HEALY HYDRAULIC PIT RECLAMATION PROJECT SUBSURFACE EXPLORATION AND THAW STABILITY EVALUATION

Prepared For:
Alaska Department of Natural Resources
550 West 7th Avenue, Suite 900D
Anchorage, AK 99501-3577
USA
April 8, 2016

The following Healy Hydraulic Pit Reclamation Geotechnical Report for the Alaska Department of Natural Resources has been prepared under the direct supervision of Michael E. Henderson, a registered Professional Engineer in the State of Alaska. The findings and recommendations presented have been prepared in accordance with generally accepted professional engineering principles and practices.

Prepared by: Michael E. Henderson, P.E.
DOWL
Principal & Mining Practice Leader
Alaska P.E. No.: 8944

STATE OF ALASKA
49TH
Michael E. Henderson
No. 8944
April 8, 16
REGISTERED PROFESSIONAL ENGINEER

X ______________________

April 7, 2016
W.O. 1543.90056.01
Area 9
Report No. 5732

Mr. Roger Allely
Project Manager
Alaska Department of Natural Resources
550 West 7th Avenue, Suite 900D
Anchorage, AK 99501-3577

Subject: Healy Hydraulic Pit Reclamation Project – Subsurface Exploration and Thaw Stability Evaluation

Dear Mr. Allely:

The Alaska Department of Natural Resource (ADNR) is in the process of reclaiming a 70-acre abandoned surface coal mine along Healy Creek, approximately 6.5 miles east of Healy, Alaska. Reclamation of the site requires that the existing vertical headwalls be sloped for stability and revegetation. Efforts to reduce the slope of the northern headwall have already begun and work on the eastern wall is now planned.

INTRODUCTION

Purpose of Investigation

The purpose of this investigation is to assess subsurface soil and groundwater conditions at the site, perform laboratory soil tests to evaluate the moisture content of the soils, evaluate the site data with respect to the planned reclamation, and provide geotechnical recommendations based on these evaluations.

Scope of Work

DOWL submitted a proposal, dated February 10, 2016, to conduct a geotechnical exploration of the site, evaluate the findings, and prepare a geotechnical report. Notice-to-Proceed was provided on February 17, 2016. Following the start of the field exploration, the scope was increased on March 2, 2016 to include three additional borings (the original scope included 18) and limited geotechnical laboratory testing to support the evaluation of potential flow/collapse failures during excavation activities.

In general, the final scope included:

- 21 borings to depths of 21 to 62 feet, over a 1.1 acre area above/east of the exposed highwall;
- Laboratory testing of select samples for moisture content;
- An analysis of the anticipated conditions and behavior of the site soils and groundwater with respect to the planned development; and
- Preparation of a brief letter report that includes subsurface information, potential impacts to the project reclamation grading plan, and any other observations and professional opinions on the suitability of the grading plan.

BACKGROUND

In October 2013, DOWL staff conducted a site visit at the Healy Hydraulic Pit, during which observations concerning the orientation of the significant geologic units were recorded, and samples of these materials were obtained from the northern headwall in the eastern portion of the pit, and from the northeast headwall in the western portion of the pit. Following the site visit, slope stability analyses were performed for the footwall in the southern portion of the pit, which had already experienced slope failures. This work was summarized in a letter dated November 13, 2013. In brief, it was concluded that the southern portion of the pit was most susceptible to slope instability, and DOWL recommended the installation of properly sized underdrains to control groundwater seeps in that area.

According to Mr. Allely of the Alaska Department of Natural Resources (ADNR), several slope/slump failures occurred during excavations of permafrost in unconsolidated sands and gravels above and behind the headwall to the east. The excavations were performed in the summer of 2015, and fluid sediments flowed from the excavations for over 24 hours. Based on DOWL's geologic observations, it is suspected that the water encountered was perched, and not part of a regional groundwater system. One possible explanation for this sediment flow relates to the presence of ice lenses and frozen silty sands observed on site. Permafrost thaw-water from the slope to the south may have been dammed by the frozen silty sands, and, as the frozen silty sand barrier was removed during excavation, its removal could have allowed the dammed fluid and sediment to flow into the excavation. The flowing sands slope failure that occurred during the 2015 reclamation activities, and the possibility for another such event, are understood to be part of the impetus for the current work.

GEOTECHNICAL INVESTIGATION

Field Exploration

Drilling was performed at the Healy Hydraulic Pit Reclamation from February 23 through March 4, 2016. Test boring locations were recorded in the field using a Trimble Geo XH GPS, and are shown on Figure A-1, Test Boring Location Maps and Cross Sections, located in Appendix A. The test borings were drilled using a CME-850 track-mounted drill rig fitted with a continuous-flight, hollow-stem auger. The rig is owned and operated by Denali Drilling, Incorporated of Anchorage, Alaska. Drilling supervision and subsurface logging was provided by Paul Pribyl, a geologist with DOWL.

Twenty-one test borings were drilled, sampled, and logged to depths of 21.5 to 60.25 feet within the predetermined drill area provided by the ADNR. In general, the test borings were advanced to at least 10 feet below the planned final grade elevations. The three additional borings added to the original scope were drilled in the southeast portion of the site to test the hypothesis that the sediment flow that occurred during previous excavations was due to water supplied by an ice-dammed, up-gradient aquifer, flowing through preferential pathways for permafrost melt-water and infiltrated surface water.

Standard Penetration Tests (SPT) were performed in the test borings by driving a 2-inch outside-diameter, split-spoon sampler a distance of 18 inches with a 140-pound hammer falling 30 inches, in accordance with ASTM Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils (D1586). The standard penetration resistance (N) values shown on the test boring logs indicate the number of blows required to drive the sampler the last 12 inches. The results are an indication of the relative density or consistency of the subsoil. The N-values shown in the logs are raw data from the field and have not been adjusted for sampling equipment type or overburden pressure. In frozen soils, the SPT values are also highly influenced by ice content, ground temperature, and the presence of gravel.

Grab samples were obtained between 1 and 3 feet below the ground surface where each test boring was drilled. Disturbed samples were obtained at 5 feet below the ground surface, and at 5-foot intervals thereafter using the SPT split-spoon sampler. As the soil samples were recovered, they were visually classified according to ASTM D2487 and the Unified Soil Classification System (USCS), and sealed in plastic bags to preserve their natural water content. Visual classifications performed in the field included descriptions of the frozen soils, in accordance with ASTM D4083. The samples were then transported to DOWL's laboratory, in accordance with ASTM D4220, for further testing. Another visual classification was conducted on the recovered samples after the samples were allowed to thaw in order to confirm the field classification. The visual classification and water content values are reported on the test boring logs, located in Appendix B.

It should be noted that the largest particle size that can be recovered with standard drill hole samplers is often smaller than the maximum particle size in a gravelly soil deposit. Therefore, the soil descriptions and test results for gravelly soils tend to be biased toward the finer particle sizes. The reader should refer to the Test Boring Log - Descriptive Guide, located in Appendix B immediately following the test boring logs, for a more detailed presentation on sample sizes, sample quality, frost classifications, soil types, and the soil classification procedures.

Slotted PVC standpipes were installed in seven of the test borings. In four of the seven standpipe wells, Temperature Acquisition Cables (TAC) with 21 sensors spaced at 2-foot intervals, for a total measurable length of 40 feet, were installed to collect thermistor (ground temperature) measurements. In order to limit thermal conduction between the surface and the subsurface, pipe insulation was installed in the upper 3 inches of the PVC pipe around the TAC cable, the top of the pipe was sealed with plastic, and the section of PVC above the ground surface was covered with cuttings from the boring.

Laboratory Testing

Natural water content testing was performed on select samples in accordance with ASTM Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (D2216). However, due to limited recovery in some boreholes, some tests may have been performed on samples smaller than the minimum test size required by the standard. The water contents are reported on the graphic test boring logs in Appendix B.

SITE CONDITIONS

Surface

The surface of the site is composed of disturbed gravel and sand. Angular cobbles up to 2 feet in diameter are present on site. All surface vegetation has been removed and the site generally slopes from southeast to northwest. The southern and southeastern boundaries of the site grade into native slopes and vegetation. A drainage ditch has been created to drain the site toward the north and is located several feet to the east of Test Boring 18, between Test Borings 17 and 13 (Figure A-1).

Subsurface

The Healy Valley Hydraulic Pit is mainly located within the Suntrana Formation. The Suntrana Formation is Tertiary aged, poorly consolidated, cross bedded, pebbly quartz sandstone that is interbedded with subbituminous coal. At the project site, the Suntrana Formation is unconformably capped by Quaternary alluvium and pediment gravels originating from the Birch Creek Schist to the south. The Sanctuary Formation conformably underlies the Suntrana Formation, and is a Tertiary aged, poorly consolidated, shale which readily breaks down, becoming an unstable element contributing to landslides in the area. The contact between the Suntrana and Sanctuary Formations is mapped in previously published geologic literature near the south side of the hydraulic pit.

There are three interbedded coal seams exposed in the east wall of the pit. The thicknesses of the coal beds are approximately 30 feet, 15 feet and 10 feet, listed respectively up-section and measured perpendicular to dip.

The borings primarily encountered soils consisting of colluvium overlying the Suntrana Formation. The colluvium is comprised of Quaternary aged, stratified sediments originating from the Birch Creek Schist to the south of the project site. As a result, the sediment is mica rich and much of the angular gravel and cobbles are soft enough to easily break down when disturbed. The stratification ranges in thickness from less than an inch to several feet, and consists of a mixture of gravel, sand and silt. These colluvial materials generally classify as Silty Sand with Gravel (SM) to Poorly Graded Sand with Silt and Gravel (SP-SM). The colluvial sands contain 10 to 40 percent gravel, and 10 to 40 percent fines. Where thawed, the sediments are generally loose to medium dense, with N-values as low as 7. Where frozen, N-values are highly influenced by ice content, ice structure, and the presence of gravel, and commonly exceed 50. The moisture content values of the colluvium ranges from as low as 2 percent, to as high as 81 percent; higher values are associated with the presence of organic layers and/or layers containing visible ice. On average, the moisture content values are between 5 and 15 percent for non-permafrost soils. The moisture content of the permafrost soils is typically between 10 and 20 percent.

Layers of peat and organic-rich soils, usually less than one-inch thick, were mainly observed in Test Borings 1, 2, 5-10, and 18 at depths of 15 to 30 feet below the ground surface, and in a few other locations. As stated previously, these layers are associated with elevated moisture content, with values as high as 34 to 81 percent. These organic-rich layers do not appear to form continuous layers within the stratigraphy of the deposit of the site. The soil classification, moisture content, ice classification, and ice bonded depths are shown relative to both the existing ground surface and the proposed final grade elevations in cross sections (Figures A-3 through A-5) located in Appendix A.

Suntrana Formation rock was encountered in seven of the test borings. However, only the rock encountered in Test Borings 6, 11, 13 and 15 is interpreted to comprise in-situ bedrock. The rock encountered in Test Borings 8, 10, and 12 is interpreted to be float blocks, or disconnected bedrock blocks, within the site stratigraphy, as they overlie unconsolidated sediments. In general, the Suntrana Formation rock, both as float blocks and in-situ, is frozen; upon thawing, this material breaks down into sand and does not retain any of its original rock structure, indicating that the rock is typically poorly cemented at this site.

Groundwater

Where PVC standpipes were installed, groundwater level measurements were attempted 24 to 48 hours after drilling (to allow phreatic levels to stabilize). Groundwater was not observed in any of the borings. However, during drilling, a possible groundwater lens (based on liquid in the cuttings) approximately 1-foot thick may have been encountered in Test Boring 19. However, no measurable groundwater was observed in the Test Boring 19 standpipe in the following days. The elevation of this possible water-bearing zone is approximately 2213 feet. In addition, a groundwater seep issuing from the east wall at the base of the main coal unit was noted at the time of the investigation.

Permafrost

The active frost layer was observed to be approximately 4 to 8 feet below grade. The site is underlain by discontinuous permafrost, which was observed in 16 of the 21 borings. Generally, visible ice particles were not present (Nbn) or ice was present as coatings on particles (Vc) and excess irregular ice formations (Vx and Vr) to less than 5 percent by volume. However, excess ice to approximately 5 to 10 percent by volume was observed on some samples; increased excess ice and moisture content was associated with increased silt and organic content.

Soil temperatures were measured 24 hours and 48 hours after TAC installation. The measured 48-hour temperatures are presented on the test boring logs and tabulated values are also provided in Appendix C. The measured temperatures of the permafrost were within 1 to 2 degrees Fahrenheit of thawing (thawing assumed to occur at 32 degrees Fahrenheit).

SLOPE STABILITY

Based on design documents provided by the ADNR, the slopes for the final grading plan are generally less than 50 percent, where possible. Due to the need to stay within certain disturbance limits (Figure A1), a few areas, including the southeast corner of the pit, are graded with slopes occasionally exceeding the 50 percent cutoff. Due to the limited data available, simplified slope stability analyses were performed to evaluate the stability of steeper slopes (e.g., southeast corner of the pit) to changes in groundwater conditions. Basic assumptions for these stability analyses include:

1. Material properties are assumed to be for thaw-stable soils, and are based on previous laboratory testing, previous probabilistic stability modeling, and the current stability of the existing headwall.

2. Ice present in the subsurface is generally limited in volume and is therefore not interpreted to be part of a regional groundwater system. In other words, when melted, the subsurface ice is not assumed to contribute to a groundwater table near the surface, with fully saturated conditions below. However, for conservatism, this scenario was included in the modeling in order to evaluate the sensitivity of the slopes to saturation.

Methods

Stability analyses were conducted using the Slope/W component of GeoStudio 2012 (v. 8.11.1.7283) by GeoSlope International, Ltd. Slope/W was used to conduct limit equilibrium analyses using the Morgenstern-Price method, which satisfies both moment and force equilibrium. The Slope/W program incorporates a search routine to locate the failure surfaces with the lowest factor of safety within user-defined search limits. Trial failure surfaces were defined with “entry and exit” parameters. This option defines a range of possible slip surface entry and exit locations within which the most critical (lowest factor of safety) may be found.

Material Properties

In general, the material properties used previously by DOWL were adopted for use in the analyses summarized here, with a few exceptions. Fill material properties were conservatively assumed based on typical fill values from literature and compaction of native soils. The material properties assigned to the colluvium are a combination of the gravel and loose soil properties used previously, with minimal cohesion (i.e., 10 – 50 psf) from silt and/or ice. Though the colluvium may have an apparent cohesion roughly equal to 0 psf in some areas, particularly when thawed, using a generalized minimum cohesion value to represent the variability of upper soils over large areas is considered appropriate for this analysis. Using a minimum cohesion prevents the modeling software from calculating a critical FoS for only very shallow slip surfaces that tend towards an unrealistic infinite slope case, which would be the result of modeling the colluvium as a purely frictional material (cohesion = 0). When materials are modeled as purely frictional, the software must be forced to find deeper slip surfaces; rather than forcing the slip surfaces deeper, using a minimum cohesion value retains an appropriate level of conservatism while providing for more realistic strength properties and corresponding slip surfaces.

The material properties used for these analyses were checked against the stability of a generalized section of the existing eastern slope. The ranges of values used previously are likely conservative for the east-wall section analyzed, as they generally result in Factors of Safety near 1.0 for the existing slope. Factors of Safety (FoS) near 1.0 generally imply the slope is at equilibrium, with resisting forces roughly equal to driving forces. However, DOWL understands the highwall has been standing for many decades and therefore has remained stable through many seasonal freeze/thaw cycles, likely with a FoS well above 1.0. In addition, the failing slopes analyzed previously to derive the site material properties had the additional disadvantage of stratigraphy dipping out of the slope, which is not the case on the east wall.

Stability Analysis Results

The simplified analyses conducted for this project indicate that the planned slopes, even in steeper areas, are safe if groundwater is not present; the stability analyses were highly sensitive to the presence of groundwater. Sensitivity analyses were performed on the material properties as well, but the slopes analyzed proved much more sensitive to changes in groundwater than changes in material properties. If the east headwall is not void of a high groundwater table, as generally observed during the site investigation, and substantial water is present near the surface, or accumulates near the surface, the FoS against slope failure can be expected to be greatly reduced, by as much as approximately 60 percent. These results should be understood to be general, and likely conservative, both due to the conservative material properties (based on limited lab data and/or literature values), and the questionable likelihood that the entire slope would be fully saturated. However, these results do underscore the need to prevent the build-up of melted water within the pore spaces of the slope materials, particularly because the pore spaces may be temporarily enlarged in some areas due to ice expansion, which would increase the potential pore-water capacity of the slope. Drainage of the slopes, with an emphasis on the potential need to drain perched water sources, will be key to maintaining stability at this site, both short-term and long-term.

Due to the number of unknown conditions in the slope at the time excavation takes place (level of thaw, presence of substantial water, lack of specific testing, etc.), more specific results have not been included in this report. Similarly, the stability impacts from ice expansion in pore spaces and other thermal changes effecting slope stability were not included in this analysis. These effects would be better understood by performing a fully-coupled thermal-hydraulic analysis using finite element methods and a probabilistic evaluation of the variable site subsurface data. Such an evaluation would include changes in temperature, pore-water pressure, and other material properties, such as strength, with time. However, given the nature of this project, which is for reclamation in an uninhabited area, this level of detailed analysis is not considered economically viable. In addition to a rigorous modeling effort, these analyses would require a substantial laboratory testing program to provide the material properties required to make the analyses meaningful. In the absence of these additional tests and rigorous analyses, some general notes are included below.

Flow/Collapse Potential

In soils containing excess ice, grains may be partially or completely segregated; the soil structure is changed and is partially or fully supported by ice within the voids. As the ice melts, the structure will tend to collapse, causing settlement. If the quantity of excess water is such that it cannot be reabsorbed in to the soil voids or adequately drained into the soil below, the soil condition will mimic that of liquefaction, where the grains are carried by the water itself and a substantial loss of strength occurs until, through drainage, the soil regains some or all of its pre-frozen strength.

Due to the near-thawing temperatures of the permafrost and removal of insulating surface organics at the site, the permafrost should be expected to thaw to at least the depth of the active layer and continue to thaw downward as excavation continues. The soils without excess ice (Nbn) will likely remain thaw stable. Within soils with visible excess ice (Vc, Vr, Vx), some settlement should be expected upon thawing, but is anticipated to be fairly minimal. The measured water content of the permafrost samples is relatively low except where thin organic layers were concentrated. Due to the relatively low volume of excess ice and low water content, soil collapse due to thawing permafrost is unlikely to occur beyond localized lenses within/near deposits containing organics.

Discontinuous permafrost can create a “piped” aquifer system in which water flows through the thawed portions and the permafrost acts as an aquitard, preventing flow across the permafrost boundary. It is therefore common in discontinuous permafrost zones for water to become perched or confined by ice. If the permafrost aquitard is disturbed/destroyed, the perched or confined water can be released and cause a flow failure where sediments previously supported by ice re-equilibrate to their thawed conditions, moving and shifting within the melt water. Measurable groundwater was not observed on the site at the time of the investigation, but it is possible that one or more perched or confined aquifers are present and were not encountered during the investigation. Additionally, as spring thaw occurs and the permafrost thaw waters and surficial waters enter the system, groundwater levels may seasonally rise and flow through thawed spaces. This may contribute to seepage of groundwater from the open face of the excavation, and could create a seemingly “quick” condition, causing water and sands to wash into the excavation, and result in slumping and caving of slopes.

GENERAL RECOMMENDATIONS

The recommendations below are based on professional judgment and experience, the data collected during the geotechnical investigation, and the above analyses.

- Earthwork should be conducted in a manner that limits the height and relative steepness of the slopes mid-excavation, in case flowing sediments are encountered.
- Drainage ditches should be developed and maintained to direct surface and subsurface water, in a controlled manner, away from the highwall. Grading should be conducted in a progressive manner to maximize gravity drainage.

- The PVC standpipes should be checked at the beginning of spring thaw and protected from damage during earthwork activities. During excavation, the PVC standpipes should be checked periodically (e.g., as each grade of excavation is reached) to evaluate whether groundwater is collecting up-gradient of or immediately below planned excavations.

- If groundwater seeps are encountered during excavation activities, excavation should be discontinued until the flows have been further assessed. In regards to the existing seep issuing from the exposed coal seam, noted during the recent investigation, it is anticipated that the coal and the seep will be buried to a depth of 10 to 15 feet. During excavation and backfill of the coal, the seep will need to be controlled. In addition, to avoid the possibility of long term erosion/stability issues around this seep, DOWL recommends the ADNR install a permanent drain at this location.

- As stated previously, maintaining relatively dry slopes, particularly during reclamation activities, is key for the stability of the site slopes. In some cases, the installation of temporary in-slope drains, such as slotted PVC or inclined wick drains, may be considered to increase and speed drainage and consolidation. Drains should be installed strategically to drain from the bottom of planned slopes and, where possible and necessary, to drain areas known or suspected of harboring perched water (e.g., near seeps, known organic layers, or areas containing increased surface vegetation).

- At no time should excavated materials be placed on or near slope crests.

LIMITATIONS

This letter includes both facts and interpretations and opinions concerning the surface and subsurface soil and groundwater conditions at the site. The site conditions described are valid for the limited data collected within the scope of work; the data should be considered accurate only at the locations specified and only to the degree implied by the methods used. If additional data become available, some or all of the interpretations and opinions expressed herein could change. DOWL should be notified immediately if the conditions found at the site are different from those encountered during this investigation, or substantially different from those assumed in our analyses.

If you have any questions regarding this letter report or its use, or if we may provide additional services, please call.

Sincerely,
DOWL

Paul E. Pribyl
Geologist

Reviewed by:
DOWL

Diana I. Cook, Ph.D., P.E.
Senior Geological Engineer

Reviewed by:
DOWL

Michael E. Henderson, P.E.
Principal

Attachment(s): As stated

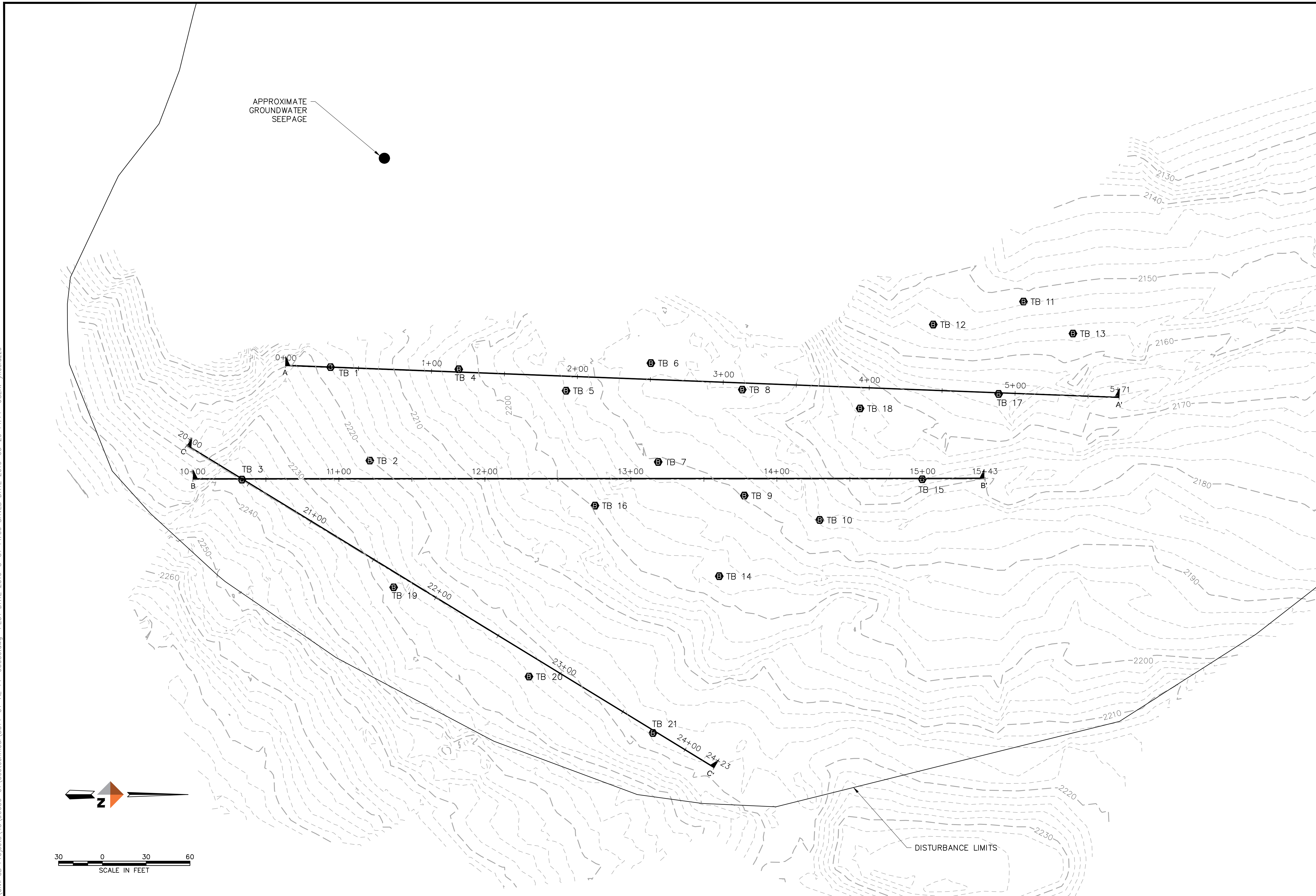
APPENDICES

Appendix A - Test Boring Location Maps Cross Sections

Appendix B - Test Boring Logs and Descriptive Guide

Appendix C - Thermistor Temperature Measurements

APPENDIX A –
TEST BORING LOCATION MAPS AND CROSS SECTIONS



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REV	DATE	REVISIONS DESCRIPTION	BY

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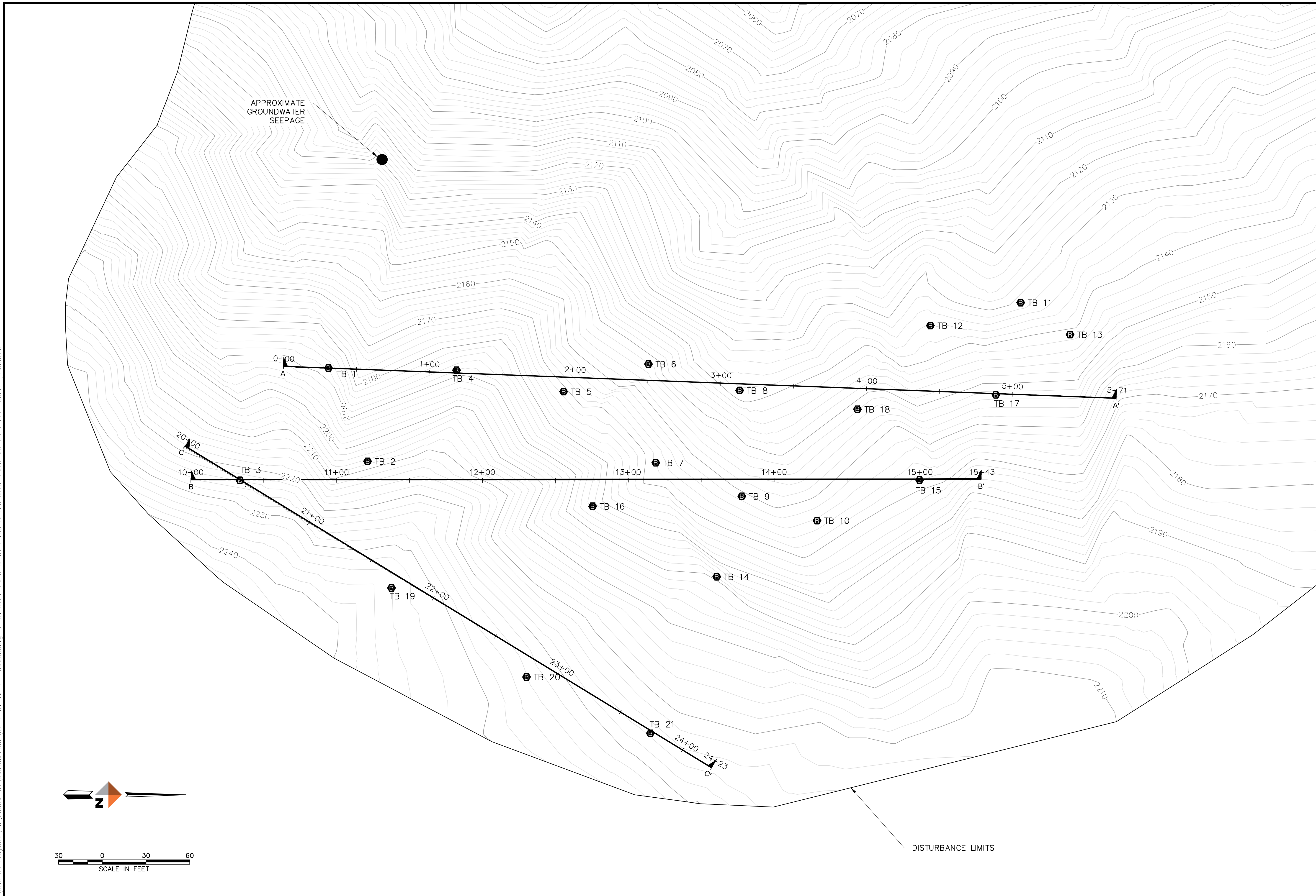
WWW.DOWL.COM

HEALY HYDRAULIC PIT RECLAMATION
HEALY, ALASKA
CROSS SECTIONS EXISTING GROUND SURFACE

PROJECT 1543.90056.01
DATE 3/29/2016

SHEET
A-1



REV	DATE	DESCRIPTION	BY
		REVISIONS	

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HEALY HYDRAULIC PIT RECLAMATION
HEALY, ALASKA
CROSS SECTIONS PROPOSED FINAL GRADES

PROJECT 1543.90056.01
DATE 3/29/2016

SHEET
A-2

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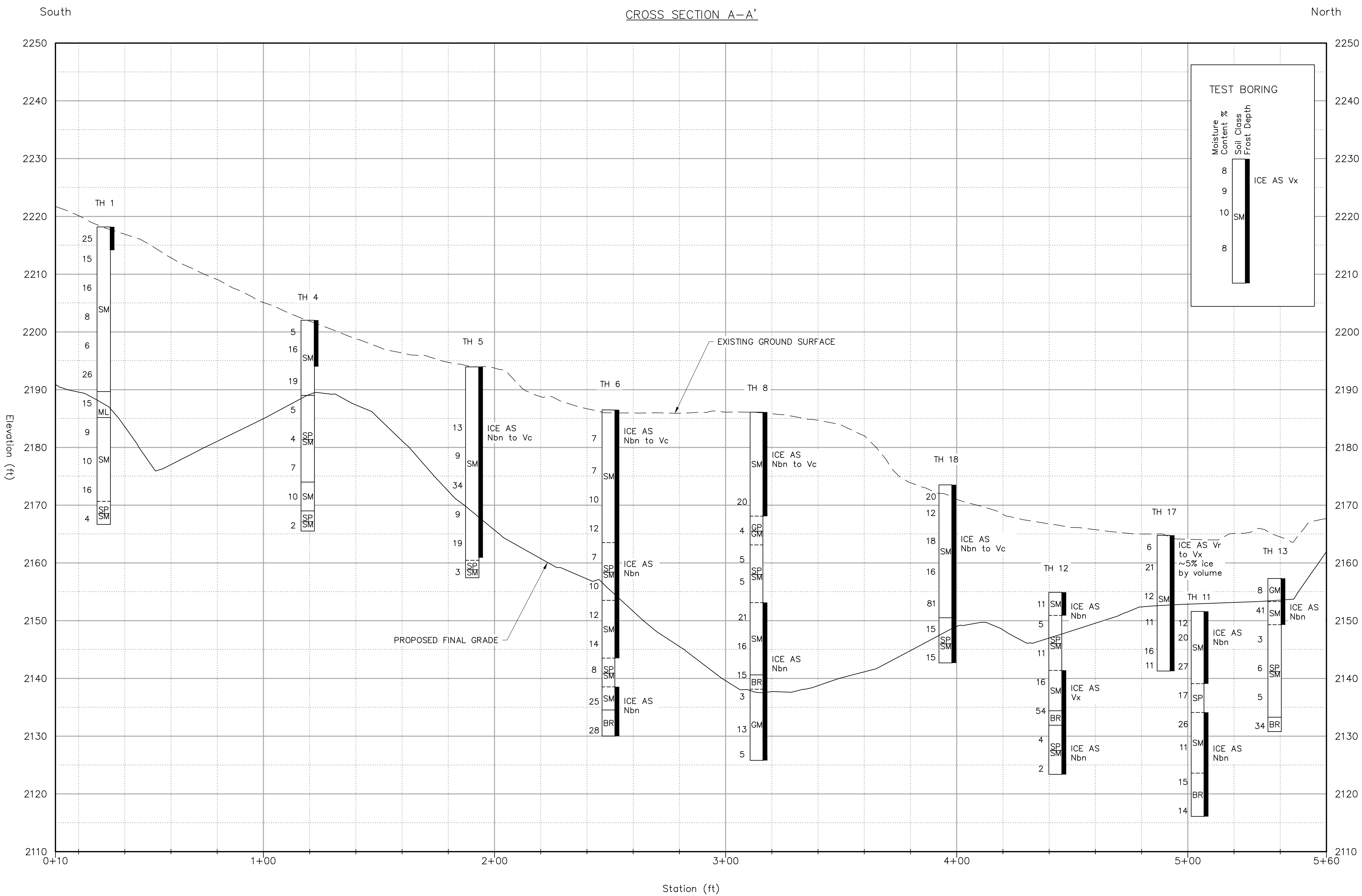

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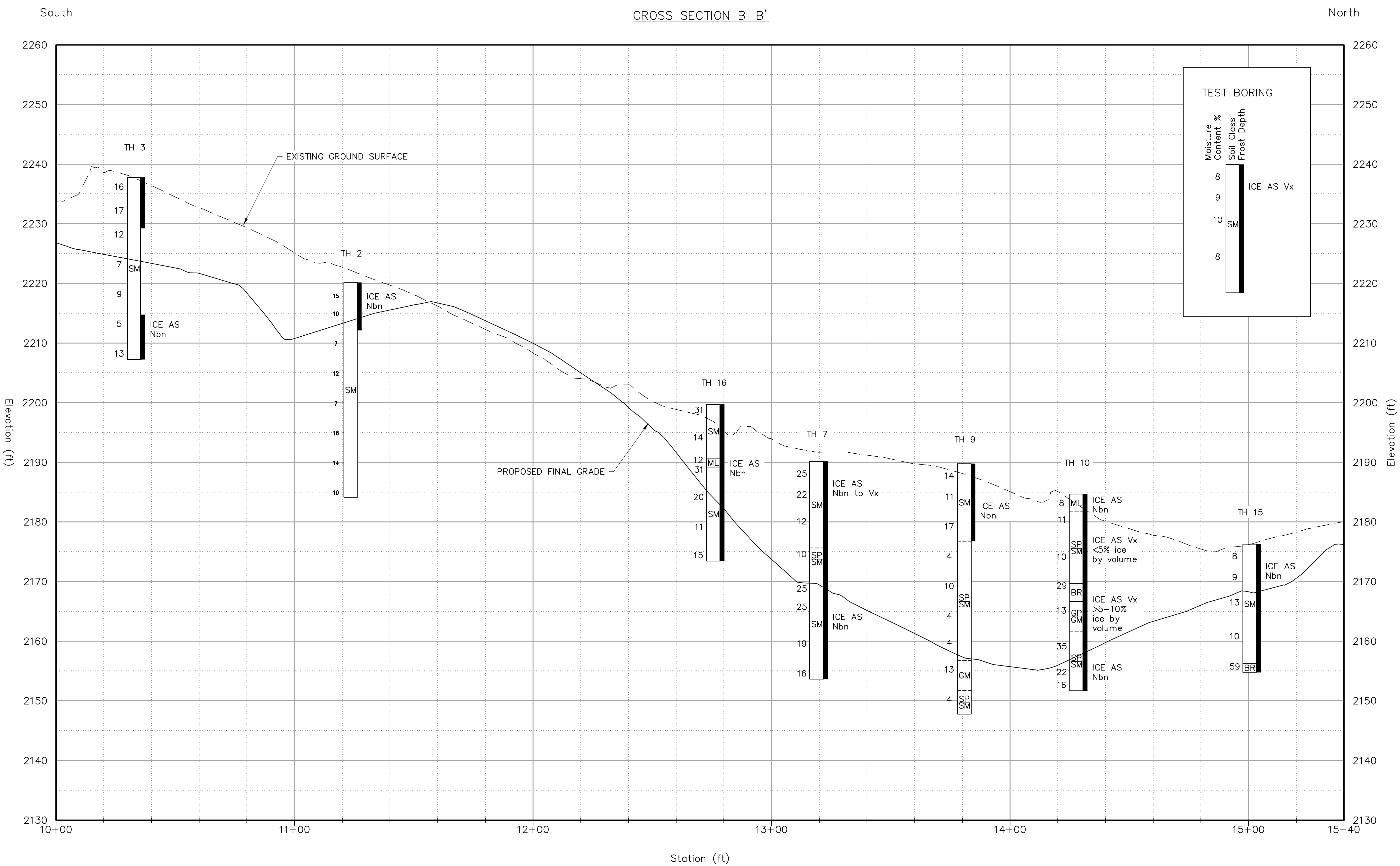
HEALY HYDRAULIC PIT RECLAMATION
HEALY, ALASKA
CROSS-SECTION A-A'

PROJECT 1543.90056.01
DATE 3/21/2016

SHEET
A-3

CROSS SECTION B–B'



HEALY HYDRAULIC PIT RECLAMATION
HEALY, ALASKA
CROSS-SECTION B-B'

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PROJECT 1543.90056.01
DATE 3/21/2016

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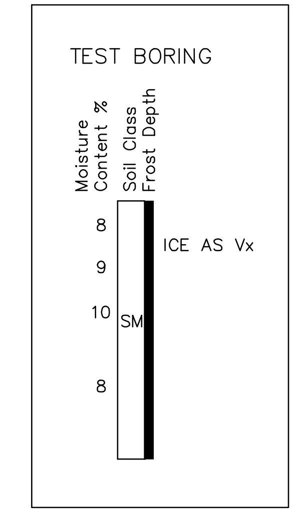
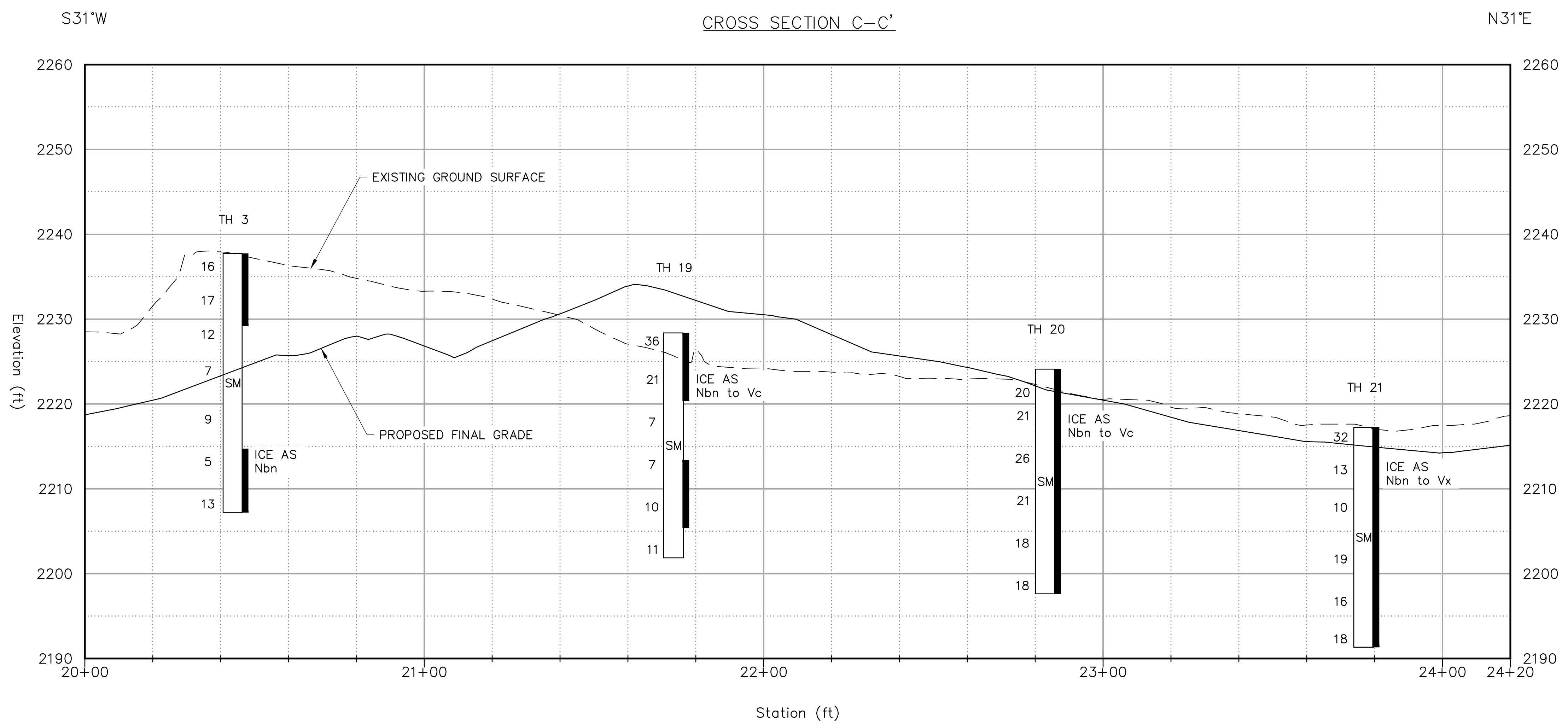
A-4





HEALY HYDRAULIC PIT RECLAMATION
HEALY, ALASKA
CROSS-SECTION C-C'

REV | DATE | DESCRIPTION | BY
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PROJECT 1543.90056.01
DATE 3/21/2016

SHEET
A-5

APPENDIX B –
TEST BORING LOGS AND DESCRIPTIVE GUIDE

TEST BORING 1

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2217.0 ft
SURFACE: GRAVEL

Sample No.	Sample Type	Moisture Content (%)	Blows / Foot	Soil Class	Frost Class
1	☐	25		SM	F3
2	◪	15	22	SM	F3
3	◪	16	9	SM	F3
4	◪	8	14	SM	F3
5	◪	6	14	SM	F3
6	◪	26	10	SM	F3
7	◪	15	16	ML	F4
8	◪	9	13	SM	F3

Temp °F
32.0
32.6
33.7
34.0
34.0
34.4
34.6
34.8
34.9
34.9
34.8
34.8
34.8
34.6
34.5
34.4
34.3
34.4
34.3

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35, 40

Description	Depth
SILTY SAND WITH GRAVEL, brown to reddish brown, about 10-25% gravel, 30% silt, nonplastic, gravel angular to 1.5", medium sand, frozen to damp, loose to medium dense 1/2" thick layer of **PEAT** at 25'	28.5
SANDY SILT WITH GRAVEL, dark gray, about 15% gravel, 25% silt, nonplastic, gravel angular to 1", fine sand, damp, very stiff	33.0
SILTY SAND, brown to gray, about 10% gravel, 30-35% silt, nonplastic, gravel subangular to 3/4"", fine to medium sand, damp, medium dense 1/4" thick layers of **PEAT** at 35'	

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
▯ = Direct Push Sample
⧗ = 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-1-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 1

FIGURE B-1

TEST BORING 1 (Continued)

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2217.0 ft
SURFACE: GRAVEL

Depth (ft)	Other Tests	Temp °F	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Depth	Frost Class	Description	Depth
40		34.0	10	18	9	SPT	SM		F3	**SILTY SAND**, brown to gray, about 10% gravel, 30-35% silt, nonplastic, gravel subangular to 3/4"", fine to medium sand, damp, medium dense	
		33.7									
45			16	13	10	SPT					47.5
			4	33	11	SPT	SP SM		F2	**SAND WITH SILT AND GRAVEL**, reddish brown, about 35% gravel, 10% silt, gravel angular to 1.5", medium sand, damp, dense	51.5

TD=51.5'

TEST BORING COMPLETED ON 3-1-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING
PVC STANDPIPE INSTALLED TO 51.5'
BENTONITE SEAL BETWEEN 1' AND 6'

DEPTH (FEET): 40, 45, 50, 55, 60, 65, 70, 75, 80

KEY
TD = Total Depth
= Grab Sample
= SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-1-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 1

FIGURE B-1

TEST BORING 2

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2219.0 ft
SURFACE: GRAVEL

Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description
	15		1	Grab	SM	F2 to F3	**SILTY SAND WITH GRAVEL**, brown to dark brown, about 10-35% gravel, 20-30% silt, gravel angular to 1.5", fine to medium sand, damp to frozen, medium dense to dense **ICE AS Nbn to Vx** (<5% by volume)
	10	78	2	SPT			
	7	20	3	SPT			
	12	13	4	SPT			
	7	18	5	SPT			
	16	19	6	SPT			3/4" thick layers of **PEAT** at 24.5' (to ~10% by volume)
	14	15	7	SPT			
	10	39	8	SPT			grayish brown, dense, pieces of schist in sampler

DEPTH 36.0

TD=36.0'

TEST BORING COMPLETED ON 3-2-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35, 40

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-2-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 2

FIGURE B-2

TEST BORING 3

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2237.0 ft
SURFACE: GRAVEL

Depth (ft)	Other Tests	Temp °F	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description
0		22.1						F2 to F3	**SILTY SAND WITH GRAVEL**, brown, about 10-30% gravel, 15-30% silt, nonplastic, gravel angular to 3", medium sand, frozen, **ICE AS Nbn**
		22.1	16		1	Grab			
		28.8							
5		31.2	17	58	2	SPT			1/4" thick **ORGANIC** layer at 5' (to <5% by volume)
		31.9							
10		32.1	12	8	3	SPT			loose, damp
		32.2							
		32.2							
15			7	15	4	SPT	SM		medium dense
		32.2							
		32.2							
20		32.2	9	8	5	SPT			loose
		32.1							
		31.8							grayish brown, frozen, **ICE AS Nbn** below 23'
25			5	32	6	SPT			
		31.9							cobble encountered at 26'
		31.9							
30		31.7	13	52	7	SPT			

DEPTH 30.5

TD=30.5'

TEST BORING COMPLETED ON 3-1-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING
PVC STANDPIPE INSTALLED TO 30.5'

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35, 40

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-1-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 3

FIGURE B-3

TEST BORING 4

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2202.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type
~2.5		5		1	Grab Sample
~5.5		16	52/6"	2	SPT Sample
~11		19	7	3	SPT Sample
~16		5	15	4	SPT Sample
~21		4	23	5	SPT Sample
~26		7	17	6	SPT Sample
~31		10	22	7	SPT Sample
~36		2	39	8	SPT Sample

Soil Class	Frost Class	Description	Depth
SM	F2 to F3	**SILTY SAND WITH GRAVEL**, brown, about 15-25% gravel, 15-25% silt, nonplastic, gravel angular to 3", medium sand, frozen cobbles in upper 6' loose, damp	13.0
SP SM	F2	low recovery, pushing rock **POORLY GRADED SAND WITH SILT AND GRAVEL**, grayish brown and reddish brown, about 20-35% gravel, 10% silt, gravel angular to 1.5", medium sand, damp, medium dense	28.0
SM	F3	**SILTY SAND**, grayish brown, about 10% gravel, 35% silt, nonplastic, medium sand, damp, medium dense	33.0
SP SM	F2	**POORLY GRADED SILTY SAND WITH GRAVEL**, reddish brown, about 30% gravel, 10% silt, gravel angular to 1.5", medium sand, damp, dense	36.5

TD=36.5'

TEST BORING COMPLETED ON 3-1-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

BENTONITE SEAL BETWEEN 2' AND 6'

KEY
TD = Total Depth
= Grab Sample
= SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-1-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 4

FIGURE B-4

TEST BORING 5

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2193.0 ft
SURFACE: GRAVEL

DEPTH (FEET)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	DEPTH
0						SM	F3	**SILTY SAND WITH GRAVEL**, brown, about 15-35% gravel, 20-30% silt, nonplastic, gravel angular to 1", medium sand, frozen, **ICE AS Nbn**	
		16		1	Grab			cobbles in upper 8'	
5		15	95/11"	2	SPT			**ICE AS Vr** (~10-15% by volume)	
10		13	64	3	SPT			**ICE AS Vc** (<5% by volume)	
15		9	91/10"	4	SPT			**ICE AS Nbn**	
20		34	32	5	SPT			**ORGANICS** (<5% by volume)	
25		9	51	6	SPT				
30		19	64	7	SPT			1/4" layers of **ORGANICS** (<5% by volume)	33.5
35		3	56	8	SPT	SP SM	F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, reddish gray, about 30% gravel, 10% silt, gravel angular to 1.5", medium sand, damp, very dense	36.5

TD=36.5'

TEST BORING COMPLETED ON 2-29-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

BENTONITE SEAL BETWEEN 2' AND 6'

KEY
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-29-16
W.O. 1131.90056.01

LOG OF EXPLORATION 90056B.GPJ BLANK2.GDT 3/15/16

DOWL

LOG OF TEST BORING 5

FIGURE B-5

TEST BORING 6

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2187.0 ft
SURFACE: GRAVEL

DEPTH (FEET)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	DEPTH
0		17		1	Grab	SM	F3	**SILTY SAND WITH GRAVEL**, brown, about 15-25% gravel, 20-30% silt, nonplastic, gravel angular to 1", medium sand, frozen, **ICE AS Nbn**	
5		7	50/5"	2	SPT				
10		7	14	3	SPT				
15		10	44	4	SPT			**ICE AS Nbn**	
20		12	60	5	SPT			reddish gray	23.0
25		7	46	6	SPT	SP-SM	F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, reddish brown to brown, about 15% gravel, 10% silt, gravel angular to 1/2", medium sand, frozen, **ICE AS Nbn to Vc**	
30		10	63	7	SPT				33.0
35		12	50	8	SPT	SM	F3	**SILTY SAND WITH GRAVEL**, brownish gray, about 15-35% gravel, 15-25% silt, nonplastic, gravel angular to 1.5", medium sand, frozen, **ICE AS Nbn**	
40									

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
S = Shelby Tube - pushed
↑ = Direct Push Sample
⧗ = 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-29-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 6

FIGURE B-6

TEST BORING 6 (Continued)

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2187.0 ft
SURFACE: GRAVEL

Depth (ft)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	Depth
40–43.0		14	39	9	SPT	SM		3" thick **ORGANIC** layer at 40' (<5% by volume)	43.0
43.0–48.0		8	51/6"	10	SPT	SP-SM	F2	**POORLY GRADED SAND WITH SILT**, grayish brown, about 10% gravel, 5-10% silt, medium to coarse sand, damp, very dense	48.0
48.0–52.0		25	73	11	SPT	SM	F3	**SILTY SAND**, reddish brown, about 10% gravel, 20% silt, nonplastic, medium sand, frozen, **ICE AS Nbn** 1/2" thick **ORGANIC** layer at 50' (<5% by volume)	52.0
52.0–56.5		28	24	12	SPT	BR		**BEDROCK**, Suntrana Sandstone, fine grained, coal strings interbedded	56.5

TD=56.5'

TEST BORING COMPLETED ON 2-29-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

BENTONITE SEAL BETWEEN 2' AND 6'

DEPTH (FEET)

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-29-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 6

FIGURE B-6

TEST BORING 7

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2190.0 ft
SURFACE: GRAVEL

Other Tests	Temp °F	Moisture Content (%)	Blows / Foot	Sample No.
	20.3			
	25.6			
		25		1
	27.3			
	28	22	86	2
	28.4			
	29.1			
		12	53/6"	3
	30			
	30.9			
	31.6	10	39	4
	31.8			
	31.8			
		25	31	5
	31.8			
	31.8			
		25	50/4"	6
	31.9			
	31.8			
	31.6			
		19	61	7
	31.8			
	31.8			
	31.6	16	47	8

Depth (ft)	Soil Class	Frost Class	Description
0 – 14.5	SM	F3	**SILTY SAND WITH GRAVEL**, dark brown to dark gray, about 15% gravel, 15-40% silt, nonplastic, gravel angular to 3/4", fine to medium sand, frozen, **ICE AS Nbn** **ICE AS Vx** (<5% by volume)
14.5 – 18.0	SP SM	F1	**POORLY GRADED SAND WITH SILT AND GRAVEL**, grayish brown, about 40% gravel, 10% silt, gravel angular to 1.5", medium sand, frozen, **ICE AS Nbn** bottom 6" of sample is black coal
18.0 – 36.5	SM	F3	**SILTY SAND**, dark brown, about 10% gravel, 25% silt, nonplastic, medium sand, frozen, **ICE AS Nbn** 1/2" thick layers of **ORGANICS** at 20' (10-15% by volume) sampler bouncing on a rock **ICE AS Vx** (~5% by volume) brownish gray

TD=36.5'

TEST BORING COMPLETED ON 2-27-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING
PVC STANDPIPE INSTALLED TO 35'
BENTONITE SEAL BETWEEN 2' AND 6'

KEY
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-27-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 7

FIGURE B-7

TEST BORING 8

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2185.0 ft
SURFACE: GRAVEL

Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type
	18		1	Grab Sample
	10	93/8"	2	SPT Sample
	11	48	3	SPT Sample
	20	28	4	SPT Sample
	4	50	5	SPT Sample
	5	34	6	SPT Sample
	5	50/4"	7	SPT Sample
	21	53	8	SPT Sample

Soil Class	Frost Class	Description	DEPTH
SM	F3	**SILTY SAND WITH GRAVEL**, grayish brown, about 15-30% gravel, 15-25% silt, nonplastic, gravel angular to 3", medium sand, frozen, **ICE AS Nbn** **ICE AS Nbn to Vc** rocky drilling **ICE AS Nbn** cobble at 13'	18.0
GP/GM	F1	**POORLY GRADED GRAVEL WITH SILT AND SAND**, grayish brown, about 30% sand, 10% silt, gravel angular to 3", medium sand, damp, dense	23.0
SP/SM	F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, light brown, about 20% gravel, 10% silt, gravel angular to 1.5", medium sand, damp, dense to very dense **ORGANIC** layers at 25' (to ~5% by volume)	33.0
SM	F3	**SILTY SAND WITH GRAVEL**, dark gray, about 15-25% gravel, 30-35% silt, nonplastic, gravel angular to 1", fine to medium sand, frozen, **ICE AS Nbn**	

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35, 40

KEY
TD = Total Depth
= Grab Sample
= SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-28-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 8

FIGURE B-8

TEST BORING 8 (Continued)

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2185.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Graph	Soil Class	Frost Depth	Frost Class	Description	DEPTH
40		16	50	9	SPT		SM		F3	**SILTY SAND WITH GRAVEL**, dark gray, about 15-25% gravel, 30-35% silt, nonplastic, gravel angular to 1", fine to medium sand, frozen, **ICE AS Nbn**	
45		15	96	10	SPT		BR			**BEDROCK**, Suntrana Sandstone, as float block, fine to coarse grained, weakly cemented, 1/4" organic layer on top	45.5
50		3	50/3"	11	SPT		GM		F2	**SILTY GRAVEL WITH SAND**, brown, about 40% sand, 15% silt, nonplastic, gravel angular to 1.5", medium sand, frozen, **ICE AS Nbn**	48.0
55		13	50/5"	12	SPT						
60		5	50/3"	13	SPT						60.3

TD=60.3'

TEST BORING COMPLETED ON 2-28-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

DEPTH (FEET): 40, 45, 50, 55, 60, 65, 70, 75, 80

KEY
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-28-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 8

FIGURE B-8

TEST BORING 9

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2189.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	DEPTH
0						SM	F3	**SILTY SAND**, grayish brown, about 0-10% gravel, 15-40% silt, nonplastic, medium sand, frozen, **ICE AS Nbn**	
		14		1	Grab				
5		11	76	2	SPT				
10		17	41	3	SPT			**ICE AS Nbn to Vx** (<5% by volume	
									13.5
15		4	63	4	SPT	SP SM	F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, light grayish brown, about 10-35% gravel, 10% silt, gravel angular to 1.5", fine to medium sand, damp, dense to very dense	
20		10	43	5	SPT			1/8" to 1/4" **ORGANIC** layers (~5% by volume)	
25		4	83	6	SPT				
30		4	54/6"	7	SPT				
									33.0
35		13	69/6"	8	SPT	GM	F2	**SILTY GRAVEL WITH SAND**, brown, about 35% sand, 15% silt, nonplastic, gravel angular to 3", medium sand, damp, very dense	
									38.0
40						SP SM	F2		

Frost Depth: frozen from 0 to approximately 13 ft.

DEPTH (FEET)

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-27-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 9

FIGURE B-9

TEST BORING 9 (Continued)

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2189.0 ft
SURFACE: GRAVEL

DEPTH (FEET)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Graph	Soil Class	Frost Depth	Frost Class	Description	DEPTH
40		4	54/6"	9	SPT		SP SM		F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, light grayish brown, about 30% gravel, 10% silt, gravel angular to 1", medium sand, damp, very dense *(Continued)*	42.5

TD=42.5'

TEST BORING COMPLETED ON 2-27-16

NO GROUNDWATER ENCOUNTERED WHILE DRILLING

Depth scale: 40, 45, 50, 55, 60, 65, 70, 75, 80

KEY
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
Ⓢ = Shelby Tube - pushed
Ⓣ = Direct Push Sample
⧗ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-27-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 9

FIGURE B-9

TEST BORING 10

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2187.0 ft
SURFACE: GRAVEL

Depth (ft)	Soil Class	Frost Class	Description
0 – 3.0	ML	F4	**SANDY SILT**, brown, about 10% gravel, 30% sand, nonplastic, fine sand, frozen, **ICE AS Nbn**
3.0 – 15.0	SP SM	F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, brown, about 40% gravel, 10% silt, gravel angular to 1.5", medium sand, frozen, **ICE AS Vx** (<5% by volume) 1" layer of **PEAT** frozen **ICE AS Vx** (to 25% by volume)
15.0 – 18.0	BR		**BEDROCK**, Suntrana Sandstone, as float block, medium grained with stringers to 1/2" of coal
18.0 – 23.0	GP GM	F2	**POORLY GRADED GRAVEL WITH SILT AND SAND**, brown, about 40% sand, 10% silt, gravel angular to 1.5", medium sand, frozen, **ICE AS Vx** (5-10% by volume)
23.0 – 33.0	SP SM	F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, brown, about 40% gravel, 10% silt, gravel angular to 1.5", medium sand, frozen, **ICE AS Nbn**, coal fragments to ~5% by volume

TD=33.0'

Temp °F	Moisture Content (%)	Blows / Foot	Sample No.
22.3			
	8		1
26.9			
27.9	11	50/3"	2
28.6			
29.2			
30.1			
	10	50/5"	3
31.3			
31.6			
	29	70/10"	4
31.8			
31.8			
	13	62/6"	5
31.7			
31.7			
31.7			
	35	78	6
31.7			
31.8			
31.7	22	52/6"	7
31.7	16	53/6"	8

TEST BORING COMPLETED ON 2-26-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING
PVC STANDPIPE INSTALLED TO 33'
BENTONITE SEAL BETWEEN 1' AND 5'

DEPTH (FEET)

KEY
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-26-16
W.O. 1131.90056.01

TEST BORING 11

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2152.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type
~2		12		1	Grab Sample
5		20	49	2	SPT Sample
10		27	20	3	SPT Sample
15		17	16	4	SPT Sample
20		26	57	5	SPT Sample
~24		11	54/6"	6	SPT Sample
30		15	59	7	SPT Sample
35		14	78	8	SPT Sample

Depth (ft)	Soil Class	Frost Class	Description
0 – 12.5	SM	F2	**SILTY SAND WITH GRAVEL**, brown to reddish brown, about 10-30% gravel, 15-20% silt, gravel angular to 3", medium sand, frozen, **ICE AS Nbn** coal fragments to 10% by volume at 10.5'
12.5 – 17.5	SP	NFS	**POORLY GRADED SAND WITH GRAVEL**, reddish brown, about 20% gravel, 5% silt, gravel angular to 1/2", medium sand, damp, medium dense
17.5 – 28.0	SM	F3	**SILTY SAND WITH GRAVEL**, grayish brown, about 15% gravel, 25% silt, nonplastic, gravel angular to 3/4", fine to medium sand, frozen, **ICE AS Nbn**, 4" **PEAT** layer cobbles to 2' from 26' to 28'
28.0 – 35.5	BR		**BEDROCK**, Suntrana Sandstone, gray, fine to medium grained, weakly cemented

TD=35.5'

TEST BORING COMPLETED ON 3-3-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

BENTONITE SEAL BETWEEN 1' AND 6'

KEY
TD = Total Depth
= Grab Sample
= SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-3-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 11

FIGURE B-11

TEST BORING 12

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2155.0 ft
SURFACE: GRAVEL

Depth (ft)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	Depth
0–4.0		11		1	Grab	SM	F2	**SILTY SAND WITH GRAVEL**, brown, about 15% gravel, 15% silt, gravel angular to 1", medium sand, frozen, **ICE AS Nbn**	4.0
4.0–13.5		5	54	2	SPT	SP SM	NFS to F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, reddish brown, about 15-35% gravel, 5-10% silt, gravel angular to 1.5", medium sand, dry to damp, loose to very dense	13.5
		11	7	3	SPT				
13.5–20.5		16	78	4	SPT	SM	F2	**SILTY SAND WITH GRAVEL**, brown, about 30% gravel, 15% silt, gravel angular to 1.5", medium to coarse sand, frozen, **ICE AS Vx** (to <5% by volume)	20.5
20.5–23.0		54	30	5	SPT	BR		**BEDROCK**, Suntrana Sandstone, as float block, light gray, fine grained, <1/8" coal stringers, frozen, **ICE AS Vx** (~5% by volume)	23.0
23.0–31.5		4	84	6	SPT	SP SM	F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, reddish brown, about 40% gravel, 10% silt, gravel angular to 1.5", medium sand, frozen, **ICE AS Nbn**	31.5
		2	68	7	SPT				

TD=31.5'

TEST BORING COMPLETED ON 3-3-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-3-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 12

FIGURE B-12

TEST BORING 13

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2157.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	DEPTH
0–4.0		8		1	Grab	GM	F2	**SILTY GRAVEL WITH SAND**, brown, about 35% sand, 15% silt, nonplastic, gravel angular to 3", medium sand, frozen, **ICE AS Nbn** cobbles to ~8" present	4.0
4.0–8.0		41	69	2	SPT	SM	F3	**SILTY SAND WITH GRAVEL**, brown, about 30% gravel, 15% silt, nonplastic, gravel angular to 1", medium sand, frozen, **ICE AS Nbn**	8.0
8.0–24.0		3	21	3	SPT	SP-SM	F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, reddish brown, about 30% gravel, 10% silt, gravel angular to 1", medium sand, damp, medium dense	
		6	16	4	SPT				
		5	24	5	SPT				24.0
24.0–26.5		34	36	6	SPT	BR		**BEDROCK**, Suntrana Sandstone, gray, 1/8" coal layers, frozen, **ICE AS Nbn**	26.5

TD=26.5'

TEST BORING COMPLETED ON 2-25-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-25-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 13

FIGURE B-13

TEST BORING 14

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2198.0 ft
SURFACE: GRAVEL

Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type
	15		1	Grab Sample
	11	84	2	SPT Sample
	10	64	3	SPT Sample
	10	50/5"	4	SPT Sample
	5	48	5	SPT Sample
	9	50/5"	6	SPT Sample
	4	50/3"	7	SPT Sample

Soil Class	Frost Class	Description	Depth
SM	F3	**SILTY SAND**, brown to dark gray, about 10-20% gravel, 20-30% silt, nonplastic, gravel angular to 3/4", medium sand, frozen, **ICE AS Nbn**	18.0
SP-SM	F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, grayish brown, about 35% gravel, 10% silt, gravel angular to 1", fine to medium sand, damp, dense	23.0
GP-GM	F1	**POORLY GRADED GRAVEL WITH SILT AND SAND**, brown, about 40% sand, 10% silt, gravel angular to 1.5", medium to coarse sand, frozen, **ICE AS Nbn**	30.3

TD=30.3'

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35, 40

TEST BORING COMPLETED ON 2-26-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-26-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 14

FIGURE B-14

TEST BORING 15

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2177.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Depth	Frost Class	Description	DEPTH
0–20.3		8		1	Grab	SM		F2	**SILTY SAND WITH GRAVEL**, brown to dark brown, about 5-40% gravel, 15% silt, nonplastic, gravel angular to 3", medium sand, frozen, **ICE AS Nbn**	
		9	7	2	SPT					
		13	50/3"	3	SPT				frozen, **ICE AS Vx** (~5% by volume)	
		10	101/11"	4	SPT					20.3
20.3–21.5		59	29	5	SPT	BR			**BEDROCK**, Suntrana Sandstone, gray, contains ~30% coal by volume, frozen, **ICE AS Vx** (~10% by volume)	21.5

TD=21.5'

TEST BORING COMPLETED ON 2-26-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35, 40

KEY
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▧ = Shelby Tube - pushed
⍐ = Direct Push Sample
⧗ = 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-26-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 15

FIGURE B-15

TEST BORING 16

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2199.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	Depth
0–9.0		31		1	Grab	SM	F3	**SILTY SAND**, dark gray to brownish gray, about 10-20% gravel, 35-40% silt, nonplastic, gravel angular to 1", fine to medium, frozen, **ICE AS Nbn**	
		14	85	2	SPT			**ICE AS Vx, Vc, Vr** (to ~5% by volume),	9.0
9.0–10.5		31		3a	Grab	ML	F4	**SANDY SILT**, dark brown, about 10% gravel, 20% sand, nonplastic, fine sand, frozen, **ICE AS Nbn** (5-10% by volume), **ORGANICS** to 30% by volume	10.5
10.5–26.3		12	70/10"	3b	SPT	SM	F3	**SILTY SAND WITH GRAVEL**, brownish gray, about 10-20% gravel, 20-25% silt, nonplastic, gravel angular 3/8", medium sand, frozen, **ICE AS Vr** (5-10% by volume), 1/4" lenses	
		20	83	4	SPT				
		11	40	5	SPT			**ICE AS Vc** (<5% by volume)	
		15	81/9"	6	SPT			**ICE AS Nbn**	26.3

TD=26.3'

TEST BORING COMPLETED ON 2-28-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35, 40

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-28-16
W.O. 1131.90056.01

LOG OF EXPLORATION 90056B.GPJ BLANK2.GDT 3/15/16

DOWL

LOG OF TEST BORING 16

FIGURE B-16

TEST BORING 17

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2165.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Depth	Frost Class	Description
0		6		1	Grab	SM		F2	**SILTY SAND WITH GRAVEL**, brown, about 15-40% gravel, 15-20% silt, nonplastic, gravel angular to 1.5", medium sand, frozen, **ICE AS Vr to Vx** (~5% by volume) cobbles present at 2'
5		21	67	2	SPT				**ICE AS Vc**
10		12	84	3	SPT				**ICE AS Vx** (~5% by volume)
15		11	44/6"	4	SPT				
20		16	45/6"	5	SPT				coal fragments at 20' **ICE AS Nbn** below 20'
		11	27/6"	6	SPT				
23.5									TD=23.5'

TEST BORING COMPLETED ON 2-25-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

KEY
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 2-25-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 17

FIGURE B-17

TEST BORING 18

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2172.0 ft
SURFACE: GRAVEL

Depth (ft)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Depth	Frost Class	Description	Depth
0–23.0						SM		F2	**SILTY SAND WITH GRAVEL**, brown to reddish brown, about 15-35% gravel, 15-30% silt, nonplastic, gravel angular to 1", medium sand, frozen, **ICE AS Nbn**	
		20		1	Grab Sample				cobbles present to 4'	
5		12	50/4"	2	SPT Sample					
10		18	50/2"	3	SPT Sample				**ICE AS Vc and Vx** (~5-10% by volume)	
15		16	54/6"	4	SPT Sample				light brown, **ICE AS Nbn to Vc and Vx** (<5% by volume)	
20		81	26	5	SPT Sample				grayish brown, **ICE AS Vx** (~5% by volume), 1/4" thick layers of **PEAT** (~5% by volume)	23.0
23.0–30.8						SP SM		F2	**POORLY GRADED SAND WITH SILT AND GRAVEL**, reddish brown, about 10% gravel, 10% silt, gravel angular to 1.5", medium sand, frozen, **ICE AS Vx** (5-10% by volume)	
25		15	50/5"	6	SPT Sample					
30		15	50/4"	7	SPT Sample					30.8

TD=30.8'

TEST BORING COMPLETED ON 3-3-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

BENTONITE SEAL BETWEEN 1' AND 6'

DEPTH (FEET)

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-3-16
W.O. 1131.90056.01

LOG OF EXPLORATION 90056B.GPJ BLANK2.GDT 3/15/16

DOWL

LOG OF TEST BORING 18

FIGURE B-18

TEST BORING 19

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2227.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description
0							F2	**SILTY SAND WITH GRAVEL**, brown to reddish brown, about 20-30% gravel, 20-30% silt, nonplastic, gravel angular to 1.5", medium sand, frozen, **ICE AS Nbn**
		36		1	Grab			
								cobbles present at 4'
5		21	46	2	SPT			
10		7	15	3	SPT			medium dense, damp to wet
						SM		
								possible groundwater at 14.5' based on cuttings
15		7	18	4	SPT			**ICE AS Nbn to Vc** (<5% by volume)
20		10	15	5	SPT			**ICE AS Nbn**
25		11	22	6	SPT			medium dense, damp

DEPTH 26.5

TD=26.5'

TEST BORING COMPLETED ON 3-2-16
PVC STANDPIPE INSTALLED TO 26.5'
BENTONITE SEAL BETWEEN 1' AND 6'

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35, 40

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊡ = Direct Push Sample
⧗ = 2.5" I.D. Spoon Sample 340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-2-16
W.O. 1131.90056.01

LOG OF EXPLORATION 90056B.GPJ BLANK2.GDT 3/15/16

DOWL

LOG OF TEST BORING 19

TEST BORING 20

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2224.0 ft
SURFACE: GRAVEL

DEPTH (FEET)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	DEPTH
0						SM	F3	**SILTY SAND WITH GRAVEL**, brown to gray, about 10-30% gravel, 30-35% silt, nonplastic, gravel angular to 1", fine to medium, frozen, **ICE AS Nbn**	
		20		1	Grab Sample				
5		21	41	2	SPT Sample			**ICE AS Vx** (<5% by volume)	
10		26	40	3	SPT Sample			**ICE AS Vc to Vx** (~5% by volume)	
15		21	37	4	SPT Sample			**ICE AS Vc** (<5% by volume) around gravels	
20		18	80	5	SPT Sample			**ICE AS Vx** (~15% by volume)	
25		18	56	6	SPT Sample			**ICE AS Vx** (<5% by volume)	26.5

TD=26.5'

TEST BORING COMPLETED ON 3-2-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING
PVC STANDPIPE INSTALLED TO 26.5'
BENTONITE SEAL BETWEEN 1' AND 6'

KEY
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-2-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 20

FIGURE B-20

TEST BORING 21

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION: 2218.0 ft
SURFACE: GRAVEL

Depth (feet)	Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Class	Frost Class	Description	Depth
0		32		1	Grab	SM	F3	**SILTY SAND WITH GRAVEL**, dark brown, about 15-20% gravel, 30-35% silt, nonplastic, gravel angular to 2", medium sand, frozen, **ICE AS Nbn**	
5		13	52/6"	2	SPT			**ICE AS Vc** (<5% by volume)	
10		10	50/5"	3	SPT			sampler bouncing on a rock	
15		19	56	4	SPT			**ICE AS Nbn to Vc** (<5% by volume)	
20		16	40	5	SPT			**ICE AS Vx** (~5% by volume)	
25		18	50/5"	6	SPT			**ICE AS Vx** (<5% by volume)	25.9

TD=25.9'

TEST BORING COMPLETED ON 3-2-16
NO GROUNDWATER ENCOUNTERED WHILE DRILLING
PVC STANDPIPE INSTALLED TO 26.5'
BENTONITE SEAL BETWEEN 1' AND 6'

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30, 35, 40

KEY
TD = Total Depth
☐ = Grab Sample
◪ = SPT Sample
= Shelby Tube - pushed
= Direct Push Sample
= 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: CME-850 Nodwell
OPERATOR: Kelly Hill
METHOD: 4 in. OD hollow-stem auger

CLIENT: State of Alaska DNR
PROJECT: Healy Hyd. Pit Reclamation
LOGGED BY: Paul E. Pribyl
TEST BORING COMPLETED: 3-2-16
W.O. 1131.90056.01

DOWL

LOG OF TEST BORING 21

FIGURE B-21

TEST BORING LOG - DESCRIPTIVE GUIDE

Soil Descriptions - The soil is classified visually in the field based on drill action, auger cuttings, and sample information. The recovered soil samples are classified visually again in the laboratory. The soil description on the boring log is based on an interpretation of the field and laboratory visual classifications, along with the results of laboratory particle-size distribution analyses and Atterberg Limits tests which may have been performed.

The soil classification is based on ASTM Designation D2487 "Standard Test Method for Classification of Soils for Engineering Purposes" and ASTM D2488 "Standard Practice for Description and Identification of Soils (Visual - Manual Procedure)". The soil frost classification is based on the system developed by the U.S. Army Corps of Engineers and is performed in accordance with the Departments of the Army and Air Force Publication TM 5-822-5 “Pavement Design for Roads, Streets, Walks, and Open Storage Areas”. Outlines of these classification procedures are presented on the following pages.

The soil color is the subjective interpretation of the individual logging the test boring.

The plasticity of the minus No. 40 fraction of the soil is described and the fine-grained soils are identified from manual tests using the following table as a guide:

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	none to low	slow to rapid	low or thread cannot be formed
CL	medium to high	none to slow	medium
MH	low to medium	none to slow	low to medium
CH	high to very high	none	high

Plasticity Description	Criteria
Nonplastic	A 1/8" (3.2mm) thread cannot be rolled at any water content.
Low	A thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Laboratory Atterberg Limits tests usually are performed on a few of the plastic soils and results are reported on the test boring log. These laboratory tests are performed in accordance with ASTM D4318 "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils."

The shape of the gravel particles is described based on this guide:

Angular: particles have sharp edges and relatively plane sides with unpolished surfaces.

Subangular: particles are similar to angular but have somewhat rounded edges.

Subrounded: particles exhibit nearly plane sides but have well-rounded corners and edges.
Rounded: particles have smoothly curved sides and no edges.

The size of gravel and sand particles is described using this guide:

	Gravel	Sand
Coarse:	Passes 3" (75 mm) sieve, retained on 3/4" (19 mm) sieve	Passes No. 4 sieve, retained on No. 10 sieve
Medium:	N/A	Passes No. 10 sieve, retained on No. 40 sieve
Fine:	Passes 3/4" (19 mm) sieve, retained on No. 4 sieve	Passes No. 40 sieve, retained on No. 200 sieve

The soil moisture is described as:

dry: powdery, dusty, no visible moisture.
damp: enough moisture to affect the color of the soil; moist.
wet: water in pores but not dripping; capillary zone above water table.
saturated: dripping wet, contains significant free water, or sampled below water table.

The subjective estimate of the density of coarse-grained soils is based on the observed drill action and on drive sample data. The guide below is used for sands with minor amounts of fine gravel; however, blowcounts can be affected strongly by gravel content, thermal state, drilling procedures, condition of equipment and performance of the test.

Standard Penetration Resistance N (blows / foot) or N (blows / 300 mm)	Soil Density
0 - 5	Very loose
6 - 10	Loose
11 - 30	Medium dense
31 - 50	Dense
More than 50	Very dense

An estimate of the consistency of fine-grained soils is based on the observed drill action and on drive sample data. The guide below is used:

Standard Penetration Resistance N (blows / foot) or N (blows / 300 mm)	Soil Consistency
0 - 2	Very soft
3 - 4	Soft
5 - 8	Firm
9 - 15	Stiff
15 - 30	Very stiff
More than 30	Hard

Soil Layer Boundaries - Generally, there is a gradual transition from one soil type to another in a natural soil deposit, and it is difficult to determine accurately the boundaries of the soil layers.

- A *diagonal line* between soil layers on the graphic boring log indicates the general region of transition from one soil layer to another.
- A *dashed diagonal line* indicates the soil boundary was detected only by a change in the recovered samples and the actual boundary may be anywhere between the indicated sample depths.
- A *horizontal line* between soil layers indicates a relatively distinct transition between soil types was observed in the recovered samples and / or by a distinct change in drill action.

Sample Interval - The sample interval is shown graphically on the test boring log and generally is accurate to about 0.5 foot (0.15 meter).

Frost Depth and Soil Temperatures - If frozen ground is encountered during drilling, the interval of frozen soil is shown graphically on the test boring log. Generally, the temperature of a few soil samples is measured and shown on the boring log. These sample temperatures only give a qualitative indication of the *in situ* soil temperatures. The temperature of samples can be influenced significantly by the ambient air temperature and friction during drilling and sampling.

Soil Moisture Content - Generally, laboratory soil moisture content tests are performed on all recovered samples. Only about 30 grams of the minus No. 4 material typically is used for the moisture content test, so results reported on the log may not reflect accurately the *in situ* moisture content of gravelly soils.

Soil Density - The soil density shown on the test boring logs generally is determined by measuring the wet weight, moisture content, and physical dimensions of relatively undisturbed specimens.

Ground Water - The depth to ground water observed during drilling generally is shown on the test boring log. The depth to ground water observed during drilling can differ significantly from the depth to the actual ground water table, particularly in fine-grained soils. When more accurate water level measurements are desired, we typically install perforated PVC pipe in a boring to monitor the ground water level.

Penetration Resistance, N - Standard penetration tests (SPT) are performed in accordance with ASTM Designation D1586 "Standard Method for Penetration Test and Split-Barrel Sampling of Soils." A modified penetration test using a 2.5-inch (63.5 mm) I.D. split spoon driven with a 340-pound (154.2 kg) hammer falling 30 inches (.76 m) is performed to obtain larger samples, particularly in gravelly soils. The boring log key describes the graphic symbols used to differentiate between sample types.

Undisturbed Samples - Undisturbed Shelby tube samples are obtained in accordance with ASTM Designation D1587, "Standard Practice for Thin-Walled Tube Sampling of Soils." Generally, 3-inch (76.2 mm) O.D. Shelby tubes are used. Relatively undisturbed liner samples are obtained in accordance with ASTM Designation D3550, "Standard Practice for Ring-Lined Barrel Sampling of Soils," except a thick-walled cutting shoe is used. Typically, the sampler is driven using a 340-pound (154.2 kg) weight falling 30 inches (.76 m). The typical brass liner has an I.D. of 2.4 inches (91 mm).

Grab Samples - Grab samples are obtained from the auger flights. The sample depth and interval indicated on the test boring log should be considered a rough approximation. The grab samples may not be representative of *in situ* soils, particularly in layered soil deposits.

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM DESIGNATION: D2487
Based on the Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on #200 sieve	Gravels More than 50% of coarse fraction retained on #4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3^E$	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3^E$	GP	Poorly graded gravel[F]
		Gravel with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes #4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3^E$	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3^E$	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty Sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey Sand[G,H,I]
Fine-Grained Soils 50% or more passes the #200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean Clay[K,L,M]
			PI < 4 or plots below "A" Line[J]	ML	Silt[K,L,M]
		Organic	Liquid limit - oven dried <0.75	OL	Organic Clay[K,L,M,N]
			Liquid limit - not dried	OL	Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		Organic	Liquid limit - oven dried <0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried	OH	Organic clay[K,L,M,Q]
Highly organic soils		Primarily organic matter,	dark in color, and organic odor	PT	Peat

A Based on the material passing the 3-in. (75mm) sieve.

B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

C Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

D Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

E $Cu = \frac{D_{60}}{D_{10}}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

F If soil contains ≥ 15% sand, add "with sand" to group name.

G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

H If fines are organic, add "with organic fines" to group name.

I If soil contains ≥ 15% gravel, add "with gravel" to group name.

J If Atterberg Limits plot in hatched area, soil is a CL-ML, silty clay.

K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

L If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.

M If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

N PI ≥ 4 and plots on or above "A" line.

O PI < 4 or plots below "A" line.

P PI plots on or above "A" line.

Q PI plots below "A" line.

DESCRIPTION OF FROZEN SOILS (Visual-Manual Procedure) ASTM Designation: D4083

Part I Description of Soil Phase	Classify Soil Phase by ASTM D2487 or D2488					
		Group Symbol	Subgroup Description	Subgroup Symbol		Field Identification
Part II Description of Frozen Soil	Segregated ice is not visible by eye	N	Poorly bonded or friable	N_f		Identify by visual examination. To determine presence of excess ice, use procedures under Note 2 and hand magnifying lens as necessary. For soils not fully saturated, estimate degree of ice saturation; medium, low. Note presence of crystals or of ice coatings around larger particles.
			No excess ice	N_b	N_{bn}	
			Well-bonded			
			Excess ice		N_{be}	
	Segregated ice is visible by eye (ice 1-inch (25 mm) or less in thickness)	V	Individual ice crystal or inclusions	V_x		For ice phase, record the following when applicable: Location — Structure Orientation — Color Thickness — Size Length — Shape Spacing — Hardness Pattern of arrangement
			Ice coatings on particles	V_c		
			Random or irregularly oriented ice formations	V_r		
			Stratified or distinctly oriented ice formations	V_s		Estimate volume of visible segregated ice present as percentage of total sample volume.
			Uniformly distributed ice	V_u		
Part III Description of Substantial Ice	Ice (greater than 1-inch (25 mm) in thickness)	ICE	Ice with soil inclusions	ICE + Soil Type		Designate material as ICE (Note 3) and use descriptive terms as follows, usually one item from each group, where applicable: **Hardness**: HARD, SOFT [of mass, not individual crystals] **Structure** (Note 4): CLEAR, CLOUDY, POROUS, CANDLED, GRANULAR, STRATIFIED **Color** (Examples): COLORLESS, GRAY, BLUE **Admixtures** (Examples): CONTAINS FEW THIN SILT INCLUSIONS
			Ice without soil inclusions	ICE		

Note 1: Frozen soils in the N group may, on close examination, indicate presence of ice within the voids of the material by crystalline reflections or by a sheen on fractured or trimmed surfaces. The impression received by the unaided eye, however, is that none of the frozen water occupies space in excess of the original voids in the soil. The opposite is true of frozen soils in the V group.

Note 2: When visual methods may be inadequate, a simple field test to aid in evaluation of the volume of excess ice can be made by placing some frozen soil in a small jar, allowing it to melt, and observing the quantity of supernatant water as a percentage of total volume.

Note 3: Where special forms of ice such as hoarfrost can be distinguished, more explicit description should be given.

Note 4: Observer should be careful to avoid being misled by surface scratches or frost coating on the ice.

DEFINITIONS

1) Ice coatings on Particles - discernible layers of ice found on or below the larger soil particles in a frozen soil mass.
2) Ice Crystal - a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in combination with other ice formations.
3) Clear Ice - ice that is transparent and contains only a moderate number of air bubbles.
4) Cloudy Ice - ice that is translucent or relatively opaque due to the content of air or for other reasons, but which is essentially sound and impervious.
5) Porous Ice - ice that contains numerous voids, usually interconnected and usually resulting from melting at air bubbles or along crystal interfaces from presence of salt or other materials in the water, or from the freezing of saturated snow. Though porous, the mass retains its structural unity.
6) Candled Ice - ice that has rotted or otherwise formed into long columnar crystals, very loosely bonded together.
7) Granular Ice - ice that is composed of coarse, more or less equidimensional crystals weakly bonded together.
8) Ice Lenses - lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss, and commonly in repeated layers.
9) Ice Segregation - the growth of ice within soil in excess of the amount that may be produced by the in-place conversion of the original void moisture to ice. Ice segregation occurs most often as distinct lenses, layers, veins, and masses, commonly, but not always, oriented normal to the direction of heat loss.
10) Well-Bonded - a condition in which the soil particles are strongly held together by the ice so that the frozen soil possesses relatively high resistance to chipping or breaking.
11) Poorly-Bonded - a condition in which the soil particles are weakly held together by the ice so that the frozen soil has poor resistance to chipping and breaking.
12) Thaw Stable - the characteristics of frozen soils that, upon thawing, do not show loss of strength in comparison to normal, long-time thawed values nor produce detrimental settlement.

FROST DESIGN SOIL CLASSIFICATION[1]

Frost[2] Group	Kind of Soil	Percentage Finer than 0.02 mm by Weight	Typical Soil Types Under Unified Soil Classification System
NFS[3]	(a) Gravels Crushed stone Crushed rock	0 to 1.5	GW and GP
	(b) Sands	0 to 3	SW and SP
PFS[4] (MOA NFS)	(a) Gravels Crushed stone Crushed rock	1.5 to 3	GW and GP
(MOA F2)	(b) Sands	3 to 10	SW and SP
S1 (MOA F1)	Gravelly soils	3 to 6	GW, GP, GW-GM, and GP-GM
S2 (MOA F2)	Sandy soils	3 to 6	SW, SP, SW-SM, and SP-SM
F1	Gravelly soils	6 to 10	GM, GW-GM, and GP-GM
F2	(a) Gravelly soils	10 to 20	GM, GW-GM, and GP-GM
	(b) Sands	6 to 15	SM, SW-SM, and SP-SM
F3	(a) Gravelly soils	Over 20	GM and GC
	(b) Sands, except very fine silty sands	Over 15	SM and SC
	(c) Clays, P1>12		CL and CH
F4	(a) All silts		ML and MH
	(b) Very fine silty sands	Over 15	SM
	(c) Clays, P1<12		CL and CL-ML
	(d) Varved clays and other fine-grained, banded sediments		CL and ML CL, ML, and SM CL, CH, and ML CL, CH, ML and SM

1

[1] Departments of the Army and Air Force Publication TM 5-822-5/AFM 88-7, "Pavement Design for Roads, Streets, Walks, and Open Storage Areas", Table 18-2.
[2] Corps of Engineers Frost groups directly correspond to the Municipality of Anchorage soil frost classification groups, except as noted.
[3] Non Frost-Susceptible.
[4] Possibly frost-susceptible, but requires laboratory test to determine frost design soil classification.

APPENDIX C –
THERMISTOR TEMPERATURE MEASUREMENTS

Healy Hydraulic Pit Reclamation Project Thermistor Readings

Data Collected on March 3, 2016

Test Boring 1	
Depth (ft)	Temp (°F)
4	32.0
6	32.6
8	33.7
10	34.0
12	34.0
14	34.4
16	34.6
18	34.8
20	34.9
22	34.9
24	34.8
26	34.8
28	34.8
30	34.6
32	34.5
34	34.4
36	34.3
38	34.4
40	34.3
42	34.0
44	33.7

44 hour equilibration time

Test Boring 3	
Depth (ft)	Temp (°F)
Surface	22.2
0.5	22.1
2.5	22.1
4.5	28.8
6.5	31.2
8.5	31.9
10.5	32.1
12.5	32.2
14.5	32.2
16.5	32.2
18.5	32.2
20.5	32.2
22.5	32.1
24.5	31.8
26.5	31.9
28.5	31.9
30.5	31.7

44 hour equilibration time

Test Boring 7	
Depth (ft)	Temp (°F)
Surface	23.1
0.5	20.3
2.5	25.6
4.5	27.3
6.5	28
8.5	28.4
10.5	29.1
12.5	30
14.5	30.9
16.5	31.6
18.5	31.8
20.5	31.8
22.5	31.8
24.5	31.8
26.5	31.9
28.5	31.8
30.5	31.6
32.5	31.8
34.5	31.8
36.5	31.6

49 hour equilibration time

Test Boring 10	
Depth (ft)	Temp (°F)
Surface	22.2
1	22.3
3	26.9
5	27.9
7	28.6
9	29.2
11	30.1
13	31.3
15	31.6
17	31.8
19	31.8
21	31.7
23	31.7
25	31.7
27	31.7
29	31.8
31	31.7
33	31.7

49 hour equilibration time