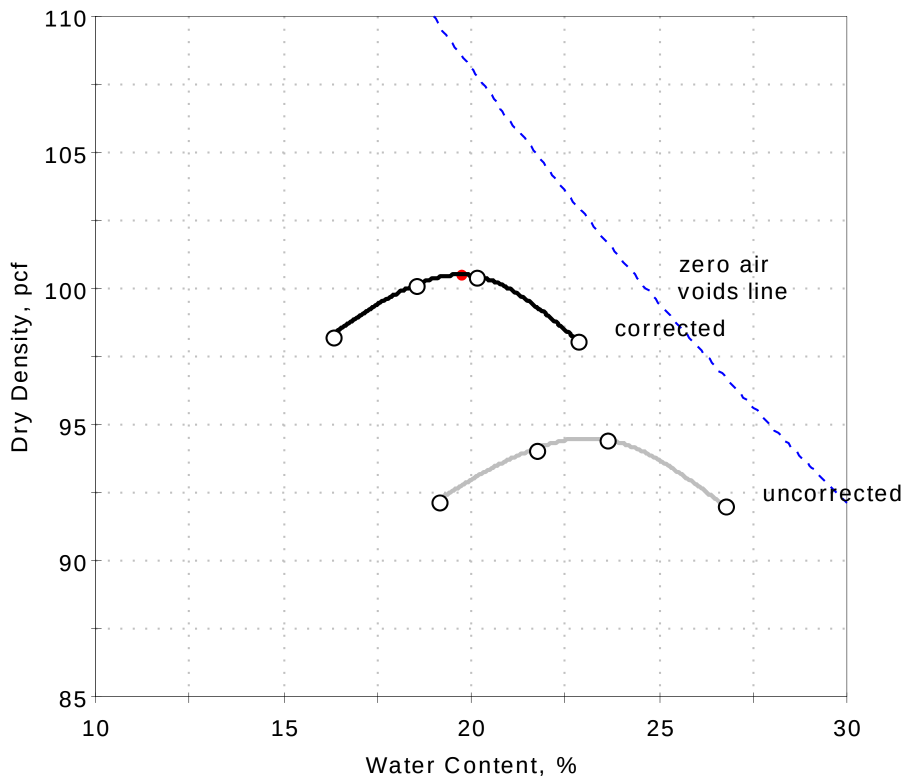
Toughness: LOW

In order to properly describe the soil an Oven Dried Liquid Limit test was performed.
The Oven Dried Liquid Limit was determined to be non-plastic.

GeoTesting EXPRESS

Client:	Test America				
Project:	Wrangell Junkyard				
Location:	---			Project No:	GTX-306247
Boring ID:	001/002/003	Sample Type:	tube	Tested By:	cwd
Sample ID:	17031 Composite	Test Date:	05/17/17	Checked By:	emm
Depth :	Site Soil Stockpile	Test Id:	411350		
Test Comment:	---				
Visual Description:	Moist, very dark gray silty sand with gravel and organic fines				
Sample Comment:	---				

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	92.2	94.1	94.5	92.0
Moisture Content, %	19.1	21.7	23.6	26.7

Method : C

Preparation : DRY

As received Moisture :---

Rammer : Manual

Zero voids line based on assumed specific gravity of 2.65

Maximum Dry Density= 94.5 pcf
Optimum Moisture= 23.1 %

Oversize Correction (14.7% > 3/4 inch Sieve)

Corrected Maximum Dry Density= 100.5 pcf
Corrected Optimum Moisture= 19.7 %
Assumed Average Bulk Specific Gravity = 2.55

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GeoTesting EXPRESS

Client:	Test America		
Project Name:	Wrangell Junkyard		
Project Location:	---		
GTX #:	306247		
Start Date:	5/15/2017	Tested By:	jcw/eec
End Date:	5/18/2017	Checked By:	emm
Boring #:	001/002/003		
Sample #:	17031 Composite		
Depth:	Site Soil Stockpile		
Visual Description:	Moist, very dark gray silty sand with gravel and organic fines		

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084
Constant Volume

Sample Type:	Remolded	Permeant Fluid:	De-aired Distilled water
Orientation:	Vertical	Cell #:	8/13

Sample Preparation: Target Compaction: 90% of maximum dry density (100.5 pcf) at the optimum moisture content (19.6%). Values specified by client. Material >1/2-inch screened out of sample prior to testing (21.8%). Trimmings moisture content = 21.3%

Assumed Specific Gravity: 2.50

Parameter	Initial	Final
Height, in	3.01	3.00
Diameter, in	4.05	4.06
Area, in^2	12.88	12.95
Volume, in^3	38.8	38.8
Mass, g	1125	1193
Bulk Density, pcf	110.3	116.8
Moisture Content, %	19.8	27.0
Dry Density, pcf	92.1	91.9
Degree of Saturation, %	71	97

B COEFFICIENT DETERMINATION

Cell Pressure, psi:	90.00	Increased Cell Pressure, psi:	94.96	Cell Pressure Increment, psi:	4.96
Sample Pressure, psi:	84.95	Corresponding Sample Pressure, psi:	89.76	Sample Pressure Increment, psi:	4.81
				B Coefficient:	0.97

FLOW DATA

Date	Trial #	Pressure, psi		Manometer Readings			Elapsed Time, sec	Gradient	Permeability K, cm/sec	Temp, °C	R_t	Permeability K @ 20 °C, cm/sec
		Cell	Sample	Z_1	Z_2	Z_1-Z_2						
5/17	1	90.0	85.0	5.0	3.0	2.0	31	8.3	3.8E-06	19.7	1.008	3.8E-06
5/17	2	90.0	85.0	5.0	3.0	2.0	32	8.3	3.7E-06	19.7	1.008	3.7E-06
5/17	3	90.0	85.0	5.0	3.0	2.0	31	8.3	3.8E-06	19.7	1.008	3.8E-06
5/17	4	90.0	85.0	5.0	3.0	2.0	35	8.3	3.4E-06	19.7	1.008	3.4E-06

PERMEABILITY AT 20° C: 3.7×10^{-6} cm/sec (@ 5 psi effective stress)

Client:	Test America		
Project Name:	Wrangell Junkyard		
Project Location:	---		
GTX #:	306247		
Start Date:	05/15/17	Tested By:	est
End Date:	05/17/17	Checked By:	jdt
Boring ID:	---		
Sample ID:	Composite 17031001, 002, 003		
Depth, ft:	Site Soil Stockpile		
Soil Description:	Moist, very dark gray silty sand with gravel and organic fines		

Direct Shear Test Series by ASTM D3080

Soil Preparation: Target Compaction: 90% of Maximum Dry Density at the Optimum Moisture Content

Compaction Characteristics:

- Maximum Dry Density: 100.5 pcf
- Optimum Moisture Content: 19.7 %
- Compaction Test Method: ASTM D1557

Test Equipment: Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; surface area = 144 in^2

Maximum Particle Size Used, in:	0.5	Horizontal Displacement, in/min:	0.04
Soil Height, in:	6	Test Condition:	inundated
Gap Between Boxes, in:	0.25		

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	20.1	19.6	21.7	---	---	---
Initial Dry Density, pcf	89.9	90.3	88.7	---	---	---
Percent Compaction, %	89.4	89.8	88.3	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	102	450	828	---	---	---
Final Moisture Content, %	36.2	35.7	27.9	---	---	---

Notes:

Peak Friction Angle: 38.8 degrees

Peak Cohesion: 30.6 psf

Figure a. Shear Force vs. Horizontal Displacement

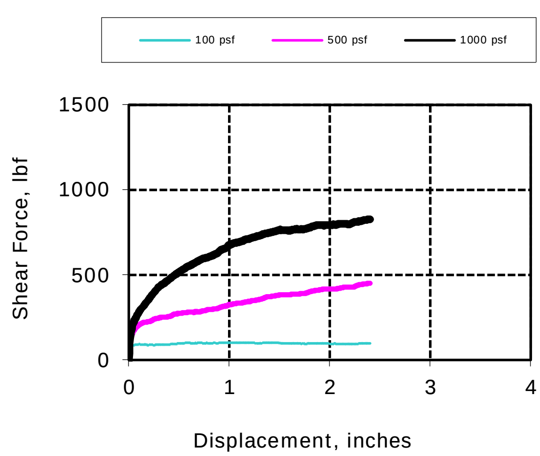
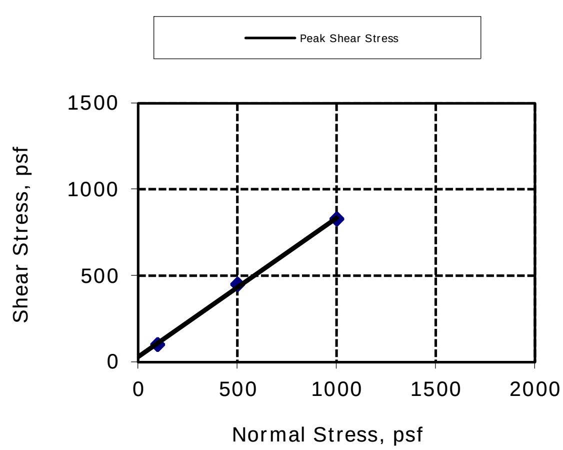


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

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ATTACHMENT 003132-B
3/8-inch Minus Aggregate

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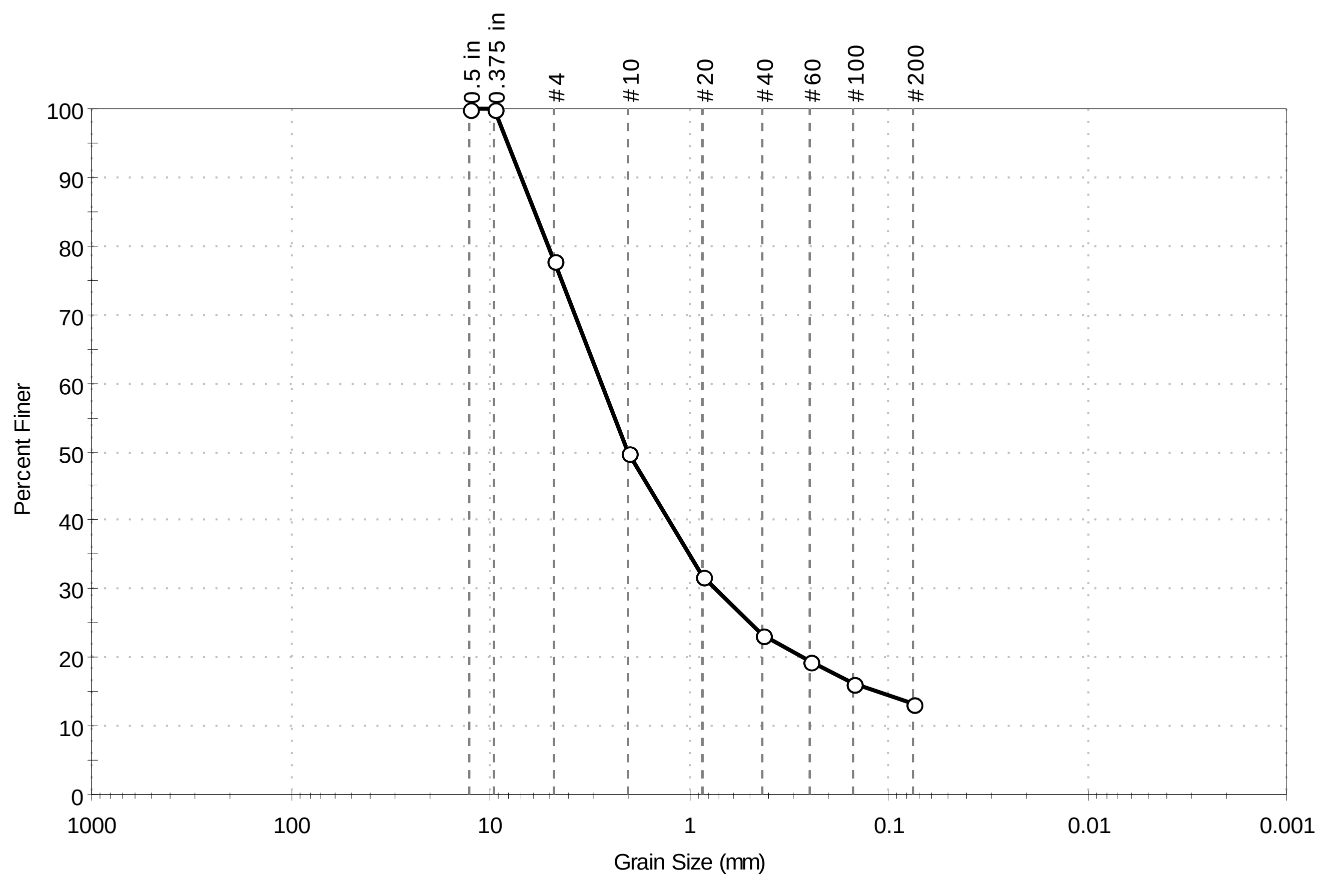
Client: Test America			
Project: Wrangell Junkyard			
Location: ---		Project No: GTX-306247	
Boring ID: ---	Sample Type: bucket	Tested By: jbr	
Sample ID: 17031004	Test Date: 04/12/17	Checked By: emm	
Depth : ---	Test Id: 407952		

Test Comment: ---

Visual Description: Moist, very dark gray silty sand with gravel

Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	22.0	64.8	13.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.70	100		
0.375 in	9.50	100		
#4	4.75	78		
#10	2.00	50		
#20	0.85	32		
#40	0.42	23		
#60	0.25	19		
#100	0.15	16		
#200	0.075	13		

Coefficients

D_{85} = 5.9241 mm | D_{30} = 0.7275 mm

D_{60} = 2.7322 mm | D_{15} = 0.1122 mm

D_{50} = 2.0091 mm | D_{10} = N/A

C_u = N/A | C_c = N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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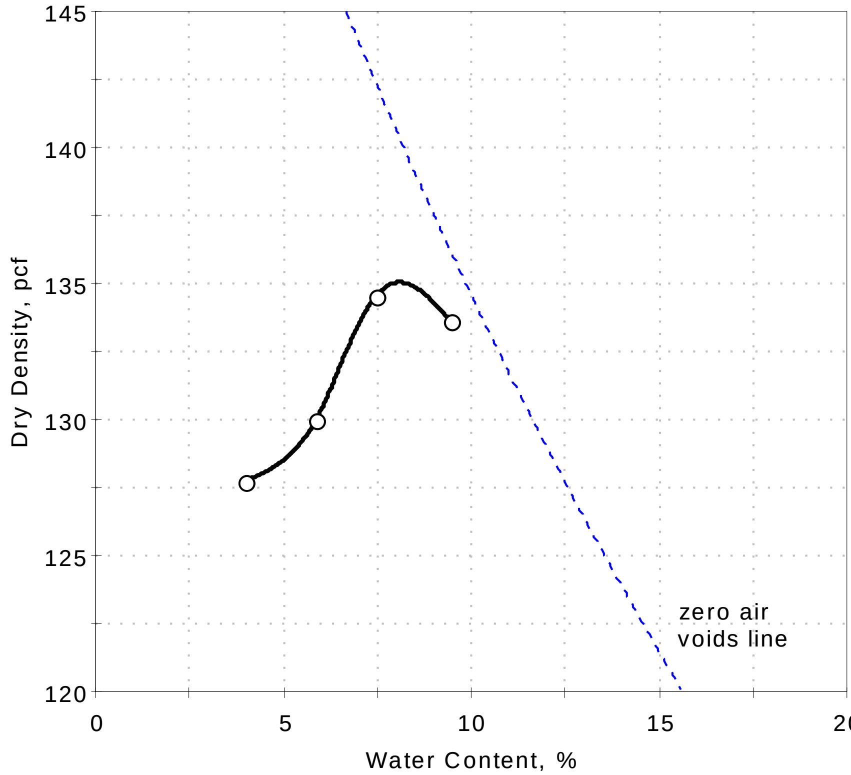
Client:	Test America				
Project:	Wrangell Junkyard				
Location:	---			Project No:	GTX-306247
Boring ID:	---	Sample Type:	bucket	Tested By:	cwd
Sample ID:	17031004	Test Date:	04/27/17	Checked By:	emm
Depth :	---	Test Id:	407973		

Test Comment: ---

Visual Description: Moist, very dark gray silty sand with gravel

Sample Comment: ---

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	127.7	130.0	134.5	133.6
Moisture Content, %	4.0	5.9	7.5	9.5

Method : C

Preparation : WET

As received Moisture :10 %

Rammer : Manual

Zero voids line based on assumed specific gravity of 2.75

Maximum Dry Density= 135.0 pcf
Optimum Moisture= 8.1 %

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GeoTesting EXPRESS

Client:	Test America
Project Name:	Wrangell Junkyard
Project Location:	---
GTX #:	306247
Start Date:	04/27/17
End Date:	04/28/17
Tested By:	jcw
Checked By:	emm
Boring #:	---
Sample #:	17031004
Depth:	---
Visual Description:	Moist, very dark gray silty sand with gravel

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

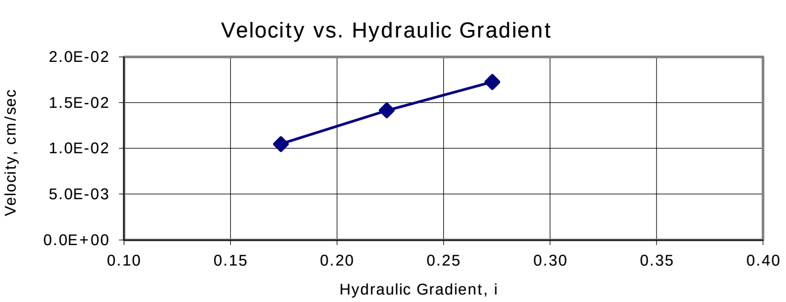
Sample Information:

Maximum Dry Density:	135.0 pcf
Optimum Moisture Content:	8.1 %
Compaction Test Method:	ASTM D698
Classification (ASTM D2487):	---
Assumed Specific Gravity:	2.65

Sample Preparation / Test Setup: Target Compaction: 90% of the maximum dry density (135.0 pcf) at air-dried moisture content. Material >3/8-inch screened out of sample prior to testing (0%).

Parameter	Initial	Final
Height, in	4.03	4.03
Diameter, in	3.98	3.98
Area, in^2	12.4	12.4
Volume, in^3	50.1	50.1
Mass, g	1603	1807
Bulk Density, pcf	121.8	137.3
Moisture Content, %	0.3	13.0
Dry Density, pcf	121.5	121.5
Degree of Saturation, %	---	95.2
Void Ratio, e	---	0.36

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
4/27	1	8.4	10	0.84	0.17	6.0E-02	17.9	1.054	6.4E-02
4/27	2	8.4	10	0.84	0.17	6.0E-02	17.9	1.054	6.3E-02
4/27	3	8.4	10	0.84	0.17	6.0E-02	17.9	1.054	6.4E-02
4/27	4	11.3	10	1.13	0.22	6.3E-02	17.9	1.054	6.7E-02
4/27	5	11.4	10	1.14	0.22	6.3E-02	17.9	1.054	6.7E-02
4/27	6	11.3	10	1.13	0.22	6.3E-02	17.9	1.054	6.7E-02
4/27	7	13.9	10	1.39	0.27	6.3E-02	17.9	1.054	6.7E-02
4/27	8	13.8	10	1.38	0.27	6.3E-02	17.9	1.054	6.7E-02
4/27	9	13.8	10	1.38	0.27	6.3E-02	17.9	1.054	6.6E-02



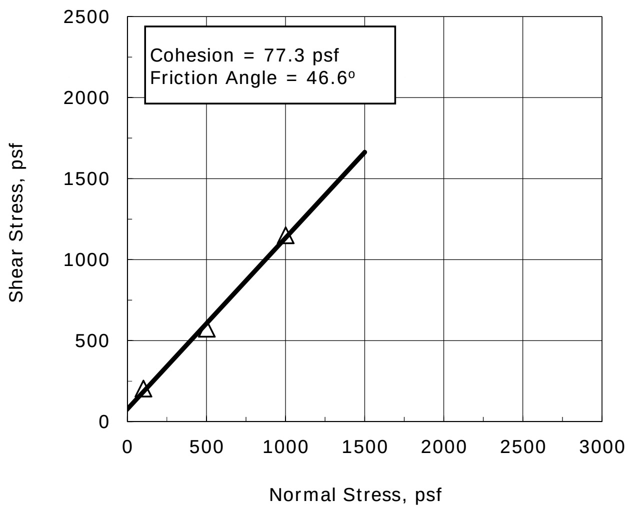
PERMEABILITY @ 20 °C =

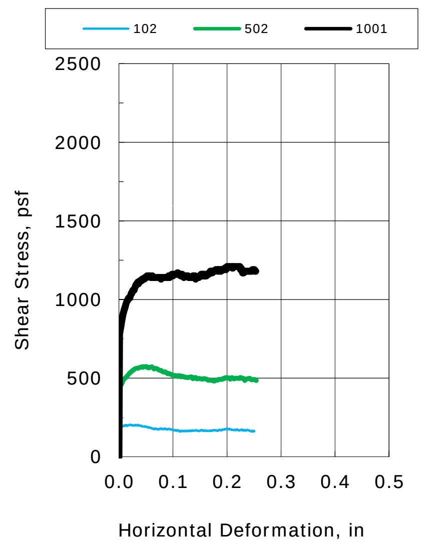
6.6×10^{-2} cm/sec

Note: This standard has been withdrawn by ASTM with no replacement.

Client:	Test America
Project Name:	Wrangell Junkyard
Project Location:	---
GTX #:	306247
Test Date:	05/01/17
Tested By:	jm
Checked By:	njh
Boring ID:	---
Sample ID:	17031004
Depth, ft:	---
Visual Description:	Moist, very dark gray silty sand with gravel

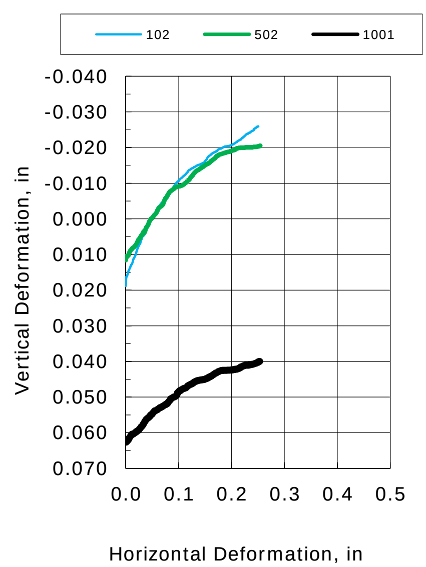
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D3080





Test No.:	DS-1-1	DS-1-2	DS-1-3
Initial Diameter, in:	2.5	2.5	2.5
Initial Height, in:	1.0	1.0	1.0
Initial Mass, grams:	169	169	169
Initial Dry Density, pcf:	121.8	121.8	121.8
Initial Moisture Content, %:	7.9	7.8	7.8
Initial Bulk Density, pcf:	131.4	131.3	131.3
Initial Degree of Saturation:	58.2	58.0	58.0
Initial Void Ratio:	0.36	0.36	0.36
Final Dry Density, pcf:	118.7	119.3	126.9
Final Moisture Content, %:	14.0	13.8	13.8
Final Bulk Density, pcf:	135.3	135.7	144.5
Normal Stress, psf:	102	502	1001
Maximum Shear Stress, psf:	204	574	1150
Shear Rate, in/min:	0.002	0.002	0.002

Sample Type:	reconstituted
Estimated Specific Gravity:	2.65
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	13.2
Soil Classification:	---
Group Symbol:	---



Notes:
Material greater than #5 sieve screened out of sample prior to testing
Moisture content obtained before shear from sample trimmings
Moisture Content determined by ASTM D2216
Percent passing #200 sieve determined by ASTM D422
Target Compaction: 90% of the maximum dry density (135.0 pcf) at the optimum moisture content (8.1%). Values specified by client.
Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.
"---" indicates testing required to determine these values was not requested.

ATTACHMENT 003132-C
Topsoil and Clean Backfill

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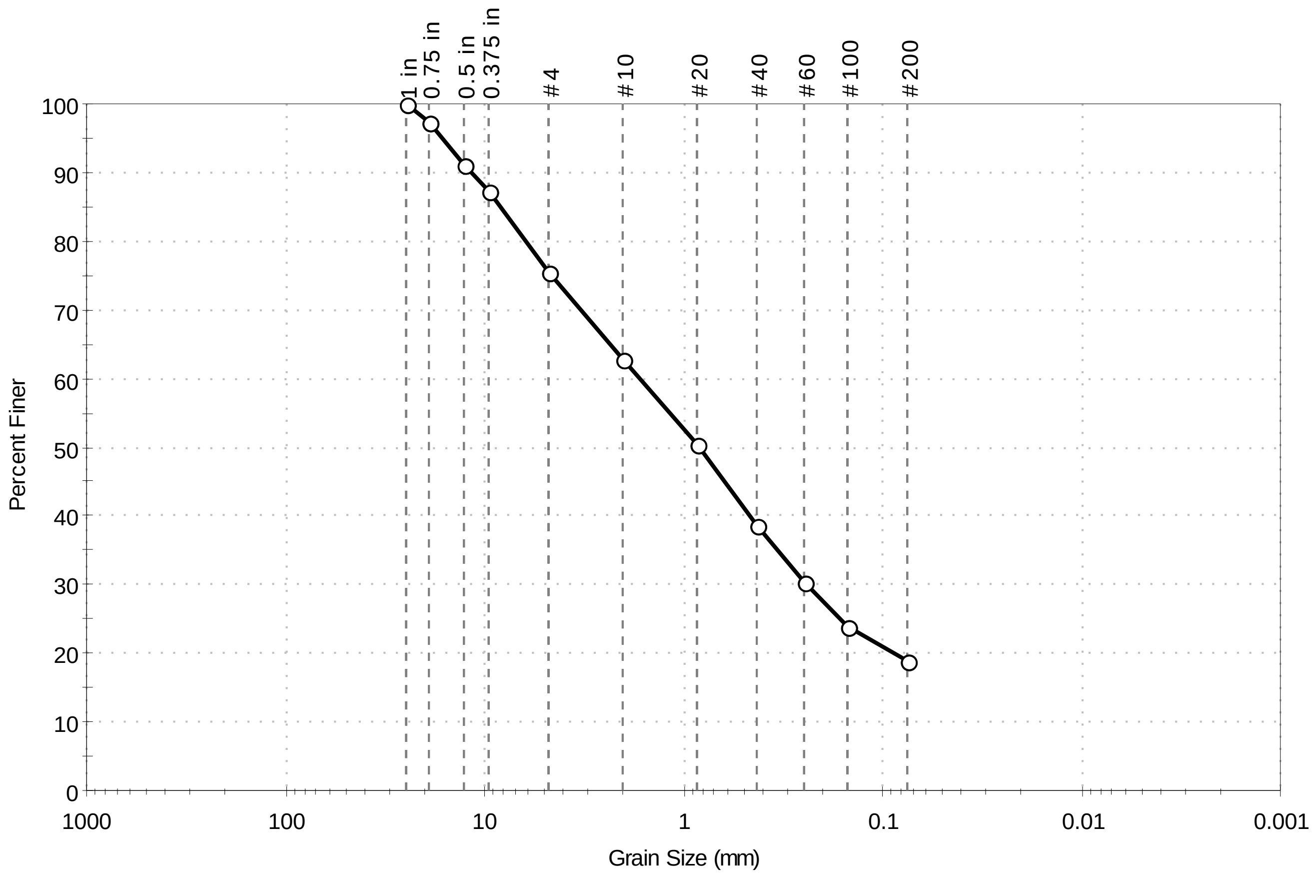
Client:	Test America				
Project:	Wrangell Junkyard				
Location:	---			Project No:	GTX-306247
Boring ID:	---	Sample Type:	bucket	Tested By:	jbr
Sample ID:	17031005	Test Date:	04/10/17	Checked By:	emm
Depth :	---	Test Id:	407953		

Test Comment: ---
Visual Description: Moist, very dark gray silty sand with gravel and organic fines
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	24.6	56.6	18.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	97		
0.5 in	12.70	91		
0.375 in	9.50	87		
#4	4.75	75		
#10	2.00	63		
#20	0.85	50		
#40	0.42	39		
#60	0.25	30		
#100	0.15	24		
#200	0.075	19		

Coefficients

D_{85} = 8.2887 mm
D_{30} = 0.2414 mm
D_{60} = 1.6495 mm
D_{15} = N/A
D_{50} = 0.8279 mm
D_{10} = N/A
C_u = N/A
C_c = N/A

Classification

ASTM Silty sand with gravel and organic fines (SM)

AASHTO Clayey Gravel and Sand (A-2-7 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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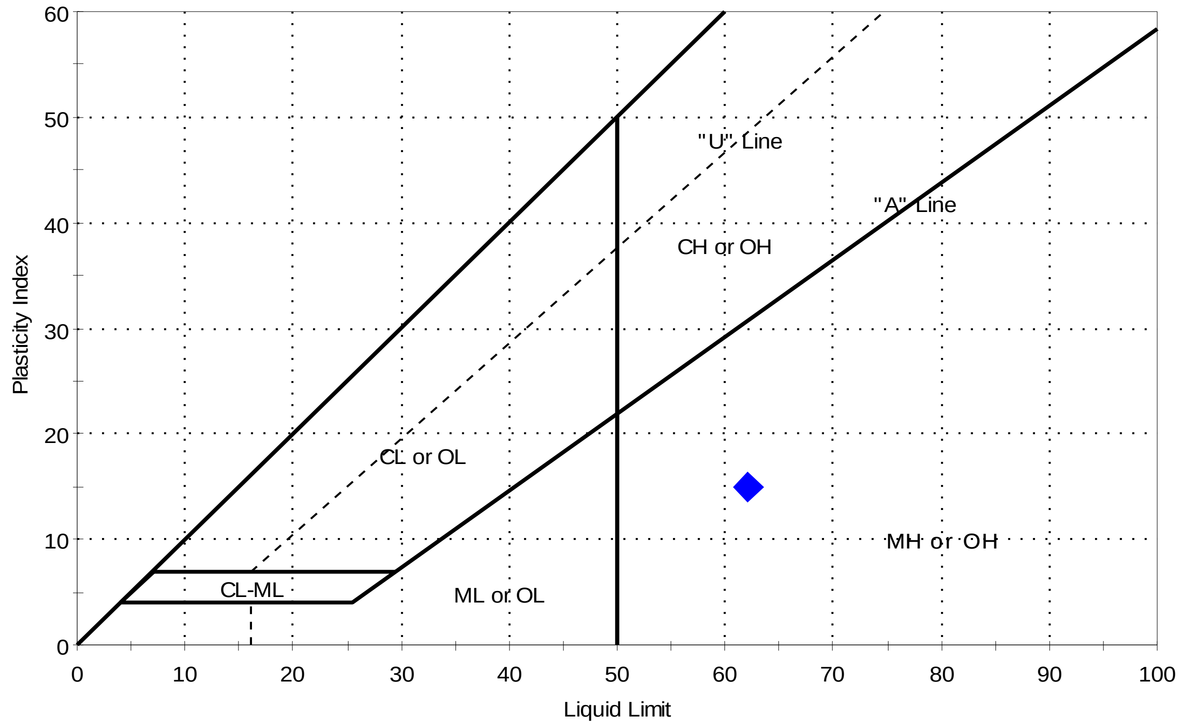
Client: Test America			
Project: Wrangell Junkyard			
Location: ---		Project No:	GTX-306247
Boring ID: ---	Sample Type: bucket	Tested By:	cam
Sample ID: 17031005	Test Date: 04/11/17	Checked By:	emm
Depth : ---	Test Id: 407958		
Test Comment: ---			
Visual Description: Moist, very dark gray silty sand with gravel and organic fines			
Sample Comment: ---			

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	17031005	---	---	33	62	47	15	-0.9	Silty sand with gravel and organic fines (SM)

Sample Prepared using the WET method

61% Retained on #40 Sieve

Dry Strength: HIGH

Dilatancy: SLOW

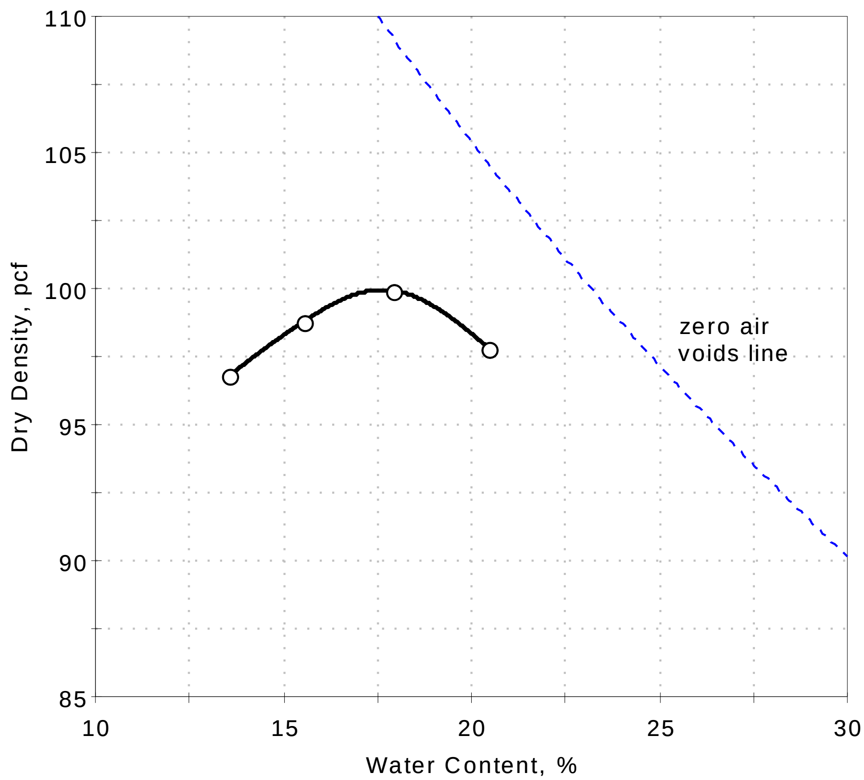
Toughness: LOW

In order to properly describe the soil an Oven Dried Liquid Limit test was performed.
The Oven Dried Liquid Limit was determined to be non-plastic.

Client:	Test America				
Project:	Wrangell Junkyard				
Location:	---			Project No:	GTX-306247
Boring ID:	---	Sample Type:	bucket	Tested By:	cwd
Sample ID:	17031005	Test Date:	04/26/17	Checked By:	emm
Depth :	---	Test Id:	407974		

Test Comment: ---
Visual Description: Moist, very dark gray silty sand with gravel and organic fines
Sample Comment: ---

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	96.8	98.8	99.9	97.8
Moisture Content, %	13.5	15.6	17.9	20.5

Method : C
Preparation : WET
As received Moisture :33 %
Rammer : Manual
Zero voids line based on assumed specific gravity of 2.55

Maximum Dry Density= 100.0 pcf
Optimum Moisture= 17.6 %

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GeoTesting EXPRESS

Client:	Test America
Project Name:	Wrangell Junkyard
Project Location:	---
GTX #:	306247
Start Date:	4/26/2017
End Date:	4/27/2017
Tested By:	jcw
Checked By:	emm
Boring #:	---
Sample #:	17031005
Depth:	---
Visual Description:	Moist, very dark gray silty sand with gravel and organic fines

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084
Constant Gradient

Sample Type: Remolded
Permeant Fluid: De-aired Distilled water
Orientation: Vertical
Cell #: 5/23

Sample Preparation: Target Compaction: 90% of 100.0 pcf at the optimum moisture content (17.6%). Values specified by client. Material >3/8-inch screened out of sample prior to testing (12.7%). Trimmings moisture content = 19.8%

Assumed Specific Gravity: 2.50

Parameter	Initial	Final
Height, in	3.00	3.01
Diameter, in	2.87	2.86
Area, in^2	6.47	6.42
Volume, in^3	19.4	19.3
Mass, g	537.4	582.9
Bulk Density, pcf	105.3	114.6
Moisture Content, %	18.8	28.9
Dry Density, pcf	88.6	88.9
Degree of Saturation, %	62	96

B COEFFICIENT DETERMINATION

Cell Pressure, psi:	90.02	Increased Cell Pressure, psi:	94.93	Cell Pressure Increment, ps	4.91
Sample Pressure, psi:	84.97	Corresponding Sample Pressure, psi:	89.70	Sample Pressure Increment	4.73
				B Coefficient:	0.96

FLOW DATA

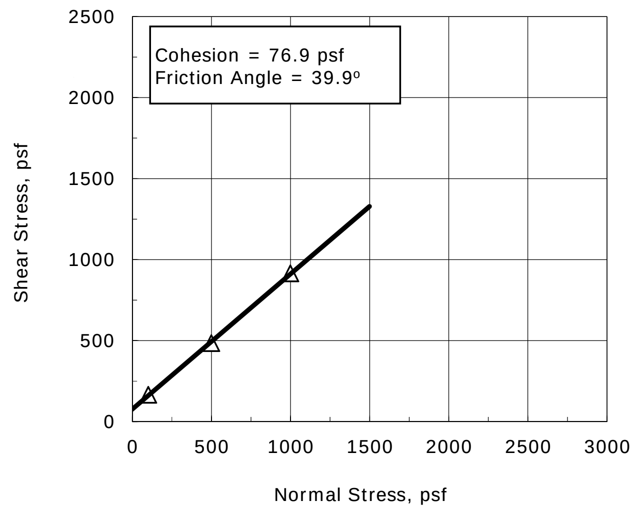
Date	Time, sec	Pressure, psi			Gradient	Flow Volume, cc				Temp, °C	R_t	Permeability K @ 20 °C, cm/sec
		Cell	Inlet	Outlet		In	Out	Δ In	Δ Out			
4/27	---	90.0	85.2	84.8	3.7	13.00	13.40	---	---	---	---	---
4/27	39	90.0	85.2	84.8	3.7	13.20	13.20	0.20	0.20	19.8	1.005	3.4E-05
4/27	----	90.0	85.2	84.8	3.7	12.90	13.60	---	---	---	---	---
4/27	39	90.0	85.2	84.8	3.7	13.10	13.40	0.20	0.20	19.8	1.005	3.4E-05
4/27	----	90.0	85.2	84.8	3.7	13.10	13.50	---	---	---	---	---
4/27	40	90.0	85.2	84.8	3.7	13.30	13.30	0.20	0.20	19.8	1.005	3.3E-05
4/27	----	90.0	85.2	84.8	3.7	13.20	13.30	---	---	---	---	---
4/27	39	90.0	85.2	84.8	3.7	13.40	13.10	0.20	0.20	19.8	1.005	3.4E-05

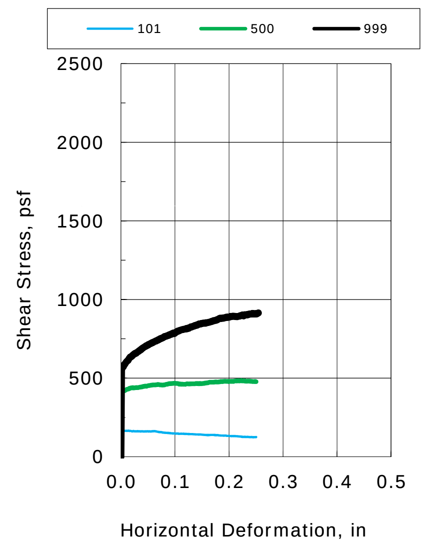
PERMEABILITY AT 20° C: 3.4×10^{-5} cm/sec (@ 5 psi effective stress)

GeoTesting EXPRESS

Client:	Test America
Project Name:	Wrangell Junkyard
Project Location:	---
GTX #:	306247
Test Date:	05/04/17
Tested By:	jm
Checked By:	njh
Boring ID:	---
Sample ID:	17031005
Depth, ft:	---
Visual Description:	Moist, very dark gray silty sand with gravel and organic fines

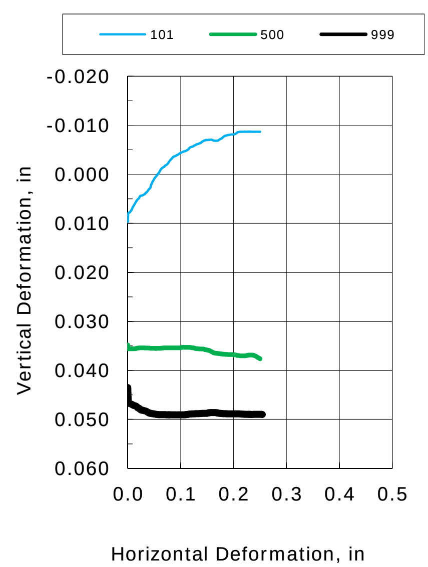
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D3080





Test No.:	DS-2-1	DS-2-2	DS-2-3
Initial Diameter, in:	2.5	2.5	2.5
Initial Height, in:	1.0	1.0	1.0
Initial Mass, grams:	136	136	136
Initial Dry Density, pcf:	90.5	90.6	90.5
Initial Moisture Content, %:	17.0	16.8	16.9
Initial Bulk Density, pcf:	105.9	105.8	105.8
Initial Degree of Saturation:	54.3	53.9	54.1
Initial Void Ratio:	0.83	0.83	0.83
Final Dry Density, pcf:	89.7	94.2	95.2
Final Moisture Content, %:	37.8	35.3	35.2
Final Bulk Density, pcf:	123.6	127.4	128.7
Normal Stress, psf:	101	500	999
Maximum Shear Stress, psf:	166	485	915
Shear Rate, in/min:	0.002	0.002	0.002

Sample Type:	reconstituted
Estimated Specific Gravity:	2.65
Liquid Limit:	62
Plastic Limit:	47
Plasticity Index:	15
% Passing #200 sieve:	19.8
Soil Classification:	silty sand with gravel
Group Symbol:	SM



Notes:
Material greater than #5 sieve screened out of sample prior to testing
Moisture content obtained before shear from sample trimmings
Moisture Content determined by ASTM D2216
Atterberg Limit determined by ASTM D4318
Percent passing #200 sieve determined by ASTM D422
Target Compaction: 90% of the maximum dry density (100.0 pcf) at the optimum moisture content (17.6%). Values specified by client.

Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

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ATTACHMENT 003132-D
1-inch Minus Drain Rock

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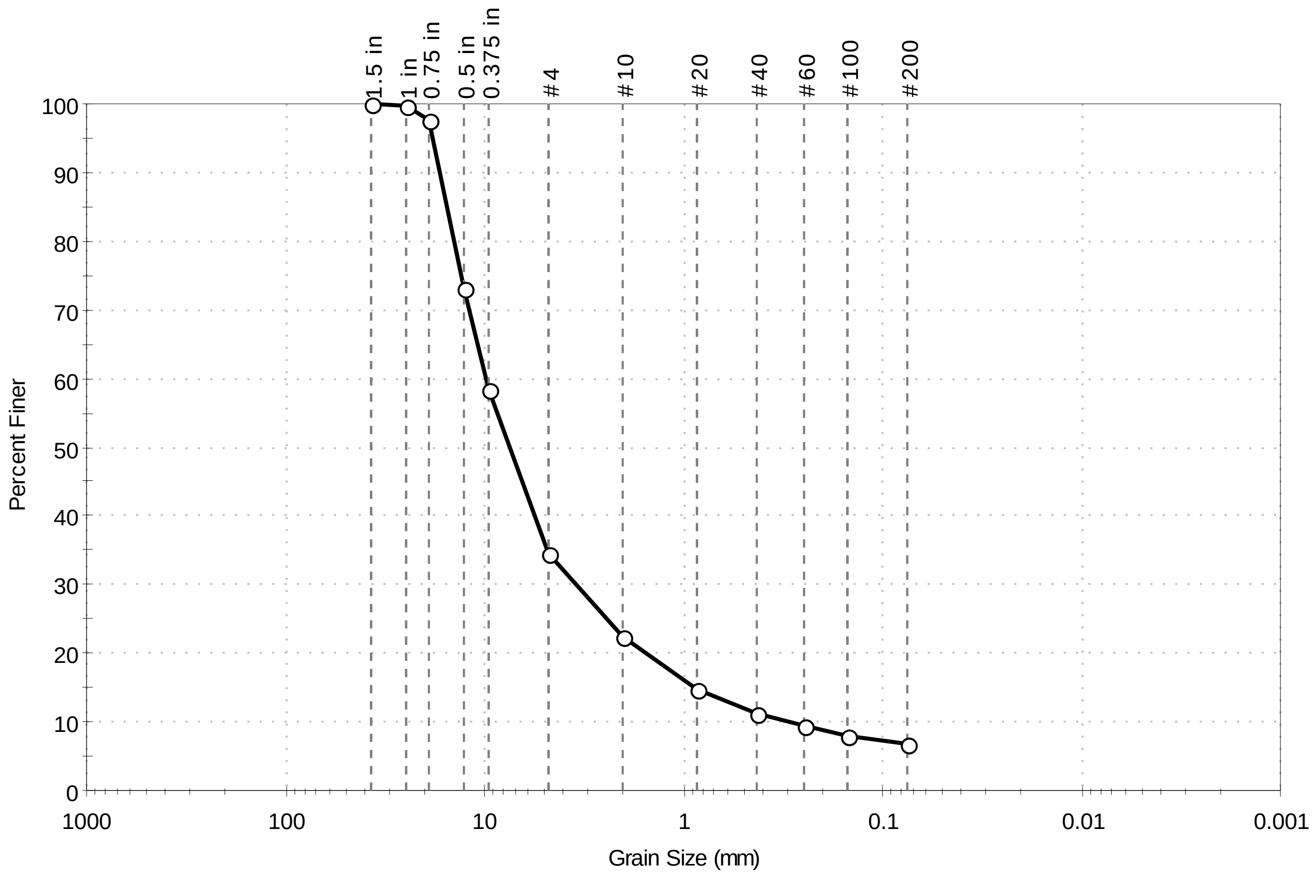
GeoTesting EXPRESS

Client:	Test America		
Project:	Wrangell Junkyard		
Location:	---	Project No:	GTX-306247
Boring ID: ---	Sample Type: bucket	Tested By:	jbr
Sample ID: 17031006	Test Date: 04/13/17	Checked By:	emm
Depth : ---	Test Id: 407954		

Test Comment: ---
Visual Description: Moist, very dark gray gravel with silt and sand
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	65.6	27.7	6.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	100		
0.75 in	19.00	98		
0.5 in	12.70	73		
0.375 in	9.50	58		
#4	4.75	34		
#10	2.00	22		
#20	0.85	15		
#40	0.42	11		
#60	0.25	9		
#100	0.15	8		
#200	0.075	6.7		

Coefficients

D_{85} = 15.4570 mm D_{30} = 3.4563 mm
D_{60} = 9.8021 mm D_{15} = 0.8663 mm
D_{50} = 7.4455 mm D_{10} = 0.2997 mm
C_u = 32.706 C_c = 4.066

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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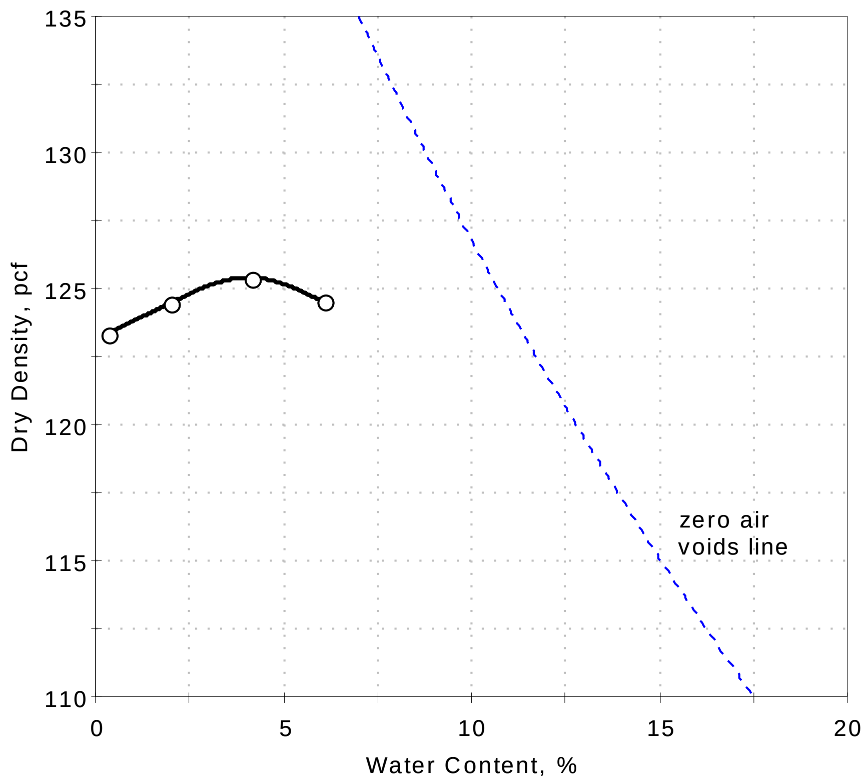
Client:	Test America			
Project:	Wrangell Junkyard			
Location:	---		Project No:	GTX-306247
Boring ID:	---	Sample Type: bucket	Tested By:	cwd
Sample ID:	17031006	Test Date: 04/28/17	Checked By:	emm
Depth :	---	Test Id: 407975		
Test Comment:	Standing water present at point 4			
Visual Description:	Moist, very dark gray gravel with silt and sand			
Sample Comment:	---			

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	123.3	124.5	125.4	124.5
Moisture Content, %	0.3	2.0	4.2	6.1

Method : C

Preparation : WET

As received Moisture :4 %

Rammer : Manual

Zero voids line based on assumed specific gravity of 2.55

Maximum Dry Density= 125.4 pcf
Optimum Moisture= 4.1 %

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GeoTesting EXPRESS

Client:	Test America		
Project Name:	Wrangell Junkyard		
Project Location:	---		
GTX #:	306247		
Start Date:	04/28/17	Tested By:	jcw
End Date:	05/01/17	Checked By:	emm
Boring #:	---		
Sample #:	17031006		
Depth:	---		
Visual Description:	Moist, very dark gray gravel with silt and sand		

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

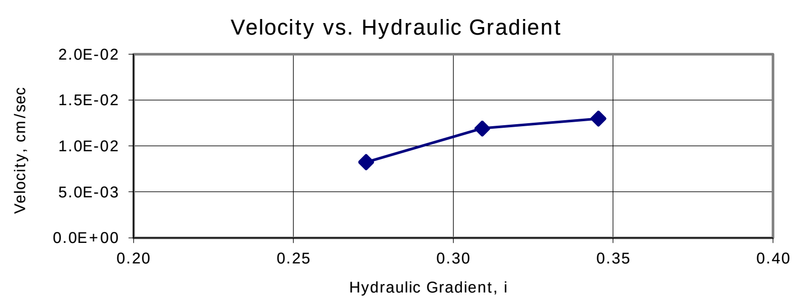
Sample Information:

Maximum Dry Density:	125.4 pcf
Optimum Moisture Content:	4.1 %
Compaction Test Method:	D698
Classification (ASTM D2487):	---
Assumed Specific Gravity:	2.65

Sample Preparation / Test Setup: Target Compaction: 90% of maximum dry density (125.4 pcf) at air-dried moisture content. Material >3/4-inch screened out of sample prior to testing (2%). GTX was unable to achieve the requested density at air-dried moisture content.

Parameter	Initial	Final
Height, in	5.90	5.50
Diameter, in	9.50	9.50
Area, in^2	70.9	70.9
Volume, in^3	418.2	389.9
Mass, g	11875	13227
Bulk Density, pcf	108.2	129.2
Moisture Content, %	0.1	18.6
Dry Density, pcf	108.0	109.0
Degree of Saturation, %	---	95.0
Void Ratio, e	---	0.52

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
4/28	1	169.2	45	3.76	0.27	3.0E-02	15.7	1.116	3.4E-02
4/28	2	170.2	45	3.78	0.27	3.0E-02	15.7	1.116	3.4E-02
4/28	3	169.2	45	3.76	0.27	3.0E-02	15.7	1.116	3.4E-02
4/28	4	245.2	45	5.45	0.31	3.9E-02	15.7	1.116	4.3E-02
4/28	5	244.2	45	5.43	0.31	3.8E-02	15.7	1.116	4.3E-02
4/28	6	245.2	45	5.45	0.31	3.9E-02	15.7	1.116	4.3E-02
4/28	7	267.3	45	5.94	0.35	3.8E-02	15.7	1.116	4.2E-02
4/28	8	266.3	45	5.92	0.35	3.7E-02	15.7	1.116	4.2E-02
4/28	9	267.3	45	5.94	0.35	3.8E-02	15.7	1.116	4.2E-02



PERMEABILITY @ 20 °C =

4.0 x 10^{-2} cm / sec

Note: This standard has been withdrawn by ASTM with no replacement.

GeoTesting EXPRESS

Client:	Test America		
Project Name:	Wrangell Junkyard		
Project Location:	---		
GTX #:	306247		
Start Date:	05/01/17	Tested By:	est
End Date:	05/05/17	Checked By:	jdt
Boring ID:	---		
Sample ID:	17031006		
Depth, ft:	---		
Soil Description:	Moist, very dark gray gravel with silt and sand		

Direct Shear Test Series by ASTM D3080

Soil Preparation:	Target Compaction: 90% of Corrected Maximum Dry Density at the Optimum Moisture Content		
Compaction Characteristics:	Maximum Dry Density	125.4 pcf	
	Optimum Moisture Content	4.1 %	
	Compaction Test Method	ASTM D1557	
Test Equipment:	Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; surface area = 144 in^2		
Maximum Particle Size Used, in:	0.5	Horizontal Displacement, in/min:	0.04
Soil Height, in:	3	Test Condition:	inundated
Gap Between Boxes, in:	0.25		

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	4.1	3.6	4.3	---	---	---
Initial Dry Density, pcf	113	113	112	---	---	---
Percent Compaction, %	89.8	90.2	89.7	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	139	788	1345	---	---	---
Final Moisture Content, %	10.6	7.3	5.6	---	---	---

Notes:

Peak Friction Angle: **53.1** **degrees**

Peak Cohesion: **47.5** **psf**

Figure a. Shear Force vs. Horizontal Displacement

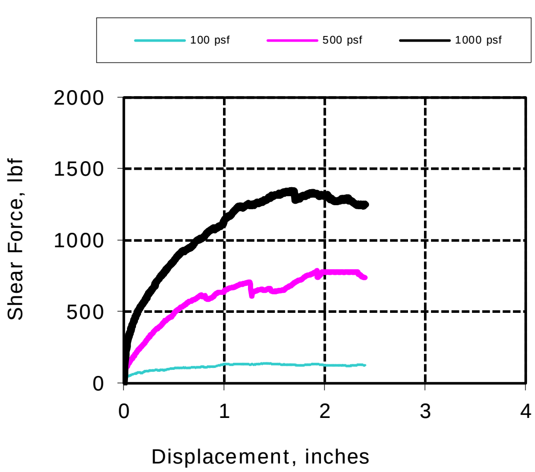
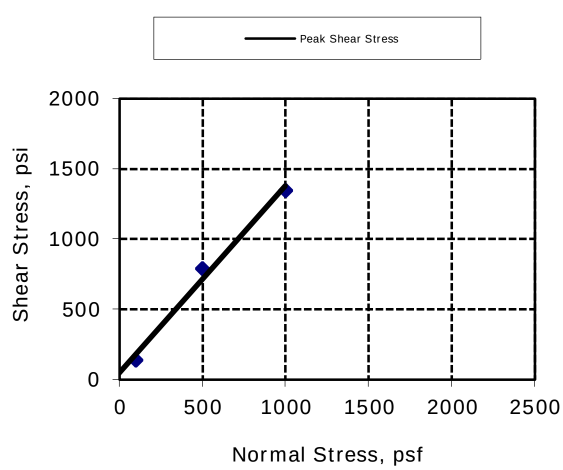


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

SECTION 007100
ABBREVIATIONS AND DEFINITIONS

1.0 GENERAL

1.1 ABBREVIATIONS

A. Whenever the following abbreviations are used in these Contract Documents, they are to be construed as represented below:

1. µg/L micrograms per liter
2. ADEC Alaska Department of Environmental Conservation
3. ADNR Alaska Department of Natural Resources
4. ANSI American National Standards Institute
5. ASTM American Society for Testing and Materials, ASTM International
6. BGS below ground surface
7. CFR Code of Federal Regulations
8. BMP best management practice
9. COC chemical of concern
10. COP Construction Operations Plan
11. CQC Contractor Quality Control
12. CSSP Contractor Site Safety Plan
13. cy cubic yard
14. DOT United States Department of Transportation
15. E & E Ecology and Environment, Inc.
16. EPA United States Environmental Protection Agency
17. FGCS Federal Geodetic Control Subcommittee
18. FML flexible membrane liner
19. H horizontal
20. HDPE high-density polyethylene
21. ID identification or inside diameter
22. lb pound
23. LLDPE linear low-density polyethylene
24. m meter
25. max. maximum
26. min. minimum
27. MHP Materials Handling Plan
28. MSL mean sea level
29. MUTCD Manual on Uniform Traffic Control Devices
30. MW monitoring well
31. NAD83 North American Datum of 1983
32. NAVD North American Vertical Datum
33. NGVD National Geodetic Vertical Datum
34. NIOSH National Institute for Occupational Safety and Health
35. no. number
36. NPDES National Pollutant Discharge Elimination System
37. OD outside diameter
38. OHV off-highway vehicle

39.	O&M	operations and maintenance
40.	OSHA	Occupational Safety and Health Administration
41.	PNEZD	point number, northing, easting, elevation, and description
42.	PPE	personal protective equipment
43.	psf	pounds per square foot
44.	psi	pounds per square inch
45.	PVC	polyvinyl chloride
46.	QA	quality assurance
47.	QAO	quality assurance officer
48.	QC	quality control
49.	RCRA	Resource Conservation and Recovery Act (as amended)
50.	REC	recognized environmental condition
51.	SDR	standard dimension ratio
52.	SOP	Standard Operating Procedure
53.	SPCS	State Plane Coordinate System
54.	TCLP	toxicity characteristic leaching procedure
55.	TSCA	Toxic Substances Control Act
56.	TSD	Treatment, Storage, and Disposal
57.	UL	Underwriters Laboratory
58.	USDA	United States Department of Agriculture
59.	USCG	United States Coast Guard
60.	V	vertical

1.2 DEFINITIONS

A. These definitions are made for the purposes of this contract only.

1. Agency – Alaska Department of Environmental Conservation.

2. Backfill - The filling of areas with Earthen Material to the lines and grades indicated on the Design Drawings using specified materials for filling of excavation areas; and the compacting of all materials used in filling or refilling by rolling, ramming, tamping, or as may otherwise be required to achieve the required level of compaction.

3. Cementitious Materials - Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other approved pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

4. Construct – To form by assembling or combining parts and materials; build.

5. Construction/Construction Activities - All Contractor activities specified by this contract or as required to carry out the Work.

6. Construction Entrance – The roadway leading into and out of both the Junkyard Site and Repository Site.

7. Day - Unless otherwise specified, day(s) shall mean Calendar Day(s).
   a. Business Day: Any day other than Saturday, Sunday, or Federal Holiday.
   b. Calendar Day: The time period of twenty-four hours measured from midnight to the next midnight.
   c. Non-Working Day: The following are Non-Working Days:
      1. Sunday;
      2. Federal Holiday;
      3. A day upon which the Agency issues a suspension order; and/or
      4. A day on which the Contract specifically requires the Contractor to suspend the Work.
   d. Working Day: A day not otherwise defined as a Non-Working Day.
   e. Unworkable Day: A partial or whole day the Agency in its sole opinion declares to be unworkable because of unusually severe weather, or another condition beyond the control of the Contractor that prevents satisfactory and timely performance of the Work, when such performance, if not hindered, would have otherwise progressed toward completion of the Work.

8. Demonstrate – To show product performance or compliance in the presence of the Engineer, Agency's Project Manager or the Agency's Authorized Representative.

9. Earth, Earthen Material - All materials, such as sand, gravel, sediment, clay, loam, ashes, cinders, muck, roots, pieces of timber, minor debris, soft or disintegrated rock, including that requiring blasting, barring, or wedging from their original beds, and including all ledge or bedrock and individual boulders.

10. Earthwork - Includes, but is not limited to: clearing, limited debris removal, topsoil removal, sediment removal, gravel removal, road base removal, classified and unclassified excavation for structures, handling and disposal of surplus materials, maintenance of excavations, removal of water, sheeting and bracing, backfilling operations, rough grading, embankments and fills, compaction, and protection of existing structures and facilities.

11. Engineer - The authorized representative of the Agency, who will be present on site as the principal point of contact, and will be assigned to make detailed inspections of any and all portions of the Work. All engineering work will be under the supervision of an engineer currently licensed in the State of Alaska. Gender-specific pronouns are used in this document for clarification and should be considered generic in meaning.

12. Equipment - All machinery and equipment with the necessary supplies for upkeep and maintenance; also tools and apparatus necessary for the proper construction and acceptable completion of the Work.

13. Firm, Non-Yielding Surface – Surface does not depress more than approximately 1 inch under the weight of equipment and is resistant to rutting.

14. Furnish – To supply products to the project site, including delivery ready for unloading and replacing damaged and rejected products.

15. Hazardous Waste - Solid waste classified as hazardous according to the Resource Conservation and Recovery Act Amendments (1984) and guidelines thereto.

16. Indicated – Shown, noted, scheduled, specified, or drawn, somewhere in the Contact documents.

17. Install – To put products in place ready for the intended use, including unloading, unpacking, handling, storing, assembling, installing, erecting, placing, applying, anchoring, working, finishing, curing, protecting, cleaning, and similar operations.

18. Materials - Any substances specified for use in the project and its appurtenances.

19. Monument - A fixed physical object used to mark either a point on the surface of the earth, used to commence or control a survey, mark the boundaries of a parcel of land, or the centerline of a right-of-way corridor. Monuments will be Primary or Secondary, as shown on the Plans.

20. Off Highway Vehicle - An off-highway vehicle is any motor vehicle operated on unimproved roads and trails not suitable for conventional two-wheel-drive vehicular travel. Examples include: all-terrain vehicles (ATVs), utility vehicles (UTVs), trail motorcycles and dirt bikes.

21. Off Site - Outside the legal property boundary of the site.

22. Point - An identified spot located on the surface of the earth. For purposes of this definition, a point can be a PK nail, wooden hub, rebar, large nail or other structure capable of being utilized as a marker.

23. Progress Reports - Submittals by the Contractor showing progress and up-to-date status of the project and anticipated variances both in work and finances.

24. Project Manager - Gender-specific pronouns are used in this document for clarification and should be considered generic in meaning.
    - Agency's Project Manager – The employee of the Agency who oversees the quality of work and budget for the items to be performed by the Contractor and Engineer. The Agency's Project Manager is authorized to communicate with the Contractor personnel, Engineering personnel, and the Agency's Representative on all matters.
    - Contractor's Project Manager – The employee of the Contractor who is responsible for the quality of work and budget for the items to be performed by the Contractor. The Contractor's Project Manager is authorized to communicate with the Agency's Project Manager on all matters.
    - Engineer's Project Manager - The Engineer's Project Manager is responsible for providing adequate staff to monitor the Contractor's work, and for remaining within the budget authorized by the Agency. The Engineer's Project Manager is authorized to report directly to the Agency Project Manager concerning the work of the Contractor.

25. Project/Project Work - Any and all work specified herein, including any associated site improvements and appurtenances and structures to be constructed. The project is more fully described elsewhere in the Contract Documents, including the Agreement.

26. Provide – To furnish and install products.

27. Reference Monument - A material mark or point placed at a known distance and direction from a property corner or other survey point, usually not on a property or survey line. A reference monument is employed to perpetuate a corner/point that cannot have a monument placed at its true location or where the corner monument is subject to destruction.

28. Replacement – Installation of a like element in the same or near-same physical location to function in place of an existing element, normally due to damage, wear, or obsolescence of the element.

29. Restoration – All work necessary to replace, repair, or otherwise reestablish the right-of-way or private property and all features contained within it to the same or equal condition, as it existed prior to any change or construction therein.

30. Right-of-Way - Land, property, or property interest, usually in a strip, acquired for or devoted to transportation purposes.

31. Shall - The word "shall" means "mandatory performance by the contracted party" to the task referred to and accompanying this word.

32. Site Entrance - The site entrance is the same as the construction entrance; refer to Construction Entrance definition for location.

33. Site Superintendent - Representative of the Contractor who shall be present on site during all Contractor activities and serve as principal point of contact, and who will be responsible for directing and overseeing all aspects of Contractor's work.

34. Site/On Site - Any area within the repository property.

35. Staging Areas - Designated areas used by the Contractor for temporary or long-term storage of construction equipment, materials, soil or gravel stockpiles, landscaping elements, and other items necessary to complete the Work.

36. Subgrade – The top surface of the roadbed on which subbase, base, surfacing, pavement, or layers of similar materials are placed.

37. Subsoil – The soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

38. Subsurface Features - Manmade features below existing grade or water surface including, but not limited to: utilities, pipelines, drain lines and drains, wells, and riprap.

39. Support Areas - Areas approved for use by the Agency that may be used by the Contractor for office and administrative functions, and parking of employee vehicles.

40. Surface Soil - Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.

41. Surveyor -The Contractor's Professional Land Surveyor, currently registered in the State of Alaska.

42. Topsoil - Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow.

43. Treated Waste Material, Treated Waste Soil – Soil treated at the Junkyard Site with ECOBOND in 2016 and currently stockpiled at the northwest corner of the Site.

44. Utility - The privately, publicly, or cooperatively owned lines, facilities, and systems for producing, transmitting, or distributing communications, power, electricity, light, heat, gas, oil, crude products, water, steam, waste, and storm-water, not connected with on-site drainage, and other similar commodities, including publicly owned fire and police signal systems and street lighting

systems, which directly or indirectly serve the public or any part thereof. The term "utility" shall also mean the utility company, inclusive of any wholly owned or controlled subsidiary.

45. Witness Corner - A material mark or point usually placed on a property or survey line, at a known distance from a property corner or other survey point. A witness corner is employed to witness the location of a corner/point that cannot have a monument placed at its true location.

46. Work – see the definition for “Project”.

1.3 NAME OF SITE

The name of the site is Wrangell Junkyard Repository Site, or “repository site,” as is used in these Contract Documents. The Wrangell Junkyard Repository Site is located on Wrangell Island, Alaska as defined in Section 011100, SUMMARY OF WORK.

2.0 PRODUCTS

[Not Used]

3.0 EXECUTION

[Not Used]

*** END OF SECTION ***

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DIVISION 01
GENERAL REQUIREMENTS

Section 011100	–	Summary of Work
Section 011310	-	Endangered Species
Section 011350	-	Preservation of Historical and Archaeological Data
Section 011400	–	Control of Work/ Work Restrictions
Section 013119	–	Project Meetings
Section 013300	–	Contractor Submittals
Section 014000	–	Quality Requirements
Section 015000	–	Temporary Facilities and Controls
Section 015700	–	Environmental Protection Procedures
Section 017000	–	Site Restoration
Section 017123	–	Survey Control
Section 017839	–	Project Record Documents

Note: This page intentionally left blank

1.0 GENERAL

1.1 PROJECT OBJECTIVES

The objectives of the proposed Work are to transport and consolidate treated material from the Wrangell Junkyard Site to a secure repository location at the Repository Site. The secure repository will manage surface water flow onto the repository cover, capture and isolate precipitation runoff from the repository cover, and prevent exposure to substances placed within the repository. ALL WORK STATED WITHIN THIS SECTION OR TO MAKE A COMPLETE AND WORKABLE SYSTEM SHALL BE IN ACCORDANCE WITH SPECIFICATIONS AND DESIGN DRAWINGS.

1.2 LOCATION OF WORK

The Wrangell Junkyard Site (referred to herein as the “Junkyard Site”) is located approximately 4 miles south of the city of Wrangell, on Wrangell Island, Alaska (see Design Drawing C-1). The Junkyard Site sits on the east side of Zimovia Highway and slopes toward Zimovia Strait. It consists of approximately 2.5 acres of land (parcel number 03-006-303) and operated as a private salvage yard beginning in the 1960s. The property was foreclosed on in 2008, at which point the Borough of Wrangell assumed ownership of the property (E & E 2015).

A separate site approximately 8 miles south of the Junkyard Site has been selected by ADEC as a permanent repository location for treated waste material from the former junkyard. This site, referred to herein as the Wrangell Junkyard Repository Site, or the “repository site,” is a former ADNR rock quarry south of Pat Creek Road, approximately 1.5 miles east of Zimovia Highway (see Design Drawing C-1). The repository site is surrounded on three sides by steep rock walls. The quarry floor slopes toward the quarry opening and Pat Creek Road. The existing site conditions are presented on Design Drawing C-2. Primary access to the site is as specified in Section 011400, CONTROL OF WORK/WORK RESTRICTIONS.

1.3 BACKGROUND INFORMATION

Reports generated to date are detailed in Section 003126, EXISTING HAZARDOUS MATERIAL INFORMATION, and although most reports focus on the Junkyard Site a hydrologic and geotechnical investigation was performed at the Repository Site.

As noted in Section 003126, EXISTING HAZARDOUS MATERIAL INFORMATION , a hydrologic and geotechnical investigation was conducted by Ahtna in December of 2016 and summarized in the report *Proposed Wrangell Monofill Report of Findings, Wrangell, Alaska* (Ahtna 2017). As part of this investigation, three exploratory borings were advanced at the repository site to characterize subsurface conditions, determine site groundwater depths, and identify baseline groundwater quality conditions at the rock quarry location that has been selected as the repository site.

In accordance with AAC 60.217, unlined landfills must have a minimum of 10 feet of separation between the highest measured level of an aquifer and the bottom of the waste, unless the landfill is constructed 2 feet or more above the natural ground surface. Due to the shallow depth of groundwater, the construction of a foundation layer between the Junkyard Site treated waste material and the ground surface will be required at the Repository Site. The waste material at the Junkyard Site was determined to have elevated concentrations of lead, and the total volume of material requiring consolidation and capping was estimated as 18,515 cubic yards. The treated waste material has been treated with a chemical binder, ECOBOND, which encapsulates lead and other metals in the soil, making them insoluble in order to reduce the leaching potential. TCLP and synthetic precipitation leaching procedure confirmation laboratory testing was conducted on the treated soil; the testing confirmed that lead does not leach from the treated soil and that the concentrations in the waste material at the Junkyard Site are present in non-hazardous concentrations (NRC Alaska and NORTECH 2016). Note that if consumed by humans, plants, or animals, the lead may have some bioavailability that is potentially toxic. Concentrations of lead in soil are still considered hazardous for the direct contact/ingestion human health exposure pathways.

1.4 REPOSITORY SITE GROUNDWATER ELEVATION

The borings completed at the proposed Repository Site were advanced to depths ranging from 6 to approximately 34 feet below ground surface (bgs). Subsurface material consisted primarily of crushed rock overburden underlain by fractured bedrock. The thickness of the overburden material ranged from 1 to 10 feet bgs across the site (Ahtna 2017). Either a groundwater monitoring well or piezometer was installed at each of the three boring locations, and groundwater levels were recorded to establish a baseline. Groundwater was identified in the overburden and fractured rock at depths of approximately 2.5 to 3.2 feet bgs (Ahtna 2017); however, these elevations may not be representative of the highest groundwater elevations, as they were discrete readings and do not account for seasonal fluctuations. The hydraulic gradient was calculated as approximately 0.0077 feet per foot with the general direction of flow toward Pat Creek Road (Ahtna 2017). It should be noted that two of the borings were terminated just above bedrock due to the presence of an oily sheen observed in the groundwater. The source of the oil was not identified during the site investigation.

1.5 REPOSITORY SITE ANALYTICAL RESULTS

Analytical samples were collected from the boring advanced to 34 feet bgs to establish background concentrations in site groundwater. Despite evidence of oil in groundwater, analytical testing was limited to metals, and the primary contaminant of concern was identified as lead based on the concentrations found in the waste material consolidated at the Junkyard Site. The laboratory results indicated that the baseline concentrations of metal contaminants at the Repository Site are below the maximum contamination levels, as summarized under Title 18 Alaska Administrative Code (AAC) Section 75: Table C. These baseline groundwater concentrations can be used in post-construction monitoring to aid in ADEC's assessment of the effectiveness of the monofill design.

1.6 SCOPE OF WORK

A. The Contractor shall perform all activities and furnish all labor, materials, equipment, subcontractor services, and incidentals necessary to implement the design in accordance with the Contract between the Agency and the Contractor. In general, the Work involves: 1) abandoning selected monitoring wells and piezometers; 2) clearing and grubbing the repository base; 3) transporting treated waste material from the Junkyard Site to the Repository Site; 4) obtaining and installing selected materials for the engineered cover; 5) installation of both surface and subsurface drainage features; 6) erection of an entrance gate and OHV barriers; and 7) performance of all other work incidental to implementation of the design.

The Work shall include all activities required of the Contractor to plan, organize, monitor, and coordinate the logical and timely sequence of site activities in accordance with all regulatory requirements. This includes, but is not limited to, activities such as preparation of technical and operational submittals, construction-related permits, attendance at project meetings, incidental expenses (e.g., erosion and sediment control, water management, site housekeeping), and administrative activities.

B. Prepare and submit a health and safety plan, Construction Operations Plan, and other submittals as specified in Section 013300, CONTRACTOR SUBMITTALS, and as referenced throughout this document.

C. Obtain access and permits required for Work.

D. Mobilize to, and demobilize from, the project site. This includes mobilizing and setting up a field office, support staff, and construction facilities; mobilizing and demobilizing all equipment, materials, and labor; performing site monitoring and protection, implementing appropriate health and safety practices, and performing site security during the Work.

E. Survey the site, as needed, to confirm vertical elevations, establish horizontal control, provide controls during work, and as indicated in these specifications. This will include post-construction documentation activities (e.g., record [as-built] survey documentation).

F. Site preparation, though not limited to these activities, will include: providing erosion and sedimentation, dust, and other environmental control best management practices (BMPs); site clearing and grubbing, surface compaction, and surface leveling; providing site access control and traffic management; removing site structures listed for removal and protecting those not listed for removal; setting up work zones including installation of access roads, staging areas, and turn-around areas.

G. Provide site security, as necessary, for the protection of equipment and materials stored on site.

H. Perform selective well abandonment; see Section 332900, WELL ABANDONMENT.

I. Construct repository base.

J. Excavate, load, transport and place treated waste material in the repository.

K. Obtain borrow material necessary for performing the Work.

L. Construct and complete the repository cover, drainage layer, surface water diversions, as indicated in the design.

M. Final grade and seed repository cover.

N. Install a secure gate at the repository entrance to prevent access to the repository location and install OHV barriers to prevent OHV use on the repository cover.

O. Return roads to previous conditions and reclaim any temporary access roads, parking areas, and material staging areas.

P. Perform miscellaneous debris disposal, see Section 015700, ENVIRONMENTAL PROTECTION PROCEDURES.

Q. Assemble closeout documents and prepare record drawings.

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

[Not used.]

*** END OF SECTION ***

1.0 GENERAL

A. Certain native species in the State of Alaska are considered protected plant or animal species under State law(s) and the Federal government lists Threatened, Endangered, Candidate, and Strategy Species. A preliminary assessment performed by ADEC determined that no endangered species are expected to occur at the Site.

B. In the event that a species, listed as threatened or endangered, is observed during the course of Work, the Contractor shall notify the Agency. The Agency will work with the Contractor and US Fish and Wildlife Service (USFS). The USFS is responsible for administration of the Endangered Species Act and is the only agency authorized for removal or take of a listed species. If a species is not listed as threatened or endangered but are sensitive species, in accordance with state law, the Agency may arrange for removal of species not listed as threatened or endangered, and the Contractor shall cooperate with those performing such removal. If these species are not removed, the contractor shall cooperate with and abide by protection plans to avoid damage to or disturbance of protected species.

2.0 PRODUCTS

[Not Used]

3.0 EXECUTION

[Not Used]

*** END OF SECTION ***

Note: This page intentionally left blank.

1.0 GENERAL

A. To comply with Section 106 of the National Historic Preservation Act, ADEC performed a cultural review and survey of the repository site. The Alaska State Historic Preservation Officer returned a finding of No Historic Properties Affected.

B. Any person, who, without permission, injures, destroys, excavates, appropriates, or removes any historical or prehistorical artifact, object of antiquity, or archaeological resource on public lands of the United States is subject to arrest and penalty of law.

C. The Contractor shall comply with state laws when operating on non-Federal and non-Indian lands.

2.0 PRODUCTS

[Not Used]

3.0 EXECUTION

A. If the Contractor, or any of the Contractor's employees, or parties operating or associated with the Contractor, in performance of this contract discover cultural resources:

1. Cease work in that particular area.
2. Immediately notify the Agency.
3. Exercise care to not disturb or damage cultural resources uncovered during excavation operations, and provide such cooperation and assistance to archaeologist(s) as needed.
4. Do not resume work in the area until notice to proceed by the Agency.

*** END OF SECTION ***

Note: This page intentionally left blank.

1.0 GENERAL

1.1 WORK HOURS

A. Working Days/Hours shall be Daylight Hours, Monday through Saturday, unless otherwise approved by the Agency. No work shall occur except between the hours of 8:00 A.M. and 6:00 P.M. No deliveries shall be scheduled before 8:00 A.M. or after 5:00 P.M., and delivery trucks shall not be allowed to wait outside the site entrance before or after hours. Work on Sundays, if approved, shall be scheduled such that no more than twelve (12) consecutive days are worked.

B. It is expected that the Contractor will work at least forty (40) hours per week.

C. The noise (and lights if night work is approved) will impact residents near the site of the work. Levels of noise (and possibly light) will be major criteria used by the Agency to determine if work beyond the hours specified above will be allowed.

D. The Engineer shall be present whenever on-site work, as defined in Section 007100, ABBREVIATIONS-DEFINITIONS, is being performed.

E. At the preconstruction conference, the Contractor shall establish the work hours schedule. The Contractor shall not change the work hours without giving one (1) week's notice to the Engineer, with copies to the Agency's Project Manager and the Agency's Authorized Representative.

1.2 ACCESS TO WORK

A. ADEC has the necessary clearance with ADNR for construction of the repository; however, the contractor is responsible for contacting ADNR and the City of Wrangell to obtain the right-of-entry prior to conducting field activity at the Junkyard Site and Repository Site.

B. It is the responsibility of the Contractor to ensure that all parties contracted to do work at the Site, for all purposes that may be required by their contracts, and representatives of State and Federal regulatory agencies, for any purpose, shall have access to the Work and the premises used by the Contractor, and the Contactor shall provide safe and proper access and facilities.

1.3 LAND AVAILABLE TO CONTRACTOR

A. The Contractor shall confine its operations to the Junkyard Site, Repository Site, and any work areas shown on the Design Drawings.

B. All work shall be conducted in such a manner as will cause minimum inconvenience and disturbance to existing lands. No excavated materials or supplies shall be stored on private land unless directed by the Agency.

C. The contractor shall erect fencing along roadways and grounds occupied by the Contractor within the site work limits, as required to protect the public and maintain site security.

2.0 PRODUCTS

[Not Used]

3.0 EXECUTION

[Not Used]

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. A preconstruction meeting, progress meetings, coordination meetings, and other site meetings will occur throughout the progress of the Work. For each meeting the Contractor will:

1. Prepare agendas for meetings.

2. Make physical arrangements for meetings.

3. Preside at meetings.

4. Record the minutes and include significant proceedings and decisions.

5. Reproduce and distribute copies of minutes after each meeting to participants in the meeting and to parties affected by decisions made at the meeting.

B. Representatives of Contractors, Subcontractors, and suppliers attending meetings shall be qualified and authorized to act on behalf of the entity each represents.

C. Contractor attendance at all meetings is mandatory.

1.2 NATURE OF MEETINGS

A. The meetings specified herein are formal in nature and should be attended by both the Contractor's and Engineer's project managers and the key technical personnel. Agency personnel may also attend these meetings.

B. Unless requested otherwise by the Engineer, the Contractor's overall superintendent (primary site representative) should attend preconstruction and project meetings.

C. Nothing in this section should preclude the usual informal meetings held daily between the Contractor's and Engineer's staffs.

1.3 DOCUMENTATION

A. The Contractor shall prepare a summary of each meeting within two (2) days following the meeting, especially noting any decisions made, and shall deliver a copy to the Engineer and the Agency.

B. The Agency and Engineer shall review the summary of the meeting and immediately inform the Contractor if it believes the summary is not completely accurate. Failure to inform the Contractor of any inaccuracies within three (3) calendar days of the meeting shall indicate concurrence with the summary of the meeting.

1.4 SCHEDULING MEETINGS

A. The preconstruction meeting shall be scheduled by the Contractor shortly after the formal Award of Contract.

B. Project meetings shall be held on the construction site at a minimum of once per week. Before project construction begins, a day and time shall be agreed upon on which the meetings shall take place each week.

C. Either party, with adequate advance notice, may request a meeting not otherwise scheduled.

1.5 LOCATION OF MEETINGS

A. The Agency will arrange for the location of the preconstruction meeting.

B. Normally all other meetings will occur at the site field office.

1.6 PRECONSTRUCTION MEETING

A. The purpose of the preconstruction meeting is to review Contract requirements; establish a detailed schedule of operations; discuss the Contractor's safety rules and regulations and the Contractor's Site Safety Plan; discuss material handling; discuss the transportation plan; introduce various members of the Contractor’s, Agency’s, and Engineer’s staffs; and resolve any questions raised by any party.

B. Anticipated agenda items:

1. Safety/safe work practices

2. Sequencing and schedule considerations

3. Discussion of design

   a. Drawings
   b. Technical Specifications

4. Overview of Work objectives

   a. Site preparation

   b. Subgrade construction

    c. Drainage construction

    d. Cover construction

5. Anticipated overall project construction schedule

6. Contractor's submittals

7. Contract issues

8. Project Coordination and Communication

    a. Designation of responsible personnel

    b. Lines of communication

9. Procedures for maintaining record documents

10. Use of premises

11. Construction facilities, controls, and construction aids

12. Deliverables

1.7 PROGRESS MEETINGS

A. The purpose of progress meetings is to update the job progress, update cost estimates for work accomplished, review submittals log, review requests for payment, resolve problems that may arise, discuss any accidents or near accidents since the last meeting, and address any other matters of concern to any party.

B. Anticipated agenda items:

1. Safety/safe work practices

2. Review of prior meeting minutes and outstanding items

3. Review of work progress since previous meeting

4. Field observations, problems, and conflicts

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

[Not used.]

*** END OF SECTION ***

1.0 GENERAL

1.1 REQUIREMENTS

A. This section specifies the general methods and requirements of submissions applicable to Contractor Submittals, including various plans, shop drawings, test reports, data on materials and equipment, and material samples required for the proper control of the Work.

B. All submittals shall be clearly identified by reference to Section Number, Paragraph, Drawing Number, or Detail as applicable. Submittals shall be clear and legible and of sufficient size for presentation of data.

C. The Contractor will maintain an accurate, updated submittal log and will bring this log to each scheduled progress meeting.

D. No work will be allowed to proceed until submittals for that portion of work have been received, reviewed, and approved by the Engineer and/or the Agency.

1.2 RELATED WORK

A. In addition to the requirements for submittals to the Engineer described in this section, Contractor is also responsible for submittals to local, state, and federal agencies that may be needed for completion of the Work.

1.3 SHOP DRAWINGS

A. When used in the Contract Documents, the term “shop drawings” shall be considered to mean Contractor's plans for material and equipment, which become an integral part of the Project. These drawings shall be complete and detailed. Shop drawings shall consist of fabrication and setting drawings and schedule drawings, manufacturer's scale drawings, bills of material, and inspection and test reports including certifications as applicable to the Work.

1.4 PRODUCT DATA

A. Product data as specified in individual sections, includes, but is not necessarily limited to, standard prepared data for manufactured products (sometimes referred to as catalog data), such as the manufacturer's product specification and installation instructions, availability patterns, manufacturer's printed statements of compliance and applicability, roughing-in diagrams and templates, catalog cuts, product photographs, production or quality control inspection and test reports and certifications, mill reports, and printed product warranties, as applicable to the Work.

1.5 SAMPLES

A. The Contractor shall furnish, for the approval of the Engineer, samples required by the Contract Documents or requested by the Engineer. Samples shall be delivered to the Engineer as specified or directed and in quantities and sizes as specified. The Contractor shall prepay all shipping charges on samples. Materials or equipment for which samples are required shall not be used in the Work until approved by the Engineer.

B. The Contractor shall prepare a transmittal letter for each shipment of samples. He shall enclose a copy of this letter with the shipment. Approval of a sample shall be only for the characteristics or use named in such approval and shall not be construed to change or modify any Contract requirements.

1.6 SUBMITTAL REQUIREMENTS

A. The Contractor shall review, approve, and submit, with reasonable promptness to cause no delay in the Contract Work or in the Work of the Agency or any separate contractor, all submittals as may be required.

B. The Contractor shall submit four (4) copies of all Submittals. The Engineer will retain one (1) set, forward two (2) sets to the Agency, and return one (1) set to the Contractor with appropriate review comments. The Engineer will review the submittal and return to the Contractor the set of marked-up copies with appropriate review comments.

C. All submittals shall be made directly to the Engineer.

D. Plans, shop drawings, and samples shall be furnished with the following information:

1. Title.
2. Date.
3. Name of contractor, subcontractor, and manufacturer submitting information.
4. Clear identification of contents, location of the Work, and the Section Number, Paragraph, Drawing Number, or Detail as applicable where the product is referred to in the Contract Documents.
5. Contractor Certification Statement as defined below.
6. Submittal Identification Number.

7. Contract Drawing Number Reference (if applicable).

E. Each plan, shop drawing, sample, and catalog data submittal from the Contractor shall have affixed to it the following Certification Statement, signed by the Contractor to verify Contractor review and approval: "Certification Statement: By this submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers, and similar data and I have checked and coordinated each item with other applicable approved shop drawings and all Contractor requirements."

F. Items specified are not necessarily intended to be a manufacturer's standard product. Variations from specified items will be considered on an "or equal" basis. If submittals show variations from Contract requirements because of standard shop practice or for other reasons, the Contractor shall describe such variations in his letter of transmittal and on the shop drawings along with notification of his intent to seek contract adjustment. If acceptable, proper adjustment in the Contract shall be implemented where appropriate. If the Contractor fails to describe such variations, he shall not be relieved of the responsibility for executing the Work in accordance with the Contract, even though such drawings have been reviewed. Variations submitted but not described may be cause for rejection. Any variations initiated by the Contractor will not be considered as an addition to the scope of Work unless specifically noted and then approved as such in writing by the Engineer.

G. Data on materials and equipment shall include materials and equipment lists giving, for each item thereon, the name and location of the supplier or manufacturer, trade name, catalog reference, material, size, finish, and all other pertinent data.

H. All submittals shall be made on a form acceptable to the Contractor and Engineer.

1.7 CONTRACTOR'S RESPONSIBILITY

A. It is the duty of the Contractor to check, and coordinate with the work of all trades, all drawings, data, schedules, and samples prepared by or for him before submitting them to the Engineer for review. Each and every copy of any drawing or data sheet larger than eleven by seventeen (11x17) inches shall bear Contractor's Certification Statement showing that they have been so checked and approved. Drawings or data sheets eleven by seventeen (11x17) inches and smaller shall be bound together in an orderly fashion and bear the Contractor's Certification Statement on the cover sheet. The cover sheet shall fully describe the packaged data and include a list of all sheet numbers within the package. Shop drawings submitted to the Engineer without the Contractor's Certification Statement will be returned to the Contractor, without review at the Engineer's option, for nonconformance with this requirement.

B. The Contractor shall review shop drawings, product data, and samples prior to submission to determine and verify the following:

1. Field measurements.

2. Field construction criteria.

3. Manufacturer's catalog numbers and similar data.

4. Conformance with Specifications.

C. Shop drawings shall clearly indicate any deviations or variations in the submittal from the requirements of the Contract Documents.

D. Within seven (7) days after the Date of the Notice to Proceed, the Contractor shall furnish the Engineer a <u>Submittal Schedule</u> fixing the respective dates for the initial submittals, testing, and installation of materials, supplies, and equipment as applicable. The Contractor shall prepare and transmit each submittal sufficiently in advance of performing the related work or other applicable activities, or within the time specified in the individual work sections of the Specifications, so that the installation will not be delayed by processing times including disapproval and resubmittal (if required), coordination with other submittals, testing, purchasing, fabrication, delivery, and similar sequenced activities. No extension of time will be authorized because of the Contractor's failure to transmit complete and acceptable submittals sufficiently in advance of the Work.

E. The Contractor shall not begin any work affected by a submittal returned "*not approved*" until a revision or correction of the submittal has been resubmitted and returned "*approved*" or "*approved as noted.*" Any corrections made to the submittals are to be followed without exception.

F. The Contractor shall submit to the Engineer all shop drawings and data sufficiently in advance of construction requirements to provide no less than seven (7) calendar days for review from the time the Engineer receives the submittals.

G. The Contractor shall be responsible for and bear all costs of damages that may result from the ordering of any material or from proceeding with any part of Work prior to the review and approval by Engineer of the necessary submittals.

H. All shop drawings, product data, and samples submitted by subcontractors for approval shall be sent directly to the Contractor for checking. The Contractor shall be responsible for their submission according to the approved submittal schedule to prevent delays in delivery of materials and project completion.

I. The Contractor shall check all subcontractor's shop drawings, product data, and samples regarding measurements, size of members, materials, and details to satisfy himself that the documents are in conformance with the Contract Documents.

Submittals found to be inaccurate or otherwise in error shall be returned to the subcontractors for correction before submission to the Engineer.

1.8 ENGINEER'S REVIEW OF SUBMITTALS

A. The Engineer has seven (7) days for review starting on the date of receipt of submittals.

B. The Engineer's review is for general conformance with the design concept and Contract Documents. Markings or comments shall not be construed as relieving the Contractor from compliance with the Contract Documents or from departures therefrom. The Contractor remains responsible for details and accuracy, for coordinating the Work with all other associated work and trades, for selecting fabrication processes, for techniques of assembly, and for performing work in a safe manner.

C. The review of Contractor submittals will be general and shall not be construed:

1. As permitting any departure from the Contract requirements;

2. As relieving the Contractor of responsibility for any errors, including details, dimensions, and materials; or

3. As approving departures from details furnished by the Engineer, except as otherwise provided herein.

D. If the submittals describe variations and show a departure from the Contract requirements that the Engineer finds to be in the interest of the Agency and to be so minor as not to involve a change in Contract Price or time for performance, the Engineer may return the reviewed drawings without noting an exception.

E. Approval/disapproval designations for submittals will be identified by the Engineer.

F. Resubmittals will be handled in the same manner as first submittals. On resubmittal, the Contractor shall direct specific attention, in writing on the letter of transmittal and on resubmitted shop drawings by use of revision triangles or other similar methods, to revisions other than the corrections requested by the Engineer on previous submissions. Any such revisions that are not clearly identified shall be made at the risk of the Contractor. The Contractor shall make corrections to any work done because of this type of revision that is not in accordance with the Contract Documents as may be required by the Engineer.

G. If the Contractor considers any correction indicated on the shop drawings to constitute a change to the Contract Documents, the Contractor shall give written notice thereof to the Engineer and Agency at least seven (7) working days prior to release for manufacture.

H. When the plans and shop drawings have been completed to the satisfaction of the Engineer, the Contractor shall carry out the construction in accordance therewith and shall make no further changes therein except upon written instructions from the Engineer.

I. Partial submittals may not be reviewed. The Engineer will be the only judge as to the completeness of a submittal. Incomplete submittals will be returned to the Contractor. The Engineer may at his option provide a list or mark the submittal directing the Contractor to the areas that are incomplete.

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

[Not used.]

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. This section covers requirements for worker qualifications to ensure quality of Work.

1.2 REFERENCE STANDARDS

A. All references to standards (e.g., ANSI, AWWA, or ASTM) imply use of the most recent revision of said standards unless specifically stated otherwise.

1.3 QUALIFICATIONS OF WORKERS

A. For each portion of the Work, provide at least one (1) person per shift who shall be thoroughly trained and experienced in the skills required, who shall be completely familiar with the referenced standards and requirements of the Work, and who shall personally direct all work performed under each section.

B. For each portion of the Work, provide a sufficient number of skilled workers who are thoroughly familiar with the type of construction, materials, and techniques specified.

C. No allowance will be made in the acceptance or rejection of any portion of the Work for lack of skill on the part of the workers.

D. Where regulatory requirements mandate that one or more (1+) workers performing a task have specialized training or certification, provide workers that possess such training or certification.

1.4 QUALITY OF SUPPLIERS

A. All supplies and equipment shall be furnished by manufacturers who shall have at least three (3) years of experience in the design, production, assembly, and field service of equipment of like type, size, and capacity. Where required by the Engineer, the Contractor shall supply a list of at least three (3) successful installations.

1.5 QUALITY OF MATERIALS AND EQUIPMENT

A. All materials furnished or incorporated in the Work shall be of the best quality, and especially adapted for the service required. Whenever the characteristics of any material are not specifically specified, such material shall be utilized as is customary in first class work of a nature for which the material is employed.

B. All materials and workmanship shall be subject to inspection, examination, and tests by the Engineer, Agency, or other representatives of the Agency as any and all times during manufacture or construction and at any and all places where such manufacture or construction are conducted.

C. The Contractor's selection and use of organizations for the inspection and tests of supplies, materials, and equipment shall be subject to the approval of the Agency and Engineer. Satisfactory documentary evidence that the material has passed the required inspection and tests shall be furnished by the Contractor prior to the incorporation of the material in the Work.

D. The cost for all laboratory- and field-testing shall be borne by the Contractor unless specifically stated otherwise in Contract Documentation.

E. Whenever any product/design element is specified in the design by a reference to the name, trade name, make or catalog number of any manufacturer or supplier, the intent shall not be to limit competition, but to establish a standard of quality which the has been determined necessary for the Work. If any product/ design element other than that specified is proposed for use by the Contractor, the Contractor shall submit sufficient product/ design-element information to the Engineer, as determined and as much as may be requested by the Engineer, to determine the adequacy of the product/design-element to meet the intent of the design.

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

[Not used.]

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. This section covers requirements for provision, maintenance, and removal of the Engineer's and/or Agency's field office structure and contents.

B. The Contractor shall obtain a land use permit for onsite facilities from ADNR.

C. The Contractor shall provide for methods and materials required for mobilization to the project and demobilization from the project. Mobilization shall include provisions for connection of all necessary utilities, placement of all site facilities and controls, and construction of decontamination facilities. Demobilization shall include decontamination of all Contractor equipment, collection and disposal of all Contractor-generated material, disconnection of utilities, removal of Contractor facilities, and repair and restoration of any site roads or permanent facilities.

D. The field office should be located, preferably, at the Repository Site.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) A10.6 (1990), Safety Requirements for Construction and Demolition.

B. Temporary Electrical Facilities [Monograph in Electrical Design Library] (1985).

C. National Fire Protection Association (NFPA) 10 (1998), Portable Fire Extinguishers.

D. NFPA 70 (2002), National Electrical Code.

E. NFPA 241 (1996), Safeguarding Construction, Alternation, and Demolition Operations.

1.3 REQUIREMENTS FOR FACILITIES

A. Structurally sound, weathertight, with floors raised above ground.

B. Insulation: Compatible with occupancy and storage requirements.

C. Field office shall be equipped with adequate locks to prevent vandalism. Contractor shall provide two keys to the Engineer, and two keys to the Agency.

D. Provide potable water for drinking and washing.

E. Furnish and install portable toilet(s) for use by site personnel.

2.0 PRODUCTS

2.1 MATERIALS, EQUIPMENT, AND FURNISHINGS

A. General: Provide new materials. Undamaged, previously used materials in serviceable condition may be used if approved by Agency's Representative. Provide materials suitable for use intended.

B. Water: Potable.

2.2 EQUIPMENT

A. General: Provide equipment suitable for use intended.

B. Field Offices: Prefabricated mobile units with lockable entrances, operable windows, and serviceable finishes; heated and air-conditioned; on foundations adequate for normal loading. Generators shall be provided for powering field offices, as required.

C. Fire Extinguishers: Hand-carried, portable, Underwriters Laboratory (UL)-rated. Provide class and extinguishing agent as indicated or a combination of extinguishers of NFPA-recommended classes for exposures.

1. Comply with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

D. Self-Contained Toilet Unit(s): Single-occupant unit of chemical, aerated recirculation or combustion type; vented; fully enclosed with a glass-fiber-reinforced polyester shell or similar nonabsorbent material. Provide number of units consistent with the number of personnel on site. Units shall be located at both the Junkyard Site and the Repository Site.

E. Drinking-Water Fixtures: Containerized, tap-dispenser, bottled-drinking-water units, including paper cup supply.

1. Where power is accessible, provide electric water coolers to maintain dispensed water temperature at 45 to 55 degrees Fahrenheit (°F).

2. Contractor-provided bottled water refills.

F. Electrical Outlets: Properly configured, National Electric Manufacturers Association (NEMA)-polarized outlets to prevent insertion of 110- to 120-volt (V) plugs into higher-voltage outlets; equipped with ground-fault circuit interrupters, reset button, and pilot light.

G. Power Distribution System Circuits: Where permitted and installed overhead and exposed for surveillance, wiring circuits, not exceeding 125-V alternating current (ac), 20-ampere (A) rating, and lighting circuits may be nonmetallic sheathed cable.

3.0 EXECUTION

3.1 INSTALLATION

A. Have office equipped and ready for use at the time fieldwork begins at the site. This will require acquiring a land use permit from ADNR.

B. Construct temporary field office on proper temporary foundation; and provide connections for utility services.

1. Secure portable or mobile buildings when used.

2. Provide steps and landings at entrance doors.

C. Install at a location approved by the Agency.

3.2 REMOVAL

A. At the completion of the Work, the Contractor shall promptly remove all construction tools, equipment and machinery, surplus materials, waste materials, rubbish, refuse, and other debris from the site and leave the site in a neat and orderly fashion.

B. Remove temporary field office, contents, and services after completion of all construction work to include removal of foundations and debris; and restore the area to its original or better condition.

*** END OF SECTION ***

Note: This page intentionally left blank.

1.0 GENERAL

1.1 DESCRIPTION

A. This section covers the means and methods the Contractor shall employ in protecting the environment in and around the project site. Management of potential environmental impact shall be in conformance with applicable laws and regulations, during and because of this Project. For the purpose of this Section, environmental impacts are defined as the presence of chemical, physical, or biological elements or agents that adversely affect human health or welfare; unfavorably alter ecological balances of importance to human life; affect other species of importance to man; or degrade the utility of the environment for aesthetic and/or recreational purposes.

B. The control of environmental pollution requires consideration of air, water, and land, and involves management of noise, dust, solid waste, and sediment, as well as other pollutants. The Contractor shall strictly adhere to the measures specified herein, and take additional measures, as may be required by federal, state, and local regulations, to minimize any adverse impacts to the environment during the performance of work.

C. The Contractor's activities shall be limited to the boundaries of the work areas, and public rights-of-way. Mitigate potential disturbance to the existing ecological balance between existing water resources and their surroundings.

D. The requirements herein are in addition to requirements in other sections of the Specifications.

E. Prior to commencement of the Work, the Contractor shall meet with the Agency, Engineer, and other Agency representatives to develop mutual understandings relative to compliance with these provisions.

1.2 APPLICABLE REGULATIONS

A. Comply with all applicable Federal, State, and local regulations, laws, and ordinances concerning environmental pollution control and abatement.

1.3 SUBMITTALS

A. The Contractor shall submit to the Agency and Engineer for review, product information for erosion and sediment control measures prior to mobilization.

B. The Contractor shall prepare its own Erosion and Sediment Control Plan as required under 18 AAC 70, Construction General Permit (AKR1000000) for managing Site runoff during the course of construction, coordinated with the Contractor's proposed construction activities and sequencing, and submit such plan to Agency and Engineer for review.

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

3.1 PROTECTION OF WATER QUALITY

A. It is imperative that watercourses do not become contaminated, as applicable, with sediment, leachate, or other contaminants.

B. The Contractor shall be fully responsible for all damages to life, property, and animal life that occur because of his activities. Damages resulting from polluting watercourses shall be repaired, restored, or compensated for by the Contractor.

C. Observe rules and regulations of the State of Alaska and agencies of the U.S. Government prohibiting pollution of any stream, river, or wetland by dumping of refuse, wastewater, rubbish, or debris therein.

3.2 PROTECTION OF AIR QUALITY

A. Air Quality Objectives are:

1. Compliance with State and Federal Ambient Air Quality Standards for all parameters throughout the community surrounding the work areas as applicable.

2. All practical methods for the suppression of fugitive dust are to be used as normal practice, if applicable.

B. Minimize potential for air pollution by wetting down bare and disturbed soils; properly operate combustion emission control devices on all construction vehicles and equipment; and shut down motorized equipment when not in use.

C. Refuse burning will not be permitted except at locations and times as permitted by local regulation.

3.3 PROTECTION OF LAND RESOURCES

A. Restore affected land resources within/adjacent to the project work limits to original or better condition.

B. Remove all evidence of temporary construction facilities such as work areas, structures, stockpiles of excess or waste materials, or any other vestiges of construction upon completion of construction activities.

C. All debris and excess material shall be disposed of in an environmentally sound manner and in accordance with all applicable Federal, State, and local regulations, laws, and ordinances.

3.4 USE OF CHEMICALS

A. Chemicals used, whether herbicide, pesticide, disinfectant, polymer, reactant, or other classification, must be approved by either the State of Alaska, EPA, or United States Department of Agriculture (USDA), or any other applicable regulatory agency and be used in a manner consistent with their original purpose.

B. Use of such chemicals and disposal of residues shall be in conformance with manufacturer's instructions.

C. Use of chemicals must be approved in advance by the Engineer.

3.5 NOISE AND DUST CONTROL

A. Conduct operations to minimize the potential for annoyance to residents near the Work, and comply with applicable local ordinances.

B. Wetting must be repeated at such intervals as to keep all parts of the disturbed area at least damp at all times (but no so wet as to produce runoff), and the Contractor shall have sufficient competent equipment on the Project to accomplish this. Dust control shall be performed as the Work proceeds.

C. The Contractor shall adhere to applicable environmental regulations for dust prevention. Appropriate dust control measures may include:

1. Excavating, loading, hauling, and backfilling materials in a manner that minimizes dust generation.

2. Periodic removal of dirt/debris from active vehicle transportation routes.

3. Spraying water on access roads.

4. Spraying water on excavation faces, material stockpiles, buckets during excavation, and excavated soils when loading transport vehicles.

5. Spraying water on stockpiles and on placed backfill materials.

6. Hauling excavated materials and clean backfill materials in properly tarped vehicles.

7. Restricting vehicle speeds.

8. Covering dust-prone soils/stockpiles with a layer of polyethylene sheeting (anchored appropriately to resist wind forces).

D. The Contractor shall make every effort to minimize noises caused by the construction operations. The Contractor shall adhere to applicable environmental regulations for noise prevention. Appropriate noise control measures may include:

1. Equip compressors and other apparatus with such mechanical devices as may be necessary to minimize noise and dust. Equip compressors with silencers on intake lines.

2. Equip gasoline- or oil-operated equipment with silencers or mufflers on intake and exhaust lines.

3. Provide dust suppression using water spray on unpaved roads in construction area as needed to minimize dust. Applicable environmental regulations for dust prevention will be strictly enforced.

E. Comply with Federal, State, and noise regulations as applicable.

3.6 EROSION CONTROL MEASURES

A. The Contractor shall take all precautions to prevent, or reduce if prevention is impractical, any damage to surface water from pollution by debris, sediment, or other material, or from manipulation of equipment and/or materials within, adjacent to, and upstream of such channels/streams. Temporary measures include:

1. The Contractor shall be responsible for the selection, installation, maintenance, repair/replacement and removal of all temporary control measures to control, minimize, and prevent soil erosion and water pollution that could be brought about by the effects of his construction operations and/or procedures upon the existing terrain. The requirements of this section shall apply to all water flowing over the work areas.

2. The temporary pollution control provisions contained herein shall be coordinated with the permanent work to be performed under this Contract to the extent practical, to assure economical, effective, and continuous erosion control throughout the construction and post-construction period.

B. Construction Requirements

1. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to the requirements of authorities having jurisdiction. It shall be the responsibility of the Contractor to investigate and comply with all applicable federal, state, and local laws and regulations concerning pollution of waterways. In the event of conflict between the requirements of these Specifications and pollution control laws, rules, or regulations of Federal, State, or local agencies, the more restrictive laws, rules, or regulations shall apply.

2. Temporary pollution control measures shall be used to correct conditions that develop during construction, and shall be implemented if they are needed prior to completion of the permanent Work or are needed temporarily to control erosion that develops during normal construction activities.

3. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones (e.g., from treated waste staging areas to uncontaminated soil areas). No waste containing dissolved or suspended toxic or other objectionable material shall be discharged into a waterway.

4. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established. Following final stabilization, remove erosion and sedimentation controls, and restore and stabilize any areas disturbed during their removal.

5. The Agency and Engineer shall be immediately notified of any known occurrence of pollution. The Contractor shall be fully responsible for any damages resulting from contaminated water entering watercourses because of the Contractor’s negligence, carelessness, or failure to install required temporary or permanent pollution control measures.

6. In the event of any spill or release of pollutant(s), appropriate notification of authorities is the responsibility of the Contractor. Notification of the Agency and Engineer will not replace or relieve the Contractor of the responsibility to notify other appropriate governmental authorities.

3.7 CONSTRUCTION EQUIPMENT

A. The Contractor’s equipment that is left on site shall be maintained in such a manner as to prevent leaks and spills of oil, gasoline, lubricants, and other materials used for maintenance work.

B. The Contractor shall be responsible for cleanup and proper disposal of any materials spilled onto a work area or surrounding areas, as well as materials contaminated because of the spill. Cleanup and disposal shall be at the Contractor's expense.

3.8 PROHIBITED CONSTRUCTION PROCEDURES

A. Prohibited construction procedures include, but are not limited to, the following:

1. Tracking of impacted, including treated waste material, onto clean work areas or access roads. Work will be performed in a sequence or method to minimize potential impacts.
2. Any fueling of equipment prior to implementing proper secondary containment, grounding, and providing for readily available spill cleanup equipment and supplies.
3. Dumping of any material, including trees and brush, into any drainage way, any surface water, or at unspecified locations.
4. Pumping of sediment-laden water from trenches or other excavations into any drainage way or any stream corridors.
5. Damaging vegetation beyond the extent needed for construction.
6. Any other act that violates any applicable Federal, State, or local regulation, law, or ordinance.

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. The Contractor shall stabilize all disturbed areas upon completion of Work.

1.2 QUALITY OF MATERIALS AND EQUIPMENT

A. The quality of materials and performance of the Work used in repairs and restoration shall produce a surface or feature equal to or greater than the original condition, as determined by the Engineer.

B. All materials and workmanship shall be subject to inspection, examination, and tests by the Engineer, Agency, or other representatives of the Agency as any and all times during manufacture or construction and at any and all places where such manufacture or construction are conducted.

2.0 PRODUCTS

A. The Contractor shall propose material to be used in repairs of damaged features and surfaces that are not covered by the specifications.

3.0 EXECUTION

A. Site restoration shall be performed in a phased manner as soon as practicable.

B. Restoration of grassed areas shall be performed in accordance with Section 329000, TOPSOIL AND SEEDING.

C. Underground facilities destroyed, removed, or damaged as a result of the construction operations, and not part of the Work outlined in the Contract Documents, shall be replaced and restored in like size and material and shall be replaced at the original location and grade.

D. The Contractor shall remove all erosion and sediment controls at the appropriate time as specified in Section 015700, ENVIRONMENTAL PROTECTION PROCEDURES.

E. The Contractor shall remove all unused surplus materials, trash, and other materials brought to the site that has not been incorporated into the Project prior to demobilizing.

*** END OF SECTION ***

Note: This page intentionally left blank.

1.0 GENERAL

1.1 SUMMARY

A. This section covers requirements to perform surveying and staking essential for the completion of the Project and perform the necessary calculations required to accomplish the Work in conformance with the Drawings and Specifications and standard survey and engineering practices.

B. The Contractor shall provide survey control sufficient to support the overall Project and document the performance of the Work. Survey control must be performed to establish final grades of cover layers and conditions. Additional surveys shall be performed to ensure and verify the accuracy of work performed (e.g., placed layer thicknesses, limits of geosynthetics, surface and subsurface drainage geometries and alignments), and at the request of the Agency. No work shall be concealed or covered by successive work until the required survey information has been gathered to confirm accuracy of the installed work.

C. A topographic survey of the proposed repository site was conducted by R&M Engineering in November 2016 to establish topographic elevations of the existing rock quarry and access road that extends from the quarry to the intersection with Pat Creek Road. The survey provided 1-foot contours for the repository area; the extent of the survey is shown on Design Drawing C-2.

D. The Contractor shall perform a record (as-built) survey of final grades and all constructed site features.

1.2 RELATED WORK

A. Section 017839 – Project Record Documents

1.3 REFERENCE STANDARDS

A. Alaska Statutes, Title 8. Business and Professions, Chapter 48. Architects, Engineers, and Land Surveyors (AS 08.48).

2.0 PRODUCTS

A. Monument Cases. Castings shall conform to AASHTO M 105, Class 30A. Castings shall be coated with a bituminous damp-proof coating. Bolting tops shall be used.

B. Primary Monument. A minimum two (2)-inch diameter nonferrous pipe at least thirty (30) inches long, with a minimum four (4)-inch flange at the bottom and having magnets attached at the top and bottom. A minimum two and one-quarter (2-1/4)-inch diameter nonferrous metal cap must be permanently attached to the top.

Mark the cap around the outside edge with the words "STATE OF ALASKA DEC". Permanently stamp every monument with the Surveyor's registration number, the year set, and the point/corner identification. Orient cap so that the data may be read facing up-station.

C. Secondary Monument. A minimum five-eighths inch by thirty inch (5/8" x 30") rebar with a two (2)-inch aluminum cap attached to the top. Permanently stamp every secondary monument with the Surveyor's registration number and the year set.

3.0 EXECUTION

3.1 GENERAL

A. Use competent, qualified personnel and suitable equipment for the layout work required and furnish stakes, templates, straight-edges and other devices necessary for establishing, checking and maintaining the required points, lines and grades.

B. Furnish computer services to accomplish the work. Check data received from the computer for completeness and accuracy. As soon as practical after completion of the work, and in no case later than acceptance of the project, deliver field books, computer forms and computer output data to the Engineer.

C. Supervise construction surveying personnel. Correct errors resulting from the operations of said personnel at Contractor expense. The Contractor is responsible for the accuracy of the work.

D. Work classified as Land Surveying under AS 08.48 shall be performed by or under the responsible charge of a Professional Land Surveyor.

E. Keep field notes in standard bound notebooks in a clear, orderly, and neat manner including titles, numbering, and indexing. Make field books available for inspection by the Engineer's project personnel at any time. Legible copies of the reduced field notes shall be made daily. Store the field books in the Engineer's Project Office during periods of non-use. Copies of the field books shall be kept in a separate secure location.

F. Perform the following:

1. Staking necessary to delineate clearing and/or grubbing limits.

2. Cross sections necessary for determination of excavation and embankment quantities, including intermediate and/or progress cross sections as needed. Take cross sections, after clearing and grubbing has been completed.

3. Slope staking.

4. Staking of culverts, minor drainage structures and other appurtenances, including the necessary checking to establish the proper location and grade to best fit the conditions on site.

5. Setting finishing stakes.

6. Measurement of pay quantities that require measurement.

7. Staking of right-of-way and material source limits as deemed necessary.

8. Staking, referencing and other actions required to preserve or restore land monuments and property corners.

9. Other surveying and staking necessary to complete the project.

G. Notify the Engineer immediately if an established reference point is discovered to be in error or a reset point is not in harmonious relationship to the adjacent centerline points.

H. The following shall be required of the Contractor:

1. Field Books (Level, Cross-Section, Slope Stake, etc.). Use “Rite-in-the-Rain” or similar weather resistant books. Field books become the property of the Agency upon completion of the Work.

2. Label the books and number the pages. Make a heading in the appropriate book (date, weather, names and duties of crew members) at the beginning of each day's work.

3. Update the index of the appropriate book at the end of each day's work.

4. Reduce, check, and adjust level notes.

5. The notekeeper shall compute the cross-section level notes and slope stake catches and a different crewmember shall check the computation on a continual basis in the field.

6. Enter the grade data, shoulder width and/or ditch distance, stationing, slope, etc., in the slope stake books.

7. Maintain the position and identifying marks of slope stakes and reference points until used for their intended purpose.

8. Correct errors by drawing a line through them and writing the correct entry directly above. Erasures will not be allowed.

9. Return field books and copies of the field books to the Project office at the end of each workday or as directed.

10. Provide copies of grade sheets and temporary benchmark elevations to the Engineer forty-eight (48) hours before beginning work.

11. The Contractor's survey crews shall comply with approved traffic control plans.

12. Keep a survey Party Chief diary, and give a copy of the diary to the Engineer each day. The diary shall contain the following information:

    a. Date.

    b. Weather.

    c. Crew members' names and duties.

    d. Type and location of work performed.

    e. Hours worked.

    f. Type of equipment used (brand) and date equipment was double centered or "peg" test was performed.

    g. Signature of person in responsible charge.

13. Submit the survey field notes, for the specific area, relating to monument referencing, before beginning clearing, grubbing or excavation.

3.2 MONUMENTS

A. Prior to the start of construction, reference monuments, to include property markers/corners and accessories, that may be disturbed or buried during construction. In addition, reference monuments designated for referencing on the Plans. Prepare and record Monument Record Forms in the appropriate Recorder's Office before disturbing monuments. Re-establish monuments in their original position before completion of the project. Prepare and file a Monument Record Form for each reestablished monument.

B. Keep records and report to the Engineer evidence that a monument has been disturbed and is no longer reliable or cannot be located and is presumed to be missing. Establish a minimum of two (2) in-line reference points, or three (3) swingtie reference points in situations where in-line referencing is not desirable. Set reference points outside of the construction limits. Measure distances from the monument to the nearest one-hundredth (0.01) foot. Record referencing of monuments in a separate field book stamped by the Surveyor.

C. Replace existing monuments disturbed by construction with Primary or Secondary Monuments. When it is impractical to establish a monument in its original position, install a witness corner (WC). Place the WC to a property corner on the property line when the other property corner that defines said line is existing or there has been sufficient retracement to define said line. In other cases, place a reference monument (RM) perpendicular to the centerline at the station of the original position and at a distance from the original position measured in whole feet.

D. Those monuments found that are not shown on the Plans will be recognized by the Engineer when the following is provided by the Surveyor: Field notes identifying type and location of the monument, and a description of the point the monument marks, with the reason to preserve its location.

E. The Surveyor shall complete a State of Alaska Land Survey Monument Record form for each primary and secondary monument referenced, removed, installed, relocated or replaced. Provide the required survey information on the form according to statutory requirements, including section, township and range. Meet requirements for recording at the District Recorder's Office in which the project is located for each monument record. Deliver conforming copies of the recorded forms to the Engineer before monument removal or disturbance, and after setting any final monuments requiring monument records.

F. Set each monument and monument case accurately to lines established at the required location and in a manner as to ensure being held firmly in place. Set existing monuments and monument cases to be adjusted to new elevations in the manner and at the elevations directed.

3.3 FINISH GRADES

A. Calculate finish grades for the embankments as specified according to Drawings and/or Specifications. Use information available in the field, on record drawings, or as provided by the Engineer.

B. This work shall be performed by or under the responsible charge of a Professional Land Surveyor or a Professional Engineer currently Registered in the State of Alaska.

3.4 FINAL TRAVERSE

A. Within thirty (30) days after the Engineer receives a letter stating that construction activities that may disturb the monuments have ceased, the Surveyor shall run a final closed traverse to verify the positional accuracy of installed survey monuments. Tie into the traverse the primary and secondary monuments placed or replaced and undisturbed Department-provided control points. Meet the requirements of a secondary monument for traverse points established during this work. The Surveyor shall sign and stamp a letter that lists each monument and its coordinates. The letter shall certify that the monuments are each located within one-tenth (0.1) foot of their proposed position based on the project survey control points provided by the Department. Deliver the certification letter and field notes for this work to the Engineer.

3.5 SUBMITTALS

A. Survey information shall be submitted as electronic copies consisting of AutoCAD .dwg of .dxf file containing survey points (3D points); point descriptions and elevations (text), contours (polylines with elevations) at a minimum interval of one (1) foot; a surveyor’s TIN (3D face elements) and or breaklines (3D polylines) that were used to create the contours. File shall also contain necessary blocks, symbols, linework, text, etc. to fully illustrate and describe any surveyed site features.

B. Do not include Civil3D or similar proprietary objects in the submitted electronic files. If Civil3D of similar software is used to create TINs, contours, etc., explode such objects to their basic entities (e.g., 3D points, 3D polylines, face elements, text) prior to export.

C. All submitted survey files shall include the date of survey (i.e, the date survey performed, not the date submitted), the horizontal and vertical datums used, the surveyor’s initials, and the surveyor’s license number.

D. The following surveys, at a minimum, shall be completed and submitted to the Engineer for review:

1. Base Level Survey – conducted on fifty (50) foot grid spacing.

2. Subcushion Survey – conducted on fifty (50) foot grid spacing prior to placement of overlying FML. The subcushion survey shall cover the entire area within the limits of the FML.

3. Final Record Survey – to include topography over the fifty (50) foot grid used for the Base Level and Subcushion Surveys with spot elevations no greater than twenty-five (25) feet along drainage features and inverts of all exposed pipe. The final survey shall be submitted within one (1) month of project completion.

*** END OF SECTION ***

1.0 GENERAL

1.1 REQUIREMENTS

A. The Contractor shall maintain at the site (in an organized manner) one (1) record copy of:

1. Removal design and other documents identified in Section 013300, CONTRACTOR SUBMITTALS.

2. Addenda, change orders, responses to requests for information and other modifications to the Removal Design.

3. Reviewed submittals (i.e., shop drawings, working drawings, product data, and samples.)

4. Field test results.

5. Daily operations log.

6. Operations Plan.

7. Project specific Health and Safety Plan.

8. Contingency Plan.

1.2 CHANGES TO REMOVAL DESIGN

A. No additions to, deletions from, or alterations in the Removal Design shall be made unless first authorized in writing by the Engineer. If Removal Design bearing seal of a Professional Engineer is altered, the altering Professional Engineer shall affix his or her own seal and the notation “Altered By” followed by his or her signature and the date of such alteration, and a specific description of the alteration.

1.3 MAINTENANCE OF RECORD DOCUMENTS AND SAMPLES

A. The Contractor shall store record documents and samples in Contractor’s field office apart from documents used for construction.

B. File record documents and samples in accordance with Construction Specifications Institute (CSI) format.

C. Maintain documents in a clean, dry, legible condition and in good order. Do not use record drawings for construction purposes (i.e., in the field, where they may become battered and illegible).

D. At all times, have “up-to-date” record documents and samples available for inspection by the Engineer and Agency representative.

1.4 RECORDING

A. Label each document "PROJECT RECORD" in neat large printed letters.

B. Record information concurrently with construction progress and do not conceal any work until required information is recorded.

C. Legibly mark the Drawings to record actual construction.

1. Pertinent elevations of constructed and relevant structural elements.
2. Horizontal and vertical locations and approximate sizes/materials of underground utilities and appurtenances referenced to permanent surface structures and/or survey datum(s).
3. Field changes of dimensions and detail.
4. Changes made by field instruction/clarification, response to Request For Information (RFI), by other written instruction from the Engineer, or by Change Order.
5. Details not in original Removal Design.

D. Legibly mark Specifications and Addenda to record actual construction.

1. Manufacture, trade name, catalog number, and Supplier of each product and item of equipment actually installed.
2. Changes made by field instruction/clarification, response to Request For Information (RFI), by other written instruction from the Engineer, or by Change Order.
3. Details not in original Removal Design.

E. Maintain a complete, accurate log of all control and survey work as it progresses.

F. Update the Record Drawings on a weekly, or more frequent, basis based on the work performed during the week.

1.5 DAILY OPERATIONS LOG

A. Contractor shall maintain a continuous log of work activities performed each day during construction (i.e., any day that the Contractor or Contractor's subcontractors are actively performing Work at the Site). Daily logs shall include the following information, at a minimum:

1. Date, weather conditions, and name of person filling out the Daily Operations Log.
2. General description of work activities completed that day.
3. Area(s) worked.
4. Volume(s) of materials removed from/placed within each area.
5. Daily truck counts (including area materials were trucked to and/or from).
6. Description of any performance testing performed.
7. Daily deliveries to the Site (including descriptions of materials and quantities delivered; transporter's information, time of delivery, and what was done with the materials once received).
8. Photographic log with representative photographs and associated descriptions of all work completed that day.
9. Any health and safety or security related issues/concerns.
10. Any other information pertinent to the performance of the work that day (e.g., nature and duration of delays; unscheduled meetings; description of any warnings or fines received; and other information specifically requested to be included in the Daily Operations Log by the Agency representative or Engineer).
11. Signature of person filling out the Daily Operations Log attesting to the accuracy of the information provided.

B. If the correct response to any of the above noted items is "none", then clearly indicate "none" or "N/A" in the Daily Operations Log.

C. The Daily Operations Log shall be maintained at the Site and shall be immediately available to the Agency representative or Engineer for review.

D. Each day's Daily Operations log shall be submitted electronically to the Agency representative and Engineer within twenty-four (24) hours of completion of each day's activities.

1.6 SUBMITTALS

A. Submit name and address of any Registered Professional Engineer or Licensed Land Surveyor making changes to the Removal Design, in accordance with Part 1.2(A) of this Section.

B. At Project substantial completion, provide reproducible Record Drawings on sheet(s) twenty-four by thirty-six inches (24”x36”) to the Agency and Engineer.

C. Within thirty (30)-days following Project completion, submit complete Record Drawings containing the items listed below. These drawings shall be included with, and made a part of, the Project record documents. These drawings shall be supplied as both hardcopy twenty-four by thirty-six inches (24”x36”) reproducible sheets and digital format (AutoCAD DWG and PDF).

1. “As-built” topographic and features survey – final topographic and features survey of all completed Work. Survey activities shall be performed in accordance with Section 017123, SURVEY CONTROL. Hardcopy shall be signed and stamped by a Registered Professional Engineer of Licensed Land Surveyor.

D. Accompany submittals with transmittal letter containing date, project title, Contractor’s name and address, title and record number of each document, and signature of Contractor or authorized representative.

2.0 PRODUCTS

[Not Used]

3.0 EXECUTION

[Not Used]

*** END OF SECTION ***

DIVISION 02
EXISTING CONDITIONS

Section 020301 – Maintenance of Existing Conditions

Section 026113 – Excavation and Handling of Contaminated Material

Note: This page intentionally left blank

1.0 GENERAL

1.1 SUMMARY

A. This Section includes construction practices that relate to items at the commencement of Work, to include protection of existing conditions and site documentation.

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

3.1 PREPARATION

A. Obtain the location of all buried conduit, pipe, cable, and other buried items within the Project Area before performing Work.

B. Determine the location of all overhead obstructions within the Project Area and anticipated haul routes before performing Work.

C. Note the location, sizes, and condition of each water conveyance item within the Project Area so that they can be restored to their original condition or better. Installations shall be photographed by the Contractor for documentation.

D. Video document the road conditions along haul routes before performing Work.

E. Locate and mark existing property boundary markers, benchmarks and survey control points.

3.2 PROTECTION

A. Provide protection for personnel and existing facilities from harm due to the Contractor's operations. Protection shall be subject to the approval of the Agency.

B. Arrange protective installations to permit the continued operation of existing equipment, facilities, and water conveyance structures while work is in progress.

C. Do not discharge anything but clear water into drainage systems.

D. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place, including monitoring wells, as called out in Section 332900, WELL ABANDONMENT.

E. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

F. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

3.3 REPAIR

A. Repair damage to existing installations due to Contractor’s or Contractor’s subcontractors performance of Work. At the Agency’s option, damage may be repaired by the Agency and the Contractor shall be back charged repair costs.

3.4 REMOVAL OF PROTECTIVE INSTALLATIONS

A. Remove protective installations after purpose has been served. Materials furnished by the Contractor to provide protection remain property of the Contractor.

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. Provide labor, equipment, and materials, and use efficient methods wherever and whenever required for preventing dust nuisance, loss of material from vehicles, or damage to person, property, or activities. This includes, but is not limited to, wildlife, habitats, dwellings and residences, recreational activities, traffic, and similar conditions while performing excavation, handling, hauling, and temporary storage of contaminated soils that will be encountered during the course of the Work.

B. The Contractor shall be responsible for damages resulting from dust or unauthorized loss of waste materials from transport vehicles as a result of Contractor operations.

C. The Agency or Engineer may stop any construction activity contributing to visible dust levels or loss of waste materials from transport vehicles.

D. Contractor shall provide for the decontamination of all construction equipment and materials that encounter treated waste soil, runoff from treated waste soil, and other potentially contaminated soil, water, or wastewater during the Work.

E. For the purposes of this section, all treated waste soil, runoff from treated waste soil, and other potentially contaminated soil, water, or wastewater shall be known collectively as “waste” or “waste material”.

1.2 QUALITY ASSURANCE

A. Submit copies of the following:

1. Evidence that personnel directly involved with on-site excavation activities have received initial OSHA 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training and initial 24-hour supervised field work, and current under 29CFR 1910.120 refresher training requirements.

2. Evidence that Subcontractor personnel who supervise waste handling have additionally completed the 8 hour HAZWOPER Supervisor training requirements.

1.3 SITE CONDITIONS

A. Lead is the predominant contaminant of concern, and initial sample results indicated the presence of lead concentrations exceeding ADEC cleanup levels. The Junkyard Site waste material has been treated with a chemical binder, ECOBOND, which encapsulates lead and other metals in the soil, making them insoluble in order to reduce the leaching potential. TCLP and synthetic precipitation leaching procedure confirmation laboratory testing was conducted on the treated soil; the testing confirmed that lead does not leach from the treated soil and that the concentrations in the waste material at the Junkyard Site are present in non-hazardous concentrations. Note that if consumed by humans, plants, or animals, the lead may have potentially toxic bioavailability. Concentrations of lead in soil are still considered hazardous for the direct contact/ingestion human health exposure pathways. The treated material was wrapped with black plastic and supported by a 6- to 16-foot-tall berm of 6-inch minus clean rock fill.

2.0 PRODUCTS

A. Pressure washer capable of producing a minimum pressure of two thousand five hundred (2,500) pounds per square inch (psi) to decontaminate equipment. Less capable equipment may be used if it can be demonstrated to be effective.

B. Water shall be used with the pressure washer and for dust control.

C. Polyethylene sheeting or bed liners, 6-mil minimum thickness, for use when transporting waste material.

3.0 EXECUTION

3.1 CONTAMINATED SOIL HANDLING AND STORAGE

A. Provide dust control during grading, excavating, compacting and any other activity that may contribute to dust generation from waste material.

B. Cover waste stockpiles with a layer of polyethylene sheeting (anchored appropriately to resist wind forces) when not in use and, minimally, at the end of each workday.

C. Wetting must be repeated at such intervals as to keep all parts of the disturbed area at least damp at all times (but no so wet as to produce runoff or affect compaction), Dust control shall be performed as the Work proceeds.

D. See Section 015700, ENVIRONMENTAL PROTECTION PROCEDURES for additional information on dust control.

3.2 CONTAMINATED SOIL TRANSPORT

A. Place waste material in properly lined haul truck beds.

1. Line truck beds with a single layer of 6-mil polyethylene sheet; seal seams with duct tape or provide manufactured bed liners;

2. Cover and tarp soil containers (in accordance with 18 AAC 60.015 and AS 46.06.080, waste material shall be covered or otherwise prevented from blowing out of the truck during transport to the repository);

3. Label containers as required by federal, state, and local requirements;

3.3 EQUIPMENT DECONTAMINATION

A. Before being removed from the site or before moving to "clean" soil operations (e.g., cover construction), all debris, equipment, and vehicles in contact with waste, as well as personal property in contact with waste, shall be cleaned first by brushing off gross contamination, and then with a pressure washer until all visible traces of soil are removed.

B. Personnel staffing the decontamination work shall comply with all applicable provisions of the Contractor's Site Safety Plan.

C. Hand tools and other hand-carried items that have come into contact with waste material shall be washed with detergent and water, and then rinsed with tap water.

3.4 PERSONNEL DECONTAMINATION

A. All personal protective equipment (PPE) that has come in contact with waste shall be removed and deposited in proper refuse containers.

3.5 WASTE COLLECTION AND DISPOSAL

A. All decontamination wastewater shall be containerized and filtered. This water may be used for dust control on the Treated Waste Soil, only, within the current stockpile or on the repository.

B. Soil collected during decontamination and all other waste soils shall be deposited on site at appropriate stockpile areas and placed within the repository along with Treated Waste Soil.

C. All PPE to be disposed of that has come in contact with waste material shall be brushed clean of all loose soil, rendered unusable, bagged, and placed in a container(s) for temporary storage on site. Before Project closeout, dispose of materials at an appropriate off-site disposal facility.

D. All other materials to be disposed of that have come in contact with waste material shall be double-bagged and placed in a container(s) for temporary storage on site.

Precautionary labels shall be affixed prominently to containers of contaminated scrap, waste, debris, and clothing, as necessary. Containers shall be sealed and moved only with proper equipment, and shall be secured to prevent dropping or loss of control during transport. Before Project closeout, dispose of materials at an appropriate off-site disposal facility.

E. The Contractor shall obtain all necessary permits and approvals from the disposal facility(ies) and/or governing agencies prior to hauling any waste off site. Transport and dispose of materials in accordance with applicable federal, state, and local requirements.

*** END OF SECTION ***

DIVISION 31
EARTHWORK

Section 310513 – Select Fill and Topsoil

Section 310519.13 – Geotextile Fabric

Section 310519.16 – Waste Containment Geomembrane

Section 311100 – Clearing and Grubbing

Section 312000 – Earthwork

Section 312323 – Trenching

Section 312333 – Compaction

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1.0 GENERAL

1.1 SUMMARY

A. Contractor shall supply and place all selected fill materials, as shown on the Design Drawings, as specified herein, or as directed by the Agency's representative or Engineer.

1.2 APPLICABLE CODES, STANDARDS, AND SPECS

A. The following ASTM specifications are referred to in this Section and are to be considered a part of this Section:

D422	Standard Test Method for Particle-Size Analysis of Soils
D2487	Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System [USCS])
D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3[600 kN-m/m^3])
D2434	Permeability of Granular Soils (Constant Head)
D3080	Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D5084	Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

1.3 SUBMITTALS

A. Description of the source location for each selected fill material (including name and address of supplier, if applicable).

B. Laboratory test results for particle size distribution, direct shear, hydraulic conductivity, permeability, moisture/density, and Atterberg limits, for materials not previously tested, in accordance with tests performed on samples presented in Section 003132, GEOTECHNICAL DATA.

2.0 PRODUCTS

A. Base Material

1. Description: Base Material shall consist of shot rock.

2. Use: For construction of the Base Layer to create the two (2) feet of separation between the natural ground surface and the base of the Treated Waste Soil.

3. Availability: Shot rock is available at the Repository Site found scattered in piles across the quarry floor; however, no volume estimate has been generated of loose material. Additional rock may be blasted from the quarry walls to create the volume necessary.

B. Treated Waste Soil

1. Description: Treated Waste Soil (ECOBOND-treated soil) is located in the covered stockpile at the Junkyard Site.

2. Use: Monofill material to be contained within the repository.

3. Availability: The estimated volume of Treated Waste Soil is 18,515 cubic yards.

C. 6-inch Minus Rock

1. Description: Six (6)-inch Minus Rock consisting of a naturally or artificially graded mixture of natural or crushed gravel, and crushed stone. A stockpile of this material is located at the Junkyard Site currently utilized as the berm around Treated Waste Soil stockpile.

2. Use: For construction of:
   a. Chimney drains;
   b. Drainage channels;
   c. Riprap aprons; and
   d. Potential fill for the Base Layer

3. Availability: The estimated volume of 6-inch Minus Rock is 1,200 cubic yards. Additional material needed for construction should be selected for consistency with the current material located at the Junkyard Site.

D. 3/8-inch Minus Aggregate

1. Description: Three-eighth (3/8)-inch Minus Aggregate shall consist of a naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; gradation shall be consistent, within 10%, of results presented in Section 003132, GEOTECHNICAL DATA, while holding to 100 percent passing a 3/8-inch (9.5-mm) sieve.

2. Use: For construction of:
   a. Subcushion Layer; and
   b. FML Cushion Layer;

3. Availability: 3/8-inch Minus Aggregate is not available on Site.

E. 1-inch Minus Drain Rock

1. Description: One (1)-inch Minus Drainage Rock shall consist of a narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; gradation shall be consistent, within 10%, of results presented in Section 003132, GEOTECHNICAL DATA, while holding to 100 percent passing a 1-inch (25.4 mm) sieve and zero to 10 percent passing a No. 200 (0.074 mm) sieve.

2. Use: For construction of:
   a. Drainage Layer;
   b. Riprap aprons; and
   c. Potential fill for the Base Layer

3. Availability: 1-inch Minus Drainage Rock is not available on Site.

F. Topsoil and Clean Backfill

1. Description: Topsoil and Clean Material shall be a locally available, friable soil of loamy character, obtained from well-drained arable land and reasonably free from refuse, roots, heavy or stiff clay, large stones, coarse sand, sticks, brush, litter, toxic and other deleterious substances.

   In addition to the above, Topsoil shall be reasonably free from subsoil, verified fertile, free of any material that might be harmful to plant growth or be a hindrance to planting or maintenance operations. It shall be amended in accordance with Section 329000, TOPSOIL AND SEEDING. Vegetative matter other than brush or trees may be incorporated into Topsoil.

2. Use:
   a. Clean Backfill (Cover) Layer; and
   b. Topsoil Layer

3. Availability: Topsoil and Clean Backfill are not available on Site.

3.0 EXECUTION

[Not Used]

*** END OF SECTION ***

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1.0 GENERAL

1.1 SUMMARY

A. The Contractor shall provide all equipment, materials, and personnel necessary to install geotextile materials.

B. Section Includes:

1. Class I Nonwoven Geotextile Fabric.

1.2 APPLICABLE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO)
   1. M288, Standard Specification for Geotextile Specification for Highway Applications.

B. American Section of the International Association for Testing Materials (ASTM International)
   1. ASTM D 5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
   2. ASTM D 4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   3. ASTM D 4533, Standard Test Method for Index Trapezoidal Tearing Strength of Geotextiles.
   4. ASTM D 6241, Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
   5. ASTM D 4491, Standard Test Method for Water Permeability of Geotextiles by Permittivity.
   6. ASTM D 4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.
   7. ASTM D 4354, Standard Practice for Sampling of Geosynthetics for Testing.
   8. ASTM D 4759, Standard Practice for Determining the Specifications Conformance of Geosynthetics.
   9. ASTM D4355, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
   10. ASTM D4873, Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

1.3 SUBMITTALS

A. At least fourteen (14) days prior to shipping any geotextile fabric to the site, provide the following documentation:

1. Manufacturer's certification of geotextile physical properties and roll dimensions;

2. Certified quality control testing results of the rolls to be delivered to the Site. Test results shall include lot and roll numbers that coincide with lot and roll numbers delivered to the Site. At a minimum, results shall be provided in accordance with AASHTO M288 requirements for the following properties:

   a. Unit Weight (ASTM D5261)
   b. Grab Tensile/Elongation (ASTM D4632)
   c. Tear Strength (ASTM D4533)
   d. CBR Puncture (ASTM D6241)
   e. Apparent Opening Size (ASTM D4751)
   f. Permittivity (ASTM D4491)

2.0 PRODUCTS

2.1 MATERIALS

A. Nonwoven Geotextile Fabric: Needle-punched, non-woven geotextile meeting AASHTO M288 Class 1 (One) survivability requirements for a permanent erosion control geotextile or a separation geotextile, as applicable. Unless otherwise noted on the Design Drawings or requested by the Engineer, non-woven geotextile shall have a minimum nominal weight of eight (8) ounces per square yard, or approved equivalent.

3.0 EXECUTION

3.1 NONWOVEN GEOTEXTILE INSTALLATION

A. The geotextile shall be able to withstand direct exposure to ultraviolet radiation from the sun for up to thirty (30) days without any noticeable effect on index or performance properties.

B. The geotextile shall be handled in such a manner as to ensure that it is not damaged in any way. Should the Contractor damage the geotextile to the extent that it is no longer usable as determined by these specifications or by the Engineer, the Contractor shall replace the geotextile at his own cost.

C. Machine length of the geotextile material shall be oriented in the direction of slope.

D. The geotextile shall be rolled down the slope in such a manner as to continuously keep the geotextile in tension by self-weight.

E. Adjoining edges shall have at least a twelve (12)-inch overlap, unless otherwise directed by the Engineer (overlap will be increased to twenty-four [24] inches on irregular subgrades as directed by the Engineer or Engineer's on-site representative), and shall be shingled in the downslope direction, and placed in a manner that prevents material rollup and/or displacement during overlying material placement.

F. It may be necessary to secure edges of geotextile in a shallow, backfilled anchor trench to prevent displacement during placement of overlying materials. The Contractor shall implement such measures on an as needed basis.

G. In the presence of wind, all geotextiles shall be weighted by sandbags or approved equivalent. Such anchors shall be installed during placement and shall remain in place until replaced with cover material.

H. The Contractor shall take necessary precautions to prevent damage to adjacent or underlying materials during placement of the geotextile. Should damage to such material occur due to the fault of the Contractor, the latter shall repair the damaged materials at his own cost and to the satisfaction of the Engineer.

I. The geotextile shall not be exposed to precipitation prior to being installed and shall not be exposed to direct sunlight for more than fifteen (15) days after installation.

J. The Contractor shall not subject the geotextile to heavy equipment traffic without approved protection.

K. The geotextile shall be covered as soon as possible after installation and approval. Installed geotextile shall not be left exposed for more than fifteen (15) days.

L. Material overlying the geotextile shall be carefully placed as specified in Section 312000, EARTHWORK, in a manner that avoids wrinkling or damage to the geotextile.

*** END OF SECTION ***

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1.0 GENERAL

1.1 SUMMARY

A. The Contractor shall provide all equipment, materials, and personnel necessary to install geomembrane materials.

B. Section Includes:

1. 40-mil, textured Linear Low-Density Polyethylene (LLDPE) Flexible Membrane Liner (FML).

1.2 APPLICABLE STANDARDS

A. American Section of the International Association for Testing Materials (ASTM International)

1. D638, Standard Test Methods for Tensile Properties of Plastics
2. D792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
3. D1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting
4. D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
5. D1505, Standard Test Method for Density of Plastics by Density-Gradient Technique
6. D1603, Standard Test Method for Carbon Black Content in Olefin Plastics
7. D3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
8. D4218, Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique
9. D4437, Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
10. D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
11. D5199 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
12. D5321, Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
13. D5323, Practice for Determination of 2% Secant Modulus for Polyethylene Geomembranes
14. D5397, Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
15. D5596, Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

16. D5820, Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
17. D5994, Standard Test Method for Measuring Core Thickness of Textured Geomembranes
18. D6365, Standard Practice for the Nondestructive Testing of Geomembrane Seams using the Spark Test
19. D6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
20. D6693, Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
21. D 7240 Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)

B. Geosynthetic Research Institute (GRI)

1. GRI Test Method GM17: Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
2. GRI Test Method GM19: Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes
3. GRI Test Method GM9: Cold Weather Seaming of Geomembranes

1.3 SUBMITTALS

A. Prior to shipment and installation, submit the following to the Owner and Engineer, allowing adequate time for review and comment:

1. Product, Manufacturer, and Installer Information, including a certificate or affidavit signed by a legally authorized official of the Manufacturer attesting that the LLDPE meets the physical and manufacturing requirements stated in these specifications.

2. Manufacturer's Quality Control program manual or descriptive documentation.

3. A material properties sheet, including at a minimum all properties specified in Tables 2a/2b of GRI GM17, including test methods used. Tables 2a and 2b are included as Attachment 310519.13-A.

4. Sample of the material.

5. Documentation of Installer's qualifications, as specified below:

   a. Submit a list of at least five completed facilities. For each installation, provide name and type of facility; its location; the date of installation; name and telephone number of contact at the facility; type and thickness of FML; and surface area of the installed FML.

   b. Submit resumes or qualifications of the Installation Supervisor, Master Seamer and Technicians to be assigned to this project.

   c. Submit a copy of the FML Installer's Quality Control Program.

6. Example Material Warranty from the Manufacturer and example Liner Installation Warranty from the FML Installer.

7. Resin Supplier's name, resin production plant identification, resin brand name and number, production date of the resin, resin Manufacturer's quality control certificates, and certification that the properties of the resin meet the requirements for the project.

B. Shop Drawings (Prior to Installation)

1. FML Installer shall prepare and Contractor shall submit copies of Panel Layout Drawings to Owner and Engineer, allowing adequate time for review and comment within a reasonable time so as not to delay the start of FML installation. Panel Layout Drawings shall show the proposed panel layout identifying seams and details. Seams should generally follow the direction of maximum slope. Butt seams or roll-end seams should not occur on a slope unless approved by the Engineer. Butt seams on a slope, if allowed, should be staggered a minimum of 5 feet.

2. Butt seams on slopes will be allowed, but should be minimized, to the extent practicable, as directed by the Engineer.

3. Placement of FML will not be allowed to proceed until Engineer has received, reviewed, and provided comments on the Panel Layout Drawings.

C. Additional Submittals (In-Progress and at Completion)

1. Manufacturer's quality control certifications. QC tests shall be performed at the minimum frequencies listed in Tables 2a/2b of GRI GM17. If a test result is not in conformance with a required value, all material from the lot represented by the failing test shall be considered out of Specification and rejected. Alternatively, at the option of the Engineer, one of the two following procedures may be performed, in response to a failing conformance test result:

   i. If the Contractor has reason to believe that the failing test may be the result of the CQA Laboratory incorrectly conducting the tests, the Contractor may request that the sample in question be retested by the CQA Laboratory with a technical representative of the manufacturer present during the testing. This re-testing shall be done at no additional cost to Project. Alternatively, the Contractor may have the sample retested at two different approved (i.e., by the Engineer) CQA Laboratories at no additional cost to Project. If both laboratories produce passing results, the material may be accepted. If both laboratories do not produce passing results, then the original CQA Laboratory's failing test results will be considered accurate and the material will be rejected.

ii. Additional conformance test samples may be taken to "bracket" the portion of the lot not meeting Specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of-Specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both of the additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) will be rejected. If one or both of the additional tests fail, then the entire lot will be rejected or the procedure may be repeated (again, at no additional cost to the Project) with two additional tests that bracket a greater number of rolls within the lot.

2. Manufacturer's warranty.

3. FML installation warranty.

4. Low temperature seaming procedures, if applicable.

5. As-built drawings showing actual geomembrane placement and seams including typical anchor trench detail.

2.0 PRODUCTS

2.1 MATERIALS

A. The Flexible Membrane Liner shall consist of t new, first-quality products designed and manufactured specifically for the purpose of this work which shall have been satisfactorily demonstrated by prior testing to be suitable and durable for such purposes. The FML rolls shall be seamless, linear low-density polyethylene containing no plasticizers, fillers or extenders and shall be free of holes, blisters, and contaminants. The FML shall be supplied as a continuous sheet with no factory seams in rolls. The FML shall meet the property requirements as listed in Tables 2a/2b of GRI GM13.

B. Resin used in the welding material shall be new, first quality, compounded and manufactured specifically for producing geomembrane. All welding materials shall be of a type recommended and supplied by the manufacturer and shall be delivered in the original sealed containers, each with an indelible label bearing the brand name, manufacturer's mark number, and complete directions as to proper storage.

2.2 MATERIAL LABELING, DELIVERY, STORAGE, AND HANDLING

A. Labeling - Each roll of geomembrane delivered to the site shall be labeled by the Manufacturer. The label will identify Manufacturer’s name, product identification, thickness, length, width, and roll number.

B. Delivery: Rolls of liner will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

C. Storage: The on-site storage location for geomembrane material, provided by the Contractor to protect the geomembrane from punctures, abrasions and excessive dirt and moisture should be level (no wooden pallets), smooth, dry, secure, and adjacent to the area being lined.

D. Handling: Materials are to be handled to prevent damage.

3.0 EXECUTION

3.1 FLEXIBLE MEMBRANE INSTALLATION

A. Subgrade Preparation

1. The subgrade shall be prepared as shown on the Design Drawings and in accordance with the project specifications. All consolidation materials shall be covered with a minimum specified thickness of compacted cushion layer (see Design Drawings, Section 310513, SELECT FILL AND TOPSOIL and Section 312000, EARTHWORK for additional information), unless otherwise approved by the Engineer. The consolidated material surface shall be firm and free of stones and other materials with sharp and/or angular edges that could project through the cushion layer or otherwise damage the overlying FML. Additionally, organic matter, irregularities, protrusions greater than 3/8 inch, loose soil, abrupt changes in grade, and/or any other objects or conditions that could damage the FML shall also be removed, or otherwise eliminated from the FML subgrade surface (e.g., by compacting surface with roller to eliminate protrusions or covering the surface with additional compacted cushion material).

2. The FML Installer and the Engineer’s on-site representative shall inspect the surface to be covered with the FML on each day's operations prior to placement of FML to verify suitability.

3. The FML Installer and the Engineer's on-site representative shall provide daily written acceptance for the surface to be covered by the FML in that day's operations. Daily written acceptance shall clearly identify the location of the subgrade surface receiving acceptance (i.e., by site grid cell designation and/or other appropriate and specific means). During FML installation, the surface shall be maintained in a manner that ensures subgrade suitability.

4. All subgrade damaged by construction equipment or any other means, following subgrade acceptance, and deemed unsuitable by the Engineer's on-site representative for FML deployment, shall be repaired prior to placement of the FML, at no additional cost to the Project.

5. FML shall not be placed on frozen ground surfaces or in freezing conditions unless expressly approved by the Engineer.

6. FML shall not be placed on any area that has become softened by precipitation, freeze-thaw, or other means. Appropriate methods of moisture control are the responsibility of the Contractor. If so directed by the Engineer, the Contractor shall remove softened subgrade materials and replace with suitable select fill material, at no additional cost to the Project.

B. FML Deployment

1. No FML shall be deployed until all required submittals and quality control certifications have been submitted by the Contractor and reviewed by the Engineer. Should FML material be deployed prior to such review by the Engineer, it will be at the sole risk of the FML Installer and/or Contractor. If the material does not meet Project Specifications it shall be removed from the work area and replaced with material conforming to the Project Specifications at no additional cost to the Project.

2. The FML shall be installed to the limits shown on the project drawings and essentially as shown on the Panel Layout Drawings.

3. The FML Installer shall assign an "identification number" to each FML panel placed. The number system used shall be relatively simple and logical and shall be recorded on a set of Record Panel Layout Drawings, which will be submitted to the Owner and Engineer upon completion of FML installation.

4. No FML material shall be unrolled and deployed if the material temperatures are lower than 32 degrees F unless otherwise approved by the Engineer. The specified minimum temperature for material deployment may be adjusted by the Engineer only upon written approval by the Manufacturer.

5. No vehicular traffic shall be allowed directly on the FML unless specifically approved by the Engineer, and then only an approved low ground pressure All-Terrain Vehicle or equivalent lightweight, rubber-tired vehicle. Vehicle usage on top of the FML shall only be as approved by the Engineer and shall not cause damage to the FML. In high-traffic areas, the FML shall be protected by geotextiles, extra FML, additional compacted soil cover, and/or other suitable materials as directed by the Engineer. At a minimum, at least two (2) feet of approved soil cover shall be provided over the FML under all temporary haul vehicle access routes, unless alternate cover conditions are specifically specified, approved, or requested by the Engineer.

6. Loaded haul vehicles shall only be allowed to travel directly on top of cover soils that are less than two (2) feet thick under the following circumstances:

    a. When the cover soils are at least one and one-half (1.5) feet thick, well compacted, AND the haul vehicle is only temporarily traveling onto the cover soils to deposit its current load. Upon depositing its load, the haul vehicle shall promptly return to the primary travel route.

    b. When the cover soils are at least 1 foot thick, well-compacted, the FML is protected by a non-woven geotextile fabric of at least sixteen (16) ounces per square yard nominal weight or a geosynthetic drainage composite, AND the haul vehicle is only temporarily traveling onto the cover soils to deposit its current load. Upon depositing its load, the haul vehicle shall promptly return to the primary travel route.

    c. Haul vehicles shall avoid abrupt braking and acceleration, sharp turns, and wheel spinning while traveling directly on cover soils.

    d. Haul vehicle operators shall stop their vehicle immediately if they begin spinning their tires on top of cover soils, and shall wait to be pushed out by appropriate support equipment. Areas of wheel-spin and/or rutting shall be promptly checked for potential damage to the underlying FML prior to proceeding with repair of the cover soils. Ruts shall be repaired to a smooth, uniform surface immediately following inspection for liner damage.

    e. Haul vehicle traffic shall be limited to areas meeting these minimum cover requirements, unless otherwise approved in writing by the Engineer. Contractor shall maintain tight control over haul vehicle travel patterns to ensure conformance with these specifications.

7. No personnel working on the FML shall smoke, wear damaging shoes, or engage in other activities that could damage the FML.

8. To the extent practicable, equipment used to place overlying cover materials shall avoid abrupt stops and starts, twisting and turning motions, and any other operations that could cause significant displacement of the overlying cover materials, leading to damage of the underlying FML. If such activities are required for the placement of the cover materials, as determined by the Engineer’s on-site representative, the activities shall be closely monitored by the Engineer’s on-site representative for potential damage to the underlying FML. If the FML becomes damaged by such activities (whether the activities were allowed by the Engineer’s on-site representative or not), cover materials shall be carefully removed, the damaged portion of FML repaired, the repair location marked on the Record Panel Layout Drawings, and cover materials replaced and re-compacted, at no additional cost to the Project.

9. Sand bags or equivalent ballast shall be used as necessary to temporarily hold the FML material in position under the foreseeable and reasonably expected wind conditions. Sand bag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the FML. Sand bags shall be filled only with material meeting the requirements for the Cushion Layer Material, in accordance with Section 310513, SELECT FILL AND TOPSOIL.

10. FML shall not be deployed if moisture would prevent proper panel placement, panel seaming, or result in deterioration of the subgrade during deployment.

11. The FML shall not be allowed to "bridge over" depressions in the subgrade. In these areas, the FML shall be installed to allow it to rest in intimate contact with the subgrade.

12. Wrinkles caused by panel placement or thermal expansion shall be minimized to the extent practicable.

13. The methods used to deploy the FML shall not cause excessive scratches or crimps in the FML and shall not damage or displace the underlying soil or geosynthetics.

14. Deployed FML must be visually inspected for uniformity, tears, punctures, blisters, and other damage or imperfections by the Engineer’s on-site representative and the Contractor. Any such damage or imperfections shall be clearly marked and immediately repaired and re-inspected at no additional cost to the Project. Locations of any such repairs shall be recorded on the Record Panel Layout Drawings.

15. If, in the opinion of the Engineer or Engineer’s on-site representative, damage or imperfection to a panel or portion of a panel is beyond repair, the

panel or portion of panel shall be marked for rejection and immediately removed from the work area. The removed panel or portion of panel shall then be immediately replaced and re-inspected at no additional cost to the Project. Locations of all such removals/replacements shall be recorded on the Record Panel Layout Drawings.

16. Contractor is responsible for dust control due to vehicular and construction traffic during execution of the work.

C. Pipe and Structure Penetrations – NOT USED

1. Penetrations shall be constructed from the base FML material, flat stock, prefabricated boots and/or other accessories as shown on the Drawings or as otherwise required to create a watertight seal around the penetration. The prefabricated or field-fabricated assembly shall be field welded to the FML, and possibly to the penetration, to create the watertight seal around the penetration. Where standard non-destructive seam testing (i.e., air pressure or vacuum box) cannot be performed, field-welded seams will be field spark tested by standard holiday leak detectors in accordance with ASTM D6365. Contractor shall review all project design information in its entirety prior to liner installation, and shall have all necessary equipment available for use on-site at the time of penetration construction to avoid any unnecessary project delays.

D. Seaming

1. Cold-weather installations, if required and approved, shall follow the guidelines outlined in GRI GM9.

2. No FML material shall be seamed when liner temperatures are less than 32 degrees F unless the following conditions are complied with:

   a. Seaming of the FML at material temperatures below 32 degrees F may be allowed if the FML Installer can demonstrate to the Engineer's on-site representative, using pre-qualification test seams, that field seams comply with the project specifications, the safety of the crew is ensured, and FML material can be fabricated (i.e. pipe boots, penetrations, repairs, etc.) at sub-freezing temperatures.

   b. The FML Installer shall submit to the Engineer for approval, detailed procedures for seaming at low temperatures, possibly including the following:

      i. Preheating of the FML.

ii. The provision of a tent or other device if necessary to prevent heat losses during seaming and rapid heat losses subsequent to seaming.

iii. Number of test welds to determine appropriate seaming parameters.

3. No FML material shall be seamed when the sheet temperature is above 170 degrees F as measured by an infrared thermometer or surface thermocouple unless otherwise approved by the Engineer. This approval will be based on recommendations by the Manufacturer and on a field demonstration by the FML Installer using prequalification test seams to demonstrate that seams comply with the specification.

4. FML material shall not be seamed when it is wet from precipitation, dew, fog, or when winds are in excess of 20 miles per hour.

5. Seaming shall not be performed on frozen or excessively wet underlying soil surfaces.

6. Seaming shall primarily be performed using automatic double-fusion welding equipment and techniques. Extrusion welding shall only be used where fusion welding is not possible, such as at pipe penetrations, patches, repairs and short (less than a roll width) runs of seams.

7. Excessive wrinkles at the seam overlaps shall be minimized and when necessary cut along the ridge of the wrinkles back into the panel so as to effect a flat overlap. The cut shall be terminated with a key hole cut (nominal one-half (0.5) inch diameter hole) so as to minimize crack/tear propagation. The overlay shall subsequently be seamed. The keyhole cut shall be patched with an oval or round patch of the same base FML material extending approximately six (6) inches beyond the cut in all directions.

8. In general, seams shall be oriented parallel to the line of the maximum slope. In corners and odd shaped geometric locations, the total length of field seams shall be minimized. Seams shall not be located at low points in the subgrade unless geometry requires seaming at such locations and if approved by the Engineer.

9. The panels shall be overlapped prior to seaming in accordance with the Manufacturer's installation guidelines, or as required to affect a good weld and allow for proper testing. In no case shall this overlap be less than three (3) inches.

10. The area of FML to be seamed shall be prepared according to the procedures specified by the material Manufacturer (textured FML surfaces shall be ground smooth) and cleaned, prior to seaming. Any abrading of the FML shall not extend more than one-half (0.5) inch on either side of the weld. Care shall be taken to eliminate or minimize the number of wrinkles and fishmouths resulting from seam orientation.

11. Seaming device shall not have any sharp edges that might damage the FML. Where self-propelled seaming devices are used, it shall be necessary to prevent "bulldozing" of the device into the underlying soil.

12. All seams shall be shingled in the downslope direction (i.e., overlapped to shed water, with the overlapping panel on top).

E. Prequalification Test Seams

1. Test seams shall be prepared and tested by the FML Installer to verify that seaming parameters (speed, temperature and pressure of welding equipment) are adequate.

2. Test seams shall be made by each welding technician and tested at the beginning of each seaming period. Test seaming shall be performed under the same conditions and with the same equipment and operator combination as production seaming. The test seam shall be approximately ten (10) feet long for fusion welding and approximately three (3) feet long for extrusion welding, with the seam centered lengthwise. At a minimum, tests seams shall be made by each technician once every four to six (4-6) hours; prior to the start of each seaming session; immediately after any change in seaming equipment or personnel; immediately upon any significant change in weather conditions or FML temperature; and at any other time as may be requested by the Engineer or Engineer's on-site representative.

3. Two (2) one (1)-inch wide specimens shall be die-cut by the FML Installer from each end of the test seam. These specimens shall be tested by the FML Installer using a field tensiometer testing both tracks for peel strength and for shear strength. Each specimen shall fail in the parent material and not in the weld, "Film Tear Bond" (FTB failure). Seam separation equal to or greater than ten percent (10%) of the track width shall be considered a failing test.

4. The minimum acceptable seam strength values to be obtained for all specimens tested are listed in Tables 2a/2b of GRI GM19. All four (4) specimens shall pass for the test seam to be a passing seam.

5. If a test seam fails, an additional test seam shall be immediately conducted. If the additional test seam fails, the seaming apparatus shall be rejected and not

used for production seaming until the deficiencies are corrected and a successful test seam can be produced.

6. A sample from each test seam shall be labeled. The label shall indicate the date, FML temperature, number of the seaming unit, technician performing the test seam and pass or fail description. The sample shall then be given to the Engineer's on-site representative for archiving. The Contractor shall also include the time and results of all test seams in the daily field installation reports.

F. Non-Destructive Seam Testing

1. Non-destructive seam testing shall be performed by the FML Installer on one hundred percent (100%) of field seams over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of tester and outcome of all nondestructive testing shall be recorded on the Record Panel Layout Drawings and within the Daily Field Installation Reports.

2. Testing shall be performed as the seaming work progresses, not at the completion of all field seaming, unless agreed to in advance by the Engineer. All defects found during testing shall be numbered and marked immediately after detection. All defects found shall be repaired, retested and remarked to indicate acceptable completion of the repair. The location and nature of any such defects and repairs shall be recorded on the Record Panel Layout Drawings.

3. Nondestructive testing shall be performed using vacuum box, air pressure or spark testing equipment.

4. Nondestructive tests shall be performed by experienced technicians familiar with the specified test methods. The FML Installer shall demonstrate all test methods to the Engineer's on-site representative to verify the test procedures are valid.

5. Double fusion seams with an enclosed channel shall be air pressure tested by the FML Installer in accordance with ASTM D4437, ASTM D5820, and the following equipment and procedures:

   a. Equipment for testing double fusion seams shall be comprised of, but not limited to: an air pump equipped with a pressure gauge capable of generating and sustaining a pressure of thirty (30) psig mounted on a cushion to protect the FML; and a manometer equipped with a sharp hollow needle or other approved pressure feed device.

b. Testing activities shall be performed by the FML Installer. Both ends of the seam to be tested shall be sealed and a needle or other approved pressure feed device shall be inserted into the tunnel created by the double wedge fusion weld. The air pump shall be adjusted to a pressure of thirty (30) psig, and the valve closed. Allow two (2) minutes for the injected air to come to equilibrium in the channel, and sustain pressure for five (5) minutes. If pressure loss does not exceed four (4) psig after this five (5) minute period, the seam shall be considered leak tight. Release pressure from the opposite end verifying pressure drop on needle to ensure testing of the entire seam. The needle or other approved pressure feed device shall be removed and the feed hole sealed.

c. If loss of pressure exceeds four (4) psig during the testing period or pressure does not stabilize, the faulty area shall be located, repaired and retested by the FML Installer.

d. All seams that are air pressure tested shall be marked with the date tested, the name of the technician performing the test and the results of the test.

6. Extrusion seams shall be vacuum box tested by the FML Installer in accordance with ASTM D4437, ASTM D5641, and using the following equipment and procedures:

   a. Equipment for testing extrusion seams shall be comprised of, but not limited to: a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the base, porthole or valve assembly and a vacuum gauge; a vacuum pump assembly equipped with a pressure controller and pipe connections; a rubber pressure/vacuum hose with fittings and connections; a plastic bucket; wide paint brush or mop; and a soapy solution.

   b. The vacuum pump shall be charged and the tank pressure adjusted to approximately five (5) psig.

   c. The FML Installer shall create a leak tight seal between the gasket and FML interface by wetting a strip of FML approximately twelve inch by forty eight inch (12”x 48”) (length and width of box) with a soapy solution, placing the box over the wetted area, and then compressing the box against the FML. The FML Installer shall then close the bleed valve, open the vacuum valve and maintain initial pressure of approximately five (5) psig for approximately five (5) seconds. The FML should be continuously examined through the viewing window for the presence of soap bubbles, indicating a leak. If no bubbles appear after five (5) seconds, the area shall be considered leak free. The box shall be depressurized and moved over the next adjoining area with an appropriate overlap and the process repeated.

d. All areas where soap bubbles appear shall be marked, repaired and then retested.

e. At locations where seams cannot be nondestructively tested, such as pipe penetrations, alternate nondestructive spark testing or equivalent should be substituted.

f. All seams that are vacuum tested shall be marked with the date tested, the name of the technician performing the test and the results of the test.

7. Spark testing shall be performed on any seams where both air pressure testing and vacuum testing are not possible. Procedures may vary, depending on availability of newer technology. Procedures other than those noted below may only be used with advance written approval from the Engineer.

a. Equipment for spark testing shall be comprised of, but not limited to a handheld holiday spark tester and conductive wand that generates a high voltage.

b. The testing activities shall be performed by the FML Installer by placing an electrically conductive tape or wire beneath the seam prior to welding. A trial seam containing a non-welded segment shall be subject to a calibration test to ensure that such a defect (non-welded segment) will be identified under the planned machine settings and procedures. Upon completion of the weld, enable the spark tester and hold approximately one (1) inch above the weld moving slowly over the entire length of the weld in accordance with ASTM D6365. If there is no spark, the weld is considered to be leak free.

c. A spark indicates a hole in the seam. The faulty area shall be located, repaired and retested by the FML Installer.

d. Care should be taken if flammable gases are present in the area to be tested.

e. All seams that are spark tested shall be marked with the date tested, the name of the technician performing the test and the results of the test.

G. Destructive Seam Testing

1. In addition to non-destructive seam testing, the Contractor will perform destructive testing. The destructive testing procedures are as follows:

a. Test samples will be prepared by the Installer every five hundred (500) feet of seam length, a minimum of one (1) test for each seaming machine per day, or more frequently at the discretion of the Engineer or Engineer's on-site representative. Sample location and size will be selected by the Engineer's on-site representative. The sample size twelve inch by fifty six inch (12"x 56")will be large enough to produce three (3) sets of test specimens for the following tests:

   i. Seam Shear Strength, ASTM D4437; and

   ii. Peel Adhesion, ASTM D4437.

b. Ten (10) specimens will compose a set. Five (5) of these will be tested for peel and the other five (5) for shear strength. Each specimen will be one (1)-inch wide and twelve (12)-inches long with the field seam at the center of the specimen. The fifty-six (56)-inch sample length will first be cut at the ends to produce two (2) field peel test specimens. The remaining fifty four (54) inches will be divided up into thirds and one-third submitted to the Contractor, one-third to the independent testing laboratory, and one-third to the Engineer's on-site representative for storage and future reference.

c. Test specimens will be considered passing if the minimum values below are met or exceeded for four (4) of the five (5) test specimens tested by the independent laboratories. All acceptable seams will lie between two (2) locations where samples have passed. Seam separation equal to or greater than ten percent (10%) of the track width shall be considered a failing test.

d. The cost of destructive testing will be borne by the Contractor.

e. Seams will meet minimum shear and peel strengths as listed in Table 2a of GRI GM19. Each specimen shall fail in the parent material and not in the weld, "Film Tear Bond" (FTB failure), to be considered a passing test.

2. If a sample fails destructive testing, ensure that: the seam is reconstructed in each direction between the location of the sample that failed and the location of the next acceptable sample; or the welding path is retraced to an intermediate location at least ten (10) feet in each direction from the location of the sample that failed the test, and a second sample is taken for an additional field test. If this second test sample passes, the seam must be then reconstructed between the location of the second test and the original sampled location. If the second sample fails, the process must be repeated.

a. All costs for work performed to achieve passing tests along with costs for retesting will be borne by the Contractor.

3. If double-track hot-wedge welding is used, the Engineer's on-site representative and the Installer must agree on the track weld that will be used in the destructive testing. The weld chosen inside or outside must be consistently tested, and must pass according to the criteria above.

4. All holes created by cutting out destructive samples will be patched by the Contractor immediately with an oval patch of the same material welded to the membrane using extrusion welding. The patch seams will be tested using a vacuum box and using the procedures described above.

5. At the ends of each field seam, two (2) field test specimens will be taken and field tested with a field tensiometer. Both specimens must pass prior to continuing with additional seams. Failure of these specimens will require correcting the seaming device and repair of the preceding seam according to the failure testing and procedures described above.

H. Liner Repair

1. All imperfections, flaws, construction damage, and destructive and non-destructive seam failures shall be repaired by the Installer of the FML. The appropriate methods of repair are listed below:

   a. Patching: used to repair holes, tears, undispersed raw materials, and contamination by foreign matter.

   b. Grinding and rewelding: used to repair small sections of extruded seams.

   c. Spot welding or seaming: used to repair pinholes or other minor, localized flaws.

   d. Capping: used to repair large lengths of failed seams.

   e. Topping: used to repair areas of inadequate seams which have an exposed edge.

   f. Removing bad seams and replacing with a strip of new material welded into place.

2. All repair seaming shall be performed in accordance with Part D of this Section.

3. Each repair shall be nondestructively tested using either vacuum box or spark testing methods. Seams which pass the nondestructive test shall be taken as an indication of a successful repair. Failed tests shall be reseamed and retested until a passing test results. The number, date, location, technician, and test outcome of each patch shall be recorded within the Daily Field Installation Reports and on the Record Panel Layout Drawings.

I. Wrinkles and Folds

1. Wrinkles that develop from normal placement procedures must be controlled such that the underlying FML does not fold over. Small wrinkles, defined as having their height less than or equal to one-half their base width, may be trapped and pushed down by the overlying soil. Any wrinkle that becomes too large and uncontrollable or that folds the FML over must be IMMEDIATELY brought to the attention of the Engineer's on-site representative. If necessary, the FML shall be uncovered, cut, laid flat, seamed by extrusion welding, and non-destructively tested.

J. Daily Field Installation Reports

1. At the beginning of each day's work, the Installer shall provide the Engineer's on-site representative with daily reports for all work accomplished on the previous work day. Reports shall include, at a minimum, the following:

   a. Total amount and location of FML placed.

   b. Total length and location of seams completed, name of technicians doing seaming and welding unit numbers.

   c. Drawings of the previous day's installed FML showing panel numbers, seam numbers and locations of nondestructive and destructive testing.

   d. Results of prequalification test seams.

   e. Results of non-destructive testing.

   f. Results of vacuum testing of repairs.

K. POST-CONSTRUCTION

1. The FML Installer shall prepare and the Contractor shall submit to the Owner and Engineer, Record Panel Layout Drawings illustrating the following information:

2. Dimensions of all FML field panels.
3. Panel locations referenced to the Design Drawings.
4. All field seams and panels with the appropriate number or code.
5. Location of all patches, repairs, and destructive testing samples.

*** END OF SECTION ***

ATTACHMENT 310519.16-A
Tables 2a and 2b

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English Units

Table 2(a) – Linear Low Density Polyethylene (LLDPE) Geomembrane (TEXTURED)

Properties	Test Method	Test Value								Testing Frequency (minimum)
		20 mils	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.)	D 7466	16	16	16	16	16	16	16	16	Every 2nd roll *(1)*
Density g/ml (max.)	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	200,000 lb
Tensile Properties *(2)* (min. ave.) • break strength – lb/in. • break elongation - %	D 6693 Type IV	 30 250	 45 250	 60 250	 75 250	 90 250	 120 250	 150 250	 180 250	20,000 lb
2% Modulus – lb/in. (max.)	D 5323	1200	1800	2400	3000	3600	4800	6000	7200	per formulation
Tear Resistance – lb (min. ave.)	D 1004	11	16	22	27	33	44	55	66	45,000 lb
Puncture Resistance – lb (min. ave.)	D 4833	22	33	44	55	66	88	110	132	45,000 lb
Axi-Symmetric Break Resistance Strain - % (min.)	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content - %	D 4218 *(3)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	45,000 lb
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	45,000 lb
Oxidative Induction Time (OIT) *(5)* (e) Standard OIT (min. ave.) — or — (f) High Pressure OIT (min. ave.)	 D 3895 D 5885	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	200,000 lb
Oven Aging at 85°C *(6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	per formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 7238 D 3895 D 5885	 N. R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	per formulation

(1) Alternate the measurement side for double sided textured sheet

(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
- Break elongation is calculated using a gage length of 2.0 in. at 2.0 in./min.

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2 and 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

SI (Metric) Units

Table 2(b) – Linear Low Density Polyethylene (LLDPE) Geomembrane (TEXTURED)

Properties	Test Method	Test Value								Testing Frequency (minimum)
		0.50 mm	0.75 mm	1.0 mm	1.25 mm	1.50 mm	2.00 mm	2.5 mm	3.0 mm	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mm (min. ave.)	D 7466	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	Every 2nd roll *(1)*
Density g/ml (max.)	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	90,000 kg
Tensile Properties *(2)* (min. ave.) • break strength – N/mm • break elongation - %	D 6693 Type IV	 5 250	 9 250	 11 250	 13 250	 16 250	 21 250	 26 250	 31 250	9,000 kg
2% Modulus – N/mm (max.)	D 5323	210	315	420	520	630	840	1050	1260	per formulation
Tear Resistance – N (min. ave.)	D 1004	50	70	100	120	150	200	250	300	20,000 kg
Puncture Resistance – N (min. ave.)	D 4833	100	150	200	250	300	400	500	600	20,000 kg
Axi-Symmetric Break Resistance Strain - % (min.)	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content - %	D 4218 *(3)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	20,000 kg
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	20,000 kg
Oxidative Induction Time (OIT) *(5)* (g) Standard OIT (min. ave.) — or — (h) High Pressure OIT (min. ave.)	 D 3895 D 5885	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	90,000 kg
Oven Aging at 85°C *(6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	per formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 7238 D 3895 D 5885	 N. R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	per formulation

(1) Alternate the measurement side for double sided textured sheet

(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
- Break elongation is calculated using a gage length of 50 mm at 50 mm/min.

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2 and 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

1.0 GENERAL

1.1 SUMMARY

A. Section includes provisions for protecting existing vegetation to remain, clearing of unwanted vegetation and grubbing

1.2 SUBMITTALS

A. Burning: Documentation of compliance with burning requirements and permitting of authorities having jurisdiction.

   1. 18 AAC 50, Open Burning Policy and Guidelines.

2.0 PRODUCTS

[Not used.]

3.0 EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during clearing and grubbing.

B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. See Section 015700, ENVIRONMENTAL PROTECTION PROCEDURES.

3.3 EXISTING UTILITIES

A. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place, including monitoring wells and piezometers, as called out in Section 332900, WELL ABANDONMENT.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during clearing and grubbing.

3.4 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.

2. Grind down stumps and remove roots larger than three (3) inches in diameter, obstructions, and debris to a depth of eighteen (18) inches below exposed subgrade.

3.5 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off property.

B. Burning tree, shrub, and other vegetation waste is permitted according to burning requirements and permitting of authorities having jurisdiction. Burning of other types of waste and debris is prohibited.

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. This section specifies requirements for blasting, excavation, loosening, removing, trenching, hauling, stockpiling, screening, placing, grading, shaping, and compaction of earthen materials for waste material removal, placement in repository, cover construction, and other work incidental to earthwork shown on the Drawings or required to accomplish the construction and completion of the Work.

B. Earthwork shall proceed consistent with the alignments, grades, cross-sections shown or indicated on the Drawings, detailed in the specifications, or required to complete other work shown, described, or otherwise required under this Contract.

C. Provide all necessary labor and equipment to perform the Work as described in these specifications and shown on the Design Drawings (placement, compaction, testing, etc.).

1.2 SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill in accordance with Section 026600, SELECT FILL AND TOPSOIL.

C. Blasting Plan: If blasting is performed, prepare a blasting plan reporting the following:

1. Compliance with applicable requirements in NFPA 495, "Explosive Materials Code" and 8 AAC 61.1020.

2. Types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.

1.3 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications.

2.0 PRODUCTS

2.1 SOIL AND DRAINAGE MATERIALS

A. See Section 026600, SELECT FILL AND TOPSOIL.

2.2 GEOTEXTILES

A. See Section 310519.13, GEOTEXTILE FABRIC.

2.3 GEOMEMBRANES

A. See Section 310519.16, WASTE CONTAINMENT GEOMEMBRANE.

3.0 EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Verify that utilities, trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed.

C. Permit access at all times to police and fire departments, and other points where access may involve the safety and welfare of the public.

D. It shall be the sole responsibility of the Contractor to control dust in accordance with Section 015700, ENVIRONMENTAL PROTECTION PROCEDURES, to such a degree that it will not endanger the safety and welfare of the public.

3.2 DEWATERING

A. The Contractor shall, at all times, provide and maintain proper and satisfactory means and devices for the removal of all water currently present within and/or entering the excavation areas, and shall remove all such water as it may collect, in such manner as shall not interfere with the performance of the Work.

B. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

D. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

E. Water pumped or drained from excavation areas shall be discharged (and treated, if required) in accordance with applicable local, state, and federal regulations and without injury to adjacent property, the work under construction, or to pavement, roads, drives and watercourses. Contractor shall utilize outlet protection measures (e.g., stone or other non-erodible surfacing) and/or other appropriate measures (e.g., flow spreaders) to avoid scour of the existing surface.

3.3 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. See Section 015700, ENVIRONMENTAL PROTECTION PROCEDURES.

3.4 EXISTING UTILITIES

A. Verify that utilities, to include monitoring wells and piezometers, have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place as called out in Section 332900, WELL ABANDONMENT.

3.5 STORAGE OF MATERIALS

A. All materials requiring stockpiling (e.g., excavated materials, imported fill materials) shall be stored in locations approved by the Owner's representative or Engineer so as not to endanger the work, and so that easy access may be had at all times to all parts of the work area. Stored materials shall be kept neatly piled and trimmed, to avoid inconvenience to public travelers and adjoining property holders.

B. Treated Waste Soil shall be securely covered with polyethylene sheeting when no materials are being placed or removed during the work and during non-work hours. Stockpiles of other materials may be covered to control erosion or generation of dust, as necessary or when requested by the Agency representative or Engineer.

3.6 TRANSPORT OF MATERIAL

A. When hauling Treated Waste Soil, the Contractor shall provide suitably tight vehicles lined with polyethylene sheeting to prevent leakage and deposits of material on offsite areas. In all cases where any materials are dropped from the vehicles, the Contractor shall clean up the same as often as required to keep offsite areas clean and free from dirt, mud, stone and other hauled material associated with the Work.

B. In accordance with 18 AAC 60.015 and AS 46.06.080, the waste material shall be covered or otherwise prevented from blowing out of the truck during transport to the repository. It shall be the intent to have all loaded haul vehicles, traveling on and off site, tarped to avoid fugitive dust and loss of material onto streets and offsite properties.

C. Follow requirements of Section 026113, EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL.

3.7 CLEARING AND GRUBBING

A. See Section 311100, CLEARING AND GRUBBING.

3.8 EXCAVATION OF TREATED WASTE SOIL

A. This material will be excavated from the current stockpile at the Junkyard Site and transported to the Repository Site in a manner that ensures it remains dry until final cover installation and that dust generation is controlled.

3.9 BASE DRAIN PLACEMENT

A. Grading of the Repository Site base drain layer shall be performed to achieve an overall cut-fill balance. This will be accomplished by utilizing Base Material (shot rock) already existing on the quarry floor and may entail additional removal of quarry material, to include blasting if necessary.

B. Base Material in excess of that required to achieve the design base drain layer shall be graded toward the front of Repository Site as an extension of the base drain layer.

C. If insufficient Base Material exists to achieve the design base drain layer and additional cut material is obtained from the quarry walls, cut only as much material as needed to meet backfilling requirements.

D. It is anticipated that the placed Base Material will have considerable void space; therefore, smaller aggregates such as 6-inch Rock and 1-inch Minus Drainage Rock should be used to fill the void space to prepare a surface for non-woven geotextile fabric placement.

E. The Base Drain surface shall be compacted to a firm, uniform, non-yielding surface prior to placement of non-woven geotextile fabric and Treated Waste Soil. Any areas of soft or otherwise unsuitable subgrade that are unable to be compacted to a firm, uniform, non-yielding surface, shall be amended with competent material or removed and replaced with more competent material to produce a firm, uniform, non-yielding condition.

3.10 TREATED WASTE SOIL PLACEMENT

A. The Treated Waste Soil shall be placed upon the geotextile fabric over the prepared Base Drain.

B. The Treated Waste Soil surface shall include no depressions that would promote ponding of water.

3.11 CHMINEY DRAIN

A. The Chimney Drain shall be constructed concurrent with the Treated Waste Soil Placement.

B. Utilize nonwoven geotextile fabric to prevent intrusion of Treated Waste Soil into the Chimney Drain. Throughout Work, protect the 6-inch Minus Rock from contamination from the Treated Waste Soil.

3.12 SUBCUSHION LAYER PLACEMENT

A. Subcushion Layer thickness is anticipated at depths as shown on Design Drawings, depending on the irregularity of subgrade surface and size/nature of materials contained therein. Contractor shall coordinate closely with the Engineer's on-site representative to determine minimum required Subcushion Layer thicknesses as the work proceeds, or to develop an appropriate methodology for identifying areas of inadequate Subcushion Layer thickness and amending as needed.

B. Subcushion Layer materials consisting of 3/8-inch Aggregate shall be placed and compacted in a uniform single lift.

C. Avoid abrupt changes in Subcushion Layer thickness and changes in thickness that would create surface slopes less than the minimum acceptable and/or areas of potential ponding. Where such conditions could occur, carry increased Subcushion Layer thickness out to a high point of grade or as needed to tie into steeper slopes.

D. Final Subcushion Layer surface shall be smooth and uniform and compacted to a firm, non-yielding condition. Final Subcushion Layer surface shall contain no abrupt protrusions greater than three-eighths (3/8)-inch or other sharp or angular protrusions that could potentially damage the overlying flexible membrane liner (FML). Any unacceptable protrusions shall be removed and the Subcushion Layer material replaced and compacted, or the protrusion shall be compacted into the surface using appropriate compaction equipment (e.g., smooth-drum roller, hand tamper).

E. All areas of prepared Subcushion Layer shall be reviewed by the Engineer's on-site representative and the Contractor for conformance with the Design Documents.

Engineer's on-site representative and the Contractor shall document the review and conformance of completed Subcushion Layer surfaces in writing (e.g., on a Subcushion Layer acceptance form or similar means of record-keeping) prior to placement of overlying FML.

F. Overlying FML shall not be placed on Subcushion Layer surfaces that have not received the written acceptance of the Engineer's on-site representative and the Contractor.

G. FML shall be placed on Subcushion Layer surfaces within twenty four (24) hours of receiving written acceptance. After twenty four (24) hours, the Subcushion Layer surface will no longer be considered acceptable until reviewed again by the Engineer's on-site representative and the Contractor for conformance with the Design Documents, and re-documented in writing.

3.13 FML PLACEMENT

A. See Section 310519.16, WASTE CONTAINMENT GEOMEMBRANE.

3.14 FML CUSHION LAYER PLACEMENT

A. FML Cushion Layer materials consisting of 3/8-inch Minus Aggregate shall be placed and compacted in a uniform single lift.

B. Materials placed on top of geosynthetics shall be spread uniformly over the geosynthetics to the full lift thickness by methods that do not tear, puncture, or reposition the geosynthetics. Sudden braking and sharp turning on top of the materials shall be avoided. Tracked equipment operating on top of the materials shall minimize all unnecessary turning to prevent the tracks from damaging the underlying geosynthetics. FML Cushion Layer shall be placed beginning at the bottom of the slope such that construction equipment will not be operated directly upon geosynthetics.

C. Refer to Project Specifications Sections covering specific geosynthetics materials for additional requirements. See Section 310519.16, WASTE CONTAINMENT GEOMEMBRANE.

3.15 DRAINAGE LAYER PLACEMENT

A. Drainage Layer material consisting of 1-inch Minus Drain Rock shall be placed and compacted in two (2) uniform lifts.

B. Install Drainage Layer and place layer of geotextile filter fabric over top of Drainage Layer, overlapping edges. See Section 310519.13, GEOTEXTILE FABRIC.

3.16 TRENCHING

A. Install drainage conduits as shown or indicated on the Drawings, or detailed in the Specifications.

B. For trenching requirements refer to Section 312323, TRENCHING.

3.17 COMPACTION

A. For compaction requirements refer to Section 312333, COMPACTION.

3.18 PLACEMENT OF DRAINAGE CHANNEL AND APRON RIPRAP

A. When placing riprap on top of geotextile, the riprap shall be placed using methods that do not stretch, tear, puncture, or reposition the fabric. Equipment shall be operated so as to minimize drop height of stone, without the equipment contacting and damaging the geotextile. This will generally be approximately one (1) foot of drop from the bucket to the placement surface. Construction equipment shall not be operated directly upon the geotextile.

B. When placing riprap on top of a stone bedding layer, place riprap in a manner that minimizes displacement of the underlying bedding materials. Sudden braking and turning on top of the bedding materials should be avoided. Tracked equipment shall minimize all unnecessary turning on top of bedding materials. Equipment shall be operated to minimize drop height of stone, without the equipment contacting and displacing the bedding materials. This will generally be approximately one (1) foot of drop height from the bucket to the placement surface.

C. Place riprap to its full course thickness in one (1) operation, in such a manner as to minimize segregation of rock sizes and avoid displacing underlying material. Equipment used to place riprap should have the capacity to hold enough rock to deposit a full layer thickness in each pass.

D. Place riprap from bottom of slope to top of slope, in a manner that prevents stones from rolling downhill.

E. Subsequent loads of riprap shall be placed against previously placed material in such a manner as to ensure a relatively homogeneous mass.

F. Construction equipment shall not be operated directly on top of completed riprap unless specifically authorized in writing by the Engineer.

G. If required, riprap shall be repositioned by hand or by adjustment of individual rocks with the equipment bucket. Riprap shall not be spread or repositioned by pushing across the underlying material or by tamping down with the bucket.

3.19 DISPOSAL OF SURPLUS AND WASTE MATERIALS

B. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off property.

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. Work under this section includes pipe installation in trenches, as indicated in the Design Drawings and Project Specifications.

B. Compaction shall be performed in accordance with Section 312333, COMPACTION.

2.0 PRODUCTS

2.1 SOIL AND DRAINAGE MATERIALS

A. See Section 310513, SELECT FILL AND TOPSOIL.

2.2 PIPE

A. See Section 334616, SUBDRAINAGE PIPING.

3.0 EXECUTION

3.1 EXCAVATION

A. Trench excavations shall be located as shown on the Design Drawings and/or as required to meet project design objectives. Under ordinary conditions, excavation shall be by open cut from the ground surface. Where the depth of trench and/or soil conditions necessitate, sheeting and/or bracing may be required. The determination of the need for sheeting and/or bracing shall be the responsibility of the Contractor. The design, construction, safety of any sheeting and/or bracing, and all related costs shall be the responsibility of the Contractor.

B. Trenches shall be excavated to achieve the depths as required for the type of pipe to be installed.

C. The alignment and depth of trenches shall be determined and maintained by the use of a string line installed on batter boards above the trench, a double string line installed along side of the trench or a laser beam system.

D. The minimum width of trench excavation shall be as recommended by the pipe manufacturer's installation guidelines. All trench excavations performed by the Contractor shall take into account all applicable excavating/backfilling safety standards and regulations.

E. Trenches shall not be opened for more than one hundred (100) feet in advance of pipe installation nor left unfilled for more than one hundred (100) feet in the rear of the installed pipe when work is in progress. Open trenches shall be protected and barricaded in accordance with all applicable safety standards and regulations. There will be no trenches left open at the close of each working day unless properly protected.

F. Bridging across open trenches shall be constructed and maintained where required (i.e., at driveways), or requested by the Engineer or Engineer's on-site representative, and shall be designed to safely handle the maximum anticipated loading, in accordance with all applicable standards and regulations. The design of any required bridging will be the responsibility of the Contractor.

3.2 SUBGRADE PREPARATION FOR PIPE

A. Where pipe is to be laid on the undisturbed bottom of an excavated trench, mechanical excavation shall not extend lower than the finished subgrade elevation at any point.

B. Where pipe is to be laid on special granular material, the excavation below subgrade shall be to the minimum depth required to install the pipe bedding material. The pipe bedding material shall be deposited in layers not to exceed six (6) inches and shall be thoroughly compacted prior to pipe installation.

C. Pipe subgrade preparation shall be performed immediately prior to installing the pipe in the trench. Where bell holes are required, they shall be made after the subgrade preparation is complete and shall be only of sufficient length to prevent any part of the bell from coming in contact with the trench bottom and as needed to allow sufficient space for joint assembly.

3.3 REMOVAL OF WATER AND DRAINAGE

A. The Contractor shall at all times provide and maintain proper and satisfactory means and devices for the removal of all water entering the trench, and shall remove all such water as fast as it may collect, in such manner that avoids interference with the performance of the work.

3.4 PIPE EMBEDMENT

A. Refer to the Design Drawings, Section 310513, SELECT FILL AND TOPSOIL and Section 334616, SUBDRAINAGE PIPING, for pipe and pipe embedment material requirements.

B. All pipes shall be protected from lateral displacement and possible damage resulting from superimposed backfill loads, impact, or unbalanced loading during backfilling operations by adequately embedding within suitable pipe embedment material. To ensure adequate lateral and vertical stability of the installed pipe during pipe jointing and embedment operations, a sufficient amount of the pipe embedment material to hold the pipe in rigid alignment shall be uniformly deposited and thoroughly compacted on each side of the pipe, and back of the bell, as it is laid.

C. Pipe embedment materials shall be placed in horizontal layers not exceeding six (6) inches in thickness, and compacted to at least ninety five (95) percent maximum density (Standard Proctor), unless otherwise recommended by the pipe manufacturer and accepted by the Engineer, using appropriate compaction equipment that will not damage or cause displacement of the pipe or surrounding soils. Washed and open-graded gravels may be placed in horizontal layers not exceeding twelve (12) inches and shall be tamped to a firm, uniform surface prior to placement of the next successive lift.

D. Embedment materials placed above the centerline of the pipe, or above the concrete cradle (if present), to a depth of twelve (12) inches above the top of the pipe barrel shall be deposited in such manner as to not damage the pipe. Compaction shall be as required for the type of embedment being installed.

3.5 BACKFILL ABOVE EMBEDMENT

A. The remaining portion of the pipe trench, above the embedment, shall be backfilled with suitable materials compacted as specified.

1. Where trenches are located within the ditch-to-ditch limits of any street or road or under a driveway or sidewalk, or shall be under a structure, the trench shall be backfilled in horizontal layers not more than six (6) inches in thickness, and compacted to obtain ninety-five (95) percent maximum density (Standard Proctor).

2. Where trenches are located in open fields or unimproved areas outside of the ditch limits of roads, placement and compaction of backfill materials shall be performed in accordance with Section 312000, EARTHWORK.

3. Hand tamping shall be required around buried utility lines or other subsurface features that could be damaged by mechanical compaction equipment.

B. Backfilling of trenches beneath, across or adjacent to drainage ditches and water courses shall be performed in such a manner that water will not accumulate in unfilled or partially filled trenches and the backfill shall be protected from surface erosion by appropriate means.

1. Where trenches cross waterways, the backfill surface exposed on the bottom and slopes thereof shall be protected by means of stone riprap, concrete, or pavement and appropriate underlayment materials (e.g., geotextile).

C. Any settlement of the backfill, prior to final acceptance of the Contract work, shall be refilled and compacted as it occurs by the Contractor and at no additional cost to the Project.

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. Work under this section includes compaction of earthen materials, as indicated in the Design Drawings and Project Specifications.

B. Provide for all necessary labor and equipment to perform the work described in these specifications and shown on the Design Drawings.

2.0 PRODUCTS

2.1 SOIL AND DRAINAGE MATERIALS

A. See Section 310513, SELECT FILL AND TOPSOIL.

3.0 EXECUTION

3.1 COMPACTION REQUIREMENTS

A. Unless otherwise specified on the Design Drawings, the degree of material compaction specified for the items listed in Table 312333-1, below, shall be the minimum required.

B. Unless the Contractor can successfully demonstrate that his methods will produce the required degree of compaction throughout the entirety of each lift, materials to be compacted shall be placed in layers not exceeding the compacted lift thicknesses listed in Table 312333-1.

C. Moisture/density tests shall be performed, at the Contractor's expense, on all soil materials requiring such tests, by a certified geotechnical testing laboratory, in accordance with ASTM Standard D698 (Method to be determined based on material gradation), prior to placement. Laboratory moisture/density testing shall be performed at a frequency of at least two (2) samples per ten thousand (10,000) cubic yards of each fill material type requiring a specific minimum percent compaction (e.g., 95%). Additional tests shall be performed if requested by the Engineer.

D. Backfill materials shall be placed in uniform, horizontal loose lifts.

E. In-place density, of density-controlled materials, shall be determined by ASTM D1556 or ASTM D6938 and shall be expressed as a percentage of maximum dry density, unless otherwise requested by the Engineer. In-place density testing shall be performed at an approximate minimum frequency of one (1) per ten thousand (10,000) square feet per lift, or more frequently, as deemed necessary by the Engineer to reliably and consistently determine the compaction level being achieved and/or as needed to confirm specific areas of concern. Density testing will be performed by an independent third party provided by the Contractor.

F. If in-place density testing indicates that appropriate densities have not been achieved, the Contractor may be required to re-compact and/or remove and replace the out-of-spec materials.

G. If in-place density testing indicates that appropriate densities are generally not being achieved, the Engineer may increase the frequency of in-place density testing and/or require that the compaction methods be modified to achieve the required in-place densities.

H. When required to achieve appropriate soil moisture content for compaction, sufficient water shall be added during placement and compaction activities to increase the moisture content by the required amount. If due to rain or other causes the material becomes too wet and cannot be compacted as specified, the Contractor shall mechanically adjust (reduce) the moisture content of the material as required to achieve the required degree of compaction.

I. Minimum field compaction requirements listed in Table 312333-1 are expressed as a percentage of the maximum dry unit weight of the material as determined by the geotechnical testing laboratory.

*** END OF SECTION ***

TABLE 312333-1
Minimum Compaction Requirements

Table 312333-1 – Minimum Compaction Requirements

Backfill Description	Maximum Compacted Lift Thickness [3,5]	Minimum Compaction	In-Place Density Testing Frequency
Treated Waste Soil [1,5]	9”	95% (or firm, uniform, non-yielding surface)	100,000 sf, (inspect 100% of surface)
Subcushion layer below FML [2] - 3/8-inch Minus Aggregate	12”	95% (or firm, uniform, non-yielding surface if unable to field test)	10,000 sf, (inspect 100% of surface)
Cushion layer above FML [2,3] - 3/8-inch Minus Aggregate	12”	90% (or firm, uniform, non-yielding surface if unable to field test)	10,000 sf, (inspect 100% of surface)
Drainage Layer – 1-inch Minus Drain Rock	12”	90% (or firm, uniform, non-yielding surface if unable to field test)	100,000 sf
Clean Backfill [5]	12”	90%	100,000 sf
Topsoil	6”	Lightly compacted to a relatively firm, uniform surface	NA
Rip-rap	Place in Single Lift	None Required	NA
Gravel Bedding underneath piping [4]	Place in Single Lift	Leveled to a uniform surface, as needed to achieve required pipe gradient and full contact between pipe and bedding material	NA

Notes:

1. Due to the potential for variable consistency and composition of regraded materials, Contractor shall coordinate with Engineer regarding placement and compaction requirements as the work proceeds. In general, Contractor shall consolidate regraded materials to achieve a relatively firm and non-yielding surface.

2. Cushion layers shall be compacted with an adequately sized, fully loaded, smooth-drum roller (or hand tampers in select areas inaccessible to larger compaction equipment), unless otherwise approved, in writing, by the Engineer.

3. If necessary to protect underlying geosynthetics (e.g., geotextile, FML) from damage, the overlying cover materials shall be placed and compacted in an over-thickened state (i.e., greater than the final required design thickness) and then trimmed to the required design thickness.

4. In cases where multiple conditions apply (e.g., pipe bedding that is part of the FML cushion layer), the more stringent compaction requirement shall govern (e.g., compact to 90%, in accordance with cushion layer above FML requirement).

5. Where the work requires multiple lifts of fill material, each lift shall be compacted to its full requirement (i.e., as listed in the table above), prior to placement of the next lift. The surface of the lift shall then be scarified to a minimum depth of approximately 2 inches prior to placement of the next successive lift.

DIVISION 32
EXTERIOR IMPROVEMENTS

Section 323100 – Vehicle Barriers

Section 329000 – Topsoil and Seeding

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1.0 GENERAL

1.1 SUMMARY

A. The Contractor shall provide all equipment, materials, and personnel necessary to install a gate and vehicle barriers to prevent off-highway vehicle (OHV) access at the Repository Site.

1.2 SUBMITTALS

A. Product Data for each type of product.

B. Shop drawings of gate and OHV deterrent layout.

2.0 PRODUCTS

2.1 MANUFACTURED STEEL GATE

A. Gate shall be constructed of tubular steel design. Gate shall be a minimum of ten (10) feet in width.

2.2 OHV BARRIERS

A. Bollards:
   1. Pipe: Steel pipe having a minimum diameter of six (6) inches and a length of eight (8) feet.
   2. Fill: Concrete with batch strength shall be three thousand (3,000) pounds per square inch (psi).

B. Boulders:
   1. Size: Two-man sized boulders, minimum.
   2. Number: Sufficient number to prevent OHV access between boulders.

C. Chains:
   1. Gate chain: hardened steel chain of sufficient size to prevent vandalism/cutting.
   2. Bollard Chains: Oversized, hardened chain draped through steel eyelets welded on each bollard to prevent OHV access between pipes.

D. Lock:
   1. Brand: American Lock.
   2. Sized appropriately for the installed gate chain and/or latch. Six (6) keys shall be supplied to the Agency for distribution.

3.0 EXECUTION

3.1 INSTALLATION

A. Locate the gate and vehicle barriers across the narrow opening to the south quarried area that will contain the repository. The location should fall between survey control points 1002 “Pat2” and 1005 “Pat3”.

B. Install gate according to manufacturer's written instructions and/or shop drawings.

C. Concrete-filled bollards and/or boulders used for OHV restriction shall be placed a minimum distance apart in a configuration that will deter OHV use. Depth of bollard bury shall be half the pipe length or to bedrock.

D. All excavation procedures used during installation activities shall be conducted in accordance with Section 312000, EARTHWORK.

*** END OF SECTION ***

1.0 GENERAL

1.1 SUMMARY

A. This section specifies the furnishing of topsoil, fertilizer, seed, and/or mulch; preparation of the sub-grade; and the placing of the topsoil, fertilizer, seed, and/or mulch. Topsoil is not available on site.

B. Provide all equipment, materials, and personnel necessary to conduct topsoil preparation and seeding application activities and maintenance until acceptance.

1.2 SUBMITTALS

A. Certification of Grass Seed: From seed vendor for each grass-seed mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

B. Topsoil Information: At least fourteen (14) days prior to use, provide source information (borrow location, supplier); physical and fertility test results, in accordance with Section 026600, SELECT FILL AND TOPSOIL and with Part 2.1 of this Section.

C. Fertilizer Information: At least fourteen (14) days prior to fertilizing, provide fertilizer supplier's name and description of the fertilizer materials (including the chemical make-up), and the proposed application methods and rates.

D. Mulch Information: At least fourteen (14) days prior to mulching, provide mulch supplier's name and description of the lime and fertilizer materials (including the chemical make-up), and the proposed application methods and rates.

2.0 PRODUCTS

2.1 TOPSOIL

A. Topsoil shall be in accordance with Section 026600, SELECT FILL AND TOPSOIL.

2.2 TOPSOIL AMENDMENT

A. Fertilizer 10-10-10-8.5S (sulfur) at three hundred (300) lbs./acre.

2.3 SEED MIX

A. Native-Grass Seed: Fresh, clean, and dry new seed, of mixed species:

Scientific Name	Common Name	PLS lbs/acre
Deschampsia beringénsis	‘Norcoast' Bering hairgrass	24.0 (55%)
Festuca rubra	‘Arctared' red fescue	15.2 (35%)
Lolium multiflorum	Annual ryegrass	4.4 (10%)
	Total PLS lbs/acre	**43.6**

Specified by Phil Czapla, Agronomist, Alaska Department of Natural Resources, Division of Agriculture, Plant Materials Center, 5310 S. Bodenburg Spur, Palmer, Alaska 99645. Phone: 907-745-4469. http://dnr.alaska.gov/ag/ag_es.htm

B. Seeding rate: one pound per one thousand square feet (1 lb./1,000 sq. ft.)

2.4 MULCH

A. Mulch shall be straw or wood cellulose fiber.

1. Straw mulch:

    a. Shall be comprised of small grain crops, free of undesirable seeds and coarse material.

2. Wood cellulose fiber mulch:

    a. Shall be manufactured from unadulterated wood that is not contaminated with paint, chemicals, shingles, plastics, or other foreign materials.

    b. Shall not be manufactured from or contain paper.

    c. Shall be manufactured so that wood fibers will remain uniformly suspended in water under agitation and will blend with seeds, fertilizer, and other additives to form a homogeneous slurry.

    d. Shall contain no growth or germination inhibiting factors.

    e. Shall contain a non-permanent green dye to facilitate inspection of the placement of the material.

    f. Shall include a tackifying agent to prevent displacement due to water and wind.

    g. Shall be capable of forming an absorptive mat that will allow moisture to percolate into the underlying soil.

B. Shall be supplied in the manufacturer's standard containers, with the name of the material, weight of contents, manufacturer's name, and the air dry weight of fiber (equivalent to ten percent [10%] moisture) appearing on each container.

3.0 EXECUTION

3.1 TOPSOIL PLACEMENT

A. The area to receive topsoil shall be graded such that the final top soiled surface will match the final grades shown on the Design Drawings, or as otherwise directed by the Engineer or Engineer's on-site representative (i.e., rough-graded surface prior to topsoil application should be lower than final design grade by an amount equal to the final thickness of topsoil to be placed).

1. All debris and inorganic material shall be removed and the subgrade surface loosened for a depth of two (2) inches prior to the placing of the topsoil.

2. The topsoil shall not be placed until the clean backfill subgrade is in suitable condition and shall be free of excessive moisture and frost.

3. Minimum topsoil depth shall be six (6) inches unless otherwise shown on the Design Drawings.

4. Placement requirements may be adjusted by the Engineer based on actual field conditions encountered at time of placement.

B. Apply fertilizer as recommended and work as deeply as possible into soil.

C. Prior to seed application, the topsoil surface shall be tilled to a depth of at least two (2) inches by disking, harrowing, or other acceptable means if surface is uneven, glazed, or crusted.

D. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff.

E. All excavation procedures used during topsoil placement activities shall be conducted in accordance with Section 312000, EARTHWORK.

3.2 SEEDING APPLICATION

A. After the topsoil surface has been prepared, the seed mixture shall be uniformly applied to the prepared surface by appropriate means at the rate specified in this specification, or as otherwise recommended by the seed supplier for the seed mix being used.

B. Seeding and mulching shall not be performed during windy weather (i.e., wind speeds that prevent uniform application of seed and mulch).

C. The seed shall be incorporated into the uppermost one-half (0.5) inch of soil by appropriate means.

D. Native seeds shall only be seeded during a season recommended by seed provider. If necessary, sterile annual species can be seeded separately to provide immediate cover.

E. Straw mulch, if used, shall be spread to form a continuous blanket over the seed bed, through which no more than approximately twenty percent (20%) of the ground surface can be seen (i.e., an application rate of approximately two (2) tons/acre). Excessive amounts or bunching of mulch will not be permitted.

1. Mulch shall be anchored by an acceptable method (e.g,. pinning, crimping, tackifier).

2. Unless otherwise specified, mulch shall be left in place and allowed to disintegrate.

F. Seeded areas shall be watered as often as required to obtain germination and to obtain and maintain a satisfactory sod growth. Watering shall be performed in such a manner as to prevent washing out of seed.

G. If hydroseeding is the selected method of planting, the following shall also apply:

1. Seeding and mulching shall be a one-step process in which seed, fertilizer, hydraulic mulch, and mulch adhesive (tackifier) are applied simultaneously in a homogeneous water slurry via hydraulic seeder/mulcher.

2. Hydraulic Seeder/Mulcher: Apply seed, fertilizer, hydraulic mulch, and temporary cover adhesive using an acceptable hydraulic seeder/mulcher. The hydraulic seeder/mulcher shall be equipped with mechanical agitation equipment capable of mixing the materials into homogeneous water slurry and maintaining the slurry in a homogeneous state while it is being applied. The discharge pumps and gun nozzles shall be capable of applying the materials uniformly in a spray pattern that neither concentrates the slurry nor erodes the soil.

3. Volume Certification: Hydraulic seeding/mulching equipment shall have the tank volume certified by a plate affixed by the manufacturer and confirmed by the Engineer's on-site representative by means of measurements or tests prior to the commencement of work. This plate shall be affixed in plain view on the hydraulic seeder/mulcher and shall not be removed or altered. The

plate shall certify tank volume only, and shall not imply equipment conformance to other requirements of this Section.

4. Application of Materials: Measure the quantity of each material to be charged into the hydraulic seeder/mulcher tank either by mass or by a system of mass-calibrated volume measurements acceptable to the Engineer and/or Engineer's on-site representative. Add the materials to the tank while it is being loaded with water. Thoroughly mix the materials into a homogeneous slurry and distribute uniformly over the designated surface area via the hydraulic seeder/mulcher. Apply seed, fertilizer, and where applicable, hydraulic mulch adhesive within ninety (90) minutes of being charged into the hydraulic seeder/mulcher tank. During loading of the hydraulic seeder/mulcher tank, add materials in the following sequence: seed, then fertilizer, then, where applicable, hydraulic mulch and adhesive.

5. Hydroseeding should be performed in two directions to avoid shadowing in such a manner that produces 100 percent (100%) ground coverage.

6. Blend into existing adjacent grass areas to bond new growth to existing adjacent areas or to previous applications to form uniform surfaces.

7. Seed mixture shall be applied in accordance with the manufacturer's written instructions and Part 2.3 (A) of this Section.

3.3 MAINTENANCE

A. Contractor shall maintain the newly seeded areas in good condition until seeded areas have established a minimum uniform seventy percent (70%) density of native perennial vegetation and until acceptance by the Agency and/or Engineer.

B. Contractor shall repair any areas of erosion and reseed (and re-fertilize, if necessary) any dead or dying areas of vegetation, as necessary, until complete coverage and satisfactory sod growth is achieved.

*** END OF SECTION ***

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DIVISION 33
UTILITIES

Section 332900 - Well Abandonment

Section 334616 – Subdrainage Piping

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1.0 GENERAL

1.1 SUMMARY

A. The Contractor shall provide all equipment, materials, and personnel necessary to abandon in place any damaged or obsolete extraction wells, open boreholes, open piping or conduit and to remove any protective casings, concrete pads, and protective bollards of abandoned monitoring wells.

B. The wells selected for abandonment are P-01 and MW-02 located at the Repository Site. Locations are indicated on Design Drawing C-2, and abandonments are noted on Design Drawing C-3. There are no known protective casings or bollards associated with these wells.

1.2 BACKGROUND

A. A hydrologic and geotechnical investigation was conducted at the Repository Site in December of 2016 and summarized in the report, *Proposed Wrangell Monofill Report of Findings*, *Wrangell, Alaska* (Ahtna 2017, see Section 003126, EXISTING HAZARDOUS MATERIAL INFORMATION). As part of this investigation, three exploratory borings were advanced at the Repository Site to characterize subsurface conditions, determine site groundwater depths, and identify baseline groundwater quality conditions at the Repository Site.

The borings completed at the proposed repository site were advanced to depths ranging from 6 to approximately 34 feet below ground surface (bgs). Subsurface material consisted primarily of crushed rock overburden underlain by fractured bedrock. Either a groundwater monitoring well or piezometer was installed at each of the three boring locations. Groundwater was identified in the overburden and fractured rock at depths of approximately 2.5 to 3.2 feet bgs (Ahtna 2017); however, these elevations may not be representative of the highest groundwater elevations, as they were discrete readings and do not account for seasonal fluctuations. It should be noted that the two borings to be abandoned were terminated just above bedrock due to the presence of an oily sheen observed in the groundwater. The source of the oil was not identified during the site investigation.

B. Alaska Drinking Water regulations (18 AAC 80.015(e)) require that a person who decommissions a monitoring well, a public water supply well, an observation well associated with testing a public water system supply well, or a private well shall use a method that conforms to ANSI/AWWA Standard A100-97, adopted by reference in 18 AAC 80.010 or an alternate method approved by the ADEC; however, the alternate method must be submitted to the ADEC under the signature and seal of a registered professional engineer, prior to ADEC review and approval.

C. Boring and Well Completion Logs for all three well locations on the Repository Site are included as Attachments 332900-A, Boring Logs and 332900-B, Well Completion Logs.

1.3 SUBMITTALS

A. The Contractor shall submit, prior to well abandonment work, a description of the proposed abandonment techniques to be utilized for each item specified in this section.

B. Record of Decommissioning ("well decommissioning log"). The person completing the work should provide, in the form of a written report or completed form, a well decommissioning log to the Agency within thirty- (30) days of completion of the work. The well decommissioning log should include an accurate account of the procedures, as well as materials and their associated amounts, used to perform the work. The well decommissioning log is an important record that should be carefully filed and kept with other important property documents. To assist, a form is available from ADNR, http://dnr.alaska.gov/, 907-269-8400.

2.0 PRODUCTS

2.1 BENTONITE GROUT

A. Bentonite used for grouting shall be a high-solids granular sodium bentonite mixed according to the manufacturer's directions, having a minimum mud weight of at least nine-and-one-half (9.5) pounds per gallon, and containing at least twenty percent (20%) solids. Mixing methods should be used that prevent the slurry from being excessively lumpy.

2.2 UNHYDRATED BENTONITE

A. Bentonite used in an unhydrated form shall be sodium bentonite granules, pellets, or chips.

3.0 EXECUTION

3.1 GENERAL

A. All borehole and well abandonment shall comply with ADEC regulations. If these specifications differ from ADEC requirements, the ADEC requirements shall be used.

B. Record decommissioning procedures and report to ADEC. Monitoring well closure reports will be filed by the Contractor.

C. Before any well or pipe abandonment, the Engineer and Contractor shall verify that the well or pipe to be abandoned has been located and tagged/marked for removal.

D. The preferred well decommissioning method is to first knock out the bottom of the screen with a steel drill rod/pipe, allowing the well itself to be used as a tremie pipe.

E. All excavation procedures used during abandonment activities shall be conducted in accordance with Section 312000, EARTHWORK.

3.2 BENTONITE GROUT

A. Prior to placement of grout, the grout slurry weight shall be measured according to American Society for Testing and Materials (ASTM) Test Method D-4380-84. Grout slurry shall not be placed until the grout slurry weight is within ten percent (10%) of the weight specified in Subpart 2 of this Section.

B. The grout slurry shall begin at the bottom of the well or pipe and extend to within two (2) feet of the existing ground surface, filling in all voids. Complete by filling the remaining two (2) feet with sand or gravel in accordance with Section 312000, EARTHWORK.

C. Grout slurries shall be placed through a side-discharge tremie pipe by gravity flow or by pumping to ensure positive displacement without bridging. The discharge end of the tremie pipe shall remain submerged in the grout throughout the grouting operation.

3.3 UNHYDRATED BENTONITE

A. In the event that water is encountered at the well or pipe bottom, bentonite granules, pellets, or chips shall be used in lieu of grout slurry (within the water filled portion only).

B. Note: if a high static water level exists in the well, consider using coated bentonite tablets or pouring smaller amounts of bentonite chips to avoid “bridging”.

C. Pour rate shall be three (3) minutes or slower per fifty (50)-pound sack.

D. A sounding or tamping tool shall be used during pouring to measure fill-up rate and to break up possible bridges or cake formation.

E. Unhydrated bentonite shall only be placed up to the water surface, with grouting (see Subpart 3.2, above) to be used to fill the remainder of the well or pipe.

*** END OF SECTION ***

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ATTACHMENT 332900-A
Boring Logs

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Ahtna Engineering

SOIL BORING LOG

PROJECT NUMBER:	BORING NUMBER:	SHEET:
20266022	AES16-TB01	1 of 2

Project Name	Wrangell MonoFill	Site	Pat Creek
Client	ADEC	Geologist	DuComB
Date	29-NOV-2016	Weather	Rain 40°F
Drilling Company	Discovery	Rig Type/ Drilling	6712DT/ Rock Core
Boring Size	3.75"	Hammer Drop	—
Sample Method	—	# of Samples	—
Total Depth	~~35'~~ 19.3	Depth to GW	—
Northing/ Easting	—	Elevation	— 247.96

LOCATION SKETCH/EXTRA FIELD NOTES:
[surface condition, ie. Asphalt, grass]

N

See well Sheet

SOIL DESCRIPTION AND NOTES

(color, major constituents/minor constituents [particle distribution and particle shape], density, plasticity, cohesiveness, moisture content, fracturing, weathering, depositional environment, stratigraphic unit)

DEPTH (FEET)	BLOWS/FT	INCHES DRIVEN	INCHES RECVED	PID	TIME	USCS Classification	SOIL DESCRIPTION AND NOTES
0					1300		gray, gravel Over Burden
0.8							Gray-Dark Rock, Fractured
3 (Run 1 Box 1)		5'	4.4				
5.8 (Run 2 Box 1)		4'	3.7		1350 1430		gray, Dark, Rock
9.8 (Run 3 Box 1/ Box 2)		4.6 5	5.0' 4.6		1500		gray, Dark, Rock *Measured Hole Run #2 was NOT A Full 4.0' TD@ 14.3',
~~13.5~~ 14.3 Measured (Run 4 Box 2)		5	5		1530 1545		gray, Dark Rock Fewer Fractures
19.3					1615		

Ahtna Engineering

SOIL BORING LOG

PROJECT NUMBER:	BORING NUMBER:	SHEET:
20366022	AES16-TB01	2 of 2

Project Name	Wrangell Monofill	Site	Pat Creek
Client	ADEC	Geologist	DuComB
Date	29-Nov-2016	Weather	Rain 40°F
Drilling Company	Discovery	Rig Type/ Drilling	6712DP/Rock Core
Boring Size	3.75"	Hammer Drop	—
Sample Method	—	# of Samples	—
Total Depth	34'	Depth to GW	—
Northing/ Easting	—	Elevation	— 247.96

LOCATION SKETCH/EXTRA FIELD NOTES: N
[surface condition, ie. Asphalt, grass]

See well Sheet

DEPTH (FEET)	BLOWS/FT	INCHES DRIVEN	INCHES RECVED	PID	TIME	USCS Classification	SOIL DESCRIPTION AND NOTES (color, major constituents/minor constituents [particle distribution and particle shape], density, plasticity, cohesiveness, moisture content, fracturing, weathering, depositional environment, stratigraphic unit)
19.3 0 Run5 Box 2/3					1615		
1		57	47				gray, Dark, more white veins, more Frequent Fracturing.
24.3 2 Run6 Box3					1633		
3		49	50				gray, Dark Fractures every 0.3-0.4' * >100% recovery
29.2 4 Run7 Box 3/4					1724		* Vertical Fracturing Bottom Foot of interval
5							gray Dark, Fractured
34.2 6					1818		End of Boring
7							
8							
9							

Ahtna Engineering	SOIL BORING LOG	PROJECT NUMBER: 20266.022	BORING NUMBER: AES16-TB02	SHEET: 1 of 1

Project Name	Wrangell Mono Fill	Site	Pat Creek
Client	ADEC	Geologist	DuComb
Date	1-Dec-2016	Weather	Rain
Drilling Company	Discovery	Rig Type/ Drilling	6712DT / Auger
Boring Size	8" Auger	Hammer Drop	—
Sample Method	—	# of Samples	—
Total Depth	9.83'	Depth to GW	Surface
Northing/ Easting	—	Elevation	247.97

LOCATION SKETCH/EXTRA FIELD NOTES: N
[surface condition, ie. Asphalt, grass]

See well sheet

DEPTH (FEET)	BLOWS/FT	INCHES DRIVEN	INCHES RECVED	PID	TIME	USCS Classification	SOIL DESCRIPTION AND NOTES (color, major constituents/minor constituents [particle distribution and particle shape], density, plasticity, cohesiveness, moisture content, fracturing, weathering, depositional environment, stratigraphic unit)
0–2							Crushed shot rock. 0.1-0.2' in size. Water just below ground surface in open hole. See photos
2–5							Assumed to be boulders up to 7" in size. A squared straight edge boulder is spit up by auger through smaller shot rock
5–10							↑ Same? Hole to 10' is cased w/ auger flights. Refusal is hit @ ~10.0'. Drillers believe they are in competent rock and begin rock coring when POL contamination is pumped to surface.

Contamination w/ POL

Ahtna Engineering

SOIL BORING LOG

PROJECT NUMBER:	BORING NUMBER:	SHEET:
20266022	AES16-TB-MW03	1 of 1

Project Name	Wrangell Monofill	Site	Pat Creek
Client	AOEC	Geologist	Ducomb
Date	2-Dec-2016	Weather	Rain
Drilling Company	Discovery	Rig Type/ Drilling	6712DT / Auger
Boring Size	8" Auger	Hammer Drop	—
Sample Method	—	# of Samples	—
Total Depth	6.31	Depth to GW	~~3.17' BTOC~~
Northing/ Easting	—	Elevation	246.93'

LOCATION SKETCH/EXTRA FIELD NOTES:
[surface condition, ie. Asphalt, grass]

N

See well Sheet

Below Surface

DEPTH (FEET)	BLOWS/FT	INCHES DRIVEN	INCHES RECVED	PID	TIME	USCS Classification	SOIL DESCRIPTION AND NOTES (color, major constituents/minor constituents (particle distribution and particle shape), density, plasticity, cohesiveness, moisture content, fracturing, weathering, depositional environment, stratigraphic unit)
0							
							Shot Rock
1							Augered to Bedrock Refusal
2							0.1 - 0.2' in size
3							POL Contamination in Groundwater
4							
5							
6							6.3' BGS Stop @ Refusal Bedrock
7							
8							
9							

ATTACHMENT 332900-B
Well Completion Logs

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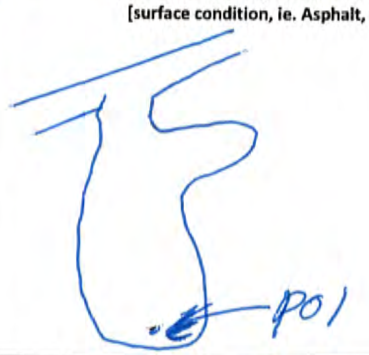
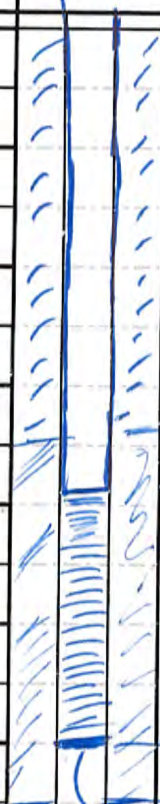
Ahtna Engineering	WELL CONSTRUCTION LOG	PROJECT NUMBER: 20266022	WELL NUMBER: AES16-P01	SHEET: 1 of 1

PROJECT NAME	Wrangell Monofill	SITE	Rock Pit PatCreek
CLIENT	ADEC	SCIENTIST	DuComb
DATE	2-Dec-2016	WEATHER	Rain 40°F
DRILLING COMPANY	Discovery	RIG TYPE	6712DT
BORING SIZE	3.75"	DRILLING METHOD	Rock Core / DHH
TOTAL DEPTH	32.30'	WELL TYPE	1" PVC
NORTHING	—	DEPTH TO GW	2.46'
EASTING	—	ELEVATION	250.69'

LOCATION SKETCH/EXTRA FIELD NOTES:
[surface condition, ie. Asphalt, grass]

N



DEPTH (FEET)	FIELD ILLUSTRATION	WELL INSTALLATION INFO	SOIL DESCRIPTION	WELL DATA
0				Monument Type: Security Casing
5		Bentonite 0-18.5'	See Soil Boring Log For AES16-TB01	Surface Seal: Bentonite
10				Stickup Height: 2.73'
15				40 ~~0.010~~ -inch Schedule PVC Well Casing
20		Sand		Screened Interval: 19.6 - 29.6' BGS
25		Screen		0.010 " Slotted Screen
30		Sand		Other:
		Capped		

Ahtna Engineering

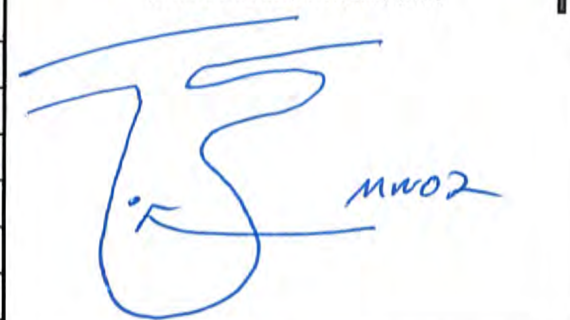
WELL CONSTRUCTION LOG

PROJECT NUMBER:	WELL NUMBER:	SHEET:
20266.022	16AES-MW02	1 of 1

PROJECT NAME	Wrangell Monofill	SITE	ROCK PIT
CLIENT	ADEC	SCIENTIST	DUCOMB
DATE	21-Dec-2016	WEATHER	Rain
DRILLING COMPANY	Discovery	RIG TYPE	6712 DT
BORING SIZE	Auger Casing	DRILLING METHOD	Auger TO refusal
TOTAL DEPTH	10'	WELL TYPE	2"
NORTHING	—	DEPTH TO GW	2.92'
EASTING	—	ELEVATION	250.59'

LOCATION SKETCH/EXTRA FIELD NOTES:
[surface condition, ie. Asphalt, grass]

N

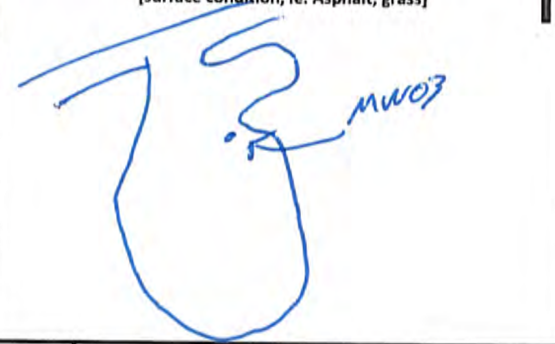


DEPTH (FEET)	FIELD ILLUSTRATION	WELL INSTALLATION INFO	SOIL DESCRIPTION	WELL DATA
0		Bentonite pellets; riser TO Above ground surface	See AES16-TB02 core FORM; * HIT CONTAMINATED POL	Monument Type: Security Casing
2				Surface Seal: Bentonite
4		1'		Stickup Height: 2.62'
5				40 -inch Schedule PVC Well Casing
6				Screened Interval: 5-10' BGS
8		SAND; 5' screen		0.010" Slotted Screen
10		← 9.83' BGS		Other:

Ahtna Engineering	WELL CONSTRUCTION LOG	PROJECT NUMBER: 20266022	WELL NUMBER: 16 AES-MW03	SHEET: 1 of 1

PROJECT NAME	Wrangel Mono Fill	SITE	ROCK PIT
CLIENT	ADEC	SCIENTIST	DeComB
DATE	2-Dec-2016	WEATHER	Rain
DRILLING COMPANY	Discovery	RIG TYPE	6712 DT
BORING SIZE	Auger Casing	DRILLING METHOD	Auger To Refusal
TOTAL DEPTH	5'	WELL TYPE	2"
NORTHING	—	DEPTH TO GW	3.17'
EASTING	—	ELEVATION	249.85

LOCATION SKETCH/EXTRA FIELD NOTES:
[surface condition, ie. Asphalt, grass]



DEPTH (FEET)	FIELD ILLUSTRATION	WELL INSTALLATION INFO	SOIL DESCRIPTION
0		Bentonite; Riser to above Ground surface	See form AES16-TB01 core
1			
2			
3		3' screen	* HIT Contamination POL
4			
5		Sand; 6.31' BGS	Bed rock Refusal

WELL DATA

Monument Type: Security casing

Surface Seal: Bentonite

Stickup Height: 2.92*

40 -inch Schedule PVC Well Casing

Screened Interval: 2-5' BGS

0.010 " Slotted Screen

Other:

Note: This page intentionally left blank

1.0 GENERAL

1.1 SUMMARY

A. The Contractor shall provide all equipment, materials, and personnel necessary to install subdrain systems as required for completion of the Work.

B. Piping shall be furnished and installed with materials and sizes and at elevations and locations shown on the Design Drawings or designated in these specifications.

1.2 SUBMITTALS

A. Product Data and ASTM certifications including rated capacities.

2.0 PRODUCTS

2.1 PERFORATED-WALL PIPES AND FITTINGS

A. Drainage Pipe shall consist of perforated Schedule 40 (forty) polyvinyl chloride (PVC) with a minimum nominal inside diameter of four (4) inches (100 mm). The pipe shall be free from visible cracks, holes, foreign inclusions, or other defects.

B. Perforations shall be either circular or slots arranged in rows parallel to the axis of the pipe. Perforations shall be evenly spaced along each row such that the center-to-center distance between perforations is not less than eight (8) times the perforation diameter. Perforations may appear at the ends of short and random lengths. The minimum perforation opening per foot of pipe shall be twenty-two hundredths (0.22) square inches per foot (in^2/ft).

C. Fittings and joints shall be compatible with the pipe material and dimensions, and shall be solvent welded.

D. Solvent cement for socket joints shall comply with ASTM D2564.

3.0 EXECUTION

3.1 SUBDRAINAGE PIPE INSTALLATION

A. Subdrainage pipe installation shall proceed in a method consistent with the alignments, grades, and cross-sections shown or indicated on the Drawings, or detailed in the Specifications.

B. Proper and suitable tools and appliances for convenient handling and laying of pipe and fittings shall be used. Great care shall be taken to prevent entrance of dirt or foreign matter, and to prevent damage of pipe lining and coating. All pieces shall be carefully examined for defect and no piece shall be laid that is known to be defective. If any defective piece is discovered after having been laid, it shall be removed and replaced with a sound piece and in a satisfactory manner.

C. All excavation procedures used, subgrade preparation, and embedment installation during installation of subdrainage pipe shall be conducted in accordance with Section 312000, EARTHWORK.

D. Wood blocking will not be permitted under pipe.

E. No pipe shall be laid on a foundation where frost exists nor at any time when there is danger of formation of ice or the penetration of frost at the bottom of the excavation.

F. Temporary bulkheads shall be placed in all open ends of pipe whenever pipe laying is not actively in process. The bulkheads shall be designed to prevent the entrance of dirt, debris, and water. Precautions shall be taken to prevent flotation of the pipe in the event of water entering the trench.

G. Joins shall be assembled using gaskets, lubricants, and solvents (as applicable) as furnished by the pipe manufacturer and in accordance with the manufacturer's installation guidelines.

H. At the conclusion of the Work, the Contractor shall remove and dispose of any temporary piping used.

3.2 FIELD CUTS AND SPECIAL HANDLING

A. Field cuts of pipes shall be in accordance with the manufacturer's installation guidelines.

B. Where a pipe requires special handling or installation, it shall be in accordance with the manufacturer's instructions for that specific type of pipe and installation.

3.3 FINAL INSPECTION

A. Each section pipe shall be inspected prior to backfilling.

B. The inspection shall determine the pipeline to be true to line and grade, to show no unintended leaks, to have no obstruction to flow, to have no projections or intrusion of connecting pipes or joint materials, shall be free from cracks, and shall contain no deposits of dirt or other foreign material.

C. All deficiencies identified during inspection shall be corrected prior to backfilling.

*** END OF SECTION ***

C Design Drawings

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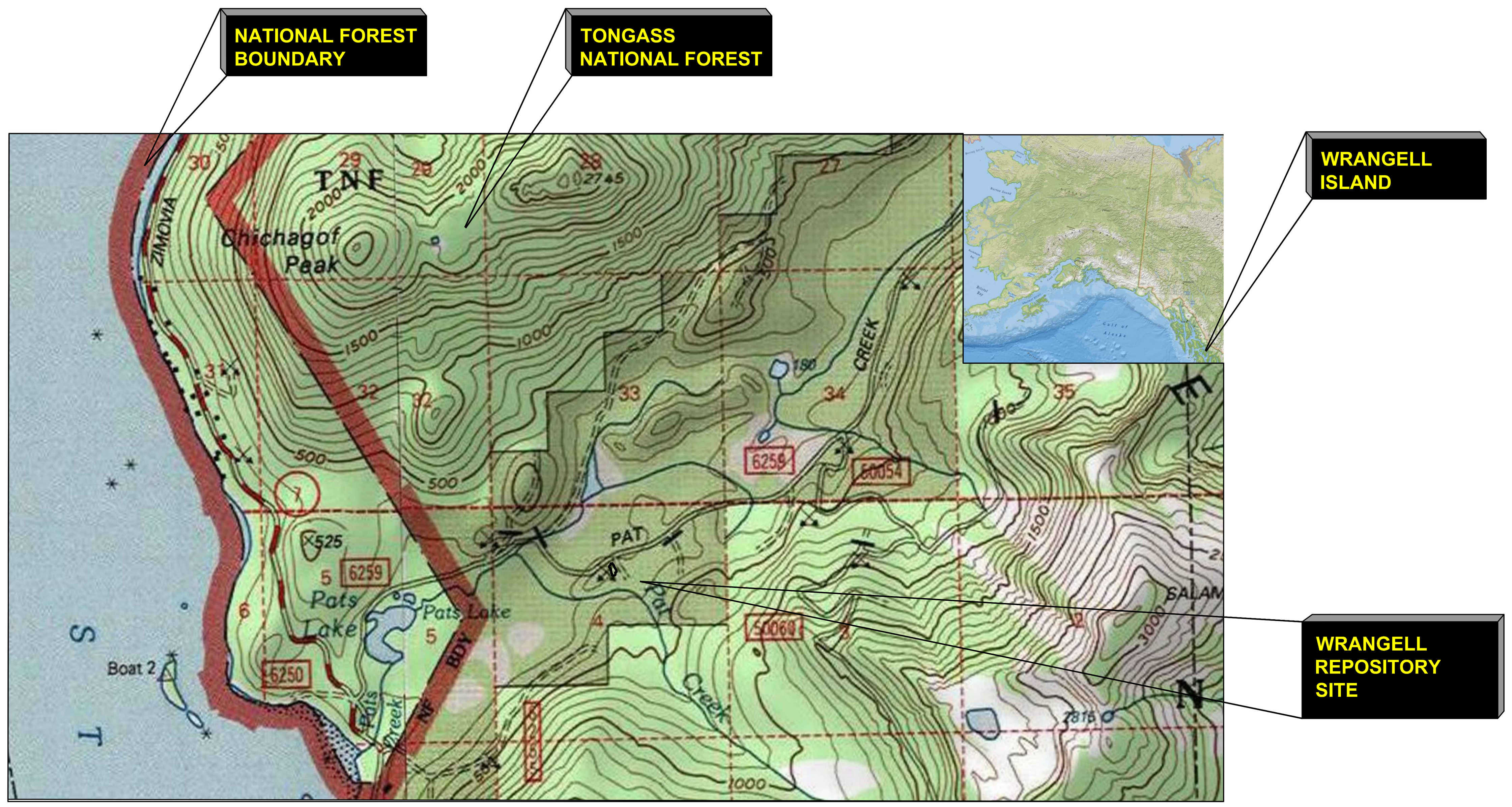
WRANGELL JUNKYARD REPOSITORY

CITY AND BOROUGH OF WRANGELL, ALASKA
TDD NO.: 17-01-0015
PAN NO.: 1004530.0004.178.01



SOURCE: ERSI INC. 2015

VICINITY MAP
1" = 2500'

SOURCE: ERSI INC. 2015

SITE LOCATION MAP
1" = 300'

LIST OF ABBREVIATIONS

APPROX	APPROXIMATE	MH	MANHOLE
℄	CENTER LINE	N	NORTH
CFS	CUBIC FOOT PER SECOND	NO., #	NUMBER
CY	CUBIC YARD	NTS	NOT TO SCALE
D, DIA, ø	DIAMETER	NAD83	NORTH AMERICAN DATUM, 1983
EL	ELEVATION	NAVD88	NORTH AMERICAN VERTICAL DATUM, 1988
FT, '	FEET, FOOT	OC	ON CENTER
GW	GROUNDWATER	OD	OUTSIDE DIAMETER
H, HORIZ	HORIZONTAL	OZ/SQ YD	OUNCE PER SQUARE YARD
HR	HOUR	PVC	POLYVINYL CHLORIDE
I.E.	INVERT ELEVATION	RCP	REINFORCED CONCRETE PIPE
IN, "	INCH	TYP	TYPICAL
MAX	MAXIMUM	V	VERTICAL
MIN	MINIMUM		

SHEET INDEX

SHEET NO.	DESCRIPTION OF DRAWINGS
C-1	VICINITY MAP, SITE LOCATION, AND SHEET INDEX
C-2	EXISTING CONDITIONS SURVEY 2016
C-3	SITE FEATURES AND GRADING PLAN
C-4	PROFILE AND SECTION VIEWS
C-5	CONSTRUCTION DETAILS

STATE OF ALASKA 49TH
Thomas C. Campbell
06-09-17
No. EV14234
REGISTERED PROFESSIONAL ENGINEER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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Drawn by: J. GUERRERO
Reviewed by: T. CAMPBELL, P.E.
Approved by: T. CAMPBELL, P.E.
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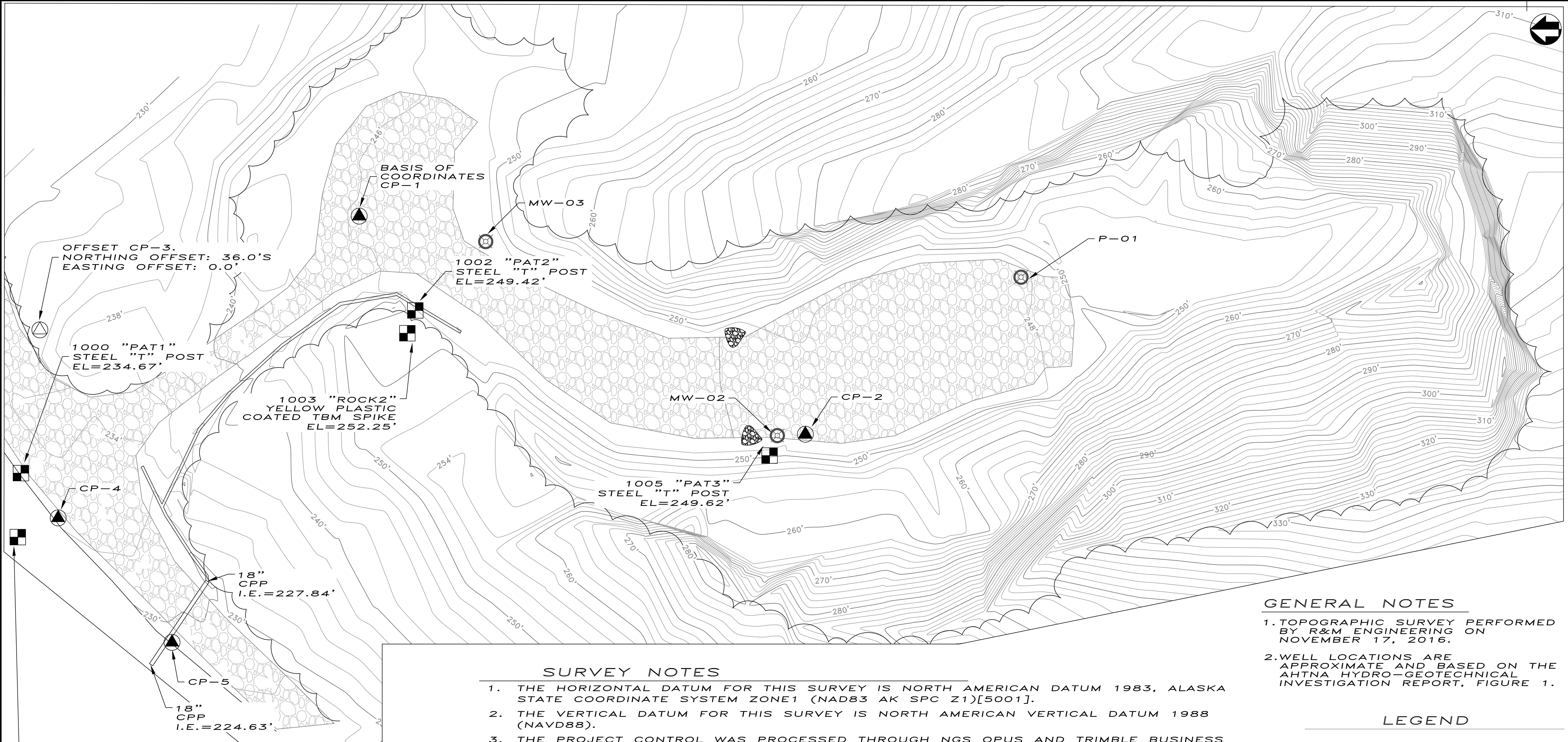
Global Environmental Specialists
720 Third Avenue, Suite 1700
Seattle, Washington 98104
(206) 624-9537 ene.com

CITY AND BOROUGH OF WRANGELL ALASKA
WRANGELL JUNKYARD REPOSITORY
VICINITY MAP, SITE LOCATION, AND SHEET INDEX

Sheet reference number:
C-1
SHEET 1 OF 5



GENERAL NOTES

1. TOPOGRAPHIC SURVEY PERFORMED BY R&M ENGINEERING ON NOVEMBER 17, 2016.
2. WELL LOCATIONS ARE APPROXIMATE AND BASED ON THE AHTNA HYDRO-GEOTECHNICAL INVESTIGATION REPORT, FIGURE 1.

LEGEND

- MONITORING WELL LOCATION
- HORIZONTAL CONTROL POINT (ESTABLISHED)
- OFFSET CONTROL POINT
- TEMPORARY BENCH MARK (ESTABLISHED)
- TOP OF BANK
- TOE OF SLOPE
- 18" CORRUGATED PLASTIC PIPE CULVERT (EXISTING)
- 95' MAJOR EXISTING CONTOUR LINE
- MINOR EXISTING CONTOUR LINE
- TREE LINE
- GRAVEL SURFACE

SURVEY NOTES

1. THE HORIZONTAL DATUM FOR THIS SURVEY IS NORTH AMERICAN DATUM 1983, ALASKA STATE COORDINATE SYSTEM ZONE1 (NAD83 AK SPC Z1)[5001].
2. THE VERTICAL DATUM FOR THIS SURVEY IS NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88).
3. THE PROJECT CONTROL WAS PROCESSED THROUGH NGS OPUS AND TRIMBLE BUSINESS CENTER, VER. 3.7.1.
4. THIS SURVEY WAS PERFORMED WITH A TRIMBLE S7 ROBOTICS INSTRUMENT USING STANDARD LASER RANGING TECHNIQUES.
5. TRIMBLE GNSS R8-2 RECEIVERS WERE USED TO PERFORM GPS STATIC SESSIONS TO OBTAIN DATUM CORRECTIONS.
6. THIS SURVEY AND ALL COORDINATES, SHOWN HEREON, ARE IN NAD 83 AK SPC Z1 GRID COORDINATES.
7. DIFFERENTIAL LEVELING WAS PERFORMED THOUGH ALL BENCHMARKS, SHOWN HEREON. ALL ELEVATIONS WERE ADJUSTED TO THE BASIS OF VERTICAL CONTROL. THIS WORK WAS PERFORMED WITH A SOKKIA B2-1 DIFFERENTIAL LEVEL. THE COLLIMATION OF THIS INSTRUMENT WAS CHECKED PRIOR TO DIFFERENTIAL LEVELING.
8. THE PROJECT SCOPE REQUIRED "T" POSTS, WITH IDENTIFYING LATH, TO BE SET FOR THIS SURVEY. THESE WERE SET, BUT STABILITY IS QUESTIONABLE. ADDITIONAL PLASTIC COATED TBM SPIKES WERE SET IN MORE STABLE POSITIONS AND ARE SHOWN, HEREON.
9. ALL CONVENTIONAL TRAVERSES WERE ADJUSTED USING THE COMPASS-BOWDITCH METHOD.
10. THE FIELD WORK WAS PERFORMED ON OCTOBER 25 – 28, 2016.
11. NO TIES TO THE PUBLIC LAND SURVEY SYSTEM WERE MADE DURING THE COURSE OF THIS SURVEY.
12. THIS SURVEY DOES NOT CONSTITUTE A SUBDIVISION, AS PER AS 40.15.900(5)(A).
13. THIS SURVEY DOES NOT EXCEED THE UNADJUSTED HORIZONTAL CLOSURE REQUIREMENTS FOR FGCS THIRD ORDER, CLASS ONE STANDARDS OF 1:10,000.
14. THIS SURVEY DOES NOT EXCEED THE VERTICAL FGCS THIRD ORDER, CLASS ii REQUIREMENTS.

TABLE OF VERTICAL CONTROL

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
1000	1,653,598	2,960,613	234.67'	STEEL "T" POST WITH IDENTIFYING LATH
1001	1,653,599	2,960,589	233.56'	YELLOW PLASTIC COATED TBM SPIKE IN 8" CEDAR
1002	1,653,446	2,960,676	249.42'	STEEL "T" POST WITH IDENTIFYING LATH
1003	1,653,449	2,960,667	252.25'	YELLOW PLASTIC COATED TBM SPIKE
1005	1653,310	2,960,620	249.62'	STEEL "T" POST WITH IDENTIFYING LATH

TABLE OF HORIZONTAL CONTROL

CP	NORTHING	EASTING	LATITUDE	LONGITUDE	ELEVATION	DESCRIPTION
1	1,653,467.90	2,960,712.17	N56°21'13.77"	W132°18'42.32"	246.20'	8" SPIKE
2	1,653,296.37	2,960,628.28	N56°21'12.09"	W132°18'43.87"	247.77'	8" SPIKE
3	1,653,626.60	2,960,668.38	N56°21'15.34"	W132°18'43.04"	232.28	14" SPIKE
4	1,653,583.57	2,960,596.09	N56°21'14.93"	W132°18'44.34"	232.66'	8" SPIKE
5	1,653,539.78	2,960,548.29	N56°21'14.51"	W132°18'45.20"	229.71'	5/8" X 30" REBAR

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Drawn by: J. GUERRERO
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Approved by: T. CAMPBELL, P.E.
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CITY AND BOROUGH OF WRANGELL ALASKA
WRANGELL JUNKYARD MONOFILL
EXISTING CONDITIONS SURVEY 2016

Sheet reference number:
C-2
SHEET 2 OF 5

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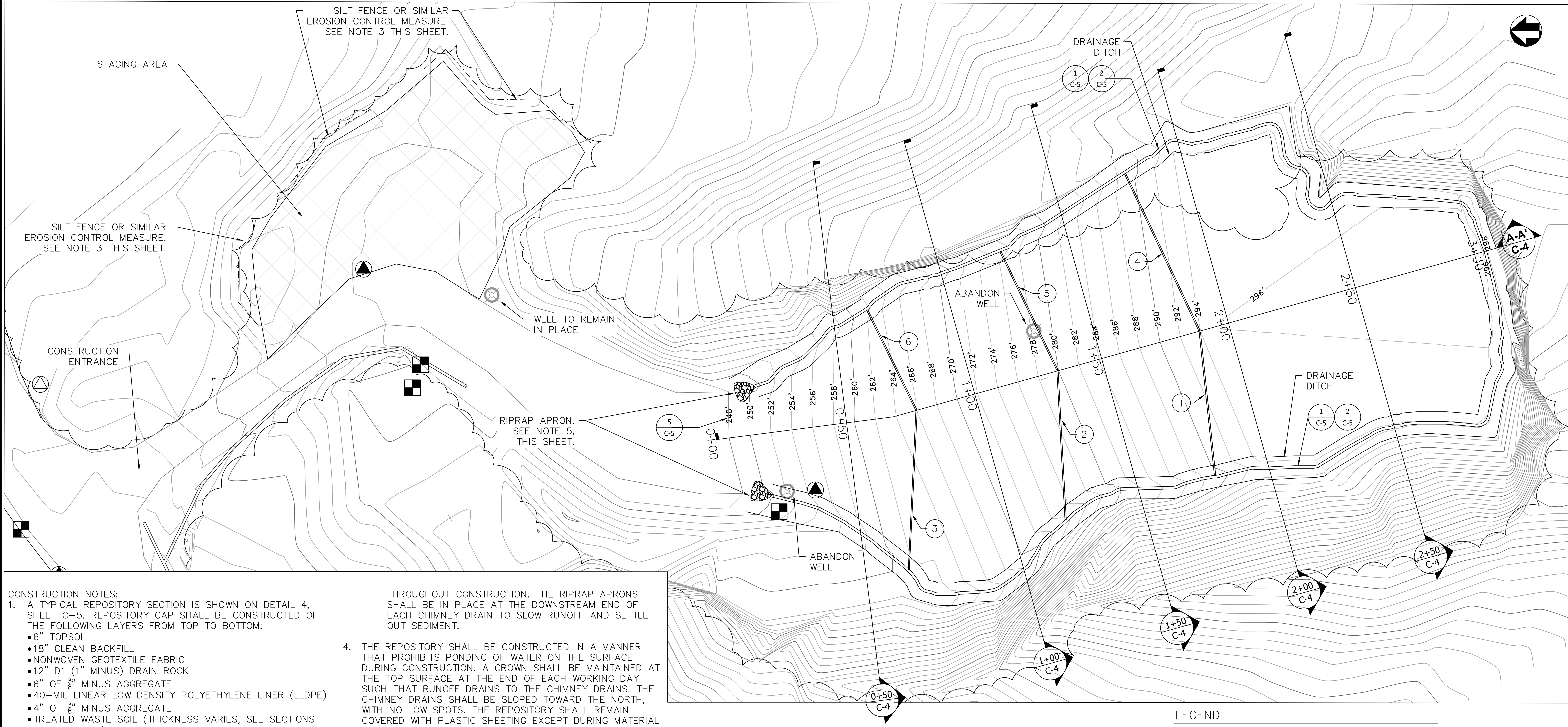

CONSTRUCTION NOTES:

1. A TYPICAL REPOSITORY SECTION IS SHOWN ON DETAIL 4, SHEET C-5. REPOSITORY CAP SHALL BE CONSTRUCTED OF THE FOLLOWING LAYERS FROM TOP TO BOTTOM:
   - 6" TOPSOIL
   - 18" CLEAN BACKFILL
   - NONWOVEN GEOTEXTILE FABRIC
   - 12" D1 (1" MINUS) DRAIN ROCK
   - 6" OF ⅝" MINUS AGGREGATE
   - 40-MIL LINEAR LOW DENSITY POLYETHYLENE LINER (LLDPE)
   - 4" OF ⅝" MINUS AGGREGATE
   - TREATED WASTE SOIL (THICKNESS VARIES, SEE SECTIONS ON SHEET C-4)
   - NON-WOVEN GEOTEXTILE FABRIC
   - 24" BASE LAYER OF SHOT ROCK TOPPED WITH SMALLER AGGREGATE SUCH AS 6" MINUS ROCK AND 1" DRAIN ROCK TO FORM A SMOOTH UNYIELDING SURFACE.

   LAYER DETAILS SHOWN ON DETAIL 3, SHEET C-5.
2. TREATED WASTE MATERIAL SHALL NOT BE PLACED ADJACENT TO EXISTING GRADE OR QUARRY WALLS. A 2' BASE LAYER OF 6" MINUS ROCK SHALL BE PLACED ALONG THE EXISTING QUARRY FLOOR OVER THE ENTIRE PROPOSED REPOSITORY FOOTPRINT. A 3' WIDE CHIMNEY DRAIN WILL EXTEND AROUND THE PERIMETER OF THE REPOSITORY TO PROVIDE DRAINAGE AND MATERIAL SEPARATION.
3. RUNOFF AND SEDIMENT SHALL BE MANAGED DURING CONSTRUCTION.
   3.1. THE STAGING AREA SHALL BE MAINTAINED IN A MANNER THAT LIMITS FUGITIVE DUST BY UTILIZING A WATER TRUCK AS NECESSARY. THE DOWN-GRADIENT PERIMETER OF THE STAGING AREA SHALL BE PROTECTED FROM EROSION AND SEDIMENTATION. BRUSH BARRIERS, SILT FENCE, OR STRAW WATTLES MAY BE USED FOR THIS PURPOSE.
   3.2. RUNOFF FROM THE REPOSITORY SHALL BE CONSIDERED DURING CONSTRUCTION. CHIMNEY DRAINS SHALL BE BUILT UP CONCURRENT WITH PLACING WASTE MATERIAL SUCH THAT THE REPOSITORY WILL DRAIN RUNOFF TO THE QUARRY SIDES AND TOWARD THE NORTH THROUGHOUT CONSTRUCTION. THE RIPRAP APRONS SHALL BE IN PLACE AT THE DOWNSTREAM END OF EACH CHIMNEY DRAIN TO SLOW RUNOFF AND SETTLE OUT SEDIMENT.
4. THE REPOSITORY SHALL BE CONSTRUCTED IN A MANNER THAT PROHIBITS PONDING OF WATER ON THE SURFACE DURING CONSTRUCTION. A CROWN SHALL BE MAINTAINED AT THE TOP SURFACE AT THE END OF EACH WORKING DAY SUCH THAT RUNOFF DRAINS TO THE CHIMNEY DRAINS. THE CHIMNEY DRAINS SHALL BE SLOPED TOWARD THE NORTH, WITH NO LOW SPOTS. THE REPOSITORY SHALL REMAIN COVERED WITH PLASTIC SHEETING EXCEPT DURING MATERIAL PLACEMENT TO PREVENT INFILTRATION PRIOR TO PLACEMENT OF ENGINEERED CAP.
5. THE DRAINAGE CHANNELS SHALL TERMINATE AT RIPRAP APRONS CONSTRUCTED OF 6" MINUS MATERIAL. THE APRONS SHALL EXTEND A MINIMUM OF 10 FEET BEYOND THE DRAINAGE CHANNEL ALONG EXISTING GRADE TO DISSIPATE ENERGY AND DEPOSIT SEDIMENT. THE APRONS SHALL BE PLACED PRIOR TO CONSTRUCTION OF THE REPOSITORY, AND SHALL BE MAINTAINED THROUGHOUT CONSTRUCTION. SIGNIFICANT SEDIMENT SHALL BE CLEANED FROM THE APRONS PRIOR TO DEMOBILIZATION. NO EXCAVATION SHALL TAKE PLACE TO CONSTRUCT APRON.
6. UPON COMPLETION OF TOPSOIL PLACEMENT, THE ENTIRE REPOSITORY CAP AREA SHALL BE SEEDED WITH NATIVE GRASS. SEE PLANTING SPECIFICATION FOR SEED MIX.
7. CLEARING AND GRUBBING SHALL BE PERFORMED AS NECESSARY. ALL TREES AND BRUSH SHALL BE REMOVED WITHIN THE REPOSITORY PRIOR TO CONSTRUCTION.

UNDERDRAIN PIPE SCHEDULE

ID	DIAMETER (IN)	LENGTH (FT)	SLOPE (%)
1	4	55	3.00
2	4	57	3.00
3	4	61	3.00
4	4	66	3.00
5	4	50	3.00
6	4	42	3.00

UNDERDRAIN PIPE NOTES:
1. UNDERDRAIN PIPE SHALL BE 4"ø PERFORATED PVC.
2. ALL UNDERDRAINS SHALL DAYLIGHT AND DISCHARGE TO THE DRAINAGE DITCH.

LEGEND
- MONITORING WELL LOCATION
- HORIZONTAL CONTROL POINT (ESTABLISHED)
- OFFSET CONTROL POINT
- TEMPORARY BENCH MARK (ESTABLISHED)
- TOP OF BANK
- TOE OF SLOPE
- 95' MAJOR EXISTING CONTOUR LINE
- MINOR EXISTING CONTOUR LINE
- TREE LINE
- 1 PROPOSED UNDERDRAIN PIPE (SEE UNDERDRAIN PIPE SCHEDULE)
- STAGING AREA
- EROSION CONTROL MEASURE
- RIPRAP APRON
- 95' MAJOR PROPOSED CONTOUR
- MINOR PROPOSED CONTOUR

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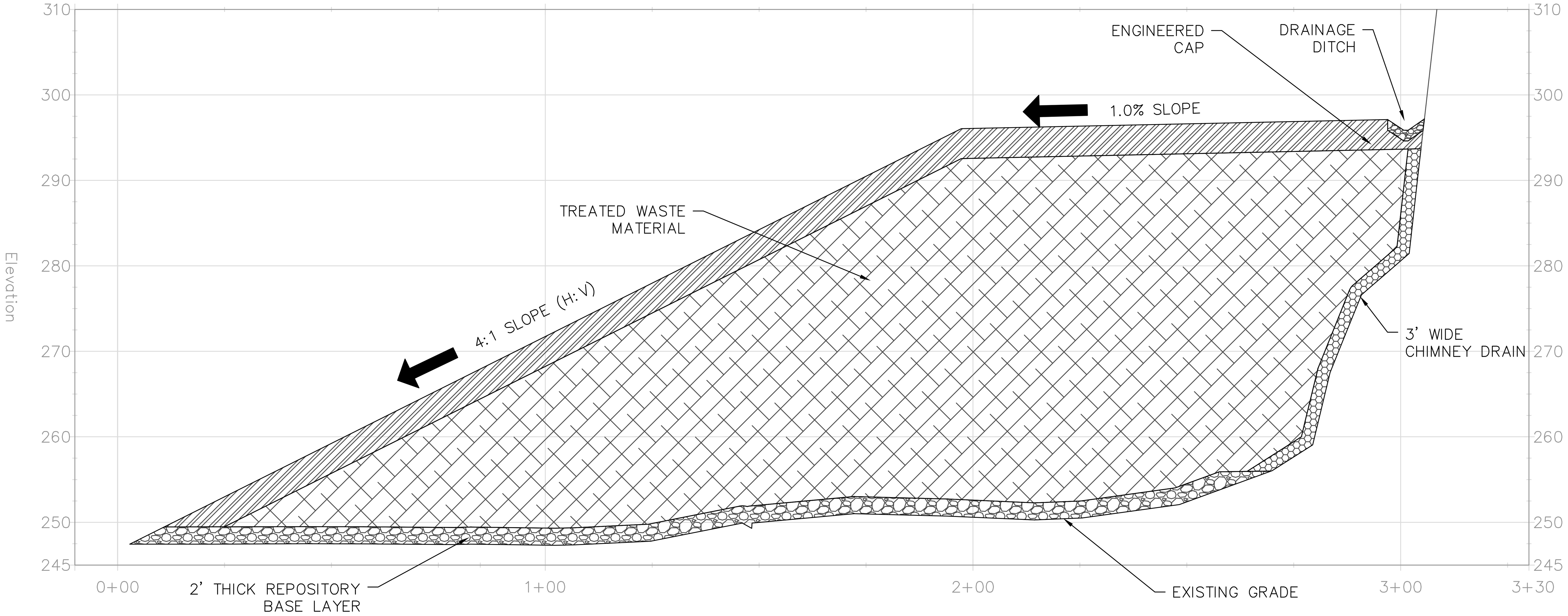
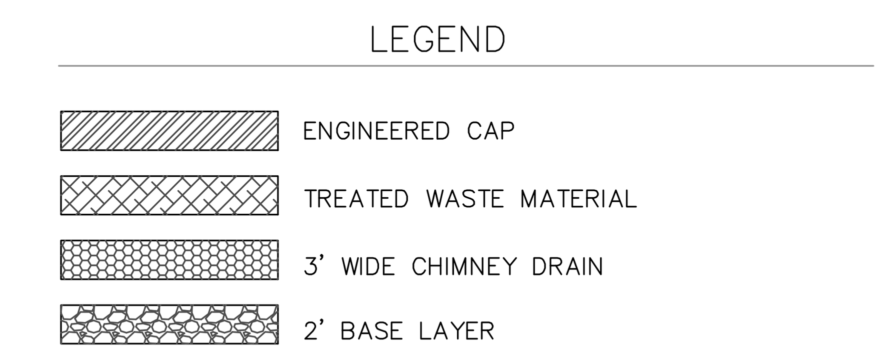
CITY AND BOROUGH OF WRANGELL ALASKA
WRANGELL JUNKYARD MONOFILL
SITE FEATURES AND GRADING PLAN

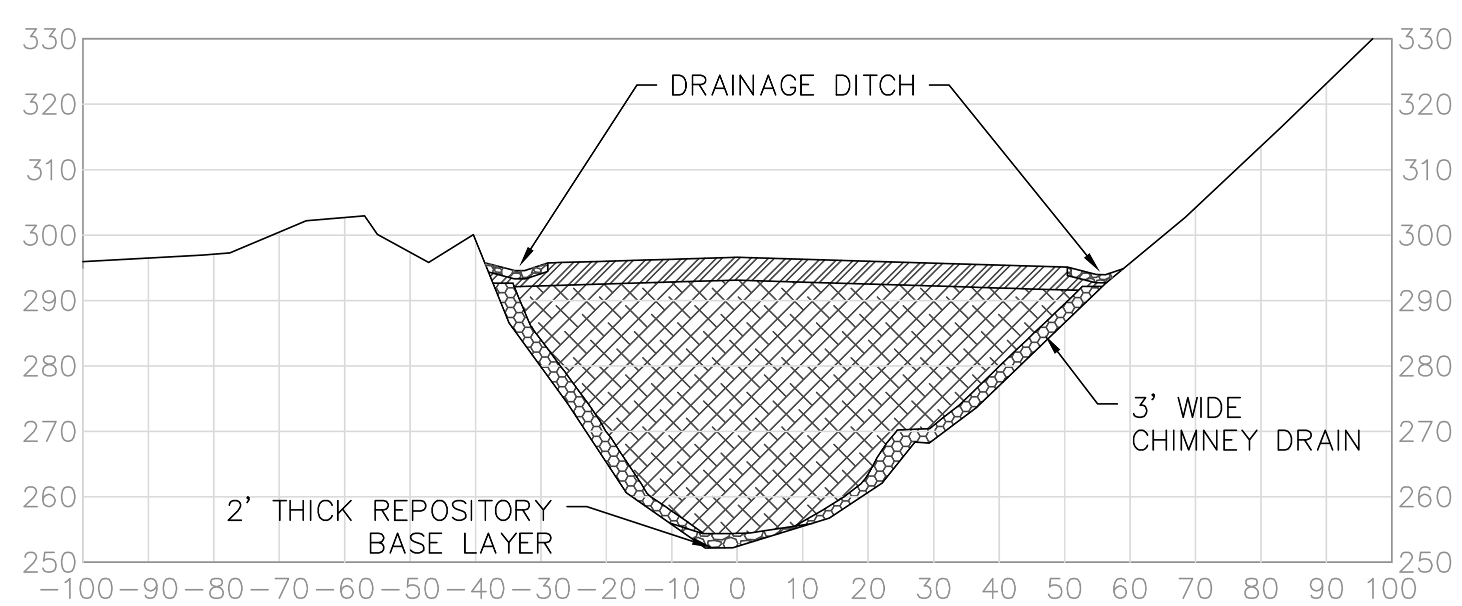
Sheet reference number:
C-3
SHEET 3 OF 5



A-A' / C-3 REPOSITORY PROFILE VIEW

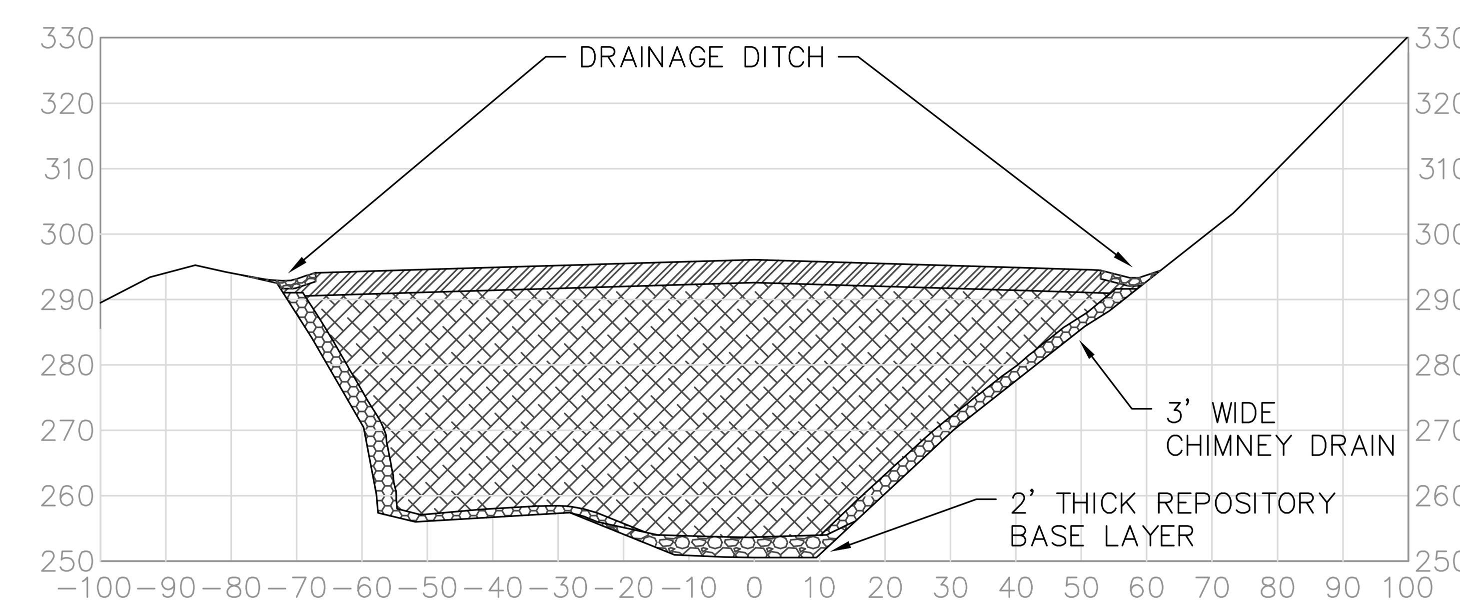
SCALE: AS SHOWN





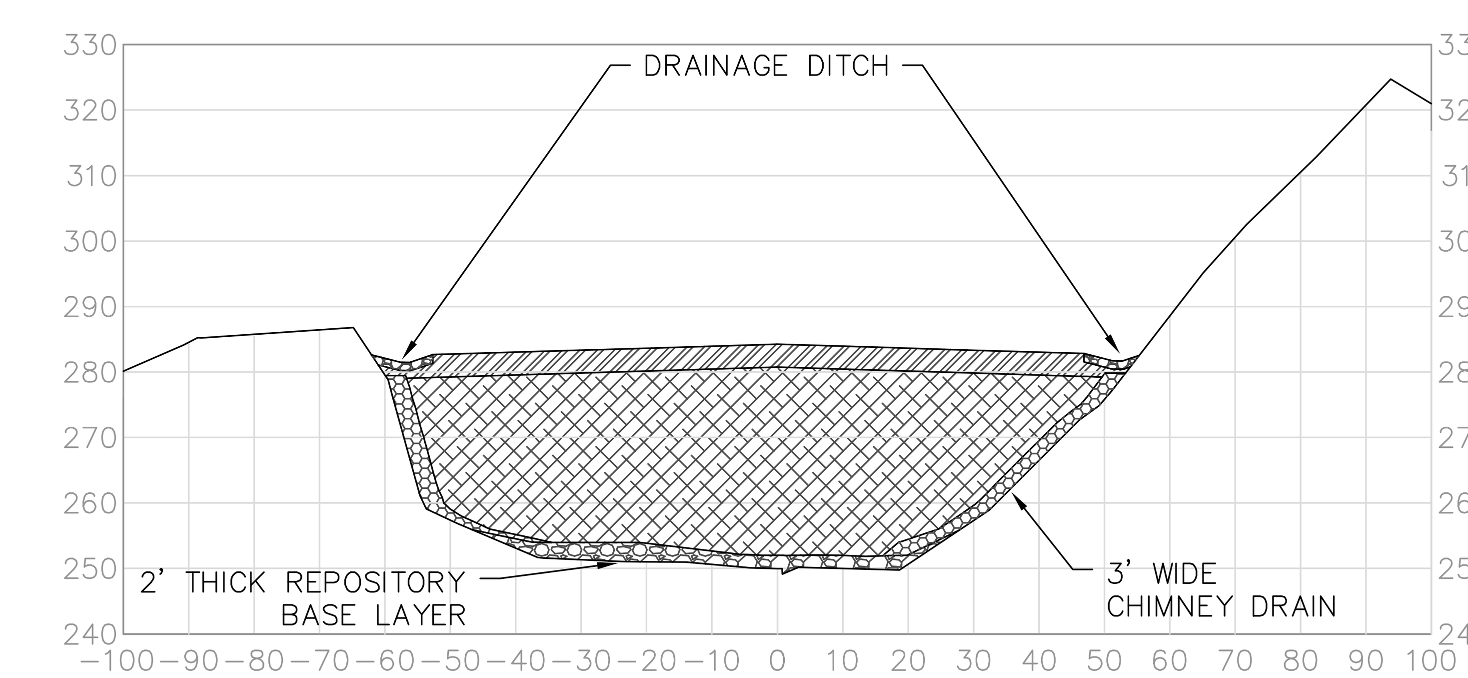
2+50 / C-3 REPOSITORY SECTION VIEW

SCALE: AS SHOWN



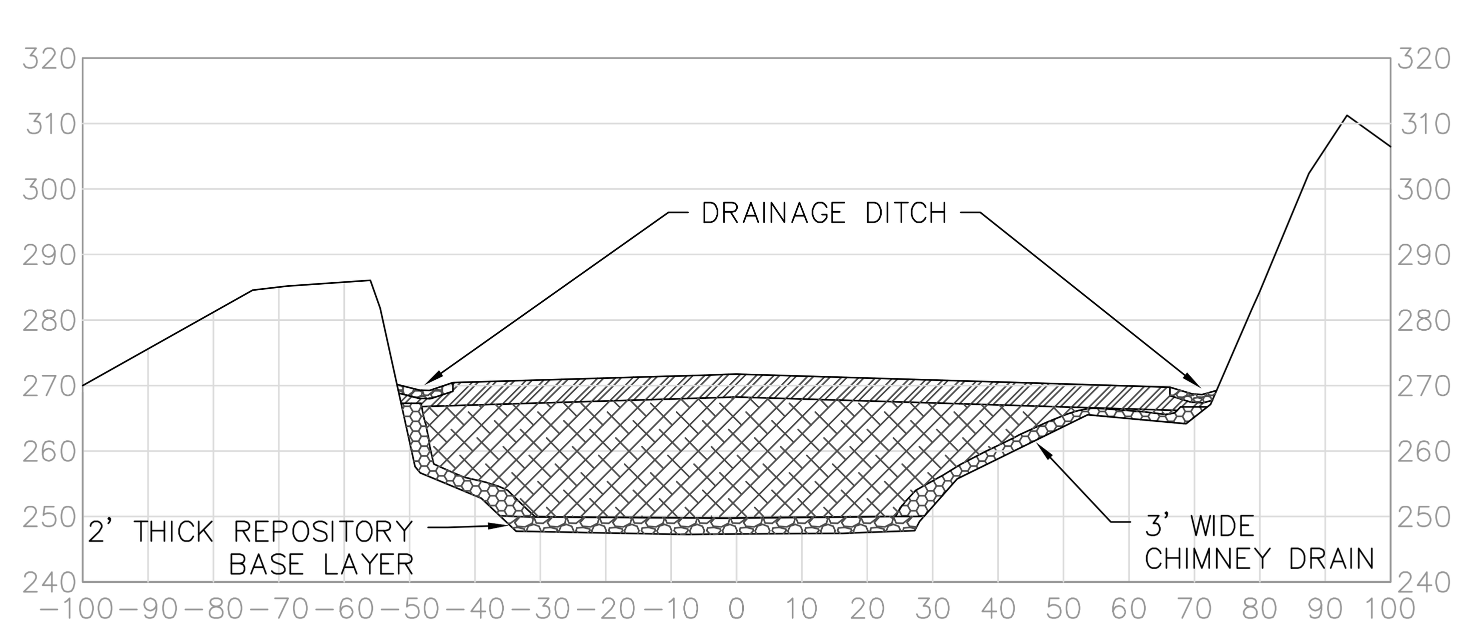
2+00 / C-3 REPOSITORY SECTION VIEW

SCALE: AS SHOWN



1+50 / C-3 REPOSITORY SECTION VIEW

SCALE: AS SHOWN



1+00 / C-3 REPOSITORY SECTION VIEW

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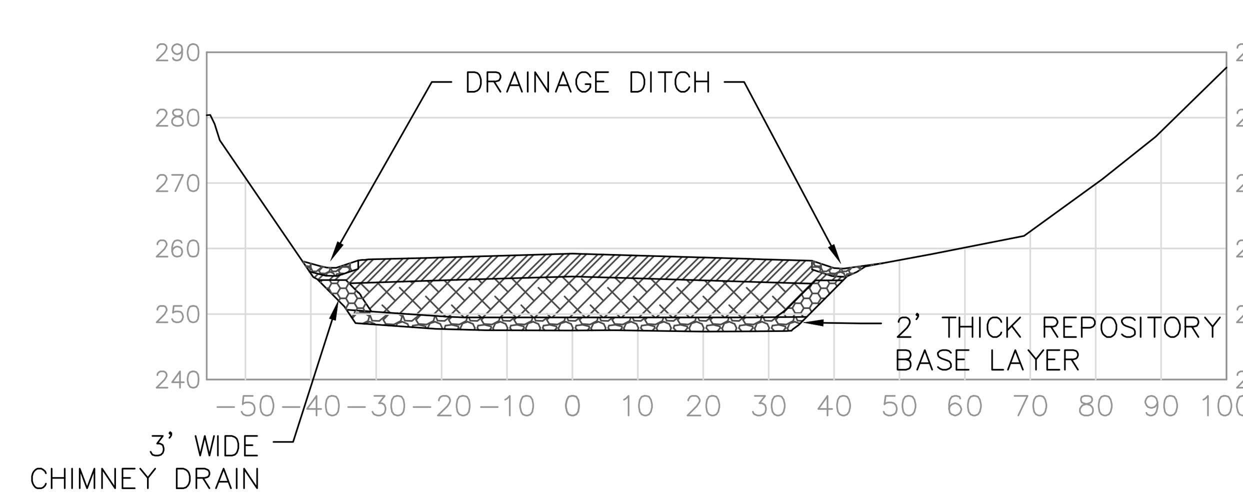

0+50 / C-3 REPOSITORY SECTION VIEW

SCALE: AS SHOWN

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Drawn by: J. GUERRERO	Spec No.:	TDD #: 17-01-0015
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Approved by: T. CAMPBELL, P.E. ALASKA_PE_LICENSE#EV14234		DWG Scale: AS SHOWN

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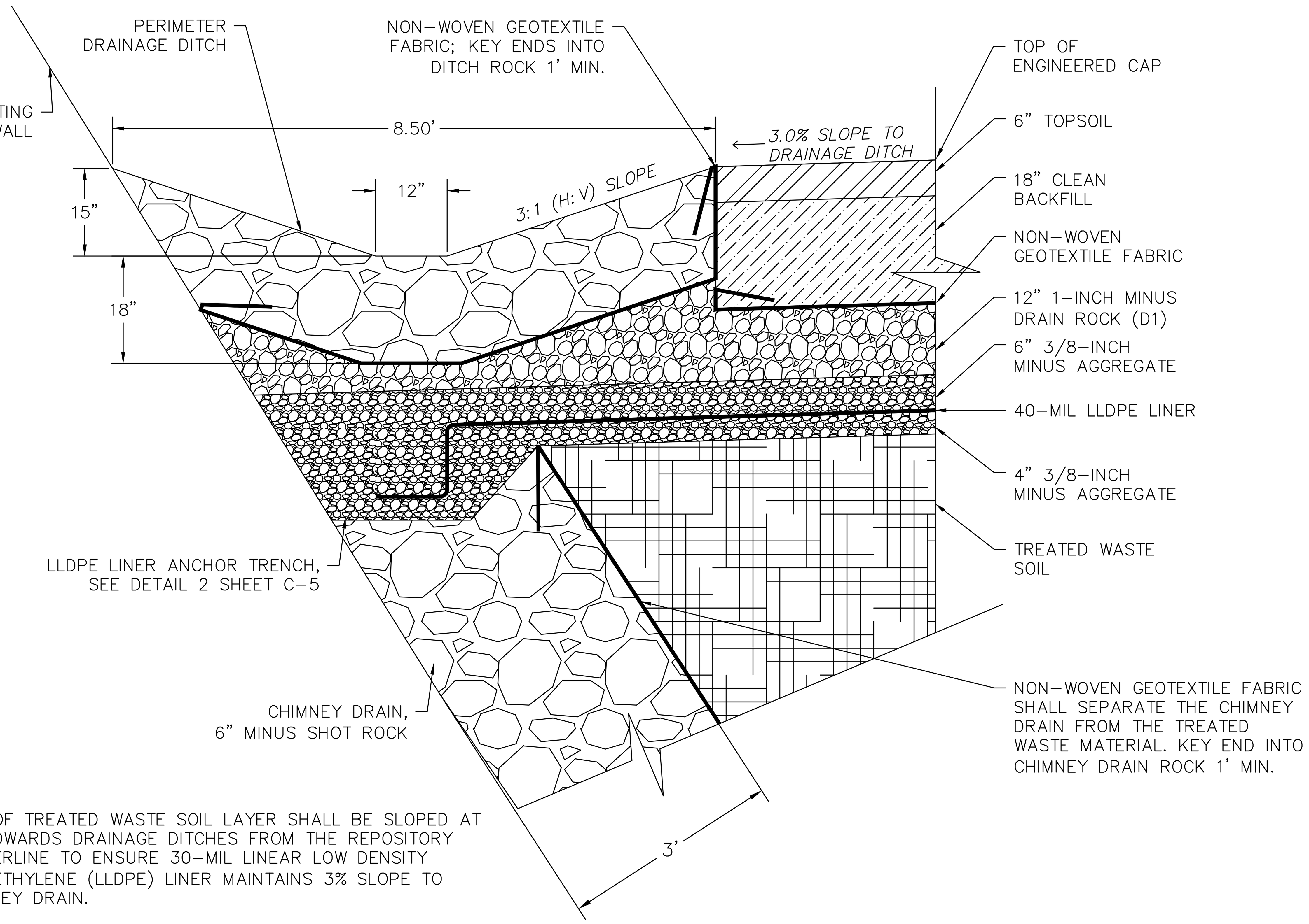
CITY AND BOROUGH OF WRANGELL ALASKA
WRANGELL JUNKYARD MONOFILL

PROFILE AND SECTION VIEWS

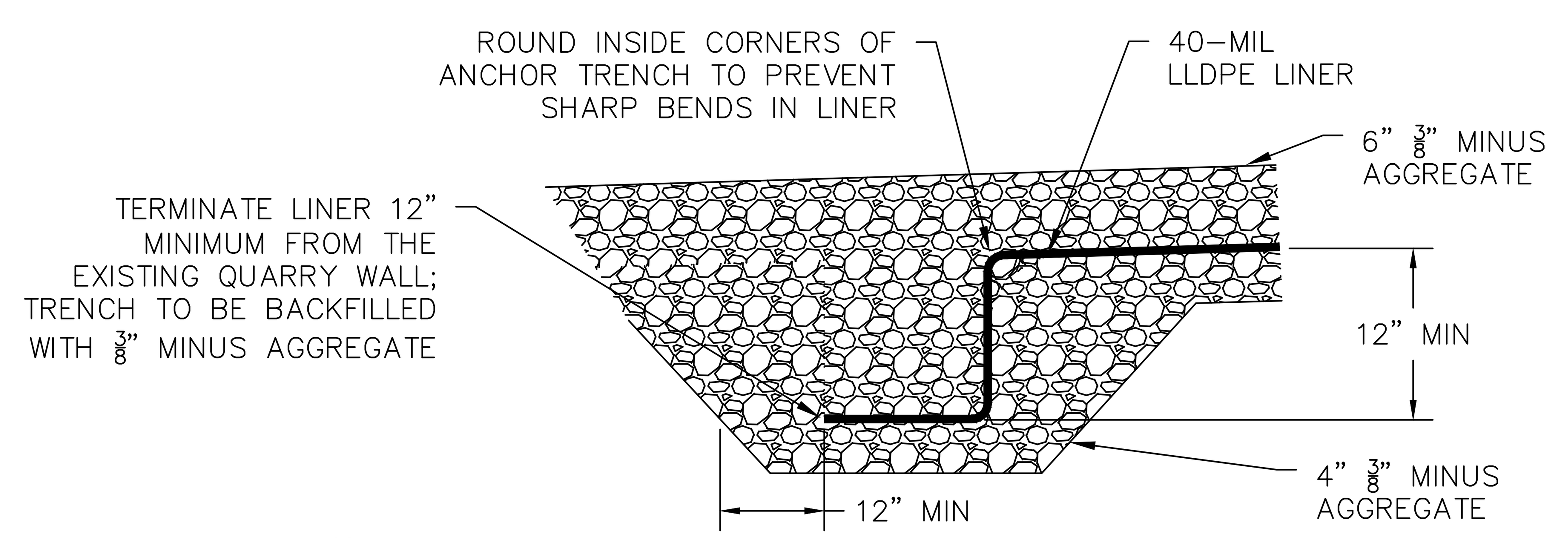
Sheet reference number: **C-4**

STATE OF ALASKA 49TH Thomas C. Campbell 06-09-17 No. EV14234 REGISTERED PROFESSIONAL ENGINEER



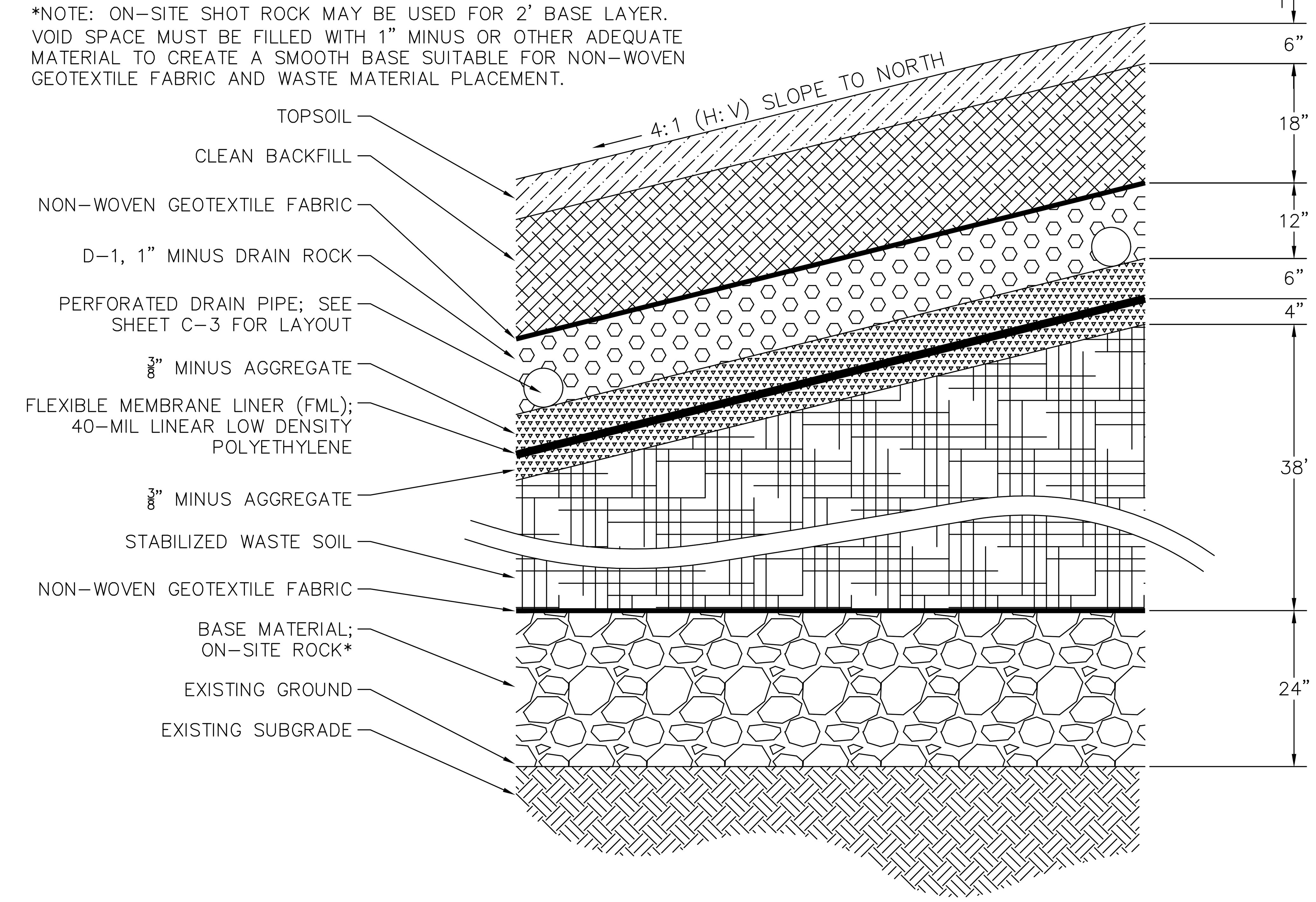
NOTES:
1. TOP OF TREATED WASTE SOIL LAYER SHALL BE SLOPED AT 3% TOWARDS DRAINAGE DITCHES FROM THE REPOSITORY CENTERLINE TO ENSURE 30-MIL LINEAR LOW DENSITY POLYETHYLENE (LLDPE) LINER MAINTAINS 3% SLOPE TO CHIMNEY DRAIN.

1 / **C-3** **DRAINAGE DITCH CONSTRUCTION DETAIL**
SCALE: AS SHOWN

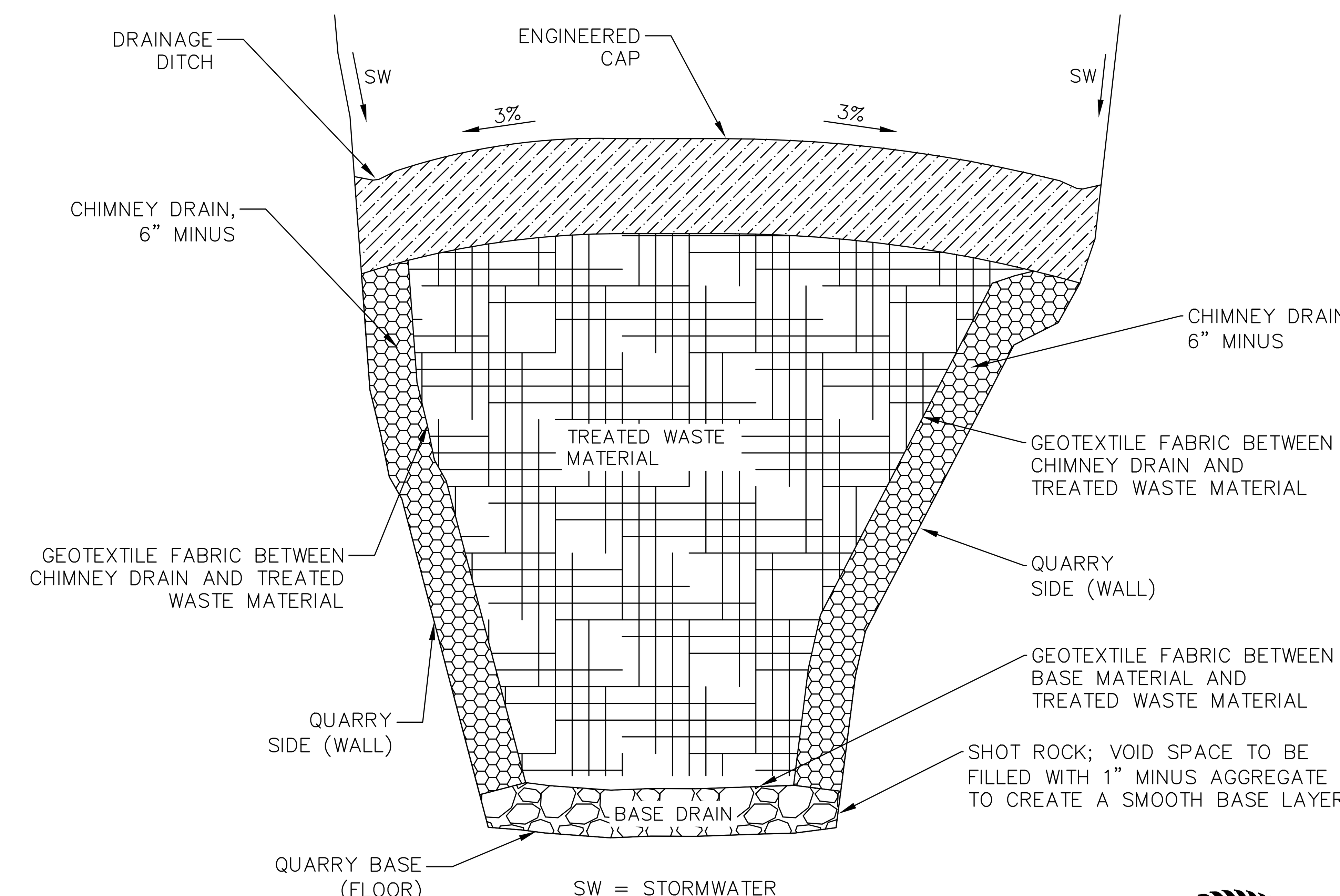


2 / **C-3** **ANCHOR TRENCH CONSTRUCTION DETAIL**
SCALE: AS SHOWN

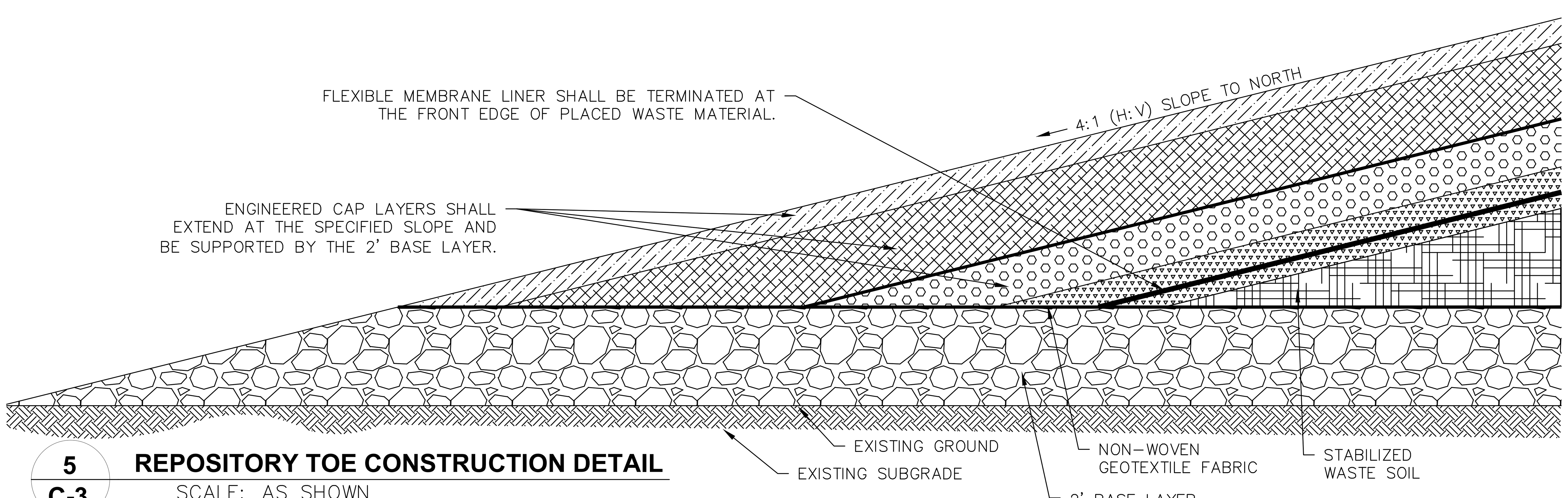
*NOTE: ON-SITE SHOT ROCK MAY BE USED FOR 2' BASE LAYER. VOID SPACE MUST BE FILLED WITH 1" MINUS OR OTHER ADEQUATE MATERIAL TO CREATE A SMOOTH BASE SUITABLE FOR NON-WOVEN GEOTEXTILE FABRIC AND WASTE MATERIAL PLACEMENT.



3 / **C-3** **REPOSITORY LAYERS CONSTRUCTION DETAIL**
SCALE: AS SHOWN



4 / **C-3** **REPOSITORY TYPICAL SECTION DETAIL**
SCALE: AS SHOWN



5 / **C-3** **REPOSITORY TOE CONSTRUCTION DETAIL**
SCALE: AS SHOWN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Symbol	Description	Date	Approved
0	ISSUED FOR CONSTRUCTION	06-09-17	TCC

SIZE D
IF SHEET IS LESS THAN 22"X34" IT IS REDUCED PRINT-SCALE REDUCED ACCORDINGLY
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Designed by: J. GUERRERO
Drawn by: J. GUERRERO
Reviewed by: T. CAMPBELL, P.E.
Approved by: T. CAMPBELL, P.E.
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Date: 06/09/2017
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ecology and environment, inc.
Global Environmental Specialists
720 Third Avenue, Suite 1700
Seattle, Washington 98104
(206) 624-9537 ene.com

CITY AND BOROUGH OF WRANGELL ALASKA
WRANGELL JUNKYARD MONOFILL
CONSTRUCTION DETAILS

STATE OF ALASKA 49TH Thomas C. Campbell 06-09-17 No. EV14234 REGISTERED PROFESSIONAL ENGINEER

Sheet reference number:
C-5
SHEET 5 OF 5

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