ARCTIC STRATEGIC TRANSPORTATION AND RESOURCES (ASTAR) PROJECT GEOPHYSICAL REPORT: CAPACITIVELY - COUPLED RESISTIVITY SURVEY FOR UTQIAGVIK, ATQASUK, AND WAINWRIGHT ROAD NETWORK, NORTH SLOPE, ALASKA

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ARCTIC STRATEGIC TRANSPORTATION AND RESOURCES (ASTAR) PROJECT GEOPHYSICAL REPORT: CAPACITIVELY-COUPLED RESISTIVITY SURVEY FOR UTQIAGVIK, ATQASUK, AND WAINWRIGHT ROAD NETWORK, NORTH SLOPE, ALASKA

Tim G. Tannenbaum[1], Garrett G. Speeter[1], and Trent D. Hubbard[2]

INTRODUCTION

The State of Alaska Department of Transportation and Public Facilities (DOT&PF), Northern Region Materials Section (NRMS) supports the feasibility planning for the Arctic Strategic Transportation and Resources (ASTAR) project, North Slope, Alaska. The goal of ASTAR is to identify, evaluate, and advance opportunities to enhance the quality of life and economic opportunities in North Slope Borough (NSB) communities through infrastructure development. One component of this project involves evaluating construction material resources that might be used for infrastructure and development projects, potentially including roads on the Arctic Coastal Plain to connect existing infrastructure with communities and resource development projects.

At the request of the Alaska Division of Geological & Geophysical Surveys (DGGS), and as suggested by NRMS Chief Engineering Geologist G. Speeter, NRMS completed a Capacitively-Coupled Resistivity (CCR) survey along the first 10 miles of the proposed corridor of the all-season road network connecting the northern Alaskan communities of Utqiagvik, Atqasuk, and Wainwright (fig. 1). The first 10 miles of the proposed corridor follow the route used for the North Slope Borough Community Winter Access Trail (CWAT). The goal of the CCR survey was to collect resistivity measurements of the subsurface soils to aid in selecting construction material site drill targets for the proposed road network. The resulting data can be downloaded from the DGGS website doi.org/10.14509/30960.

Follow-up geotechnical drilling of the materials site targets identified during the desktop study and from the CCR survey was completed in August of 2022 to potentially provide proof-of-concept that CCR data could be used for site selection and define materials sites. Geotechnical drilling results and preliminary design recommendations are presented in Tannenbaum (2022). A comparison of subsurface stratigraphy observed in test hole data, with the subsurface stratigraphy interpreted from CCR data, suggests that use of CCR to identify potential material sites is ineffective due to the local cyrostructure. The use of CCR to evaluate foundation soils for ground-ice content during alignment selection, however, is a cost-effective tool.

FIELD INVESTIGATION

Field work for the geophysical survey was conducted April 18–23, 2022, by NRMS Engineering Geologists T. Tannenbaum and M. Blake, based out of Utqiaqvik, Alaska. Snowmachines and local trail information, provided by the North Slope Borough Wildlife Management Department, were used to access field sites and collect data.

Field work for the material site investigation was conducted August 1–26, 2022, by NRMS Engineering Geologist T. Tannenbaum and NRMS Drillers P. Lanigan, D. Coke, and T. Hartford. A Bell 407 helicopter operated by Maritime Helicopters out of the Utqiagvik Airport provided daily access to field areas.

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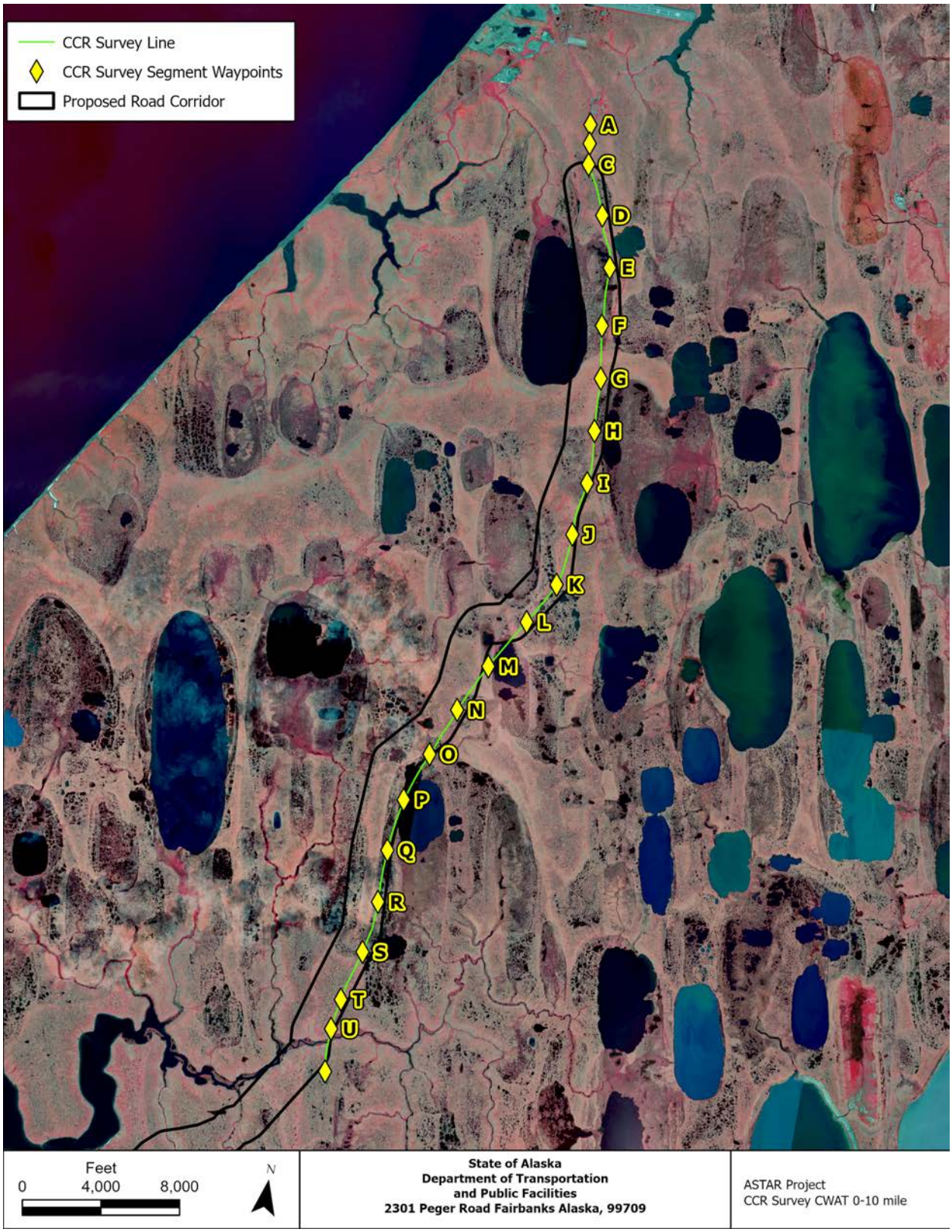

Figure 1. Capacity-coupled resistivity (CCR) survey location along proposed road corridor, Utqiagvik, Alaska. Starting points of each CCR survey line are labeled A through U.

Geophysical Investigation Methods

The CCR geophysical survey was conducted from approximately mile 0 to 10 of the CWAT, during which 50,000 survey-line feet of data were collected (fig. 1). The CCR survey was designed to be used in tandem with surficial geology terrain maps (DGGS and ASRC Energy Services, in preparation) and limited subsurface test hole data from a 2004 U.S. Army Corps of Engineers (USACE) Coastal Storm Damage Reduction Gravel Exploration study (USACE, 2005) to assist in identifying potential drill targets for construction material exploration. CCR data was collected in 0.25- to 0.5-mile segments for efficient processing with smaller batches of raw data. Data were collected along 21 survey line segments, labeled A through U (fig. 1).

Capacitively-Coupled Resistivity

CCR surveys measure the electrical properties of rock and soil by pulling a coaxial cable array with a transmitter and receivers along the ground. The transmitter sends a continuous current sine wave polarizing the surrounding earth material, and the receiver array measures the induced polarization from which resistivity can be derived.

A Geometrics OhmMapper CCR system, consisting of one transmitter and five receivers connected in series, was used for this project. Multiple passes along each survey line segment were completed using different receiver geometries to collect data at different depths (fig. 2). Changing both the dipole size (cable length) and rope length between the transmitter and receiver(s) allows multiple depths of acquisition for each survey.

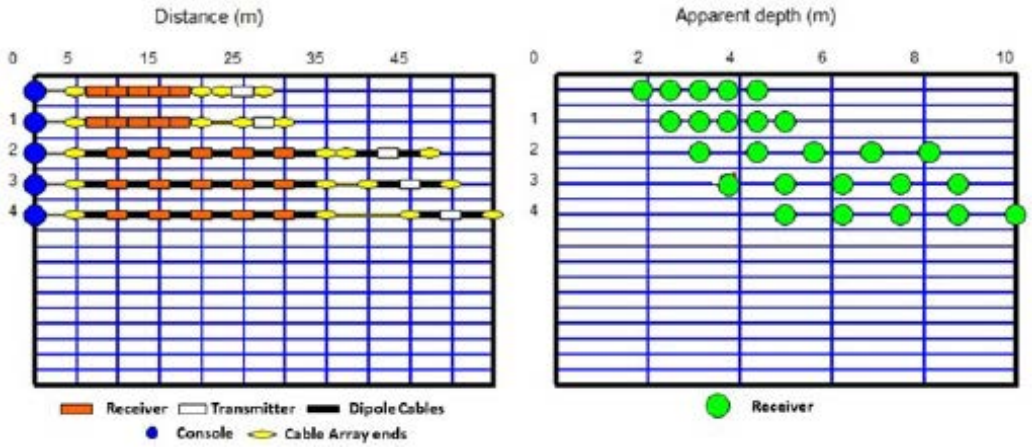

Figure 2. CCR Geophysical survey receiver geometry (left) and apparent survey depth (right).

The measured output of resistivity data from the CCR survey is reported in ohm-meters (ohm-m). The measured resistivity of subsurface materials should be considered a non-unique dataset with multiple types of soil and rock capable of producing similar measured resistivity values. As illustrated in figure 3, unweathered igneous and metamorphic bedrock, sand and gravels, limestone, and ice-rich permafrost can all produce measured resistivity in the same ranges. The electrical properties of soil and rock vary drastically due to phase changes of water in-situ. Frozen soil is resistive to current flow, especially when ice contents are high, whereas groundwater is conductive (low resistivity). The following are typical generalized resistivity ranges for soil types (Hoekstra and others, 1975):

- 0–100 ohm-m = thawed, or possibly wet material
- 100–1000 ohm-m = ice-poor frozen material and most coarse-grained materials (river gravels/sand)
- 1000–100,000 ohm-m = Ice-moderate to ice-rich material

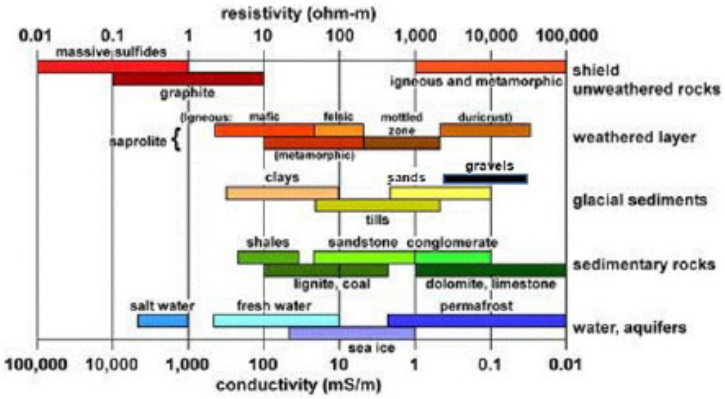

Figure 3. Generalized resistivity ranges for rocks and soils, after Palacky,1988).

Geometrics OhmImager software version 4.0.2.2 was used to process the raw CCR data, which was reviewed and checked for data quality. Next, the data were compiled into a format compatible with creating a 2D data inversion. Aarhus GeoSoftware Res2dInv version 4.10.20 was used to create 2D resistivity data models and display color contoured pseudosection plots. The resistivity pseudosections were interpreted using a combination of resistivity data, surface conditions observed from satellite imagery, surficial geology terrain maps, and test hole data.

Drilling and Sampling

Material site drilling was conducted using a helicopter-portable CME-45 drill rig equipped with 6.5-inch hollow-stem augers. Test holes were selected in areas favorable for potentially hosting construction materials. A grid pattern of holes was drilled at each site with the goal of identifying 1 million cubic yards of construction materials per site. Each test hole was located using a Garmin GPSmap 62s recreational grade GPS (datum WGS 84) with an accuracy of +/- 50-feet. The elevation at each test hole was obtained by plotting the test holes on a lidar derived digital elevation model surface in an ArcGIS Pro workspace and then using an ArcGIS Pro geoprocessing tool to extract the elevation for each location. Test holes were backfilled with cuttings after drilling was completed.

Split-spoon sampling was conducted during hollow-stem auger drilling, with a standard sampling interval of 5 feet from the ground surface to the bottom of hole (BOH). A 2-inch inner diameter, 2.5-inch outer diameter split-spoon sampler was driven into the ground using a 340-pound CME automatic hammer with a 30-inch free-fall drop during sampling. Blow count measurements were recorded as the number of hammer blows required to advance the sampler down a six-inch interval. The sum of the second and third 6-inch intervals are shown as the N-value on the test hole logs, and refusal occurred when 50 or more blows were required to advance the sampler six inches.

Samples were collected from auger cuttings or split-spoons, placed in double-layered Ziploc® brand bags or poly bags labeled with permanent marker for storage, and transported to the Mappa Test lab in North Pole, Alaska. Test hole logs are presented in appendix C.

Laboratory Data

Soil samples and test hole conditions were logged in the field following the criteria in the Alaska Geotechnical Procedures Manual (DOT&PF, 2007a) and using the Unified Soil Classification System (USCS). In addition, the Alaska Guide to Description and Classification of Peat and Organic Soil (DOT&PF, 2007b)

and the Description and Classification of Frozen Soils (USACE, 1966) were used to describe organic rich or frozen subsurface conditions. Selected samples were tested in accordance with ASTM/AASHTO methods for a determination of any one or a combination of the following properties (table 1):

- Classification (particle size distribution)
- Moisture content
- Atterberg limits
- Organic content

Table 1. List of Index Tests. AASHTO = American Association of State Highway and Transportation Officials. ASTM = American Society for Testing and Materials

Test Method	AASHTO	ASTM
Gradation	T27	C136
Liquid Limit	T89	D4318
Plastic Limit	T90	D4318
Moisture Content – Aggregate Soil	T255 T265	C566 D2216
Organic Content (Burn)	T267	
USCS Classification	D2487	

SUBSURFACE CONDITIONS AND OBSERVATIONS

The CCR survey was conducted within the first 10 miles of the proposed corridor of the ASTAR Project road network for Utqiagvik, Atqasuk, and Wainwright, beginning at Utqiagvik. NRMS Chief Engineering Geologist G. Speeter identified three high resistivity anomalies during the survey that could represent potential sites for construction material exploration (fig. 4) or ice-rich soil. The sites were selected during a desktop study of surficial geology terrain units (DGGS, in preparation) with the goal of finding materials suitable for road construction. The terrain units mapped as coastal beach and barrier island deposits, inland paleo-beach and barrier reef deposits, and gravel-bearing marine sands were interpreted to be the most probable sources of construction materials. Inland paleo-beach and barrier island, and marine sand were the only deposits present in this investigation area. Ground-truthing for CCR interpretations was aided by subsurface data from test holes drilled during the 2004 USACE Coastal Storm Damage Reduction Gravel Exploration Program and 2022 DOT&PF Materials Site Investigations, proximal to the CCR survey. Test hole logs are presented in appendix B. The proposed material site exploration targets identified during the desktop study fall within CCR survey line segments A–C, F, and M. Annotated pseudosection figures are presented in appendix A and figure numbers in this text are hyperlinked.

CCR Comparison with Test Hole Data Segments A, B, and C

Segments A through C partially underlie proposed material site exploration target 6 (fig. 5). Test holes BIA-01 and BIA-28 are located at the southwest margin of the proposed material site exploration target and approximately 3,400 feet from segment A. The generalized subsurface stratigraphy of these test holes is:

- 4.5- to 8-foot-thick layer of ice, with frozen sand and silt inclusions underlain by a;
- 2- to 10-foot-thick layer of frozen silty sand, with up to 12 percent gravel underlain by a;
- 4.5- to 10-foot-thick layer of frozen poorly graded sand with silt and gravel and silty sand with gravel with up to 46 percent gravel underlain by a;
- 4.5- to 8-foot-thick layer of frozen silty sand underlain by;
- Frozen silt.

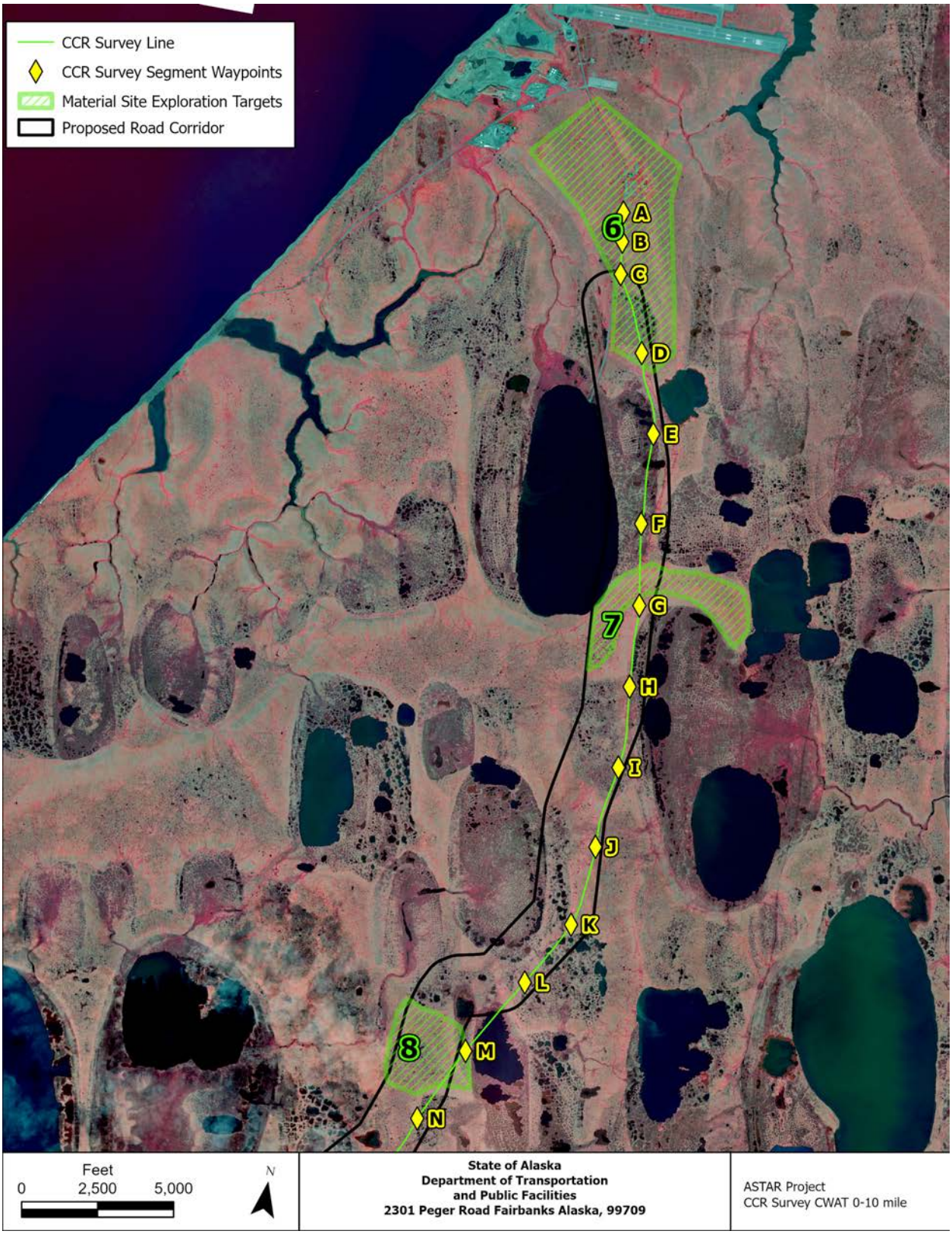

Figure 4. CCR survey line along proposed road network corridor with proposed material site exploration targets.

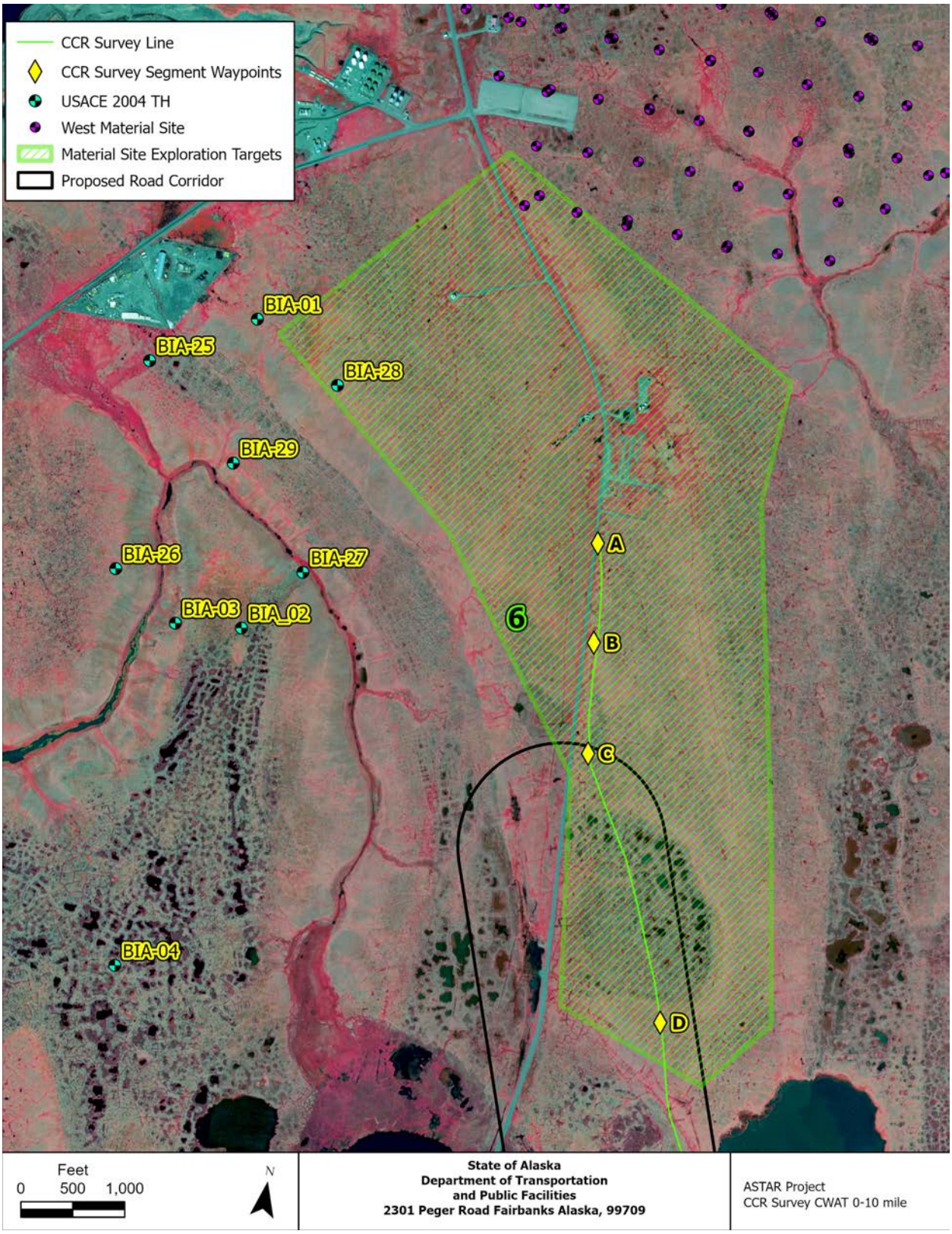

Figure 5. CCR survey line segments A through E with USACE test hole locations.

Segment A from 0 to 964 survey line-feet (fig. A1) is interpreted to represent a generalized subsurface stratigraphy of:

- 5- to 9-foot-thick layer of highly to very highly resistive material, interpreted to be frozen surface water in polygonal thermokarst troughs and organic silty ice wedge-rich permafrost underlain by a;
- 22- to 30-foot-thick layer of moderately to highly resistive material, interpreted to be frozen sand with gravel and gravel with sand with occasional ice underlain by;
- Low resistivity frozen silt and silty sand.

Segment B from 0 to 1,074 survey line-feet (fig. A2) is interpreted to represent a generalized subsurface stratigraphy of:

- 7- to 12-foot-thick layer of highly to very highly resistive material, interpreted to be frozen surface water in polygonal thermokarst troughs and organic silty ice wedge-rich permafrost underlain by a;
- 25- to 32-foot-thick layer of moderately highly resistive material, interpreted to be frozen sand with gravel and gravel with sand with occasional ice that thins to a;
- 10- to 20-foot-thick layer of moderately highly resistive material, interpreted to be frozen sand with gravel and gravel with sand with occasional ice and is underlain by;
- Frozen silt and silty sand from survey line-footage 500 to 1,074.

Segment C from 0 to 2,688 survey line-feet (fig. A3) is interpreted to represent a generalized subsurface stratigraphy of:

- 7- to 20-foot-thick layer of highly to very highly resistive material, interpreted to be frozen surface water in polygonal thermokarst troughs and organic silty ice wedge-rich permafrost underlain by a;
- 15- to 20-foot-thick layer of moderately highly resistive material, interpreted to be frozen sand with gravel and gravel with sand with occasional ice that thickens to a;
- 20- to 25-foot-thick layer of moderately highly resistive material, interpreted to be frozen sand with gravel and gravel with sand with occasional ice underlain by;
- Frozen silt and silty sand from survey line-footage 0 to 1,350.

Segment F

Segment F partially underlies proposed material site exploration target 7 (fig. 6). Test holes BIA-08 and BIA-19 are located south of the proposed material site exploration target and approximately 3,500 feet from segment F. The generalized subsurface stratigraphy of these test holes is:

- 8-foot-thick layer of ice with silt inclusions and frozen organic silt underlain by a;
- 4.5-foot-thick layer of frozen silty sand, with gravel (up to 18 percent) underlain by a;
- 10- to 20-foot-thick layer of frozen silty sand and sandy silt underlain by a;
- 3.5- to 7.5-foot-thick layer of frozen poorly graded sand underlain by frozen peat in BIA- 19.

Segment F from 0 to 2,675 survey line-feet (fig. A4) is interpreted to represent a generalized subsurface stratigraphy of:

- 7- to 10-foot-thick layer of highly to very highly resistive material, interpreted to be frozen surface water in polygonal thermokarst troughs and organic silty ice wedge-rich permafrost underlain by a;
- 5- to 12-foot-thick layer of moderately highly resistive material, interpreted to be frozen sand with gravel and gravel with sand with occasional ice that thickens to a;

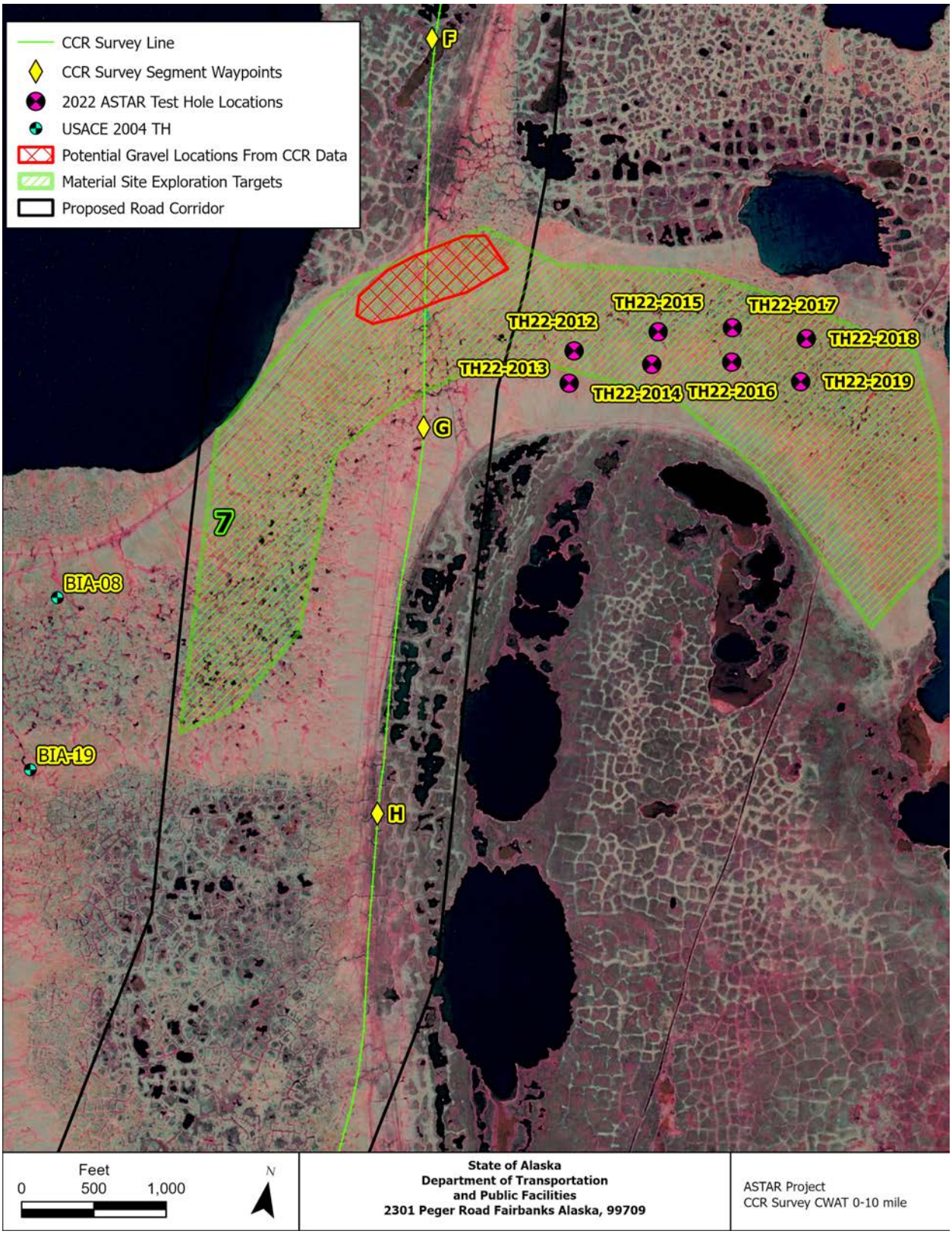

Figure 6. CCR survey line segments F through H and test hole locations.

- 10- to 20-foot-thick layer of moderately highly to highly resistive material, interpreted to be frozen gravel with sand with occasional ice from survey line footage 1,650 to 2,000, but elsewhere thins to a;
- 10- to 20-foot-thick layer of moderately highly resistive material, interpreted to be frozen sand with gravel and gravel with sand with occasional ice that is underlain by;
- Frozen silt and silty sand.

The combination of this area being mapped as beach and barrier island deposits, along with the presence of potential gravel deposits interpreted from CCR data, led to MS 7 being selected as a material site drill target. Eight test holes (TH22-2012 to TH22-2019), spaced 250 to 600 feet apart, were drilled from depths ranging from 36 to 47 feet below ground surface (bgs; fig. 6).

Test holes drilled at this site encountered a generalized subsurface stratigraphy of a:

- 0.3- to 1.0-foot-thick layer of thick thawed organic mat overlying a;
- 0.6- to 1.2-foot-thick layer of thawed, moist, organic silt overlying a;
- 1.1- to 10.0-foot-thick layer of frozen Vx/Vs silt with ice content from 10 to 70 percent and massive ice layers from 1 to 5-feet thick overlying a;
- 6.0- to 14.0-foot-thick layer of frozen Vx/Vs silty sand and sandy silt with ice content from 10 to 70 percent overlying a;
- 5.0- to 11.0-foot-thick layer of frozen Nbn/Nf poorly graded sand with gravel and well-graded sand with gravel overlying a;
- 10.0- to 15.5-foot-thick layer of frozen Nbn/Nf poorly graded sand, well-graded-sand, silty sand, and silt overlying;
- Frozen, lean clay, silty sand, and silt with sand.

A comparison of test hole data from MS 7, with stratigraphy interpreted from the CCR data, suggests a more complex subsurface stratigraphy is present than can be interpreted from resistivity pseudosections. In this case, the resistivity signature of the ice content and cryostructure of the surveyed soils is dominant over the resistivity signature of interbedded silt, silty sand, sandy silt, poorly-graded sand with silt poorly-graded sand with gravel and well-graded sand with gravel horizons observed in test holes.

Segment M

Segment M partially underlies proposed material site exploration target 8 (fig. 7). USACE test hole BIA-13 is located southwest of the proposed material site exploration target and approximately 4,500 feet from Segment M. A generalized subsurface stratigraphy of this test hole is:

- 4-foot-thick layer of frozen peat underlain by a;
- 6-foot-thick layer of ice underlain by a;
- 8-foot-thick layer of frozen silty sand underlain by a;
- 7.5-foot-thick layer of frozen poorly graded sand underlain by;
- Frozen sandy silt.

Segment M, from 0 to 2,725 survey line-feet (fig. A5), is interpreted to represent a generalized subsurface stratigraphy of:

- 5- to 12-foot-thick layer of highly to very highly resistive material, interpreted to be frozen surface water in polygonal thermokarst troughs and organic silty ice wedge-rich permafrost underlain by a;

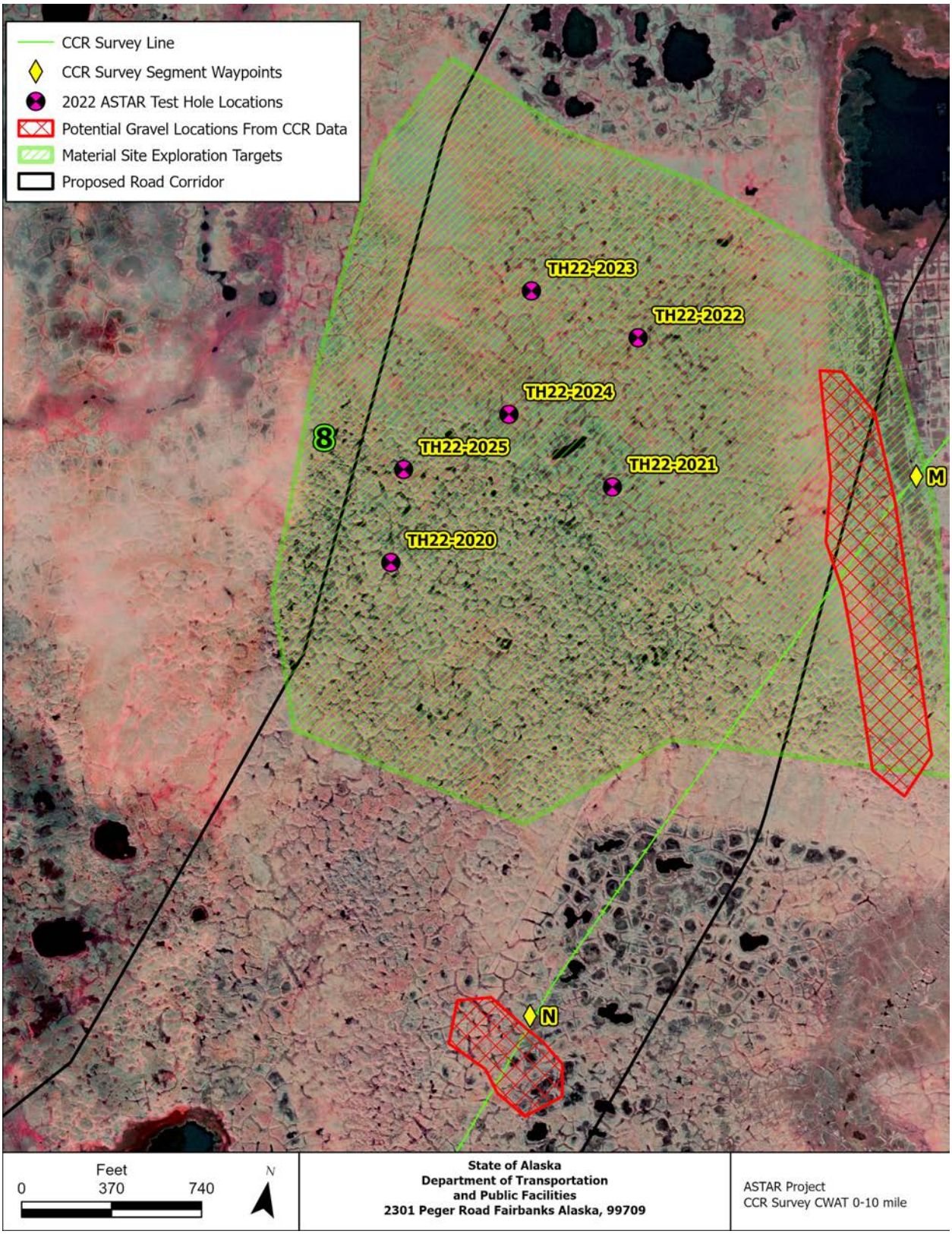

Figure 7. CCR survey line segments M through N and test hole locations.

- 2- to 27-foot-thick layer of moderately highly resistive material, interpreted to be frozen sand with gravel and gravel with sand with occasional ice with a;
- 20-foot-thick layer of highly resistive material, from 300 to 500 survey line-feet, that may be sand with gravel underlain by;
- Frozen silt.

The combination of this area being mapped as beach and barrier island deposits, along with the presence of potential gravel deposits interpreted from CCR data, led to MS 8 being chosen as a material site drill target. Five test holes (TH22-2021 to TH22-2025), spaced 450 to 875 feet apart, were drilled from depths ranging from 30 to 42 feet bgs. See figure 7 for test hole locations and appendix B for test hole logs.

Test holes drilled at this site encountered a generalized subsurface stratigraphy of a:

- 0.3- to 0.4-foot-thick layer of thawed organic mat, overlying a;
- 0.5- to 1.0-foot-thick layer of thawed, moist, organic silt, overlying a;
- 18.0- to 30.0-foot-thick layer of frozen, Vx/Vs silt, silty sand, sandy silt, and sandy silty clay with ice content from 10 to 50 percent and massive ice layers from 2- to 9-foot-thick, overlying a;
- 14.0- to 20.0-foot-thick layer of frozen, Nbn/Nf poorly graded sand with silt, poorly graded sand, and silty sand (absent in TH22-2023 and TH22-2024), overlying a;
- 4.0- to 15.0-foot-thick layer of frozen, Nf/Nbn poorly graded sand with gravel and well-graded sand with gravel (absent in TH22-2021 and TH22-2024), overlying;
- Frozen, Nbn/Nf sandy silt, silt sand, and silt.

A comparison of the test hole data from MS 8, with stratigraphy interpreted from the CCR data, suggests a more complex subsurface stratigraphy is present than can be interpreted from resistivity pseudosections. In this case, the resistivity signature of the ice content and cryostructure of the surveyed soils is dominant over the resistivity signature of interbedded silt, silty sand, sandy silt, poorly-graded sand with silt poorly-graded sand with gravel and well-graded sand with gravel horizons observed in test holes.

Subsurface Conditions Interpreted from CCR

CCR pseudosections with nearby test hole data were interpreted using a combination of resistivity values from inversion models and test hole subsurface conditions. These interpretations were than used as guidelines for interpreting CCR pseudosections with no nearby test hole data. Annotated pseudosections not discussed are presented in appendix A. These pseudosections are interpreted to have a similar subsurface stratigraphy as the pseudosections discussed in the previous section.

Segments presented in figures A6–A20 are interpreted to represent a generalized subsurface stratigraphy of:

- 5- to 14-foot-thick layer of highly to very highly resistive material, interpreted to be frozen surface water in polygonal thermokarst troughs and organic silty ice wedge-rich permafrost underlain by a;
- 5- to 25-foot-thick layer of moderately highly resistive material, interpreted to be frozen sand with gravel and gravel with sand with occasional ice or interlayered silty sand, sandy silt, poorly graded sand with silt and gravel with variable ice content underlain by;
- Frozen silt and silty sand.

Segments with resistivity values that may indicate the presence of sand with gravel and/or gravel with sand are listed by survey line segment and line footage (fig. 8):

- Segment F, survey line footage 1,600 to 2,000.
- Segment K, survey line footage 1,400 to 1,800.
- Segment L, survey line footage 500 to 800.
- Segment M, survey line footage 300 to 500.
- Segment N, survey line footage 50 to 250.

Larger, less distinct resistivity signatures are seen for the entire length of segment A and for segment B survey line footage 0 to 425.

CONCLUSIONS AND RECOMMENDATIONS

The combination of subsurface data from the USACE test holes with CCR data in areas of prospective surficial geology terrain map units suggests that areas on pseudosections with resistivity values ranging from 790 to 2,970 ohm-m (drab olive-green to yellow- to tan-colored contour on pseudosections) could be interpreted as having an increased probability of containing suitable construction material. Resistivity values in this range are thought to represent either coarse-grained granular material, such as gravel, or frozen material with higher ice content than the surrounding ground. A high resistivity signature could be produced by either gravel, ice-rich soil, or bedrock because resistivity signatures are a non-unique dataset. An understanding of the geologic depositional environment, along with subsurface ground truth from test holes, is required for interpretation of resistivity signatures.

Drill testing of material site targets with these resistivity signatures likely shows that the resistivity signature of ice content masks the resistivity of the soil profile, which suggests that using CCR as a tool for identifying coarse granular soils in areas with high ground ice content is ineffective. The Material Site Investigation and Alignment Reconnaissance Geotechnical Report (Tannenbaum, 2022) provides complete results from geotechnical drilling of potential materials sites and preliminary design recommendations.

Surficial geology terrain maps remain the most tangible starting point for identifying areas of potential construction material, however, drill testing of sites with favorable surficial geology terrain units is still required to fully define subsurface conditions. The likelihood of CCR being successfully used as a stand-alone targeting tool in areas with high ground ice content is low. Mapping the ground ice content of foundation soils with CCR alone, or in tandem with ice-wedge polygon maps, along proposed alignments, however, would be a cost-efficient method to classify foundation soils and ground truth remotely sensed terrain units.

ACKNOWLEDGMENTS

The State of Alaska funded this work through the Arctic Strategic Transportation and Resources (ASTAR) Capital Improvements Project (CIP). ASTAR work supports a collaborative effort between the North Slope Borough, the Department of Natural Resources, and the Department of Transportation and Public Facilities to strengthen community infrastructure and facilitate access to arctic resources while enhancing the quality of life and economic opportunities for North Slope communities. The project also provides valuable information for land-use management and planning decisions. The authors thanks Trent Hubbard for his thoughtful review and B. Sarren (North Slope Borough Wildlife Management) for helpful trail information.

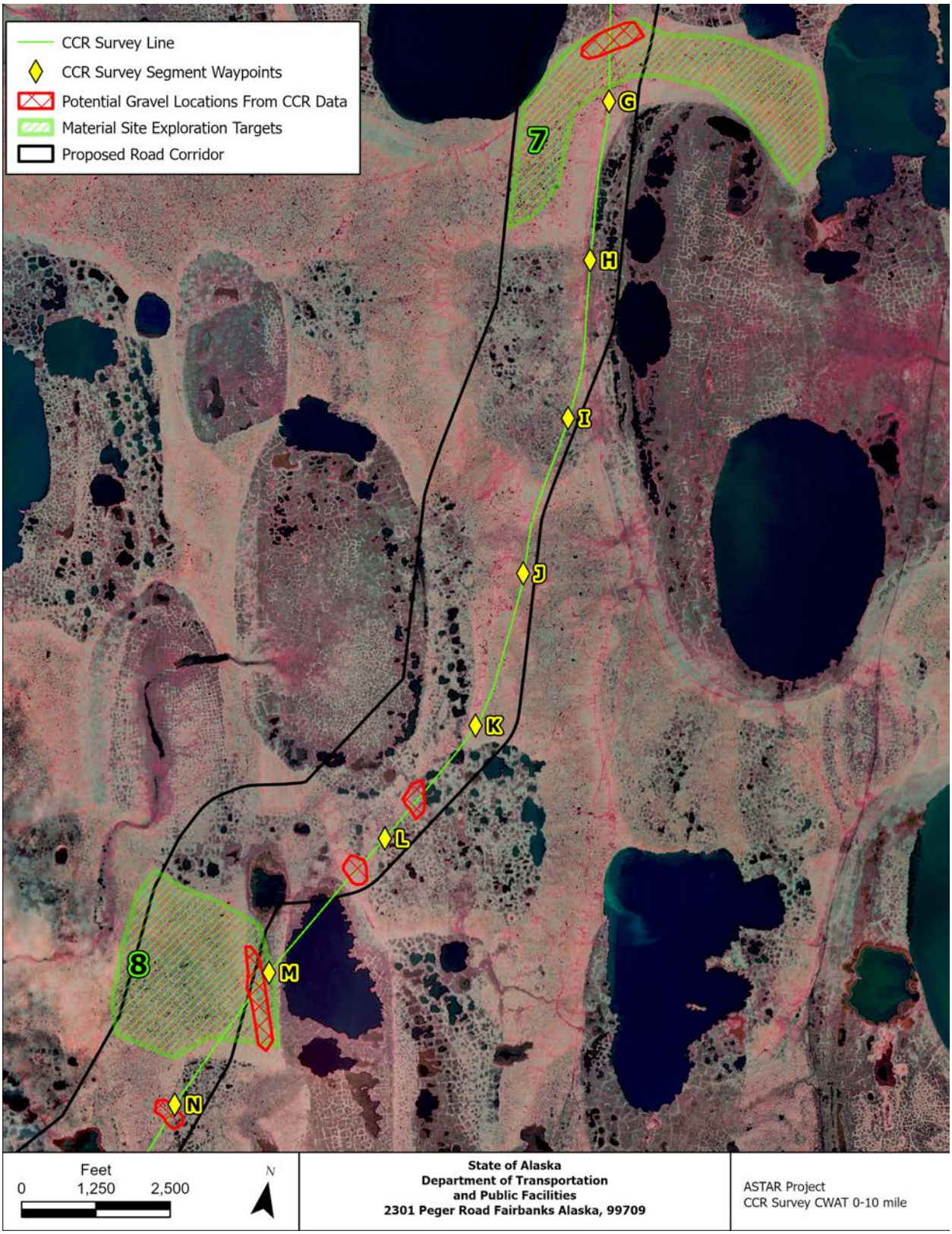

Figure 8. CCR survey line segments F through O with potential gravel locations identified by CCR survey.

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APPENDIX A: RESISTIVITY INVERSION MODEL PSEUDOSECTION

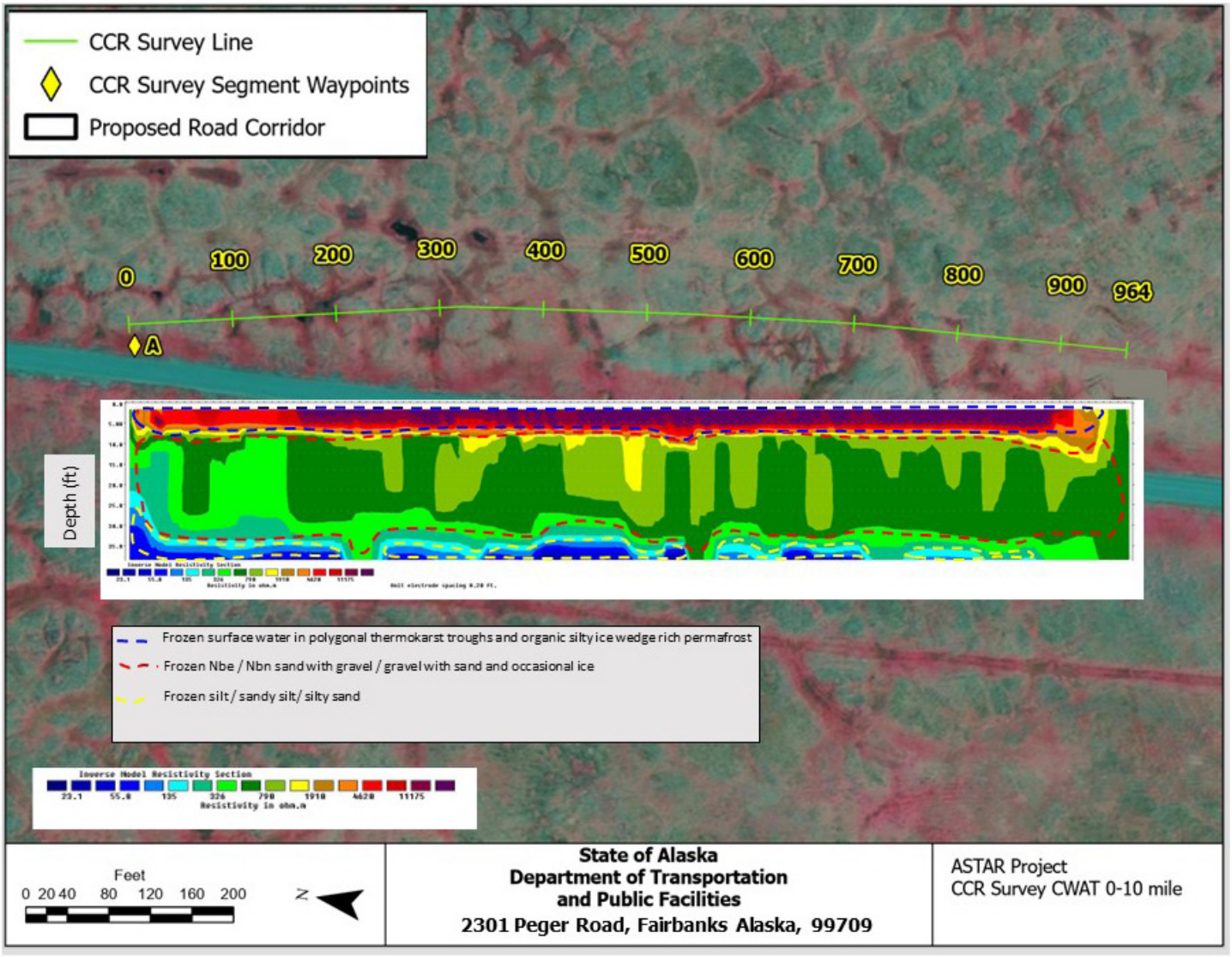

Figure A1. CCR survey line segment A with resistivity inversion model pseudosection.

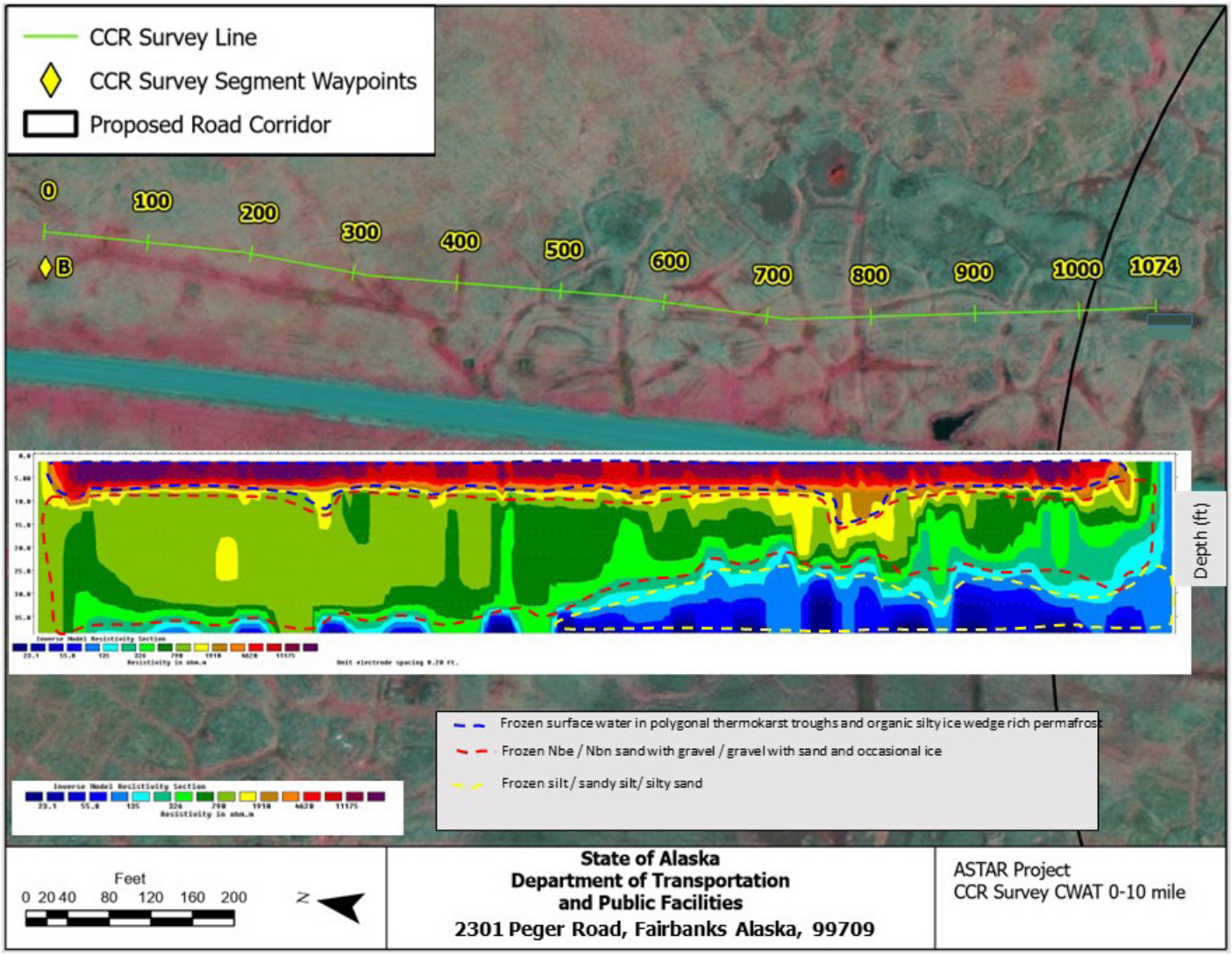

Figure A2. CCR survey line segment B with resistivity inversion model pseudosection.

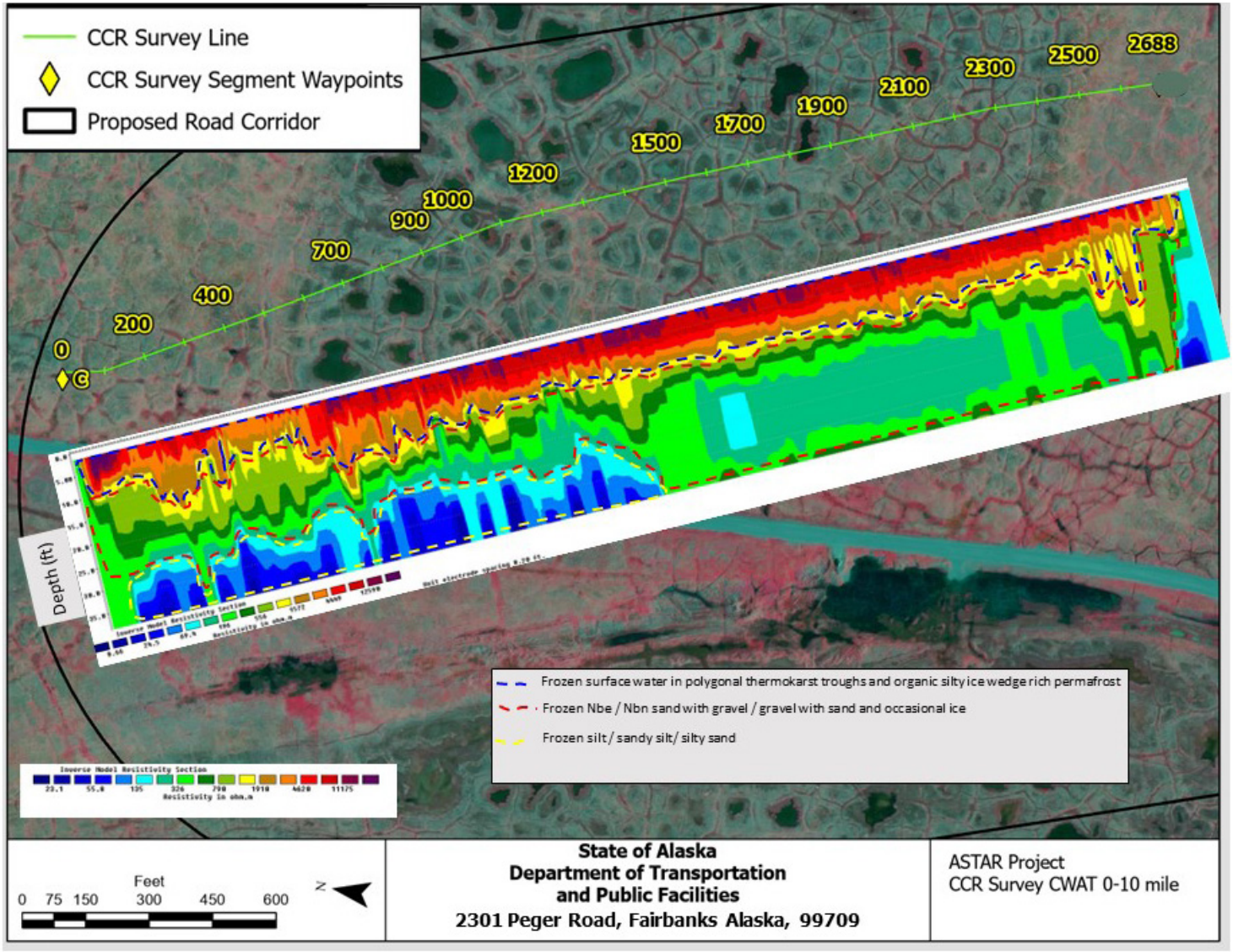

Figure A3. CCR survey line segment C with resistivity inversion model pseudosection.

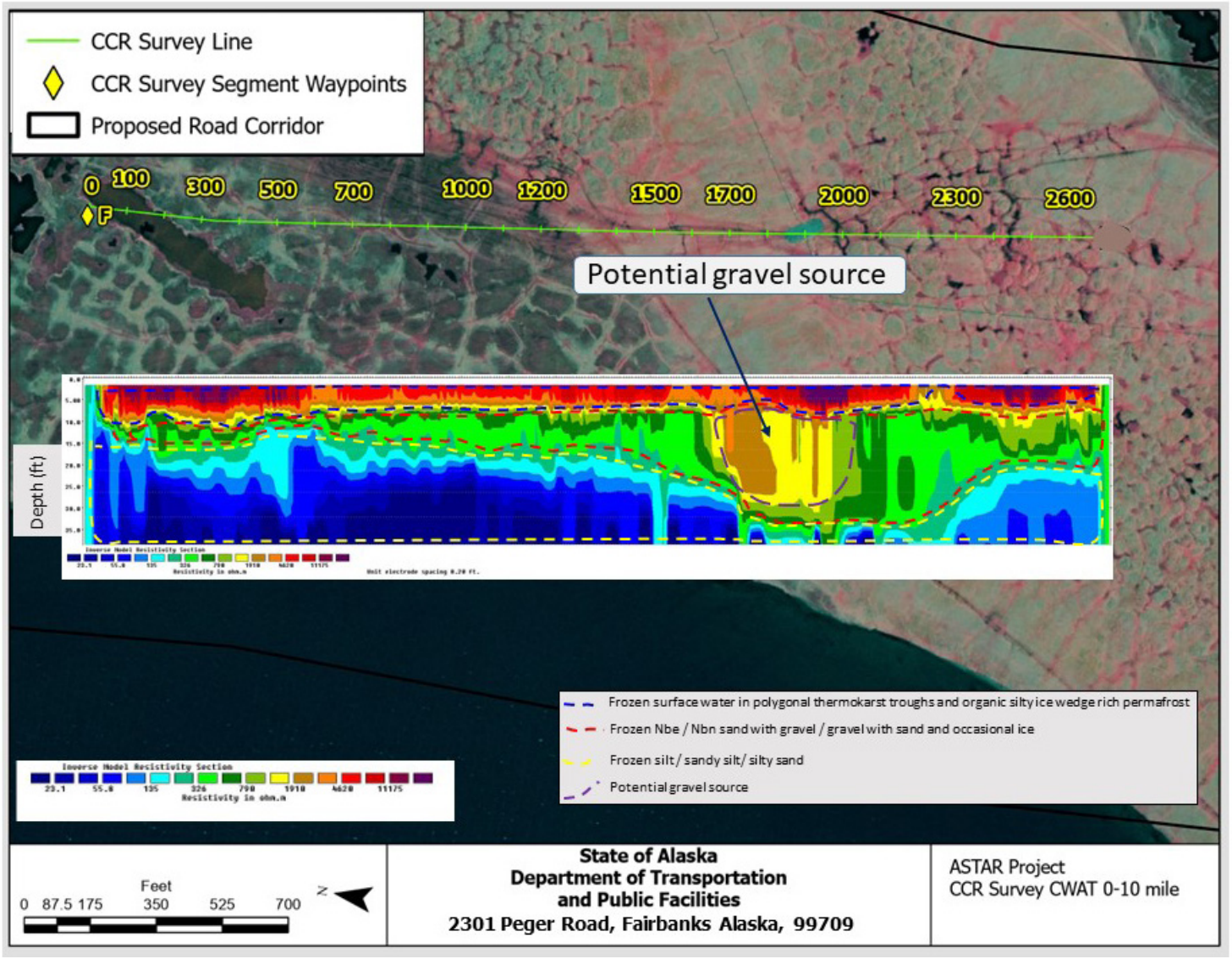

Figure A4. CCR survey line segment F with resistivity inversion model pseudosection.

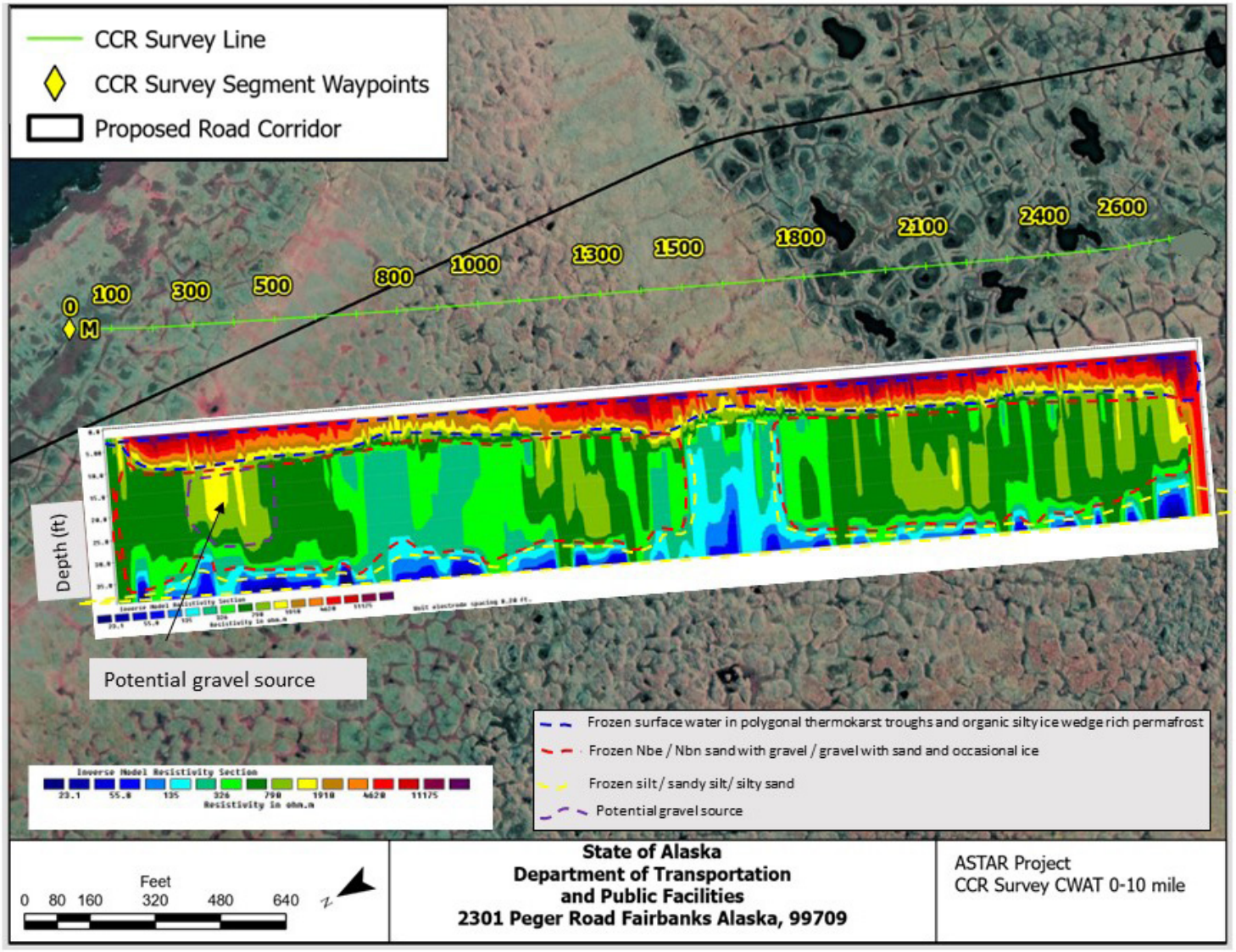

Figure A5. CCR survey line segment M with resistivity inversion model pseudosection.

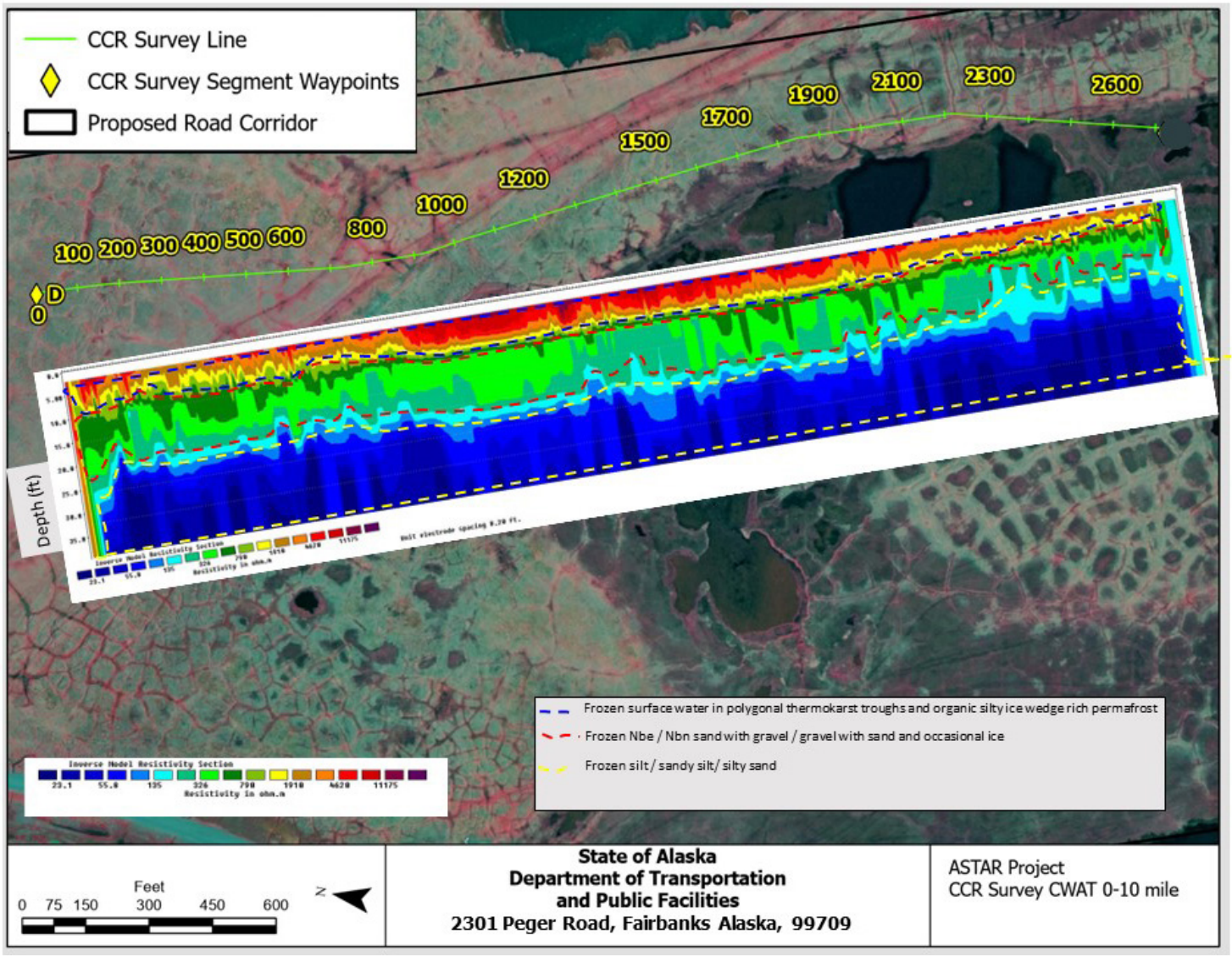

Figure A6. CCR survey line segment D with resistivity inversion model pseudosection.

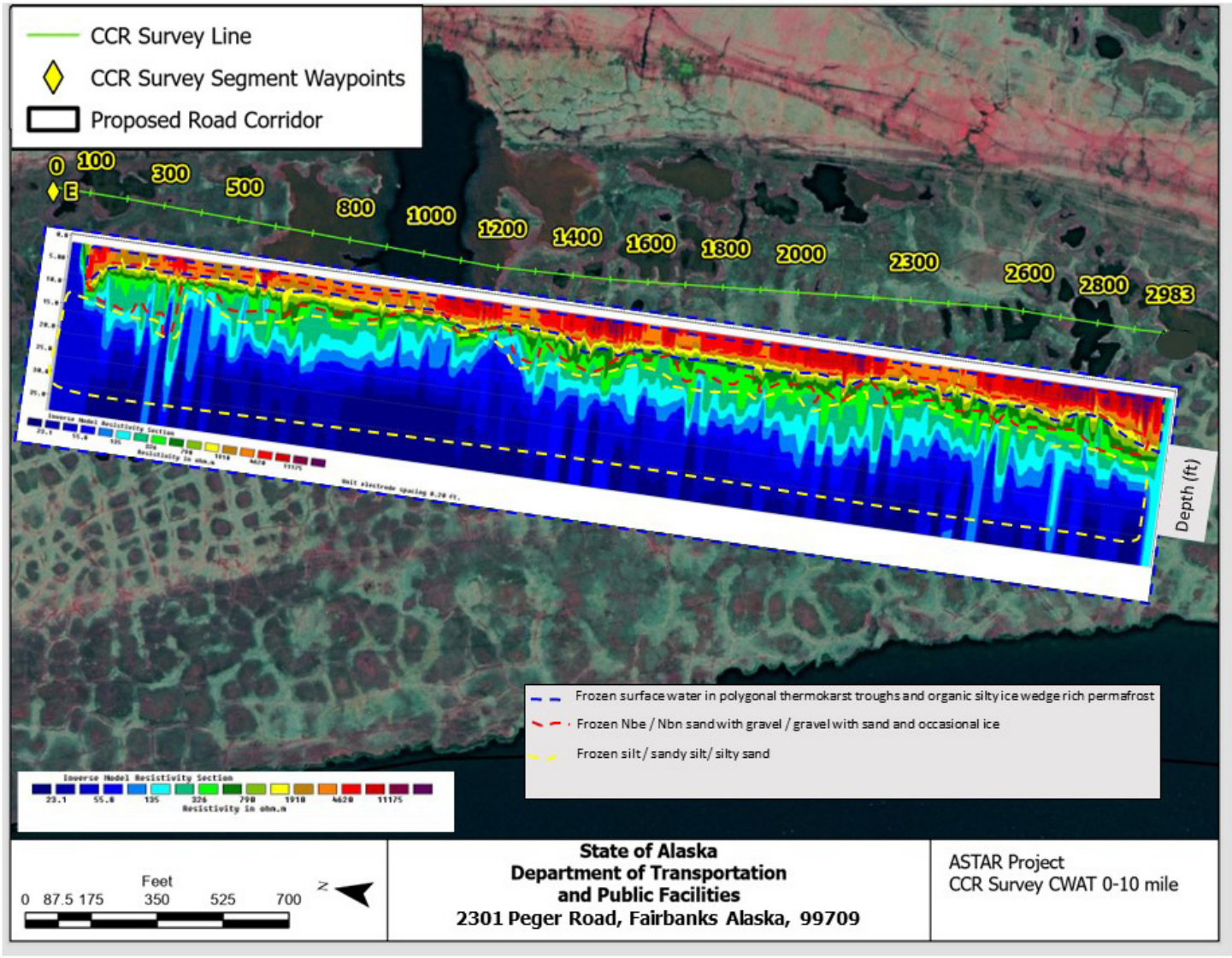

Figure A7. CCR survey line segment E with resistivity inversion model pseudosection.

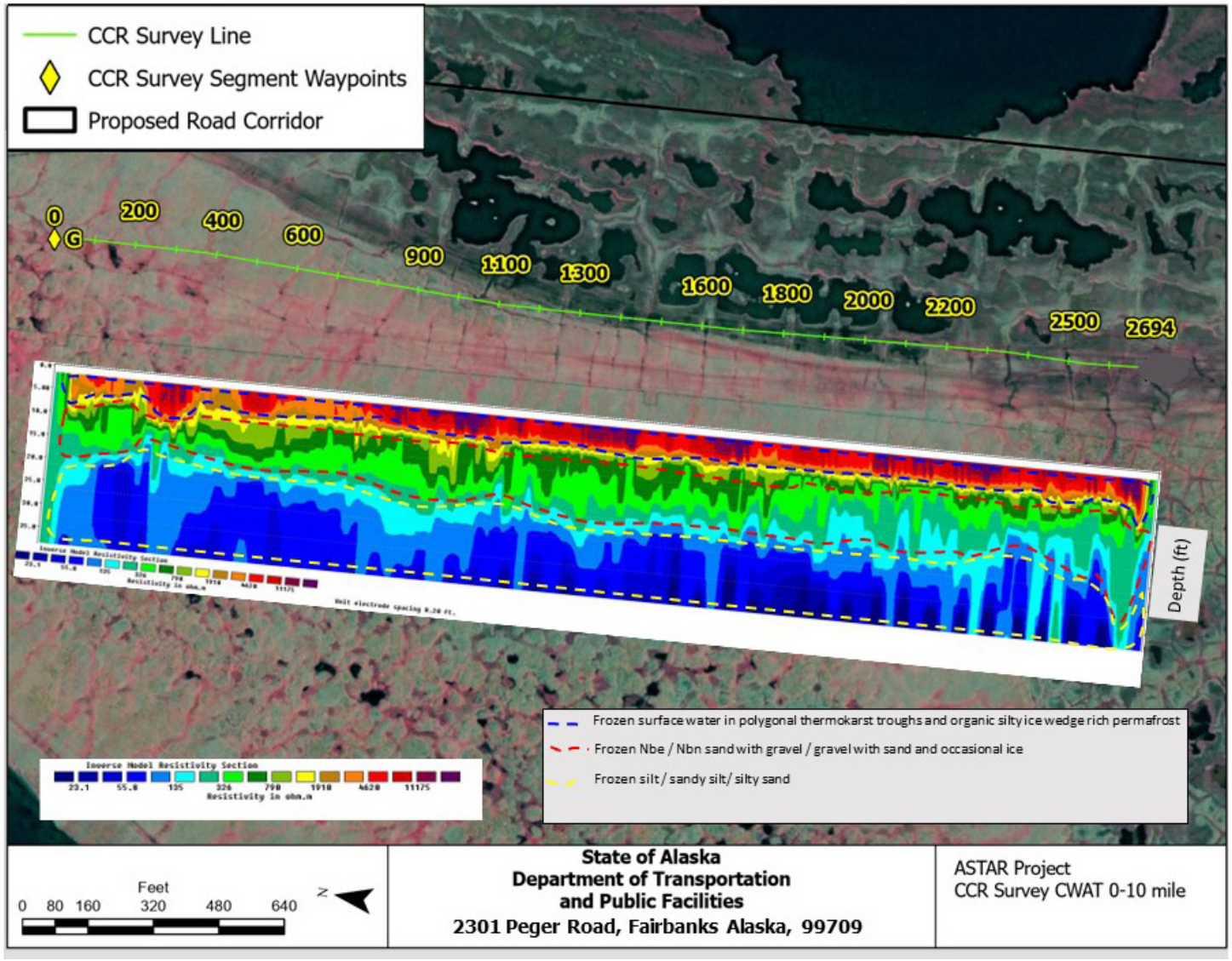

Figure A8. CCR survey line segment G with resistivity inversion model pseudosection.

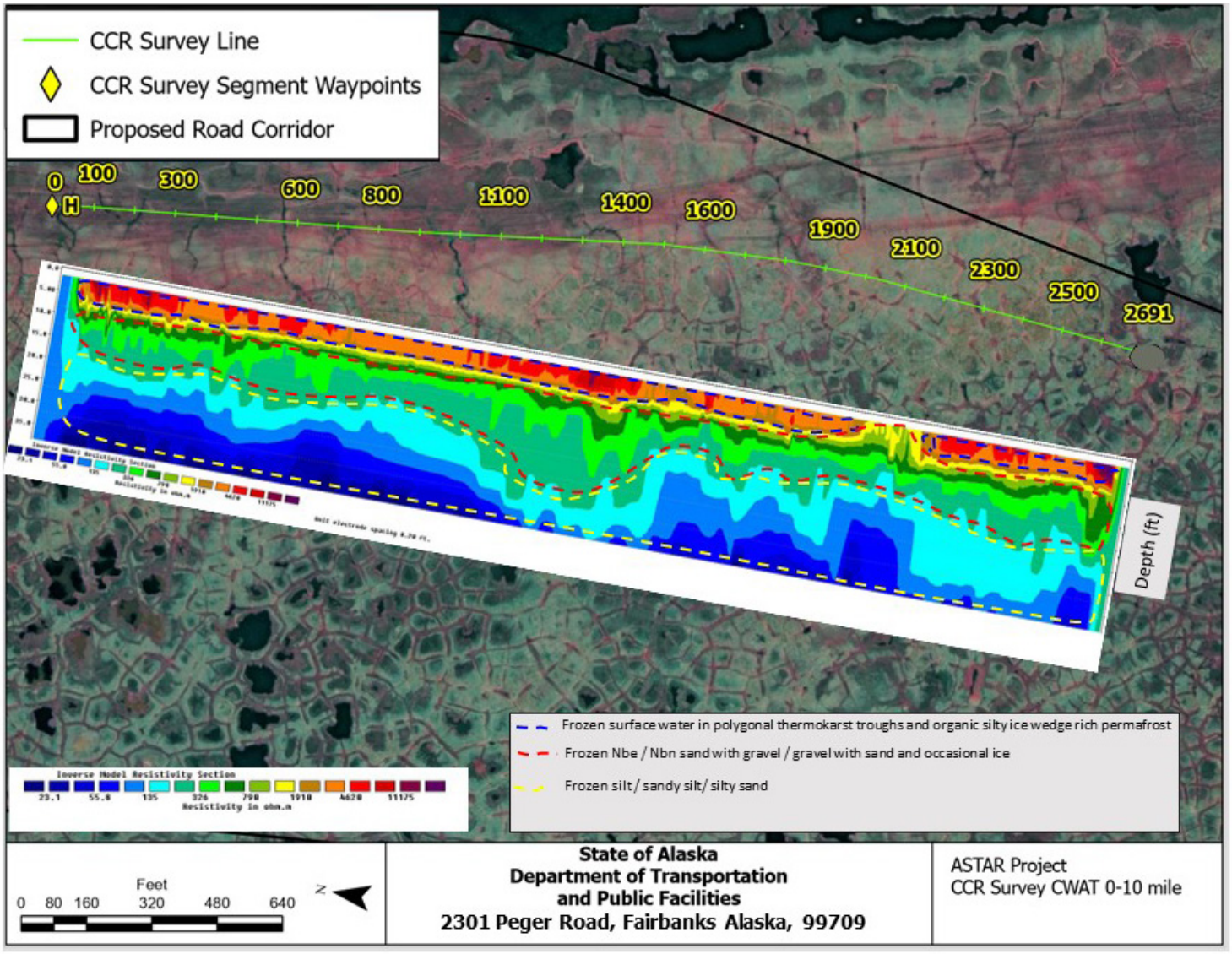

Figure A9. CCR survey line segment H with resistivity inversion model pseudosection.

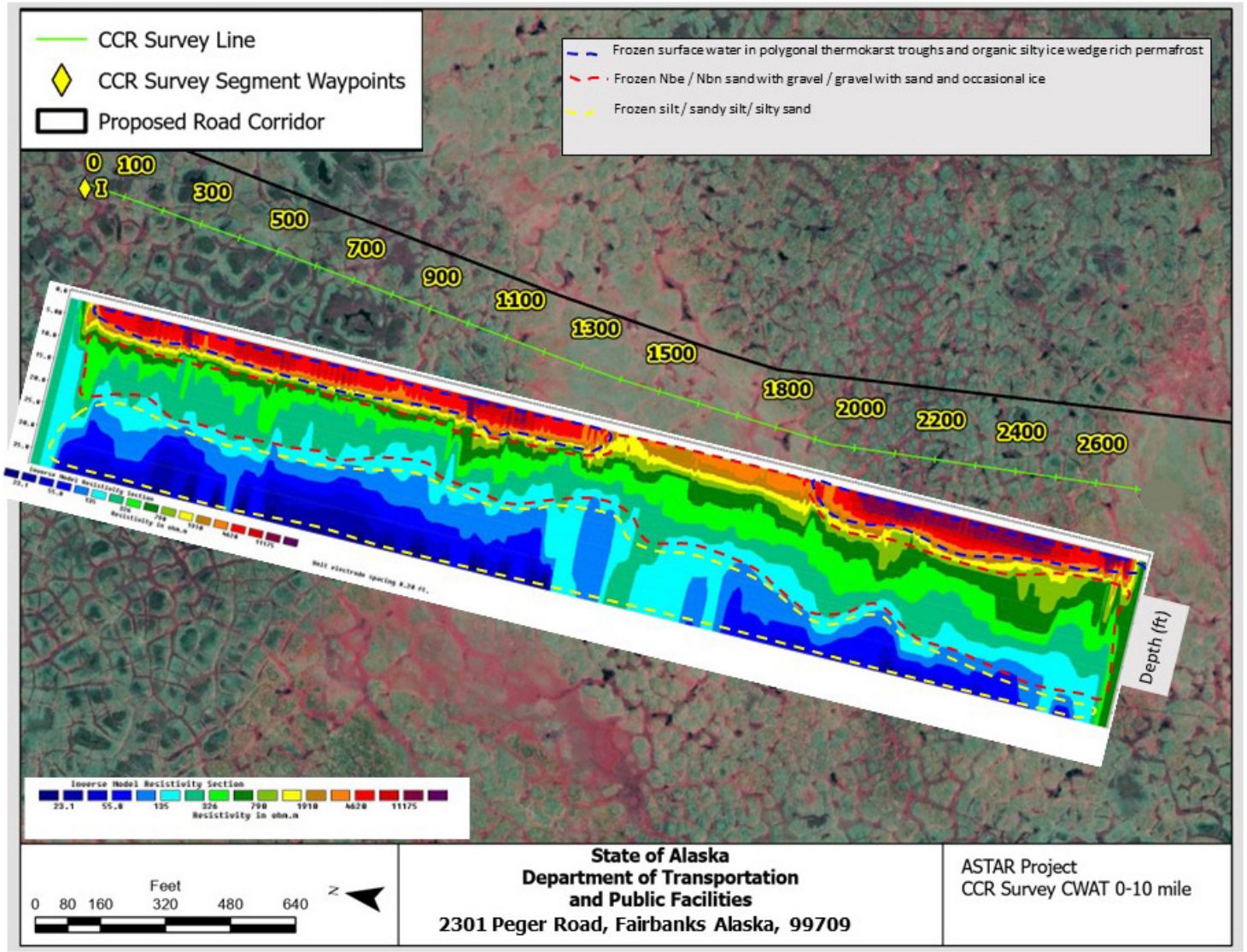

Figure A10. CCR survey line segment I with resistivity inversion model pseudosection.

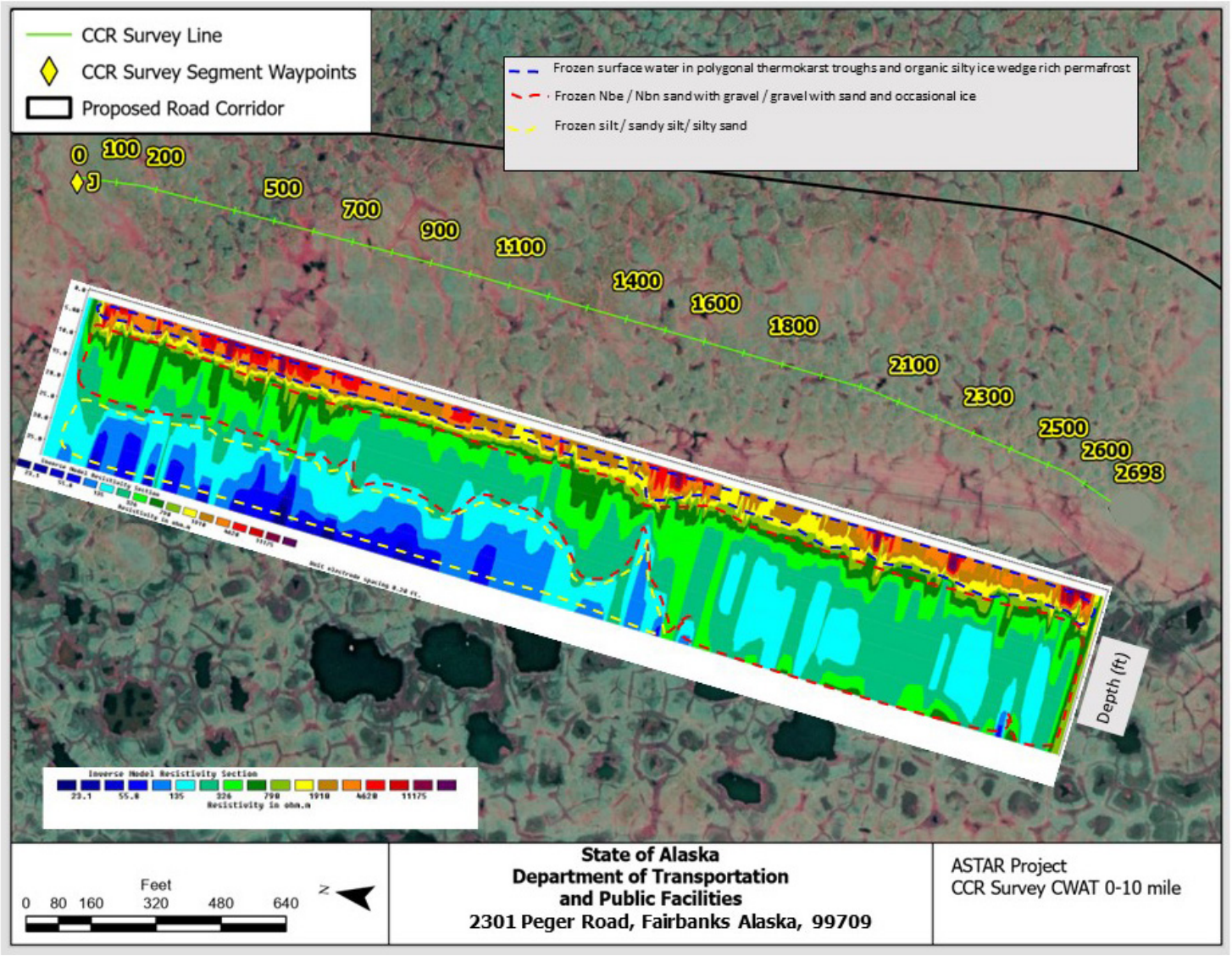

Figure A11. CCR survey line segment J with resistivity inversion model pseudosection.

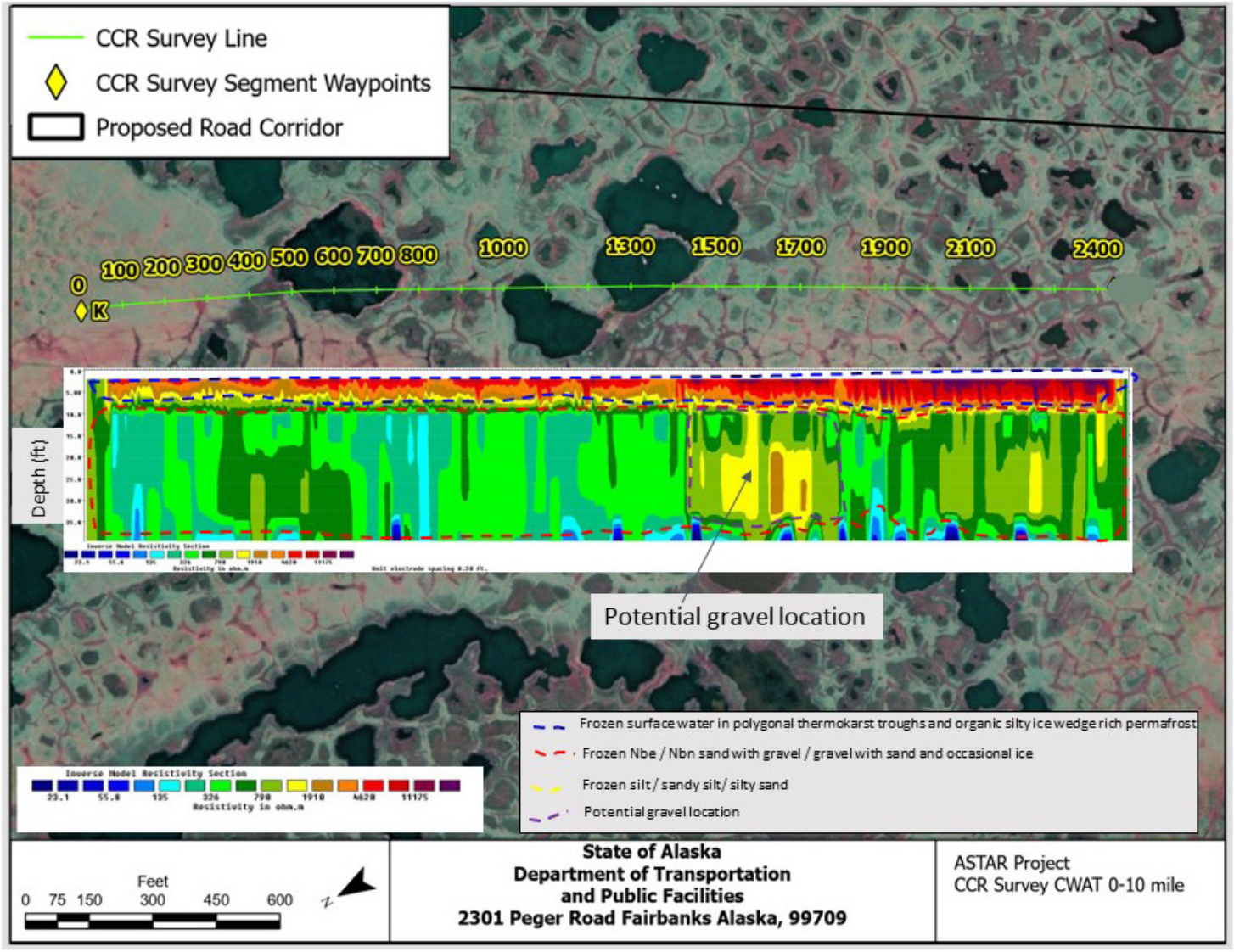

Figure A12. CCR survey line segment K with resistivity inversion model pseudosection.

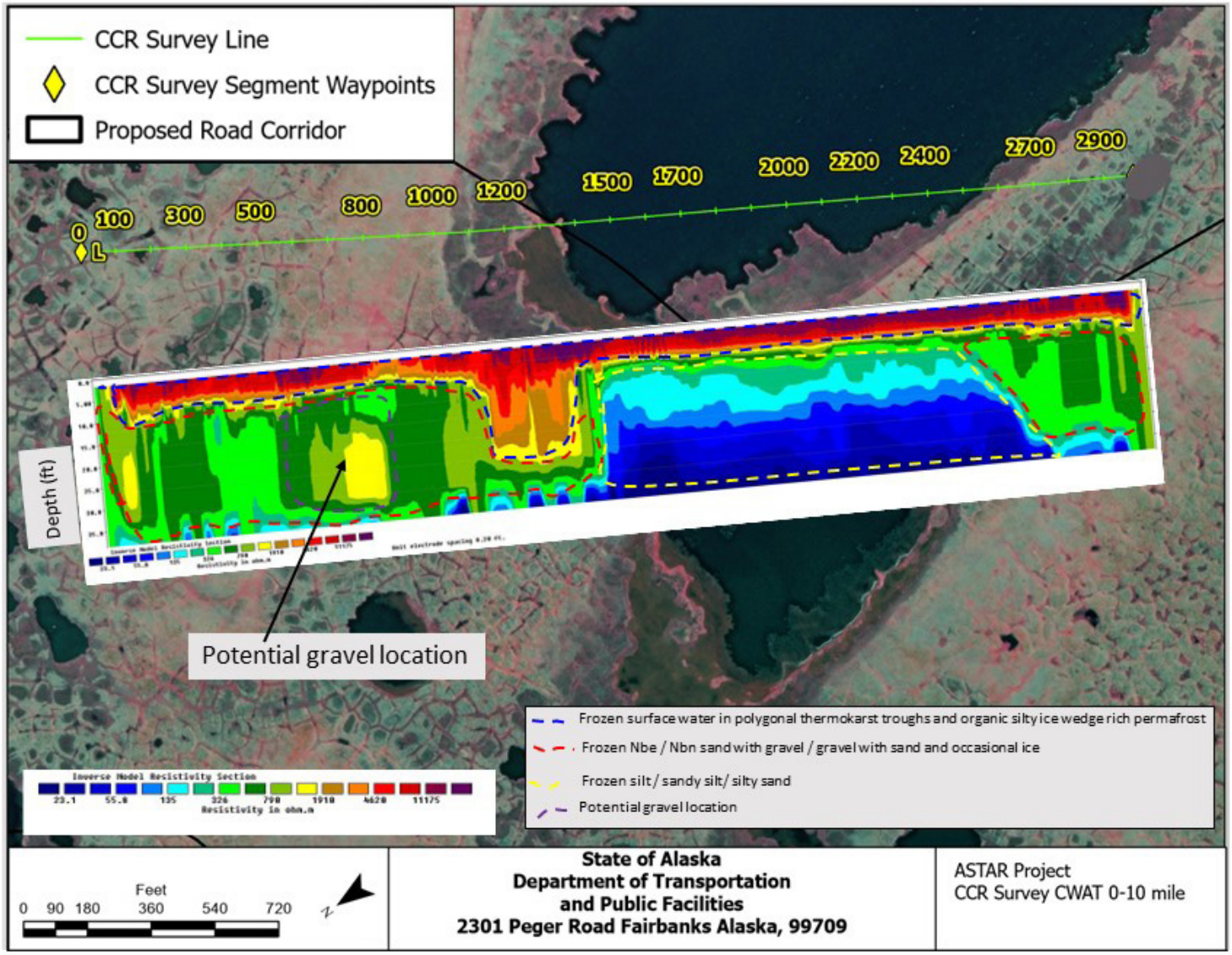

Figure A13. CCR survey line segment L with resistivity inversion model pseudosection.

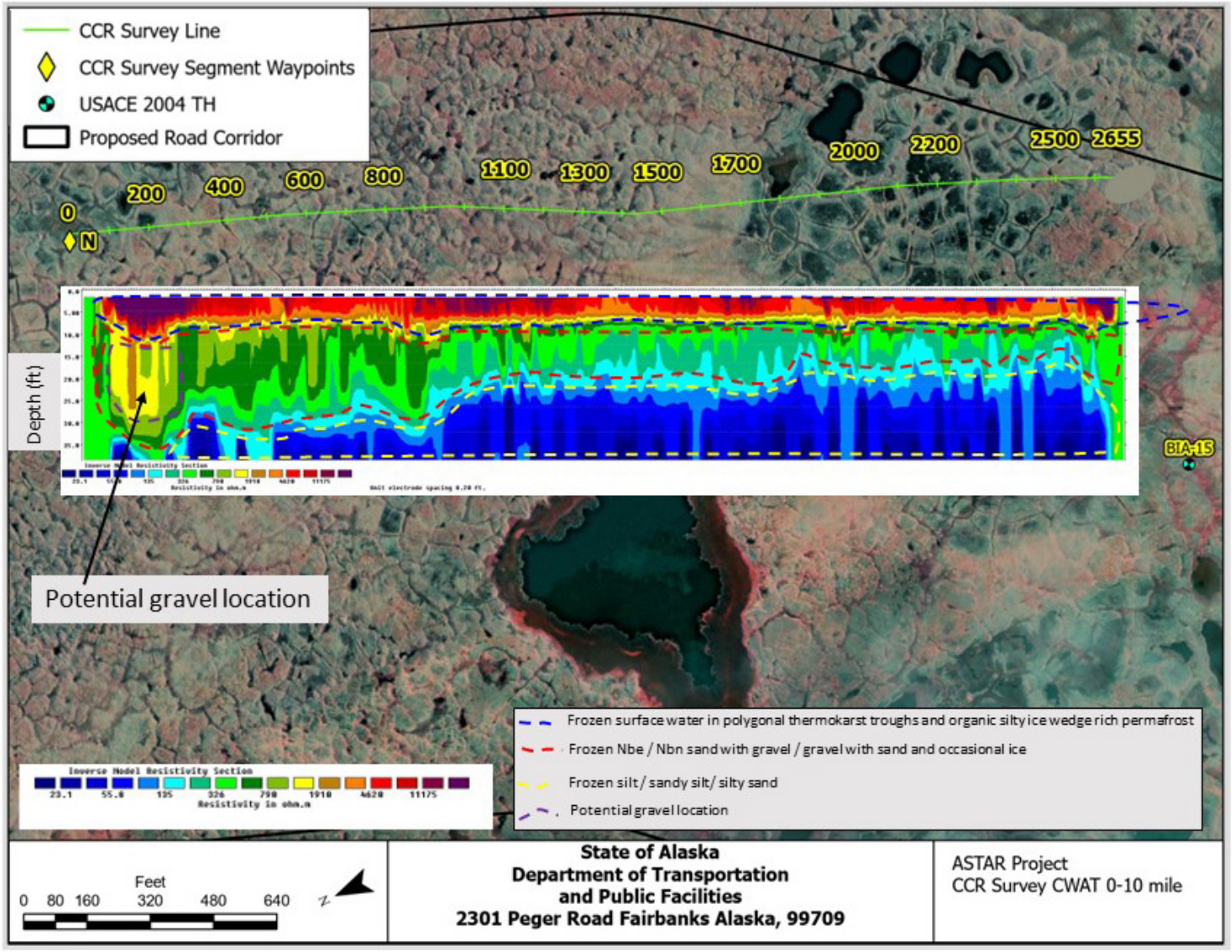

Figure A14. CCR survey line segment N with resistivity inversion model pseudosection.

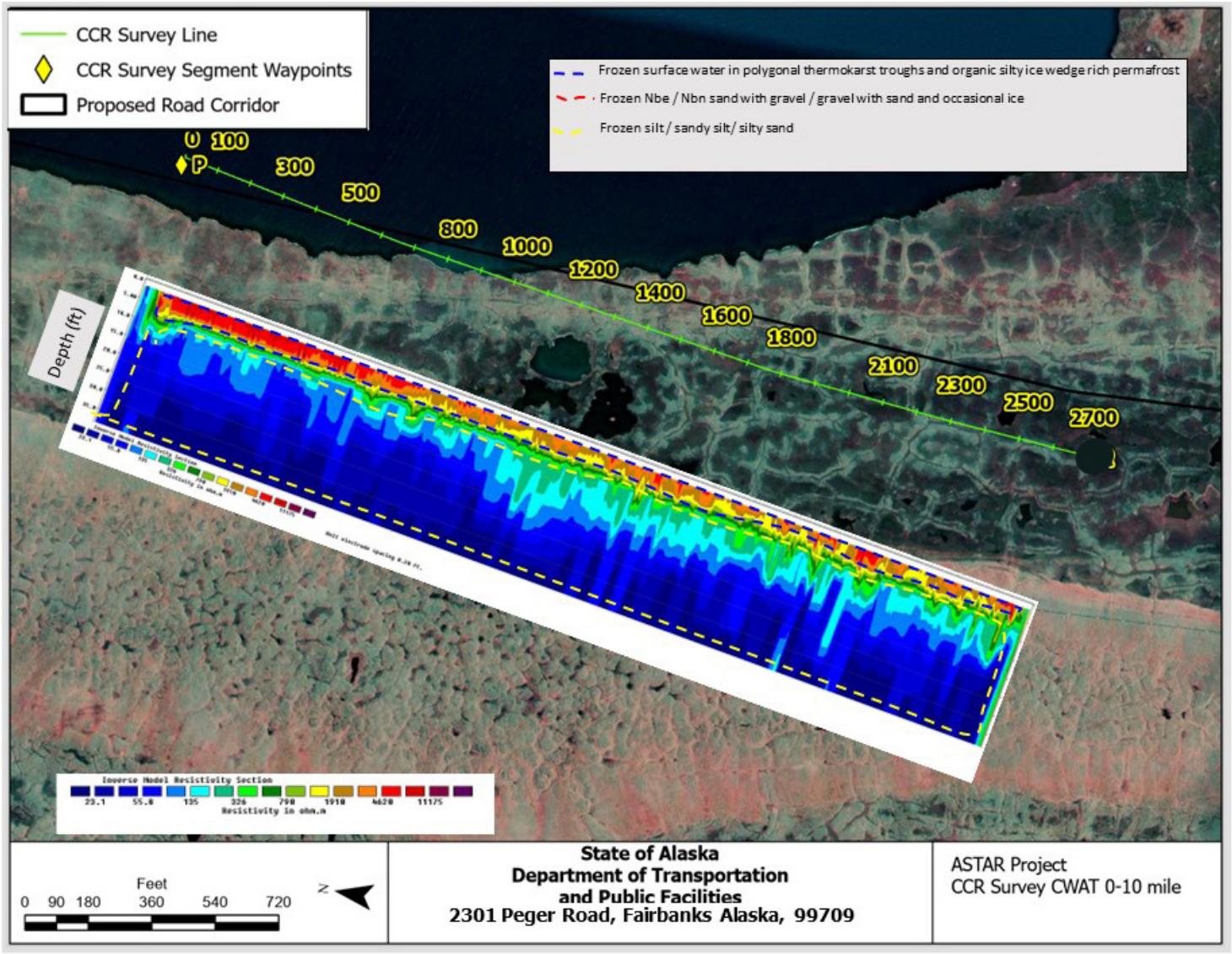

Figure A15. CCR survey line segment P with resistivity inversion model pseudosection.

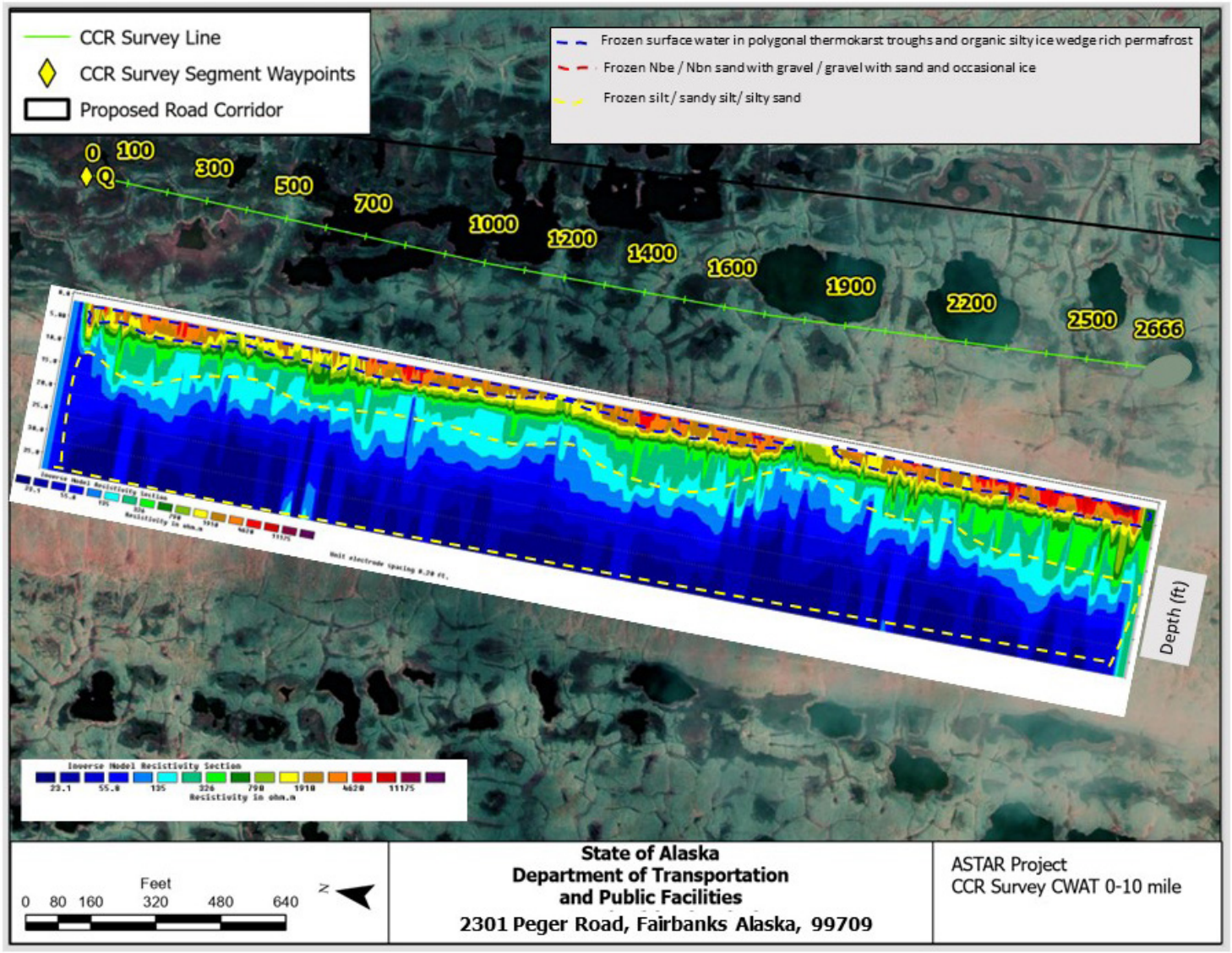

Figure A16. CCR survey line segment Q with resistivity inversion model pseudosection.

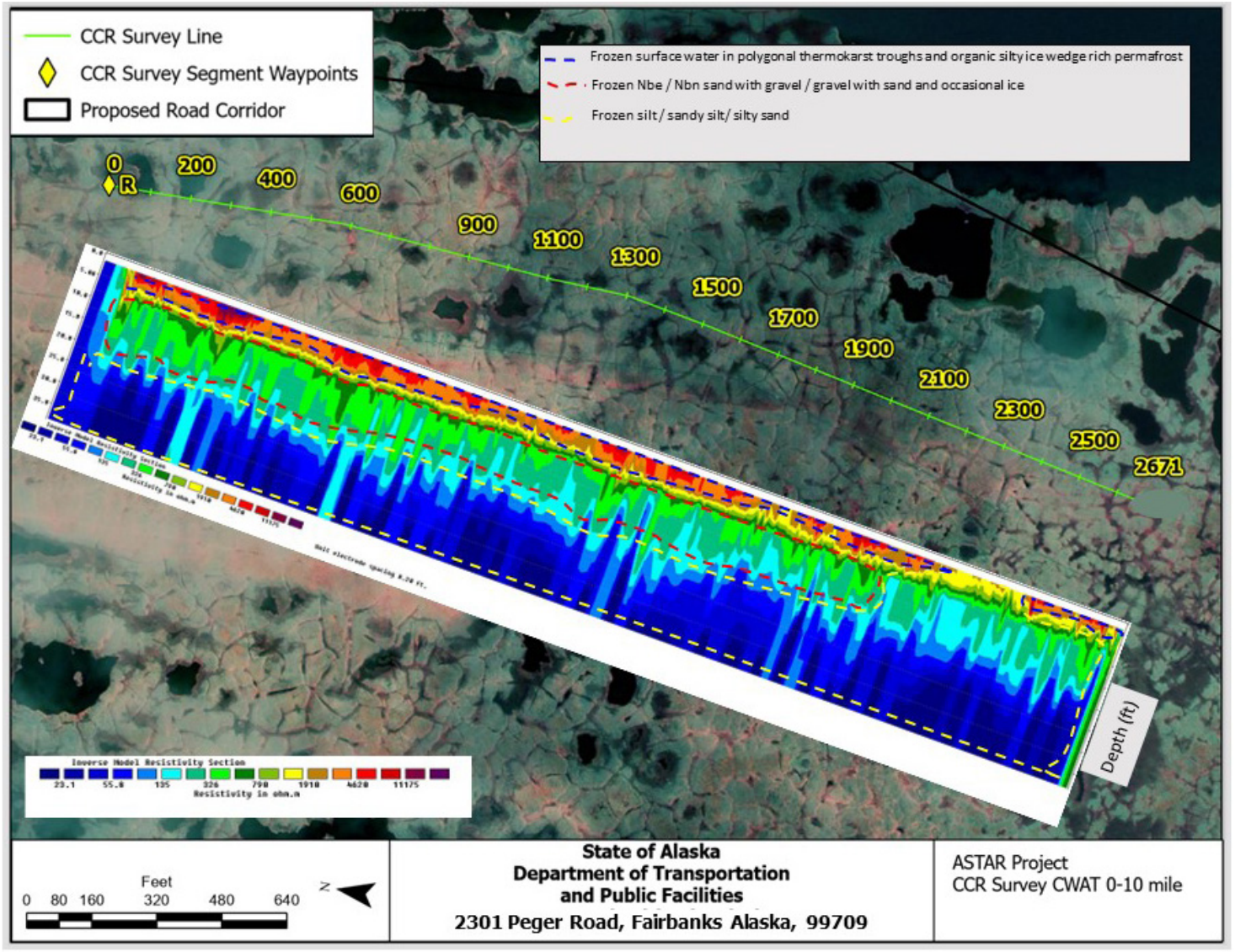

Figure A17. CCR survey line segment R with resistivity inversion model pseudosection.

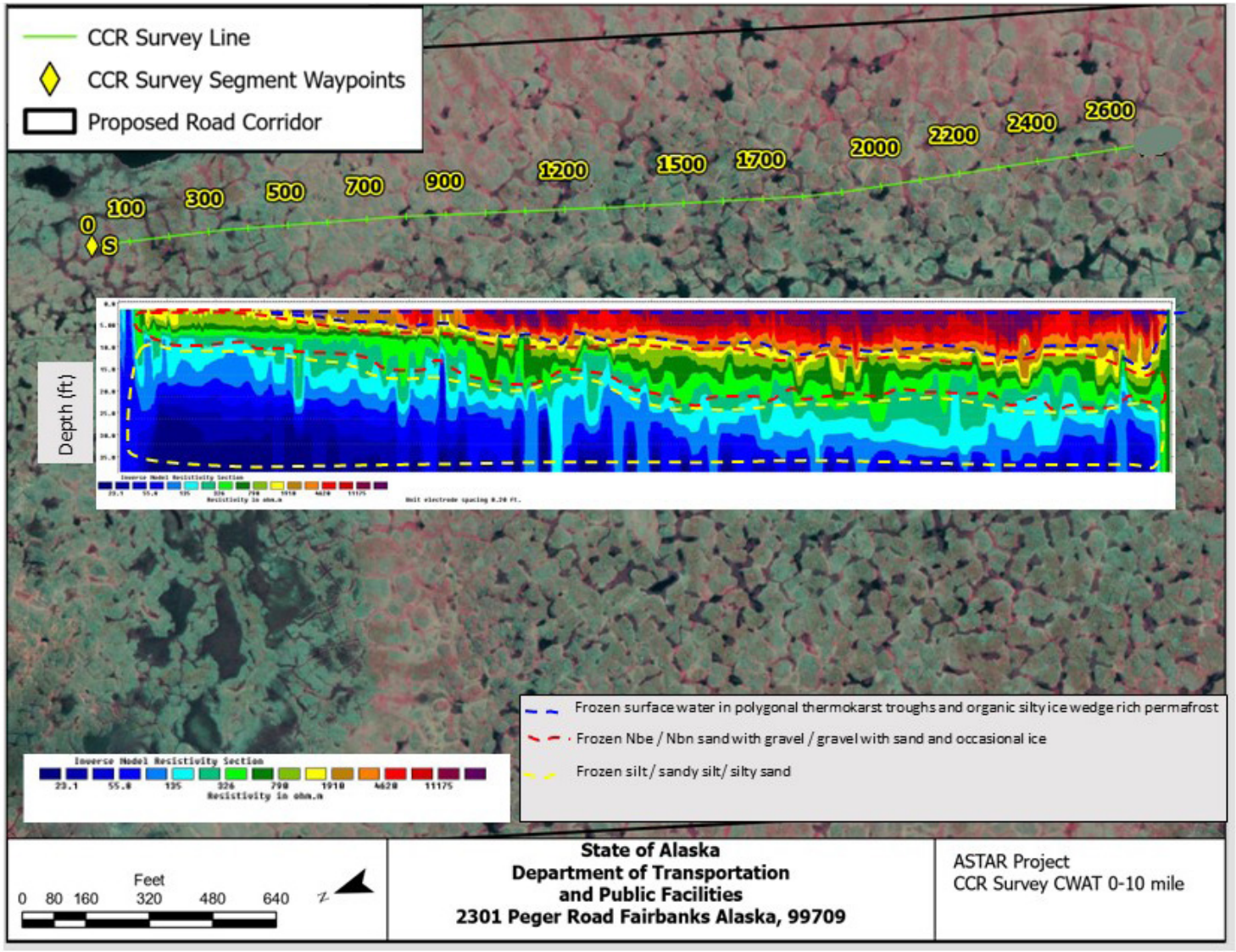

Figure A18. CCR survey line segment S with resistivity inversion model pseudosection.

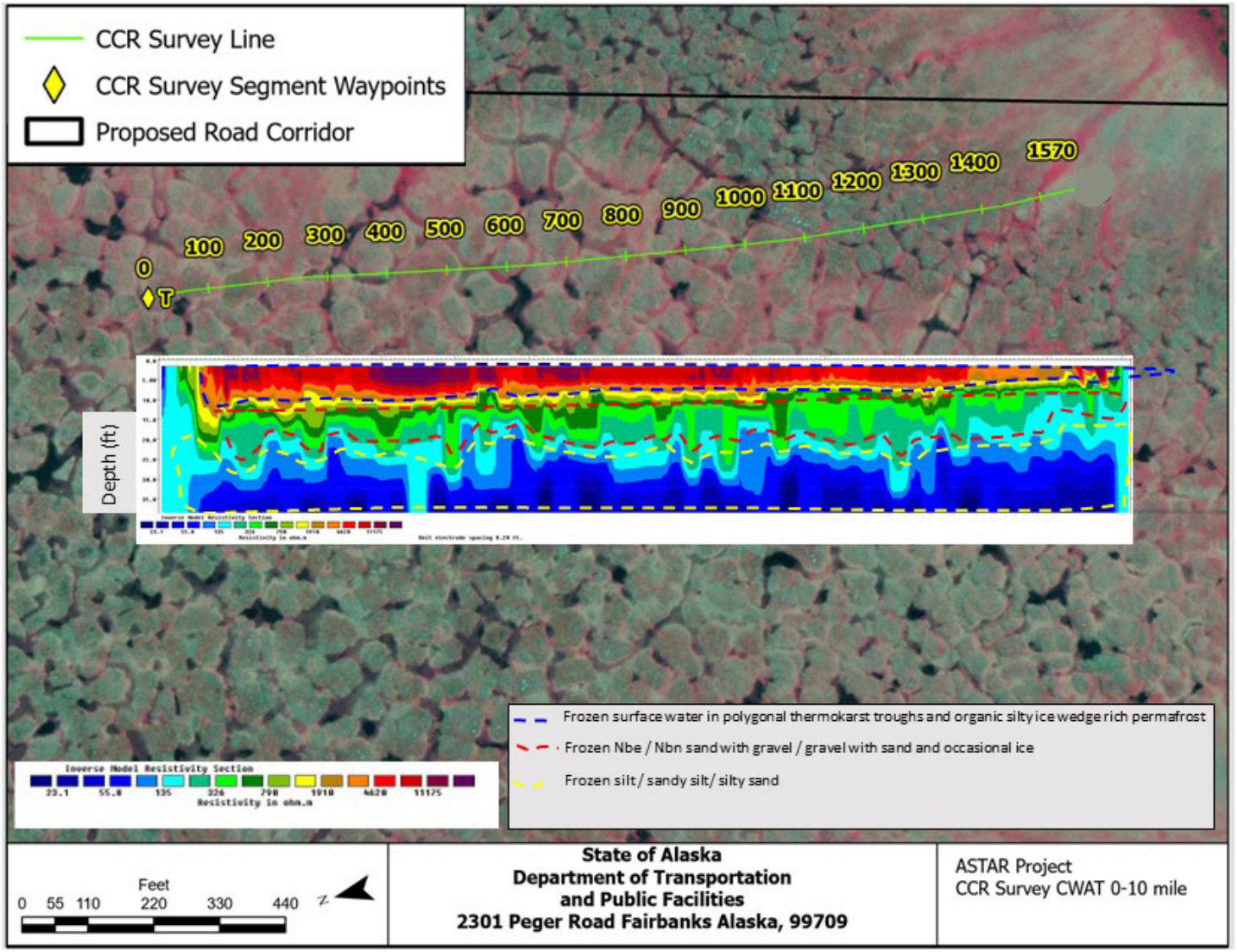

Figure A19. CCR survey line segment T with resistivity inversion model pseudosection.

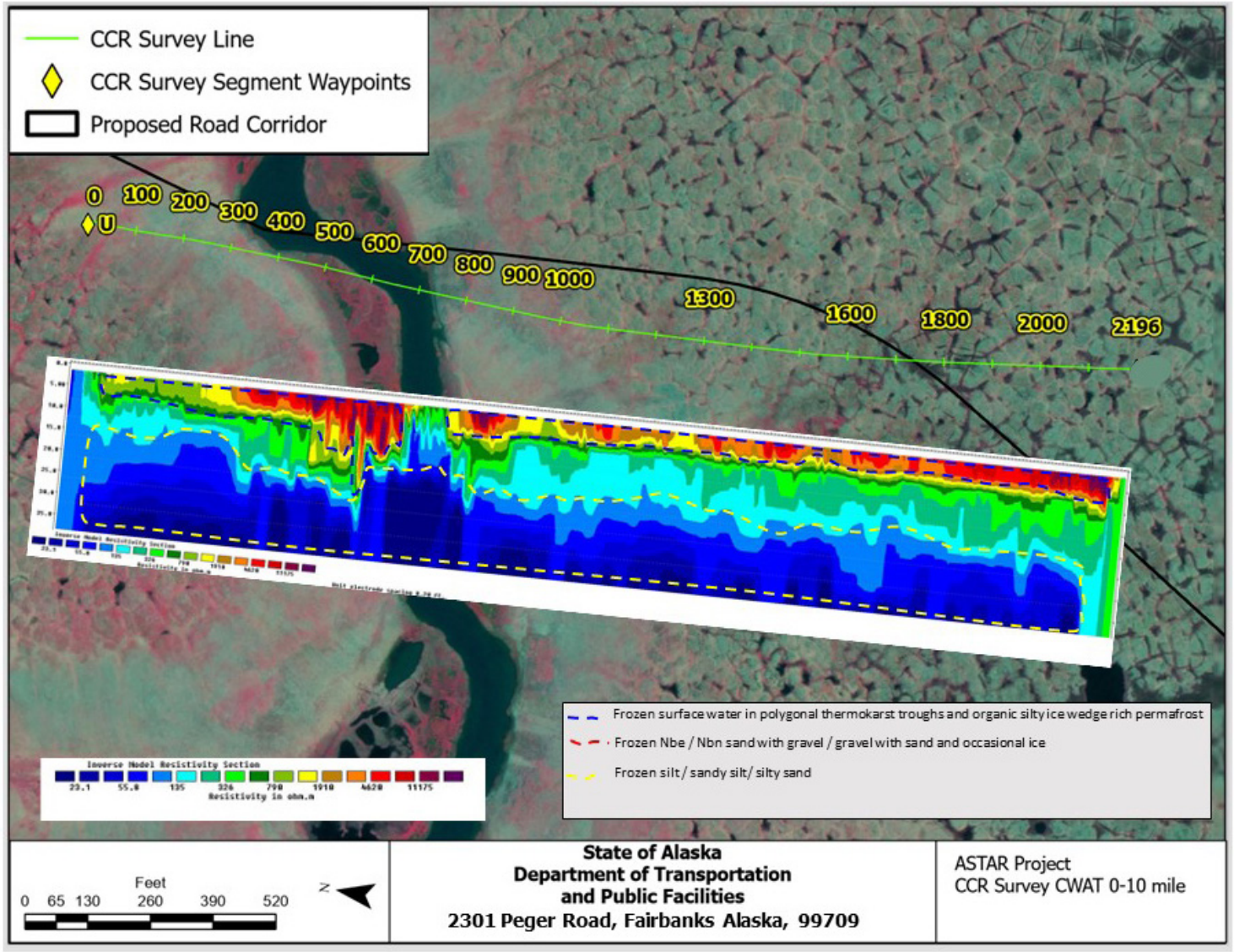

Figure A20. CCR survey line segment U with resistivity inversion model pseudosection.

APPENDIX B: USACE 2004 BIA TEST HOLE LOGS

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: Coastal Storm Damage Reduction, Barrow, Alaska		Page 1 of 1; Date: 1 Apr 2004
Drilling Agency: ☐ Alaska District ☒ Other Denali Drilling		Elevation Datum: ☐ MSL ☐ other
Location: Northing: 6,316,855 ft. ± Easting: 641,136 ft. ±		Top of Hole Elevation:
Hole Number, Field: TB-01 Permanent: BIA-01	Operator: Lyle Cain & Travis Coghill	Inspector: Aaron Banks
Type of Hole: ☒ other Auger; ☐ Test Pit ☒ Auger Hole ☐ Monitoring Well ☐ Piezometer	Depth to Groundwater:	Depth Drilled: 30.0 ft. / Total Depth: 31.5 ft.
Hammer Weight: 340 lbs	Split Spoon I.D.: 3 in.	Size and Type of Bit: 7 in. Hollow Stem Auger; Type of Equipment: CME-45; Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
0		1	Ice		5 13 21	ICE	ICE with Sand/Fines Inclusions							No sample collected, clear, ice, planar ice crystals larger than 2 inches with white interstitial ice
6		2	Vr	F4	5 15 28	SM	Silty SAND				0.25			Gray/ brown, frozen, subrounded gravel, fine to coarse sand, nonplastic (NP) fines, estimated 45% clear ice crystals less than .5 inch with interstitial ice.
10		3	Nbe	S2	19 44 50/ 4in.	SP-SM	Poorly graded SAND with Silt and Gravel	23	70	7	0.5			gravel present in cuttings Brown, frozen, subrounded gravel, fine to coarse sand
16		4	Vr	S1	29 33 54	SP-SM	Poorly graded SAND with Silt and Gravel				0.25			Light brown, frozen, subrounded gravel, fine to coarse sand, Estimated 30% clear and cloudy ice crystals randomly distributed
20		5	Vx	F4	30 40 52	SM	Silty SAND	1	74	25				Brown and gray, frozen, fine to coarse sand, NP fines, estimated 5% ice, 0.5-inch clusters of small cloudy ice crystals
26		6	Vr	F1	18 26 26	ML	SILT							Gray, frozen, NP fines, randomly oriented-clusters and veins of small white ice crystals, estimated 15% ice
30		7	Vs	F4	11 17 24	ML	SILT							Gray, frozen, NP fines, estimated 10% ice, horizontally stratified 1/16 inch veins of small cloudy ice crystals
32														Bottom of Hole 31.5 ft. PID = (Cold/Hot) Photo Ionization Detector

EXPLORATION LOG BARROWSTORMDAMAGEREDUCTION.GPJ ACE_ANC.GDT 3/11/05

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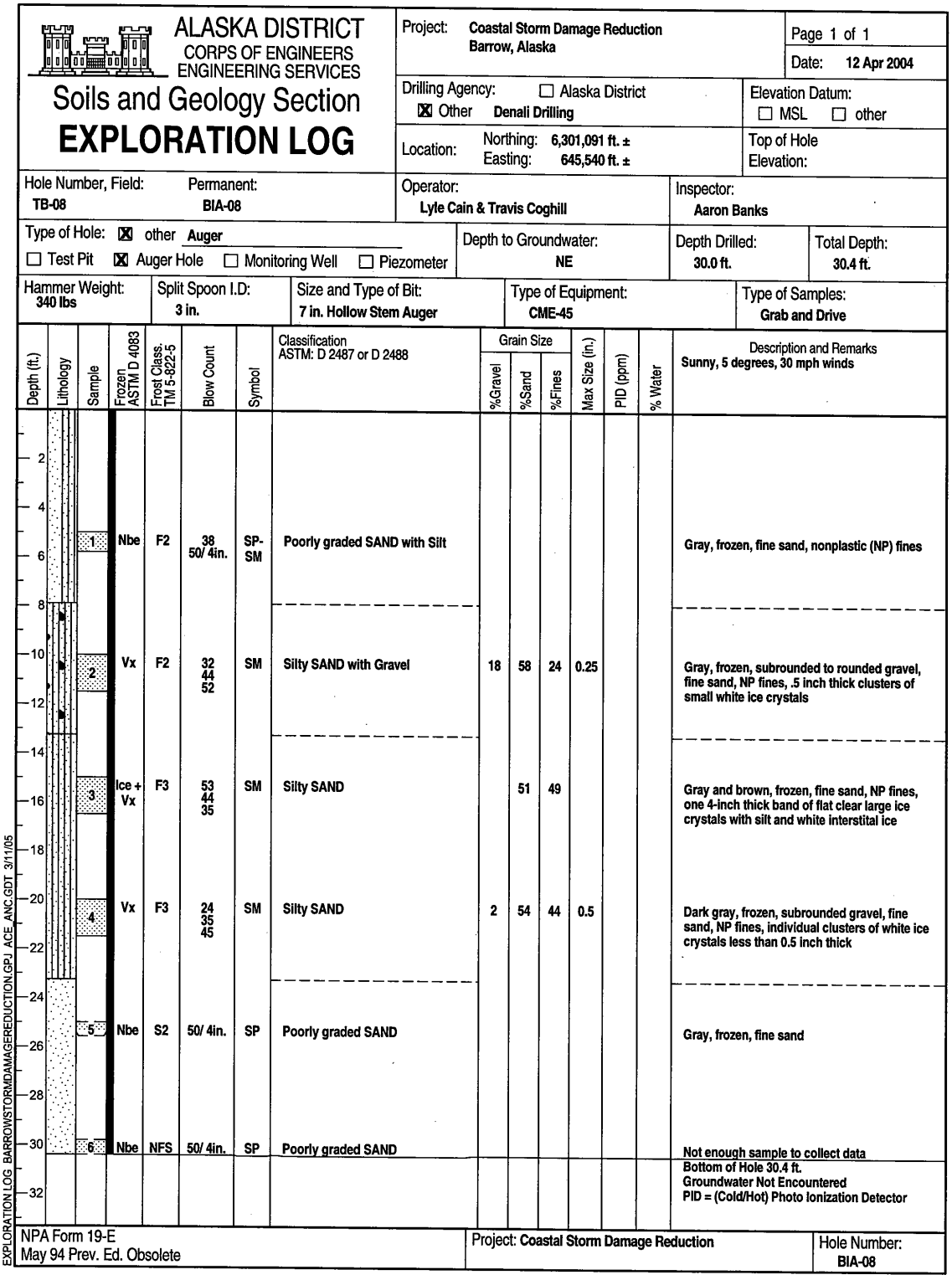
May 94 Prev. Ed. Obsolete

Project: Coastal Storm Damage Reduction — Hole Number: BIA-01



ALASKA DISTRICT
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ENGINEERING SERVICES
Soils and Geology Section
EXPLORATION LOG

Project: **Coastal Storm Damage Reduction, Barrow, Alaska**
Page 1 of 1
Date: **12 Apr 2004**

Drilling Agency: ☐ Alaska District ☒ Other **Denali Drilling**
Elevation Datum: ☐ MSL ☐ other
Location: Northing: **6,301,091 ft. ±** Easting: **645,540 ft. ±**
Top of Hole Elevation:

Hole Number, Field: **TB-08** Permanent: **BIA-08**
Operator: **Lyle Cain & Travis Coghill**
Inspector: **Aaron Banks**

Type of Hole: ☒ other **Auger**
☐ Test Pit ☒ Auger Hole ☐ Monitoring Well ☐ Piezometer
Depth to Groundwater: **NE**
Depth Drilled: **30.0 ft.**
Total Depth: **30.4 ft.**

Hammer Weight: **340 lbs**
Split Spoon I.D.: **3 in.**
Size and Type of Bit: **7 in. Hollow Stem Auger**
Type of Equipment: **CME-45**
Type of Samples: **Grab and Drive**

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
													Sunny, 5 degrees, 30 mph winds
2–6	1	Nbe	F2	38 50/ 4in.	SP-SM	**Poorly graded SAND with Silt**							**Gray, frozen, fine sand, nonplastic (NP) fines**
8–12	2	Vx	F2	32 44 52	SM	**Silty SAND with Gravel**	18	58	24	0.25			**Gray, frozen, subrounded to rounded gravel, fine sand, NP fines, .5 inch thick clusters of small white ice crystals**
14–16	3	Ice + Vx	F3	53 44 35	SM	**Silty SAND**		51	49				**Gray and brown, frozen, fine sand, NP fines, one 4-inch thick band of flat clear large ice crystals with silt and white interstital ice**
18–22	4	Vx	F3	24 35 45	SM	**Silty SAND**	2	54	44	0.5			**Dark gray, frozen, subrounded gravel, fine sand, NP fines, individual clusters of white ice crystals less than 0.5 inch thick**
24–26	5	Nbe	S2	50/ 4in.	SP	**Poorly graded SAND**							**Gray, frozen, fine sand**
28–30	6	Nbe	NFS	50/ 4in.	SP	**Poorly graded SAND**							**Not enough sample to collect data**
32													**Bottom of Hole 30.4 ft.** **Groundwater Not Encountered** **PID = (Cold/Hot) Photo Ionization Detector**

EXPLORATION.LOG BARROWSTORMDAMAGEREDUCTION.GPJ ACE_ANC.GDT 3/11/05

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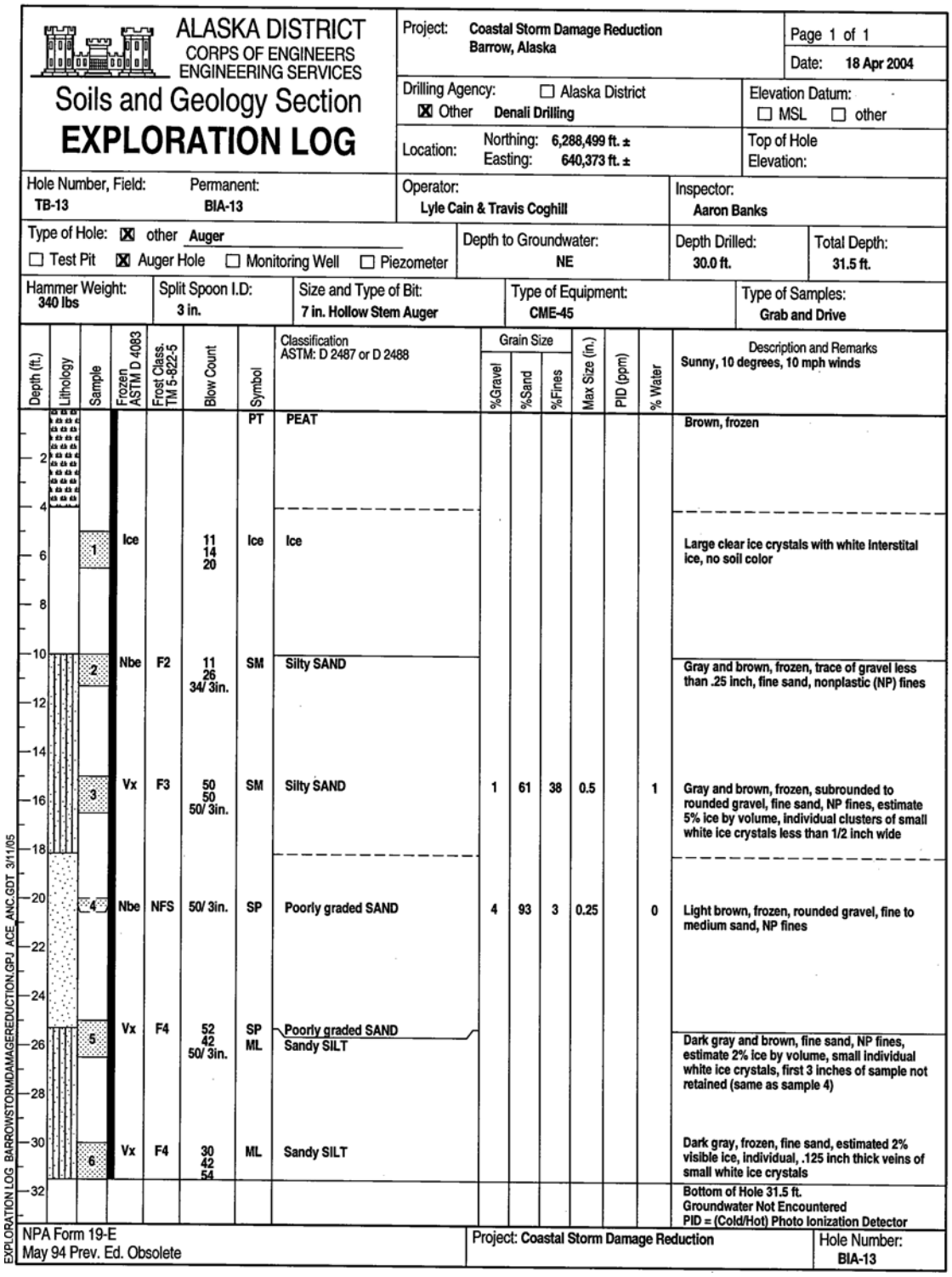
May 94 Prev. Ed. Obsolete

Project: **Coastal Storm Damage Reduction**
Hole Number: **BIA-08**



ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: **Coastal Storm Damage Reduction**
Barrow, Alaska

Page 1 of 1
Date: **18 Apr 2004**

Drilling Agency: ☐ Alaska District ☒ Other **Denali Drilling**

Elevation Datum: ☐ MSL ☐ other

Location: Northing: **6,288,499 ft. ±** Easting: **640,373 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **TB-13** Permanent: **BIA-13**

Operator: **Lyle Cain & Travis Coghill**

Inspector: **Aaron Banks**

Type of Hole: ☒ other **Auger**
☐ Test Pit ☒ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater: **NE**

Depth Drilled: **30.0 ft.**

Total Depth: **31.5 ft.**

Hammer Weight: **340 lbs**

Split Spoon I.D.: **3 in.**

Size and Type of Bit: **7 in. Hollow Stem Auger**

Type of Equipment: **CME-45**

Type of Samples: **Grab and Drive**

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
2						PT	PEAT							Brown, frozen
4														
6		1	Ice		11 14 20	Ice	Ice							Large clear ice crystals with white interstital ice, no soil color
8														
10		2	Nbe	F2	11 26 34/ 3in.	SM	Silty SAND							Gray and brown, frozen, trace of gravel less than .25 inch, fine sand, nonplastic (NP) fines
12														
14														
16		3	Vx	F3	50 50 50/ 3in.	SM	Silty SAND	1	61	38	0.5		1	Gray and brown, frozen, subrounded to rounded gravel, fine sand, NP fines, estimate 5% ice by volume, individual clusters of small white ice crystals less than 1/2 inch wide
18														
20		4	Nbe	NFS	50/ 3in.	SP	Poorly graded SAND	4	93	3	0.25		0	Light brown, frozen, rounded gravel, fine to medium sand, NP fines
22														
24														
26		5	Vx	F4	52 42 50/ 3in.	SP ML	Poorly graded SAND Sandy SILT							Dark gray and brown, fine sand, NP fines, estimate 2% ice by volume, small individual white ice crystals, first 3 inches of sample not retained (same as sample 4)
28														
30		6	Vx	F4	30 42 54	ML	Sandy SILT							Dark gray, frozen, fine sand, estimated 2% visible ice, individual, .125 inch thick veins of small white ice crystals
32														Bottom of Hole 31.5 ft. Groundwater Not Encountered PID = (Cold/Hot) Photo Ionization Detector

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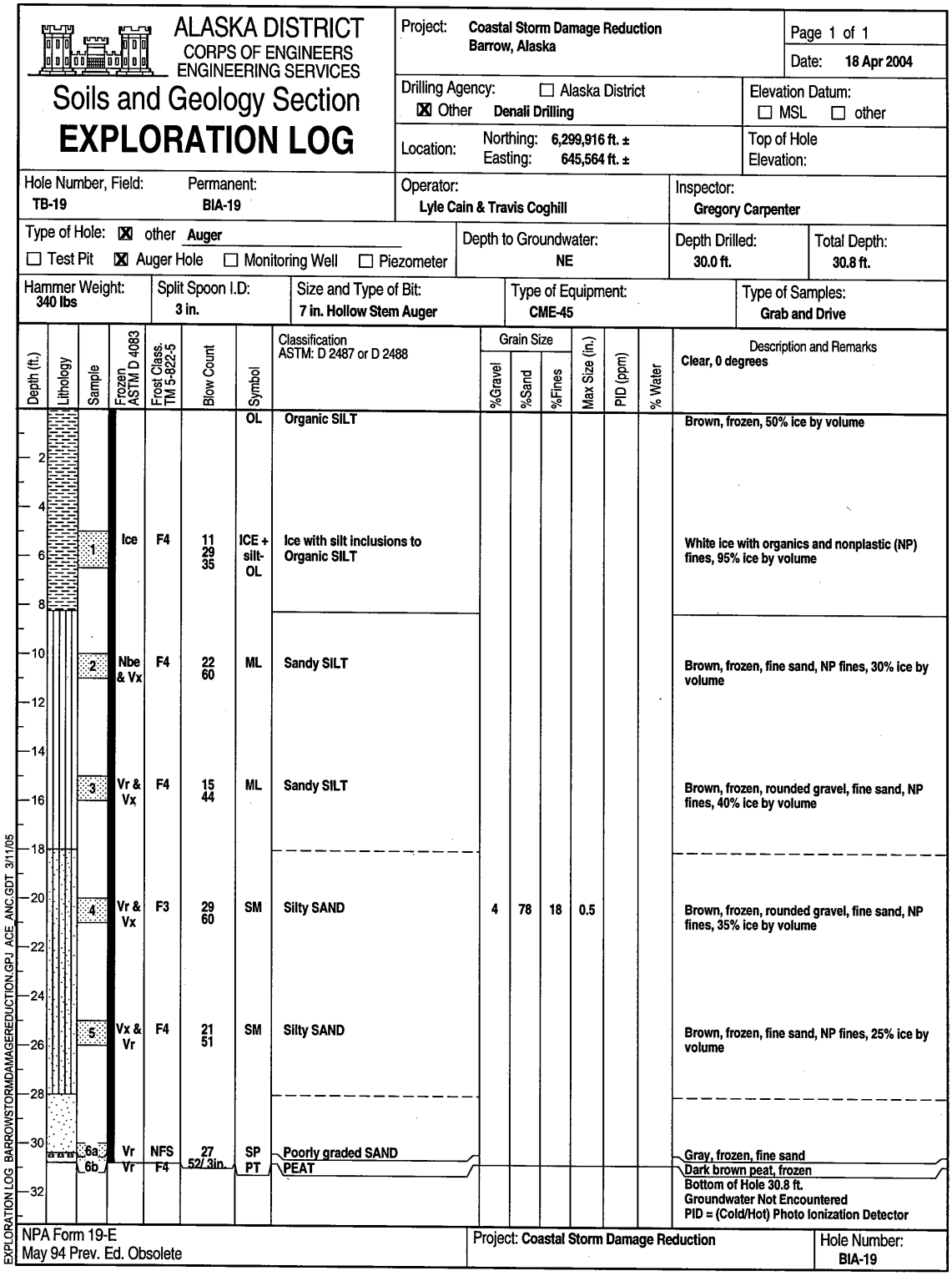
Project: **Coastal Storm Damage Reduction**

Hole Number: **BIA-13**

EXPLORATION LOG BARROWSTORMDAMAGEREDUCTION.GPJ ACE_ANC.GDT 3/11/05



ALASKA DISTRICT
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ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: **Coastal Storm Damage Reduction, Barrow, Alaska**		Page 1 of 1; Date: **18 Apr 2004**
Drilling Agency: ☐ Alaska District ☒ Other **Denali Drilling**		Elevation Datum: ☐ MSL ☐ other
Location: Northing: **6,299,916 ft. ±** Easting: **645,564 ft. ±**		Top of Hole Elevation:
Hole Number, Field: **TB-19**	Permanent: **BIA-19**	
Operator: **Lyle Cain & Travis Coghill**		Inspector: **Gregory Carpenter**
Type of Hole: ☒ other **Auger**; ☐ Test Pit ☒ Auger Hole ☐ Monitoring Well ☐ Piezometer	Depth to Groundwater: **NE**	Depth Drilled: **30.0 ft.** / Total Depth: **30.8 ft.**
Hammer Weight: **340 lbs**	Split Spoon I.D: **3 in.**	Size and Type of Bit: **7 in. Hollow Stem Auger**
Type of Equipment: **CME-45**		Type of Samples: **Grab and Drive**

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
0					OL	**Organic SILT**							**Clear, 0 degrees** **Brown, frozen, 50% ice by volume**
6	1	Ice	F4	11 29 35	ICE + silt-OL	**Ice with silt inclusions to Organic SILT**							**White ice with organics and nonplastic (NP) fines, 95% ice by volume**
10	2	Nbe & Vx	F4	22 60	ML	**Sandy SILT**							**Brown, frozen, fine sand, NP fines, 30% ice by volume**
16	3	Vr & Vx	F4	15 44	ML	**Sandy SILT**							**Brown, frozen, rounded gravel, fine sand, NP fines, 40% ice by volume**
20	4	Vr & Vx	F3	29 60	SM	**Silty SAND**	4	78	18	0.5			**Brown, frozen, rounded gravel, fine sand, NP fines, 35% ice by volume**
26	5	Vx & Vr	F4	21 51	SM	**Silty SAND**							**Brown, frozen, fine sand, NP fines, 25% ice by volume**
30	6a	Vr	NFS	27	SP	**Poorly graded SAND**							**Gray, frozen, fine sand**
	6b	Vr	F4	52/ 3in	PT	**PEAT**							**Dark brown peat, frozen**
32													**Bottom of Hole 30.8 ft.** **Groundwater Not Encountered** **PID = (Cold/Hot) Photo Ionization Detector**

EXPLORATION LOG BARROWSTORMDAMAGEREDUCTION.GPJ ACE_ANC.GDT 3/11/05

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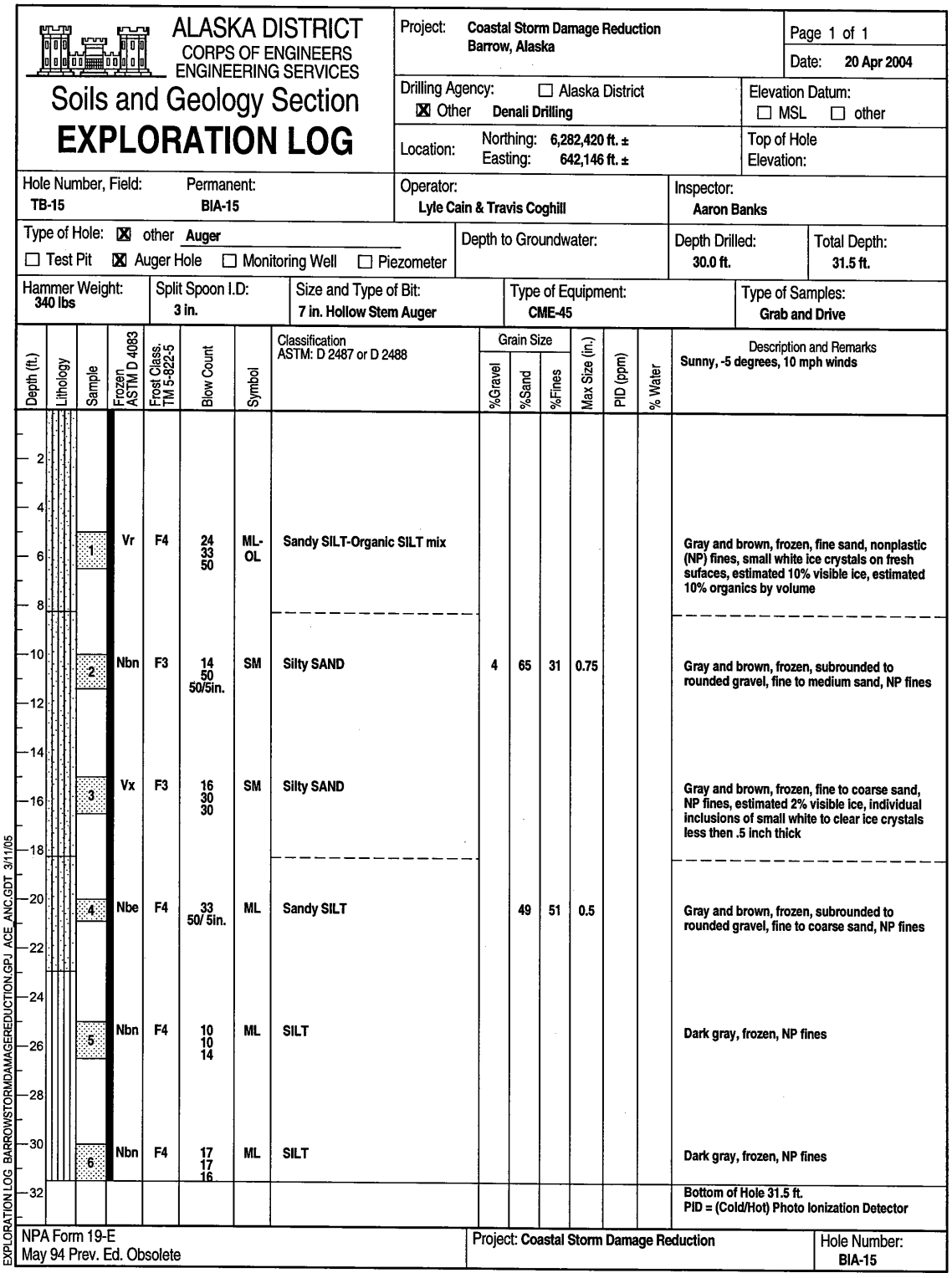
May 94 Prev. Ed. Obsolete

Project: **Coastal Storm Damage Reduction** — Hole Number: **BIA-19**



ALASKA DISTRICT
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ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: **Coastal Storm Damage Reduction, Barrow, Alaska**

Page 1 of 1

Date: **20 Apr 2004**

Drilling Agency: ☐ Alaska District ☒ Other **Denali Drilling**

Elevation Datum: ☐ MSL ☐ other

Location: Northing: **6,282,420 ft. ±** Easting: **642,146 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **TB-15**

Permanent: **BIA-15**

Operator: **Lyle Cain & Travis Coghill**

Inspector: **Aaron Banks**

Type of Hole: ☒ other **Auger** ☐ Test Pit ☒ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **30.0 ft.**

Total Depth: **31.5 ft.**

Hammer Weight: **340 lbs**

Split Spoon I.D.: **3 in.**

Size and Type of Bit: **7 in. Hollow Stem Auger**

Type of Equipment: **CME-45**

Type of Samples: **Grab and Drive**

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
2–8	1	Vr	F4	24 33 50	ML-OL	Sandy SILT-Organic SILT mix							Sunny, -5 degrees, 10 mph winds Gray and brown, frozen, fine sand, nonplastic (NP) fines, small white ice crystals on fresh sufaces, estimated 10% visible ice, estimated 10% organics by volume
8–10	2	Nbn	F3	14 50 50/5in.	SM	Silty SAND	4	65	31	0.75			Gray and brown, frozen, subrounded to rounded gravel, fine to medium sand, NP fines
14–16	3	Vx	F3	16 30 30	SM	Silty SAND							Gray and brown, frozen, fine to coarse sand, NP fines, estimated 2% visible ice, individual inclusions of small white to clear ice crystals less then .5 inch thick
18–20	4	Nbe	F4	33 50/ 5in.	ML	Sandy SILT		49	51	0.5			Gray and brown, frozen, subrounded to rounded gravel, fine to coarse sand, NP fines
24–26	5	Nbn	F4	10 10 14	ML	SILT							Dark gray, frozen, NP fines
28–30	6	Nbn	F4	17 17 16	ML	SILT							Dark gray, frozen, NP fines
32													Bottom of Hole 31.5 ft. PID = (Cold/Hot) Photo Ionization Detector

EXPLORATION LOG BARROWSTORMDAMAGEREDUCTION.GPJ ACE_ANC.GDT 3/11/05

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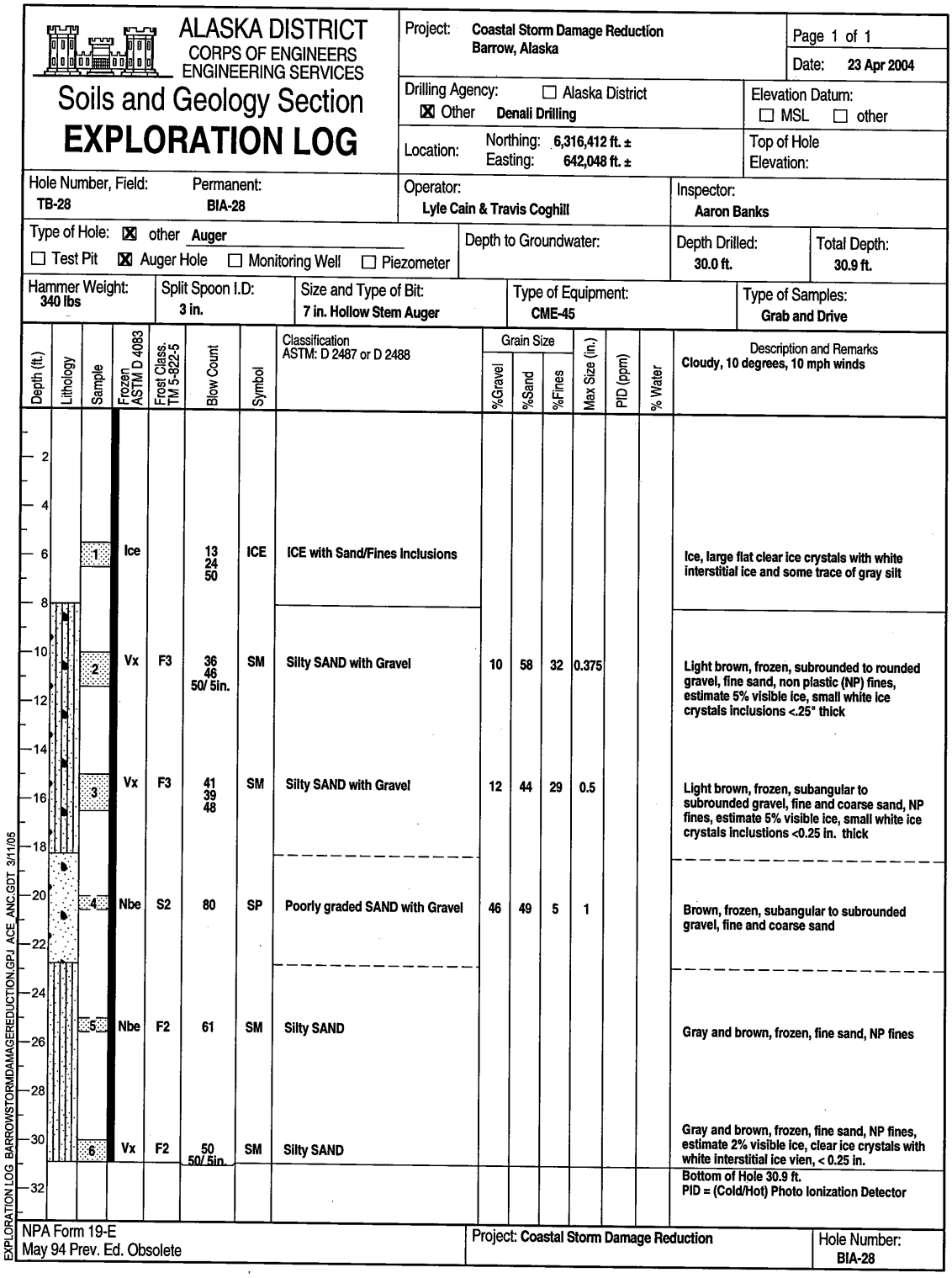
May 94 Prev. Ed. Obsolete

Project: **Coastal Storm Damage Reduction**

Hole Number: **BIA-15**



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ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: Coastal Storm Damage Reduction
Barrow, Alaska

Page 1 of 1
Date: 23 Apr 2004

Drilling Agency: ☐ Alaska District ☒ Other Denali Drilling

Elevation Datum: ☐ MSL ☐ other

Location: Northing: 6,316,412 ft. ±
Easting: 642,048 ft. ±

Top of Hole Elevation:

Hole Number, Field: TB-28
Permanent: BIA-28

Operator: Lyle Cain & Travis Coghill

Inspector: Aaron Banks

Type of Hole: ☒ other Auger
☐ Test Pit ☒ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: 30.0 ft.

Total Depth: 30.9 ft.

Hammer Weight: 340 lbs

Split Spoon I.D.: 3 in.

Size and Type of Bit: 7 in. Hollow Stem Auger

Type of Equipment: CME-45

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	Grain Size %Sand	Grain Size %Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
2														Cloudy, 10 degrees, 10 mph winds
4														
6		1	Ice		13 24 50	ICE	ICE with Sand/Fines Inclusions							Ice, large flat clear ice crystals with white interstitial ice and some trace of gray silt
8														
10		2	Vx	F3	36 46 50/ 5in.	SM	Silty SAND with Gravel	10	58	32	0.375			Light brown, frozen, subrounded to rounded gravel, fine sand, non plastic (NP) fines, estimate 5% visible ice, small white ice crystals inclusions <.25" thick
12														
14														
16		3	Vx	F3	41 39 48	SM	Silty SAND with Gravel	12	44	29	0.5			Light brown, frozen, subangular to subrounded gravel, fine and coarse sand, NP fines, estimate 5% visible ice, small white ice crystals inclustions <0.25 in. thick
18														
20		4	Nbe	S2	80	SP	Poorly graded SAND with Gravel	46	49	5	1			Brown, frozen, subangular to subrounded gravel, fine and coarse sand
22														
24														
26		5	Nbe	F2	61	SM	Silty SAND							Gray and brown, frozen, fine sand, NP fines
28														
30		6	Vx	F2	50 50/ 5in.	SM	Silty SAND							Gray and brown, frozen, fine sand, NP fines, estimate 2% visible ice, clear ice crystals with white interstitial ice vien, < 0.25 in.
32														Bottom of Hole 30.9 ft. PID = (Cold/Hot) Photo Ionization Detector

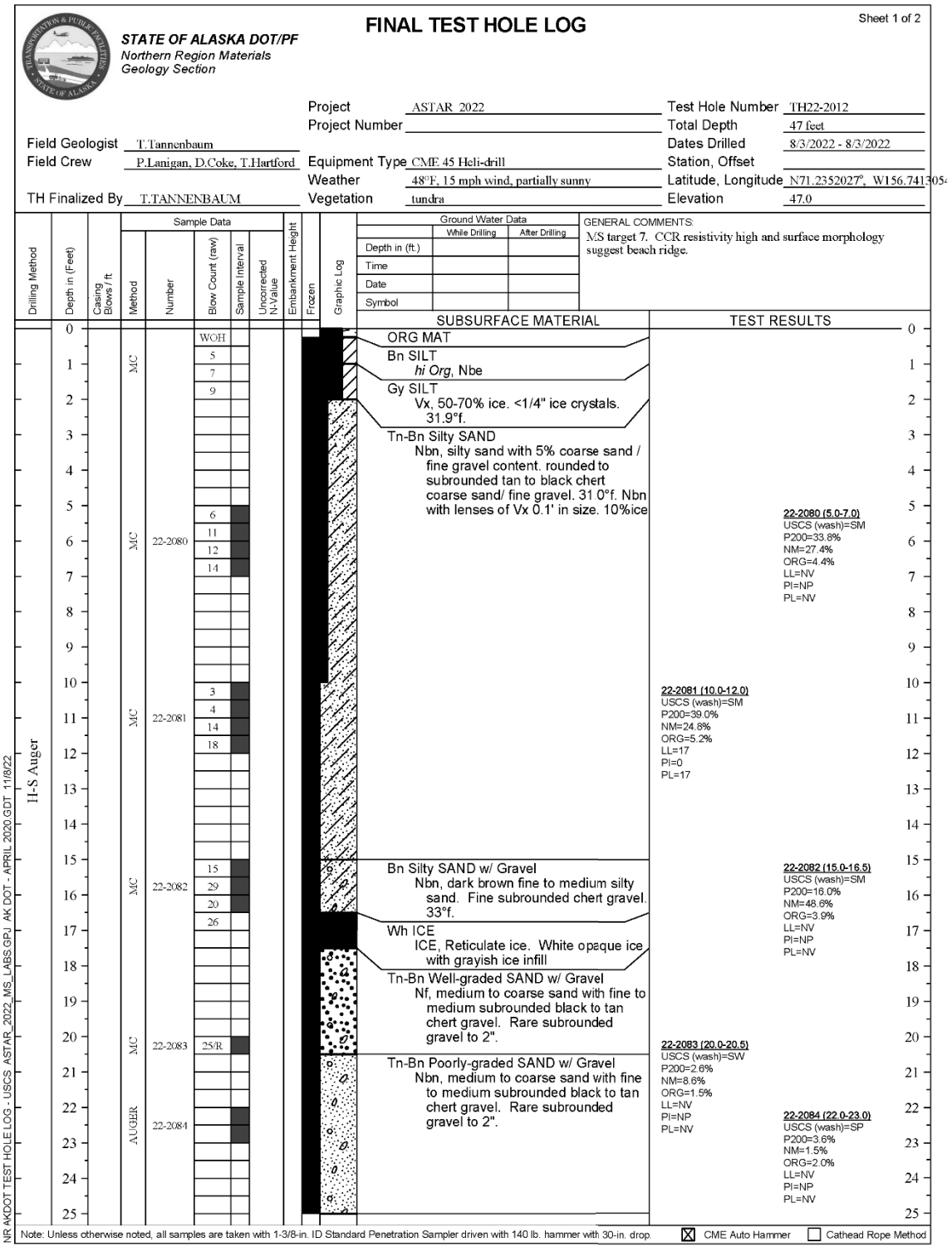
NPA Form 19-E
May 94 Prev. Ed. Obsolete

Project: Coastal Storm Damage Reduction

Hole Number: BIA-28

EXPLORATION LOG BARROWSTORMDAMAGEREDUCTION.GPJ ACE_ANC.GDT 3/11/05

APPENDIX C: 2022 DOT&PF TEST HOLE LOGS



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2012
Total Depth: 47 feet
Dates Drilled: 8/3/2022 - 8/3/2022
Field Geologist: T.Tannenbaum
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 48°F, 15 mph wind, partially sunny
Latitude, Longitude: N71.2352027°, W156.7413054°
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 47.0

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

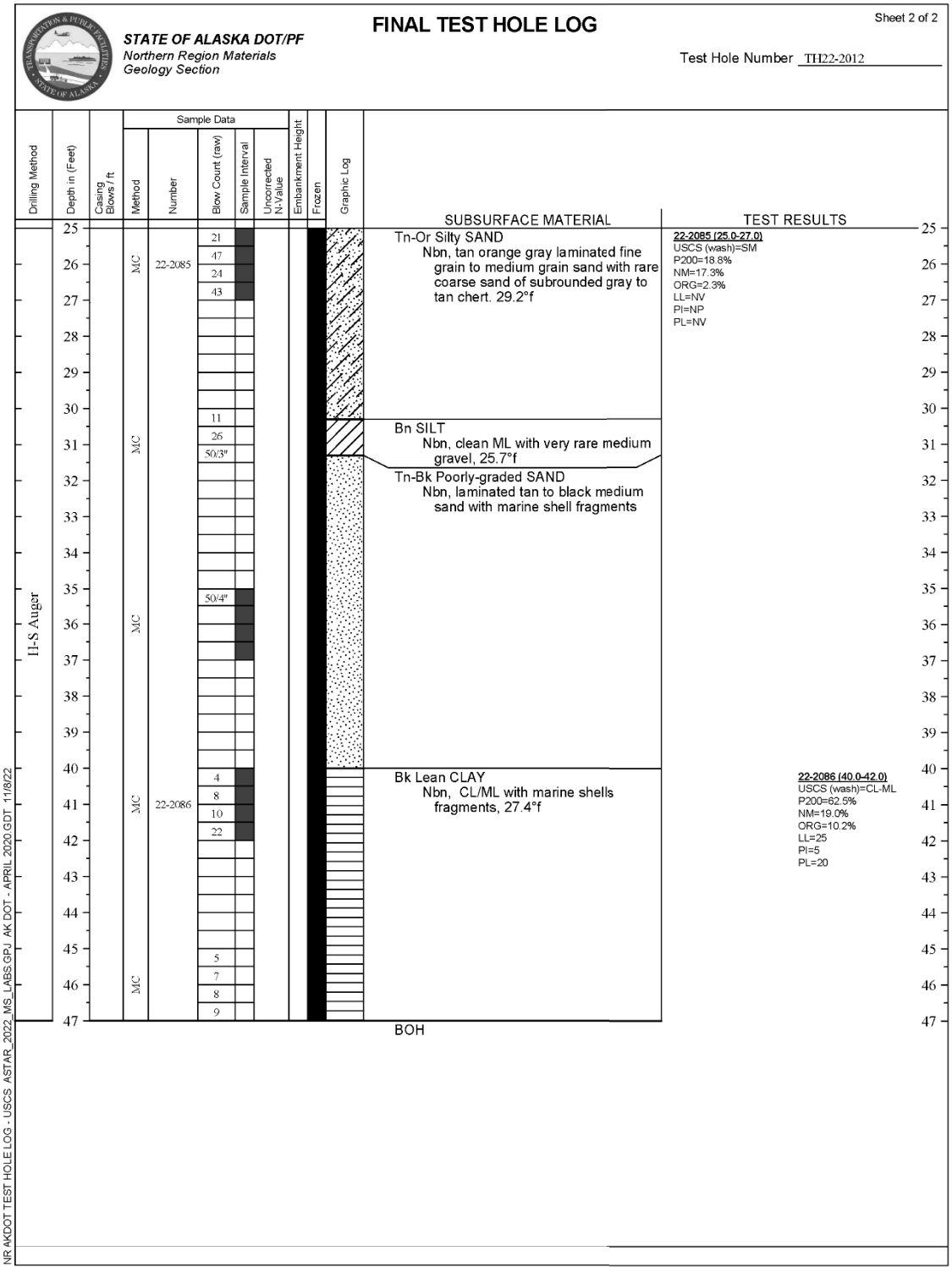
GENERAL COMMENTS:
MS target 7. CCR resistivity high and surface morphology suggest beach ridge.

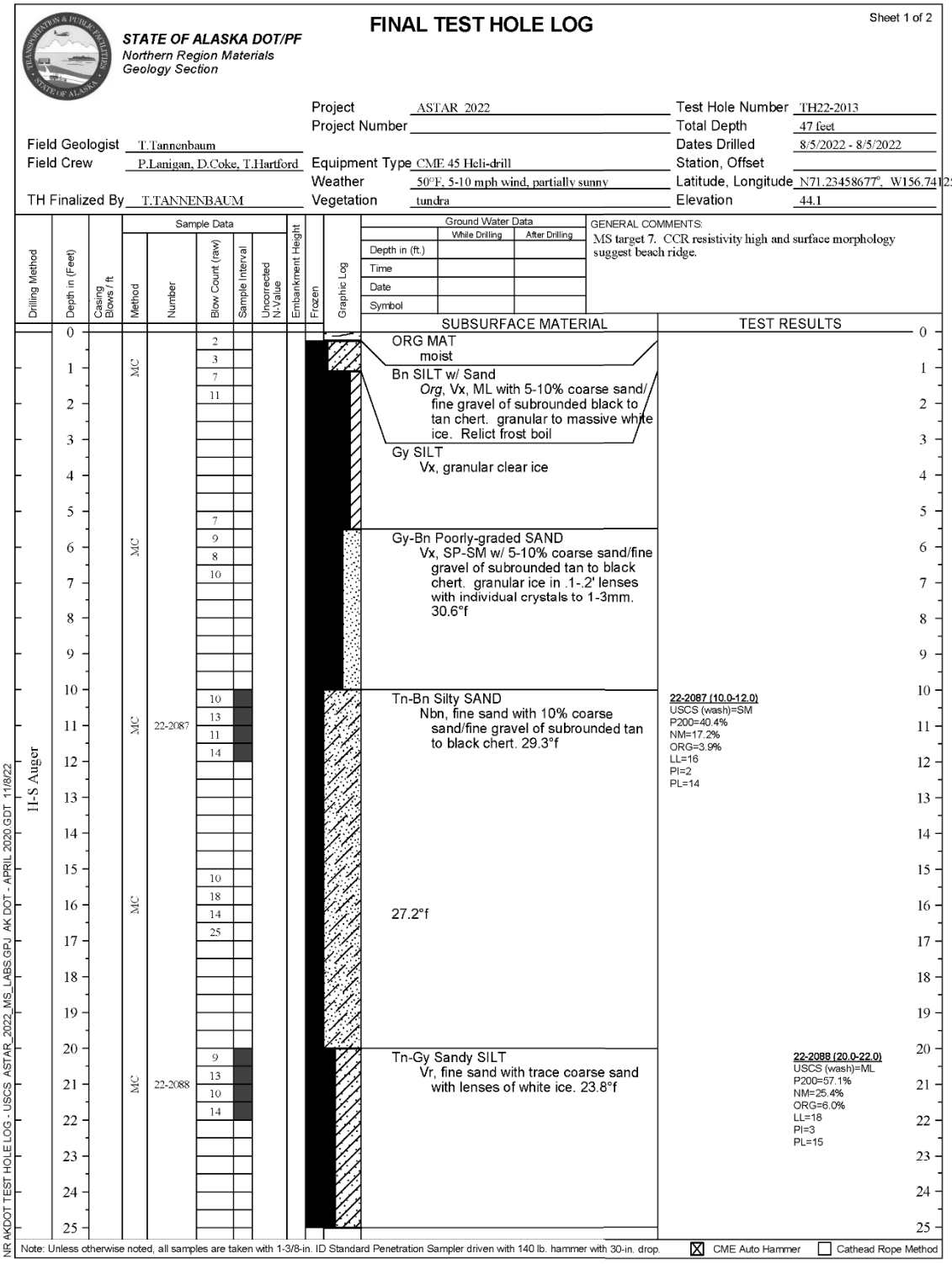
Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
H-S Auger	0				WOH						ORG MAT	
	1		MC		5						Bn SILT *hi Org*, Nbe	
	2				7						Gy SILT Vx, 50-70% ice. <1/4" ice crystals. 31.9°f.	
	3				9							
	4										Tn-Bn Silty SAND Nbn, silty sand with 5% coarse sand / fine gravel content. rounded to subrounded tan to black chert coarse sand/ fine gravel. 31.0°f. Nbn with lenses of Vx 0.1' in size. 10%ice	
	5				6							22-2080 (5.0-7.0) USCS (wash)=SM P200=33.8% NM=27.4% ORG=4.4% LL=NV PI=NP PL=NV
	6		MC	22-2080	11							
	7				12							
	8				14							
	9											
	10											
	11		MC	22-2081	3							22-2081 (10.0-12.0) USCS (wash)=SM P200=39.0% NM=24.8% ORG=5.2% LL=17 PI=0 PL=17
	12				4							
	13				14							
	14				18							
	15											
	16		MC	22-2082	15						Bn Silty SAND w/ Gravel Nbn, dark brown fine to medium silty sand. Fine subrounded chert gravel. 33°f.	22-2082 (15.0-16.5) USCS (wash)=SM P200=16.0% NM=48.6% ORG=3.9% LL=NV PI=NP PL=NV
	17				29							
	18				20						Wh ICE ICE, Reticulate ice. White opaque ice with grayish ice infill	
	19				26						Tn-Bn Well-graded SAND w/ Gravel Nf, medium to coarse sand with fine to medium subrounded black to tan chert gravel. Rare subrounded gravel to 2".	
	20		MC	22-2083	25/R							22-2083 (20.0-20.5) USCS (wash)=SW P200=2.6% NM=8.6% ORG=1.5% LL=NV PI=NP PL=NV
	21										Tn-Bn Poorly-graded SAND w/ Gravel Nbn, medium to coarse sand with fine to medium subrounded black to tan chert gravel. Rare subrounded gravel to 2".	
	22		AUGER	22-2084								22-2084 (22.0-23.0) USCS (wash)=SP P200=3.6% NM=1.5% ORG=2.0% LL=NV PI=NP PL=NV
	23											
	24											
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop.

☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2012
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
HSA
II-S Auger
MC
22-2085
22-2086
21
47
24
43
11
26
50/3"
50/4"
4
8
10
22
5
7
8
9
Tn-Or Silty SAND
Nbn, tan orange gray laminated fine grain to medium grain sand with rare coarse sand of subrounded gray to tan chert. 29.2°f
Bn SILT
Nbn, clean ML with very rare medium gravel, 25.7°f
Tn-Bk Poorly-graded SAND
Nbn, laminated tan to black medium sand with marine shell fragments
Bk Lean CLAY
Nbn, CL/ML with marine shells fragments, 27.4°f
BOH
22-2085 (25.0-27.0)
USCS (wash)=SM
P200=18.8%
NM=17.3%
ORG=2.3%
LL=NV
PI=NP
PL=NV
22-2086 (40.0-42.0)
USCS (wash)=CL-ML
P200=62.5%
NM=19.0%
ORG=10.2%
LL=25
PI=5
PL=20
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2013
Total Depth: 47 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/5/2022 - 8/5/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 50°F, 5-10 mph wind, partially sunny
Latitude, Longitude: N71.23458677°, W156.74125
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 44.1

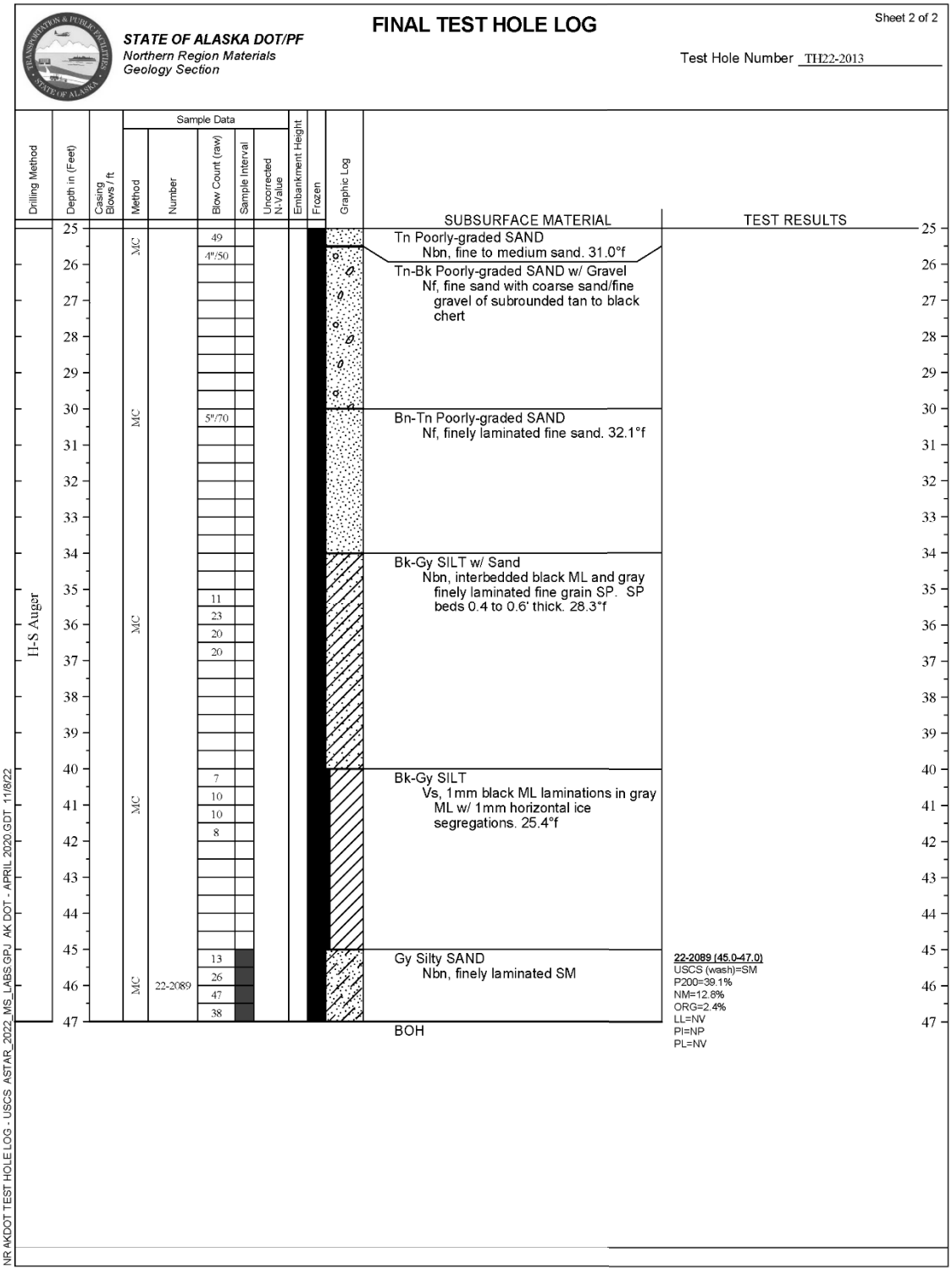
Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:
MS target 7. CCR resistivity high and surface morphology suggest beach ridge.

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				2						ORG MAT moist	
	1		MC		3							
					7						Bn SILT w/ Sand *Org*, Vx, ML with 5-10% coarse sand/ fine gravel of subrounded black to tan chert. granular to massive white ice. Relict frost boil	
	2				11							
	3										Gy SILT Vx, granular clear ice	
	4											
	5											
					7							
	6		MC		9						Gy-Bn Poorly-graded SAND Vx, SP-SM w/ 5-10% coarse sand/fine gravel of subrounded tan to black chert. granular ice in .1-.2' lenses with individual crystals to 1-3mm. 30.6°f	
					8							
	7				10							
	8											
	9											
	10				10						Tn-Bn Silty SAND Nbn, fine sand with 10% coarse sand/fine gravel of subrounded tan to black chert. 29.3°f	22-2087 (10.0-12.0) USCS (wash)=SM P200=40.4% NM=17.2% ORG=3.9% LL=16 PI=2 PL=14
			MC	22-2087	13							
	11				11							
					14							
	12											
	13											
	14											
	15				10							
					18							
	16		MC		14						27.2°f	
	17				25							
	18											
	19											
	20				9						Tn-Gy Sandy SILT Vr, fine sand with trace coarse sand with lenses of white ice. 23.8°f	22-2088 (20.0-22.0) USCS (wash)=ML P200=57.1% NM=25.4% ORG=6.0% LL=18 PI=3 PL=15
			MC	22-2088	13							
	21				10							
					14							
	22											
	23											
	24											
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2013
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
11-S Auger
MC
22-2089
49
4"/50
5"/70
11
23
20
20
7
10
10
8
13
26
47
38
Tn Poorly-graded SAND
Nbn, fine to medium sand. 31.0°f
Tn-Bk Poorly-graded SAND w/ Gravel
Nf, fine sand with coarse sand/fine gravel of subrounded tan to black chert
Bn-Tn Poorly-graded SAND
Nf, finely laminated fine sand. 32.1°f
Bk-Gy SILT w/ Sand
Nbn, interbedded black ML and gray finely laminated fine grain SP. SP beds 0.4 to 0.6' thick. 28.3°f
Bk-Gy SILT
Vs, 1mm black ML laminations in gray ML w/ 1mm horizontal ice segregations. 25.4°f
Gy Silty SAND
Nbn, finely laminated SM
BOH
22-2089 (45.0-47.0)
USCS (wash)=SM
P200=39.1%
NM=12.8%
ORG=2.4%
LL=NV
PI=NP
PL=NV
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project	ASTAR 2022	Test Hole Number	TH22-2014
Project Number		Total Depth	42 feet
Field Geologist	T.Tannenbaum	Dates Drilled	8/6/2022 - 8/6/2022
Field Crew	P.Lanigan, D.Coke, T.Hartford	Equipment Type	CME 45 Heli-drill
Station, Offset		Weather	42°F, rainy
Latitude, Longitude	N71.23520957°, W156.73669(	Vegetation	tundra
TH Finalized By	T.TANNENBAUM	Elevation	46.2

Ground Water Data

	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:
MS target 7. CCR resistivity high and surface morphology suggest beach ridge.

Drilling Method: H-S Auger

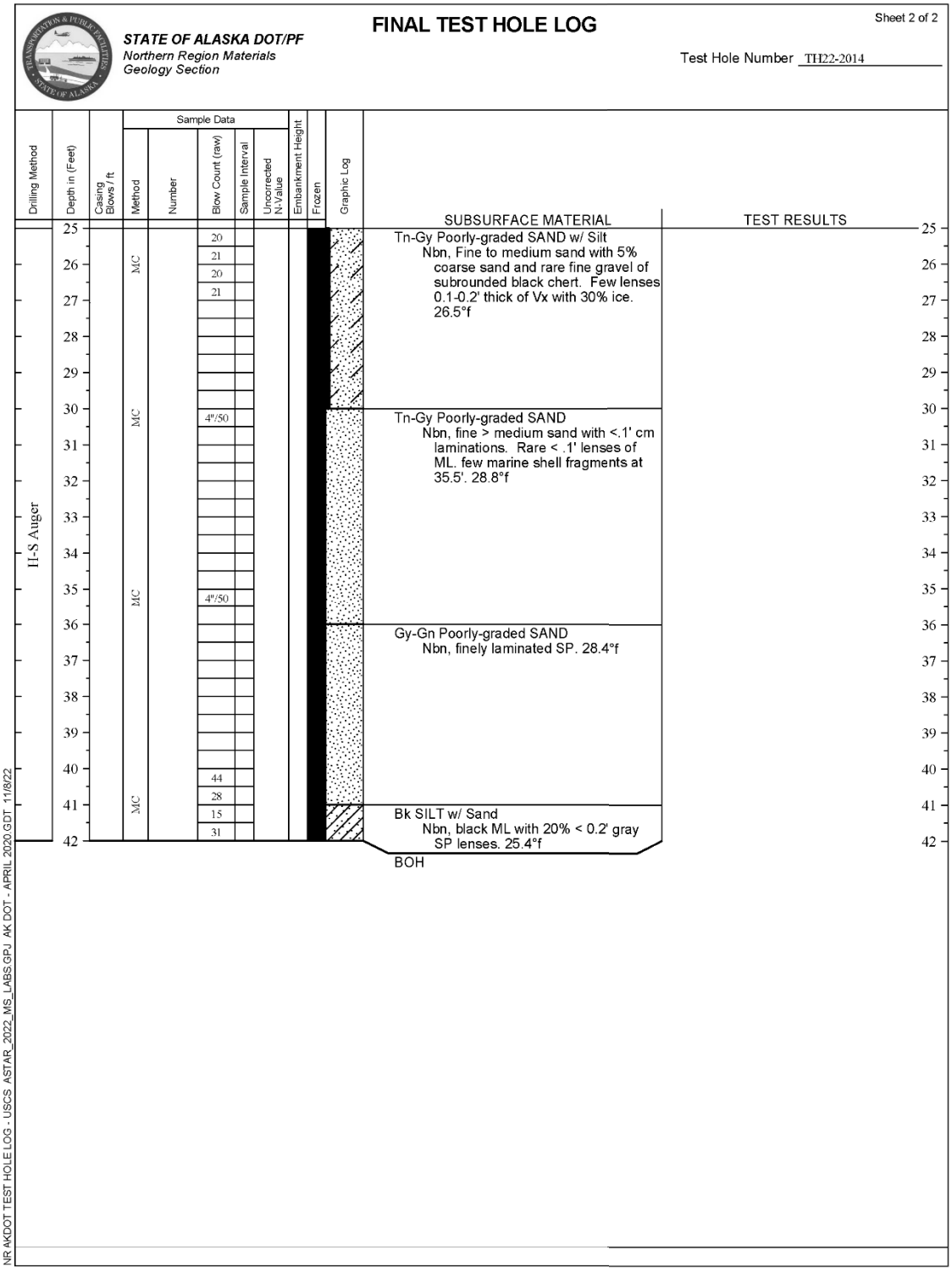
Sample Data

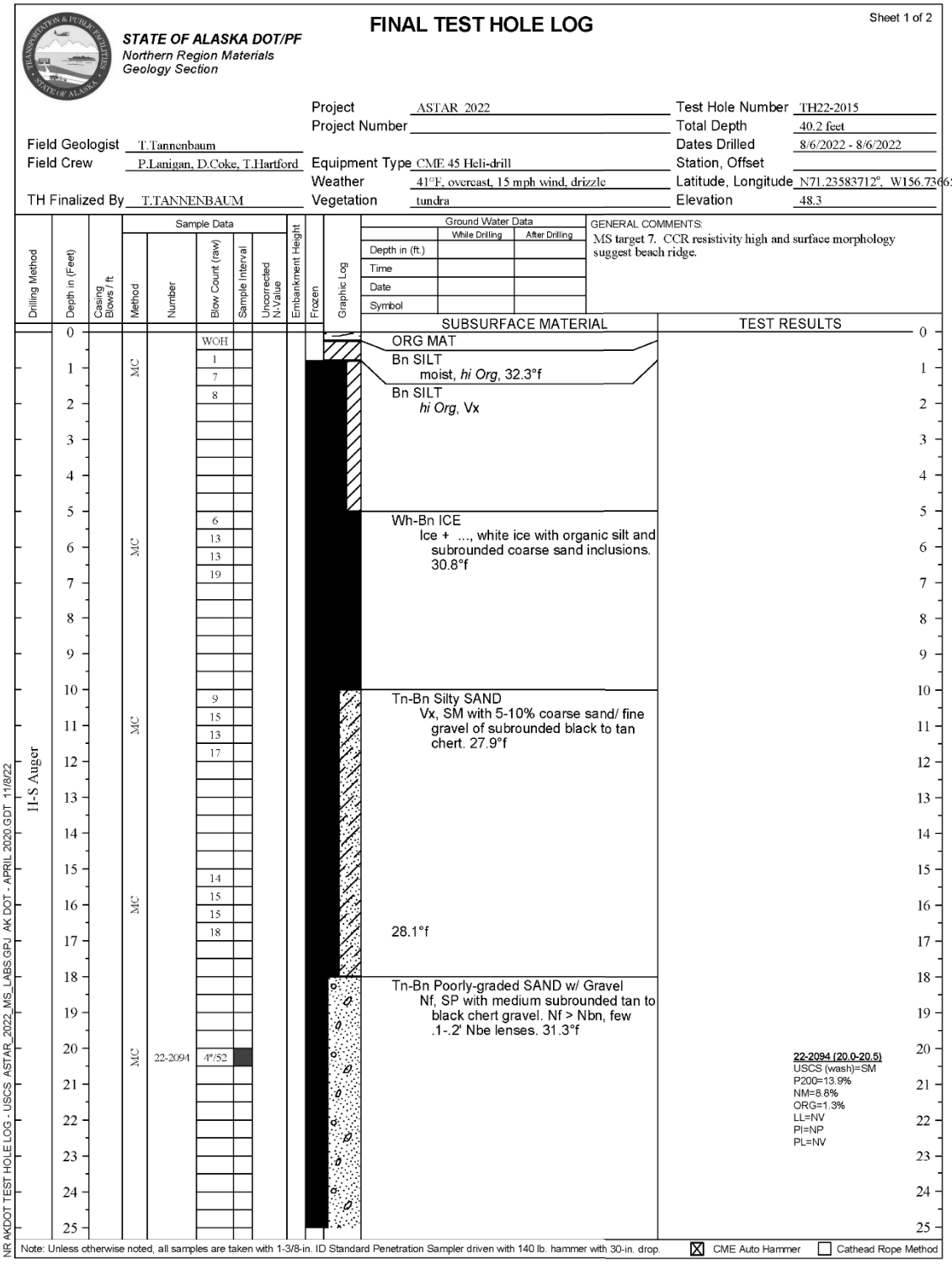
Depth in (Feet)	Method	Number	Blow Count (raw)
0–2	MC		WOH, WOH, 4, 11
5–7	MC		9, 12, 11, 13
10–12	MC	22-2090	11, 11, 11, 14
12–13	AUGER	22-2091	
15–16	MC	22-2093	18, 5"/52
20	MC		4"/50

Depth in (Feet)	SUBSURFACE MATERIAL	TEST RESULTS
0–1	Bn ORG MAT moist	
1–5	Bn SILT *hi Org*, Vx, frozen peat interlayered with organic silt with granular ice	
5–10	Gy-Bn Silty SAND Vx, granular white Vx ice. 30%SM/ 70% ice. SM with minor fine gravel of subrounded tan to gray chert. 30.2°f	
10–12	Tn Clayey SAND Vx, 0.5' layers of SC with 50 % Vx ice and SC with gravel (Nbn). Coarse sand/ fine gravel of subrounded tan - black chert. 28.7°f	**22-2090 (10.0-12.0)** USCS (wash)=SC P200=44.7% NM=19.2% ORG=4.7% LL=22 PI=8 PL=14
12–14	Tn Silty SAND w/ Gravel Vx	**22-2091 (12.0-13.0)** USCS (wash)=SM P200=32.6% NM=19.7% ORG=4.1% LL=17 PI=2 PL=15
14–19	Tn Poorly-graded SAND w/ Gravel Vx, SP with fine to medium gravel of subrounded tan to black chert. Vx ice in granular SP. 31.1°f	**22-2093 (15.0-16.0)** USCS (wash)=SP P200=2.3% NM=8.3% ORG=1.1% LL=NV PI=NP PL=NV
19–25	Tn Poorly-graded SAND Nf, SP with 10% fine gravel of subrounded tan to black chert in 0.3-0.5' lenses. Nf > Nbn ice. 31.1°f	

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2014
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
HS Auger
MC
20
21
20
21
4"/50
4"/50
44
28
15
31
Tn-Gy Poorly-graded SAND w/ Silt
Nbn, Fine to medium sand with 5% coarse sand and rare fine gravel of subrounded black chert. Few lenses 0.1-0.2' thick of Vx with 30% ice. 26.5°f
Tn-Gy Poorly-graded SAND
Nbn, fine > medium sand with <.1' cm laminations. Rare < .1' lenses of ML. few marine shell fragments at 35.5'. 28.8°f
Gy-Gn Poorly-graded SAND
Nbn, finely laminated SP. 28.4°f
Bk SILT w/ Sand
Nbn, black ML with 20% < 0.2' gray SP lenses. 25.4°f
BOH
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2015
Total Depth: 40.2 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/6/2022 - 8/6/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 41°F, overcast, 15 mph wind, drizzle
Latitude, Longitude: N71.23583712°, W156.73665
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 48.3

Ground Water Data

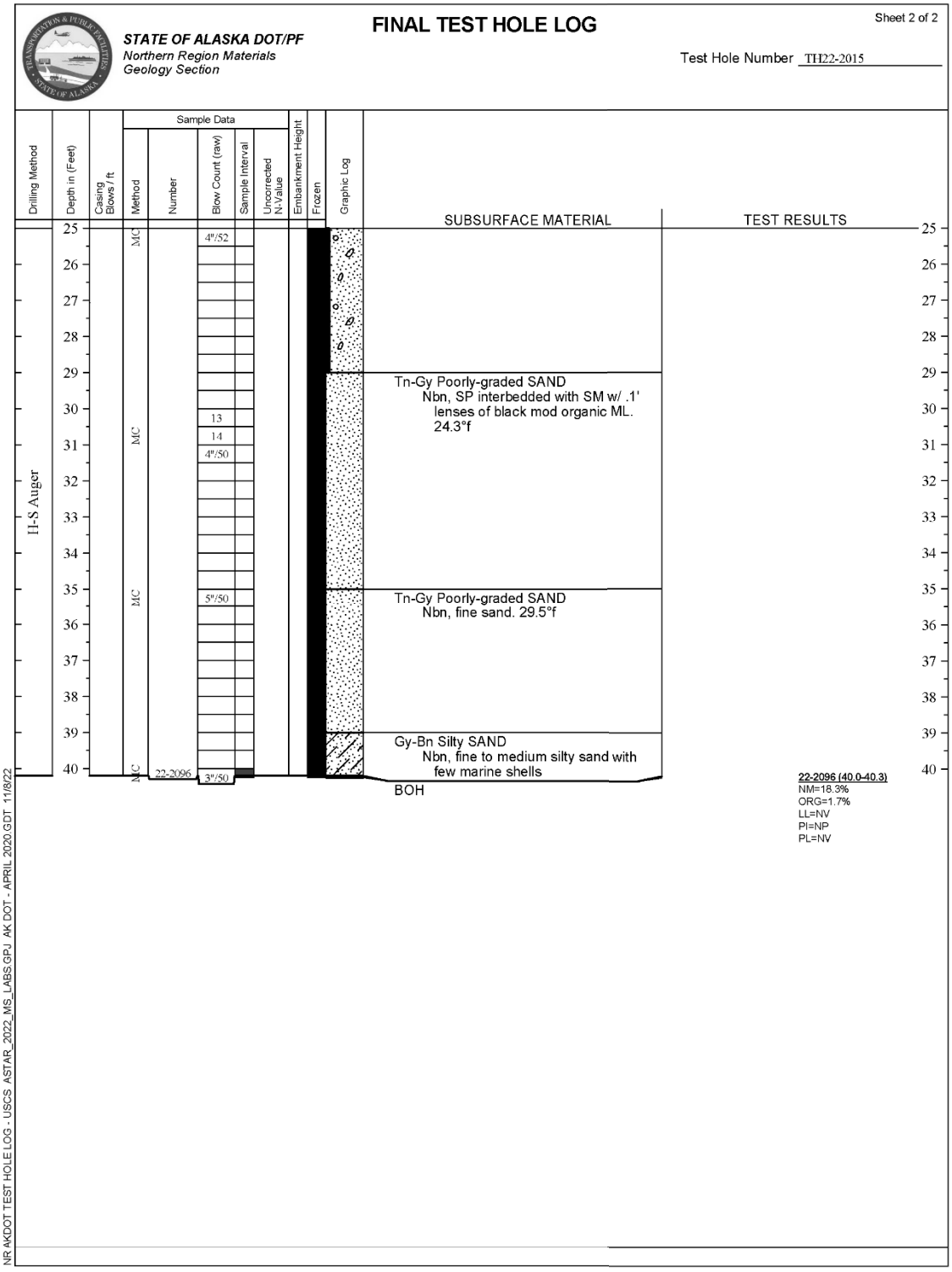
	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

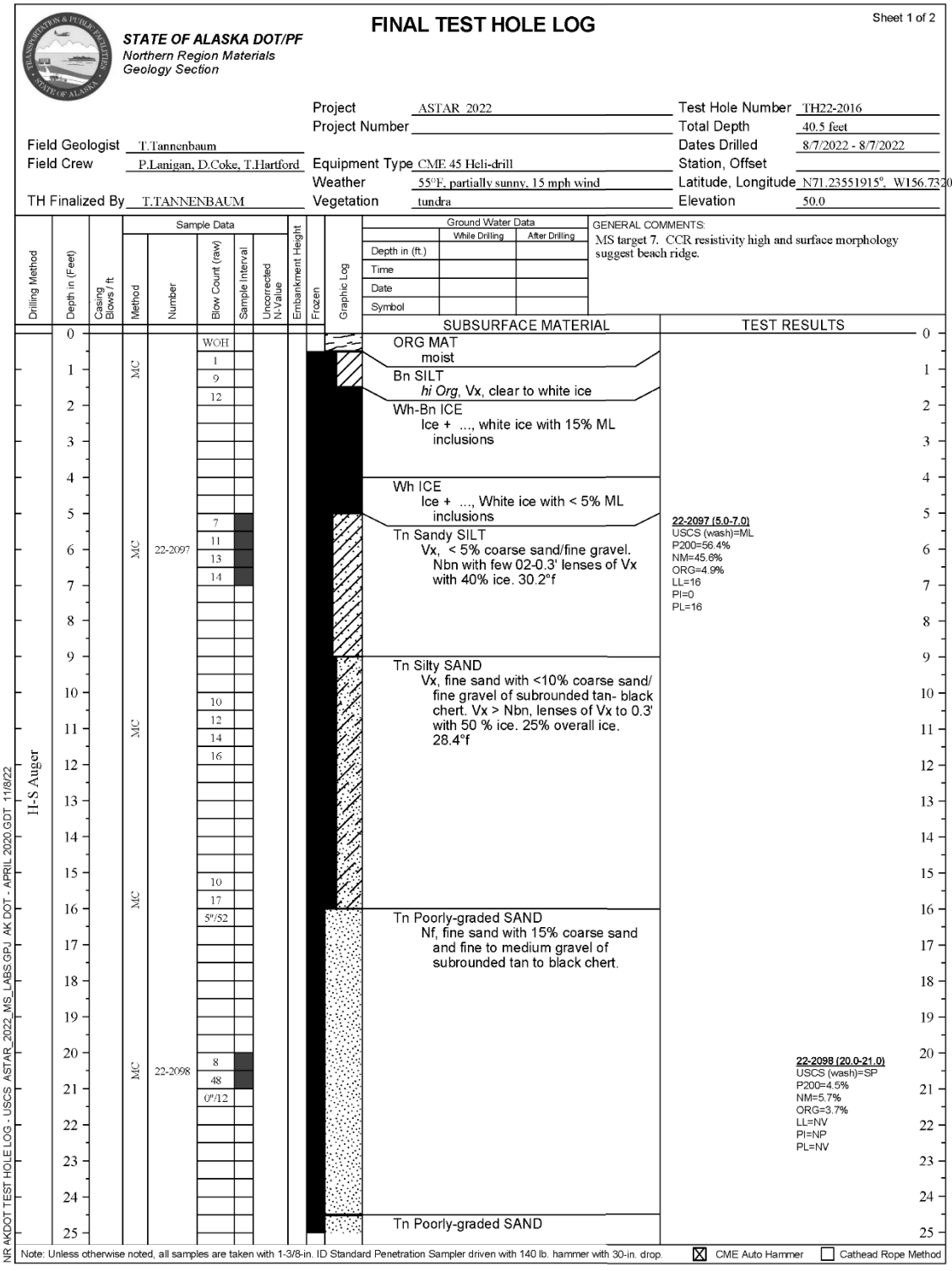
GENERAL COMMENTS:
MS target 7. CCR resistivity high and surface morphology suggest beach ridge.

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		1						Bn SILT moist, *hi Org*, 32.3°f	
					7							
	2				8						Bn SILT *hi Org*, Vx	
	3											
	4											
	5											
					6						Wh-Bn ICE Ice + ..., white ice with organic silt and subrounded coarse sand inclusions. 30.8°f	
	6		MC		13							
					13							
	7				19							
	8											
	9											
	10				9						Tn-Bn Silty SAND Vx, SM with 5-10% coarse sand/ fine gravel of subrounded black to tan chert. 27.9°f	
					15							
	11		MC		13							
					17							
	12											
	13											
	14											
	15				14							
					15							
	16		MC		15							
					18						28.1°f	
	17											
	18										Tn-Bn Poorly-graded SAND w/ Gravel Nf, SP with medium subrounded tan to black chert gravel. Nf > Nbn, few .1-.2' Nbe lenses. 31.3°f	
	19											
	20		MC	22-2094	4"/52							22-2094 (20.0-20.5) USCS (wash)=SM P200=13.9% NM=8.8% ORG=1.3% LL=NV PI=NP PL=NV
	21											
	22											
	23											
	24											
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2015
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
11-S Auger
MC
4"/52
13
14
4"/50
5"/50
22-2096
3"/50
Tn-Gy Poorly-graded SAND
Nbn, SP interbedded with SM w/ .1' lenses of black mod organic ML.
24.3°f
Tn-Gy Poorly-graded SAND
Nbn, fine sand. 29.5°f
Gy-Bn Silty SAND
Nbn, fine to medium silty sand with few marine shells
BOH
22-2096 (40.0-40.3)
NM=18.3%
ORG=1.7%
LL=NV
PI=NP
PL=NV
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2016
Total Depth: 40.5 feet
Dates Drilled: 8/7/2022 - 8/7/2022
Station, Offset:
Latitude, Longitude: N71.23551915°, W156.73209°
Elevation: 50.0
Field Geologist: T.Tannenbaum
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Weather: 55°F, partially sunny, 15 mph wind
Vegetation: tundra
TH Finalized By: T.TANNENBAUM

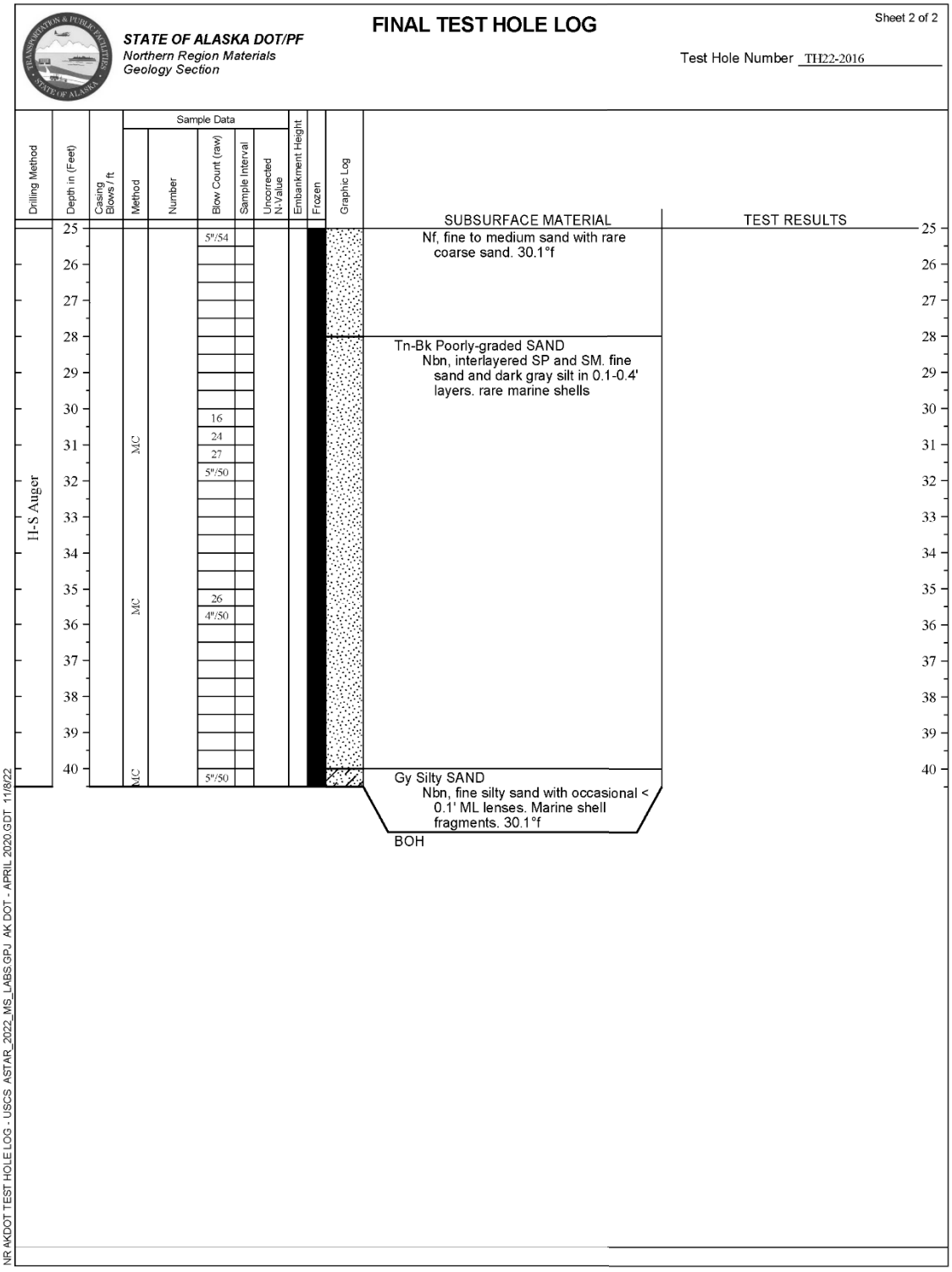
Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

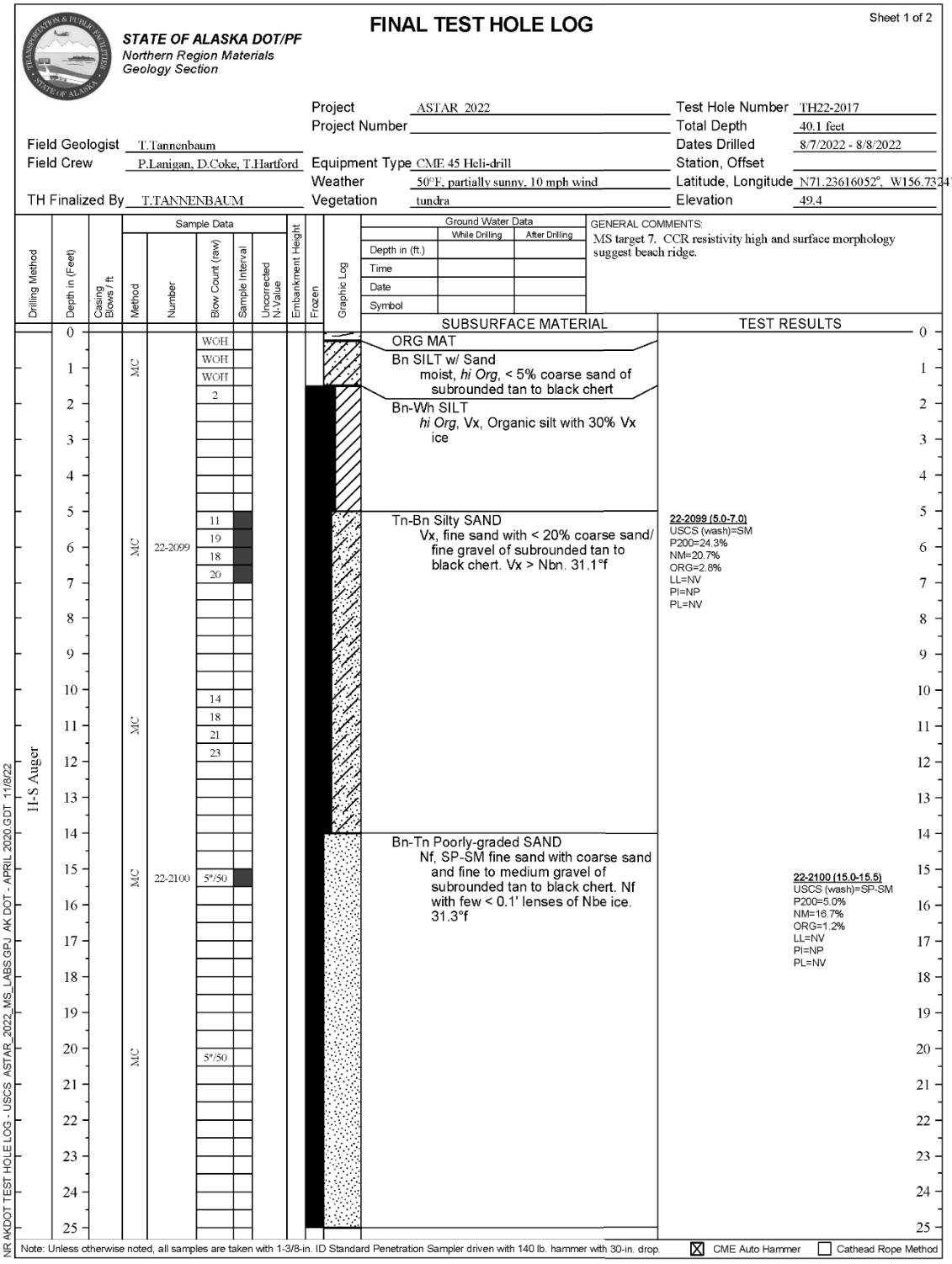
GENERAL COMMENTS:
MS target 7. CCR resistivity high and surface morphology suggest beach ridge.

Depth (ft)	Drilling Method	Casing Blows / ft	Sample Method	Sample Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
0	11-S Auger				WOH						ORG MAT moist	
1			MC		1						Bn SILT *hi Org*, Vx, clear to white ice	
2					9							
3					12						Wh-Bn ICE Ice + ..., white ice with 15% ML inclusions	
4												
5											Wh ICE Ice + ..., White ice with < 5% ML inclusions	
6			MC	22-2097	7						Tn Sandy SILT Vx, < 5% coarse sand/fine gravel. Nbn with few 02-0.3' lenses of Vx with 40% ice. 30.2°f	22-2097 (5.0-7.0) USCS (wash)=ML P200=56.4% NM=45.6% ORG=4.9% LL=16 PI=0 PL=16
7					11							
8					13							
9					14							
10											Tn Silty SAND Vx, fine sand with <10% coarse sand/ fine gravel of subrounded tan- black chert. Vx > Nbn, lenses of Vx to 0.3' with 50 % ice. 25% overall ice. 28.4°f	
11			MC		10							
12					12							
13					14							
14					16							
15												
16			MC		10						Tn Poorly-graded SAND Nf, fine sand with 15% coarse sand and fine to medium gravel of subrounded tan to black chert.	
17					17							
18					5"/52							
19												
20			MC	22-2098	8							22-2098 (20.0-21.0) USCS (wash)=SP P200=4.5% NM=5.7% ORG=3.7% LL=NV PI=NP PL=NV
21					48							
22					0"/12							
23												
24												
25											Tn Poorly-graded SAND	

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2016
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
H-S Auger
MC
MC
MC
5"/54
16
24
27
5"/50
26
4"/50
5"/50
Nf, fine to medium sand with rare coarse sand. 30.1°f
Tn-Bk Poorly-graded SAND
Nbn, interlayered SP and SM. fine sand and dark gray silt in 0.1-0.4' layers. rare marine shells
Gy Silty SAND
Nbn, fine silty sand with occasional < 0.1' ML lenses. Marine shell fragments. 30.1°f
BOH
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2017
Total Depth: 40.1 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/7/2022 - 8/8/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 50°F, partially sunny, 10 mph wind
Latitude, Longitude: N71.23616052°, W156.73414
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 49.4

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

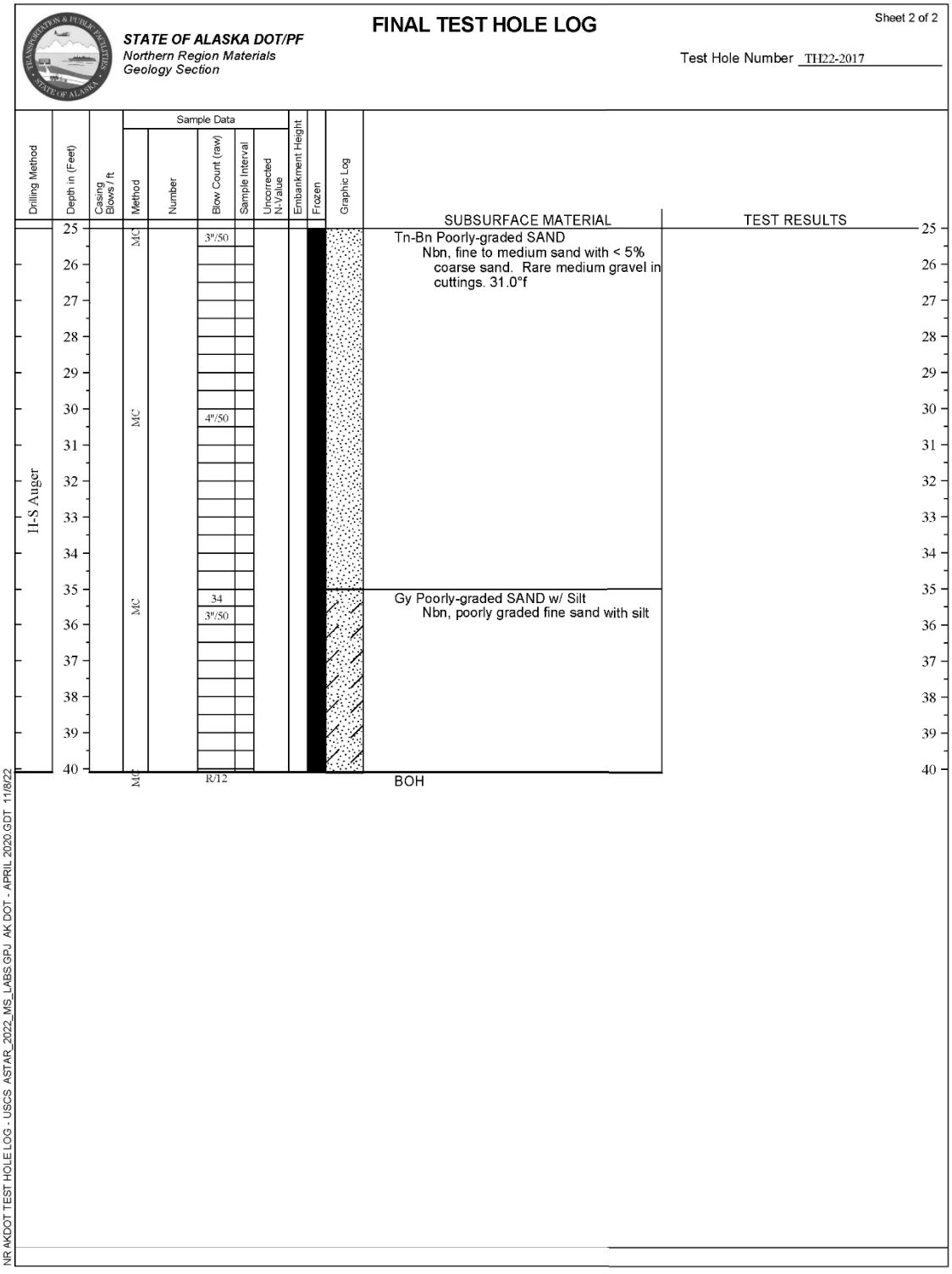
GENERAL COMMENTS:
MS target 7. CCR resistivity high and surface morphology suggest beach ridge.

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		WOH						Bn SILT w/ Sand moist, *hi Org*, < 5% coarse sand of subrounded tan to black chert	
	2				2						Bn-Wh SILT *hi Org*, Vx, Organic silt with 30% Vx ice	
	3											
	4											
	5				11						Tn-Bn Silty SAND Vx, fine sand with < 20% coarse sand/ fine gravel of subrounded tan to black chert. Vx > Nbn. 31.1°f	**22-2099 (5.0-7.0)** USCS (wash)=SM P200=24.3% NM=20.7% ORG=2.8% LL=NV PI=NP PL=NV
	6		MC	22-2099	19							
	7				18							
	8				20							
	9											
	10											
	11		MC		14							
	12				18							
	13				21							
	14				23							
	15		MC	22-2100	5"/50						Bn-Tn Poorly-graded SAND Nf, SP-SM fine sand with coarse sand and fine to medium gravel of subrounded tan to black chert. Nf with few < 0.1' lenses of Nbe ice. 31.3°f	**22-2100 (15.0-15.5)** USCS (wash)=SP-SM P200=5.0% NM=16.7% ORG=1.2% LL=NV PI=NP PL=NV
	16											
	17											
	18											
	19											
	20		MC		5"/50							
	21											
	22											
	23											
	24											
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop.

☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

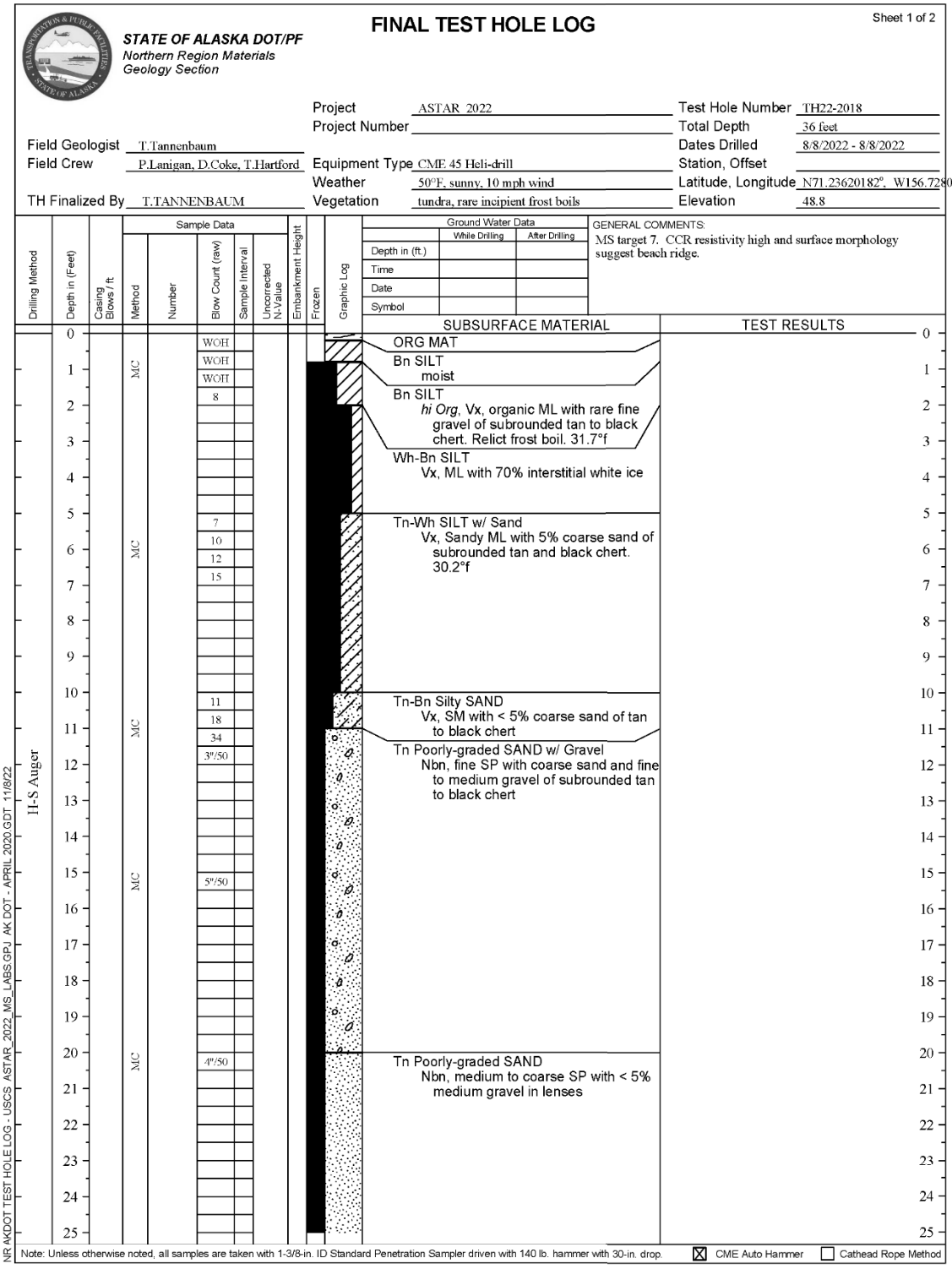
FINAL TEST HOLE LOG

Sheet 2 of 2

Test Hole Number TH22-2017

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
	25		MC		3"/50						Tn-Bn Poorly-graded SAND Nbn, fine to medium sand with < 5% coarse sand. Rare medium gravel in cuttings. 31.0°f	
	26											
	27											
	28											
	29											
	30		MC		4"/50							
11-S Auger	31											
	32											
	33											
	34											
	35		MC		34						Gy Poorly-graded SAND w/ Silt Nbn, poorly graded fine sand with silt	
	36				3"/50							
	37											
	38											
	39											
	40		MC		R/12						BOH	

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2018
Total Depth: 36 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/8/2022 - 8/8/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 50°F, sunny, 10 mph wind
Latitude, Longitude: N71.23620182°, W156.72803
TH Finalized By: T.TANNENBAUM
Vegetation: tundra, rare incipient frost boils
Elevation: 48.8

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

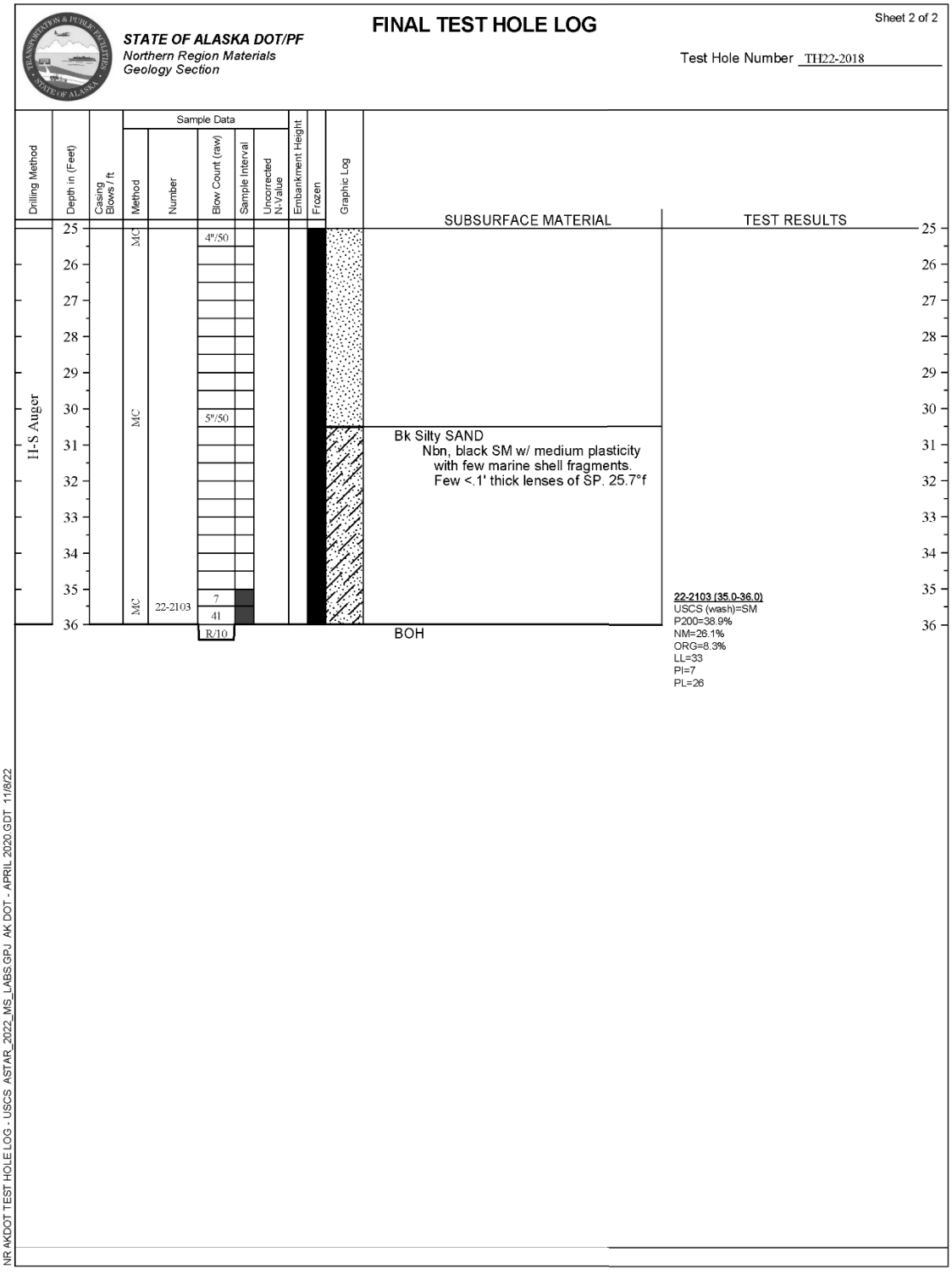
GENERAL COMMENTS:
MS target 7. CCR resistivity high and surface morphology suggest beach ridge.

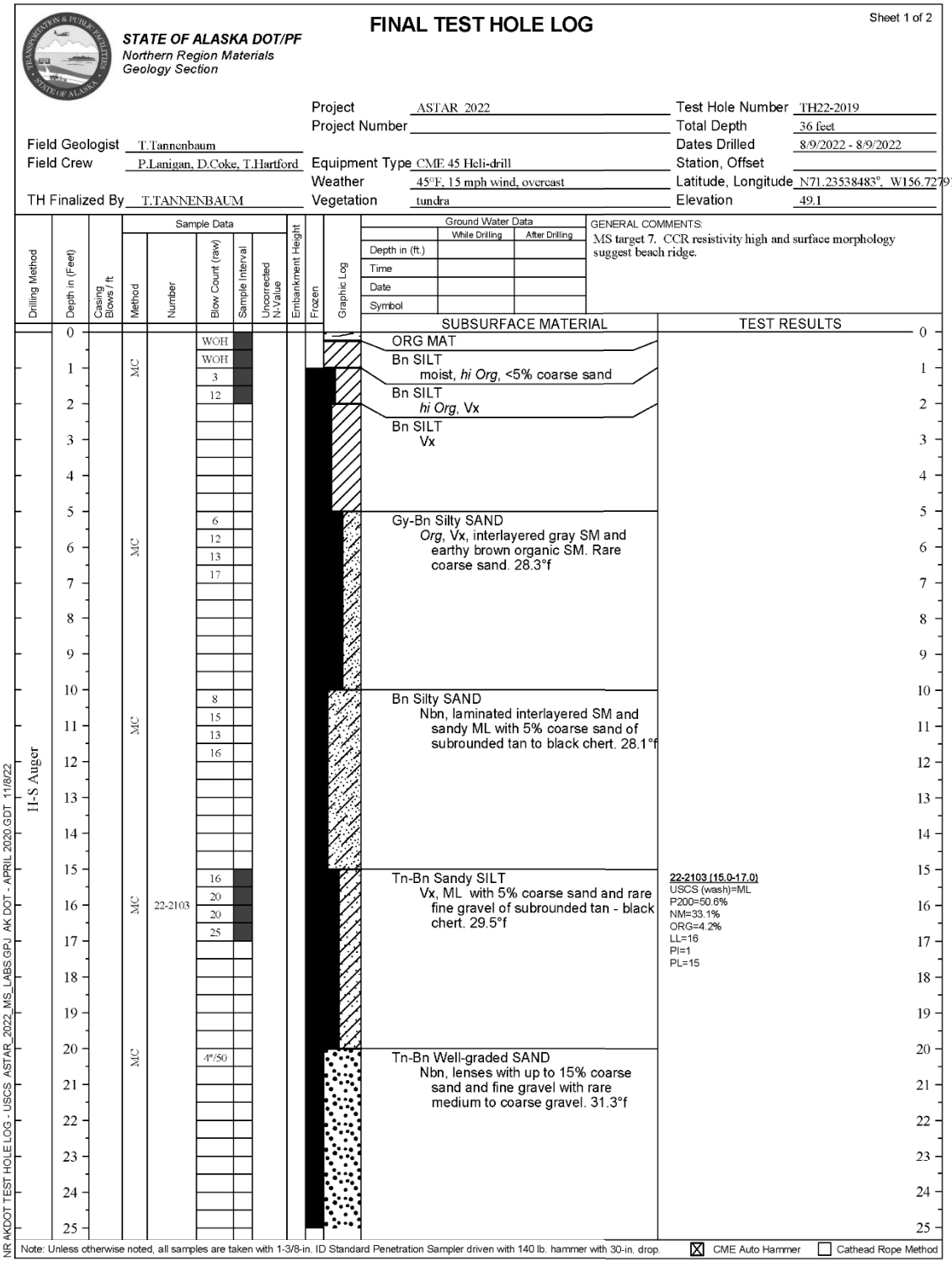
Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		WOH						Bn SILT moist	
	2				WOH						Bn SILT *hi Org*, Vx, organic ML with rare fine gravel of subrounded tan to black chert. Relict frost boil. 31.7°f	
	3				8							
	4										Wh-Bn SILT Vx, ML with 70% interstitial white ice	
	5											
	6				7						Tn-Wh SILT w/ Sand Vx, Sandy ML with 5% coarse sand of subrounded tan and black chert. 30.2°f	
	7		MC		10							
	8				12							
	9				15							
	10											
	11				11						Tn-Bn Silty SAND Vx, SM with < 5% coarse sand of tan to black chert	
	12		MC		18						Tn Poorly-graded SAND w/ Gravel Nbn, fine SP with coarse sand and fine to medium gravel of subrounded tan to black chert	
	13				34							
	14				3"/50							
	15		MC		5"/50							
	16											
	17											
	18											
	19											
	20		MC		4"/50						Tn Poorly-graded SAND Nbn, medium to coarse SP with < 5% medium gravel in lenses	
	21											
	22											
	23											
	24											
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop.

☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2018
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
11-S Auger
MC
4"/50
5"/50
22-2103
7
41
R/10
Bk Silty SAND
Nbn, black SM w/ medium plasticity
with few marine shell fragments.
Few <.1' thick lenses of SP. 25.7°f
BOH
22-2103 (35.0-36.0)
USCS (wash)=SM
P200=38.9%
NM=26.1%
ORG=8.3%
LL=33
PI=7
PL=26
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2019
Total Depth: 36 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/9/2022 - 8/9/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 45°F, 15 mph wind, overcast
Latitude, Longitude: N71.23538483°, W156.72791
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 49.1

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

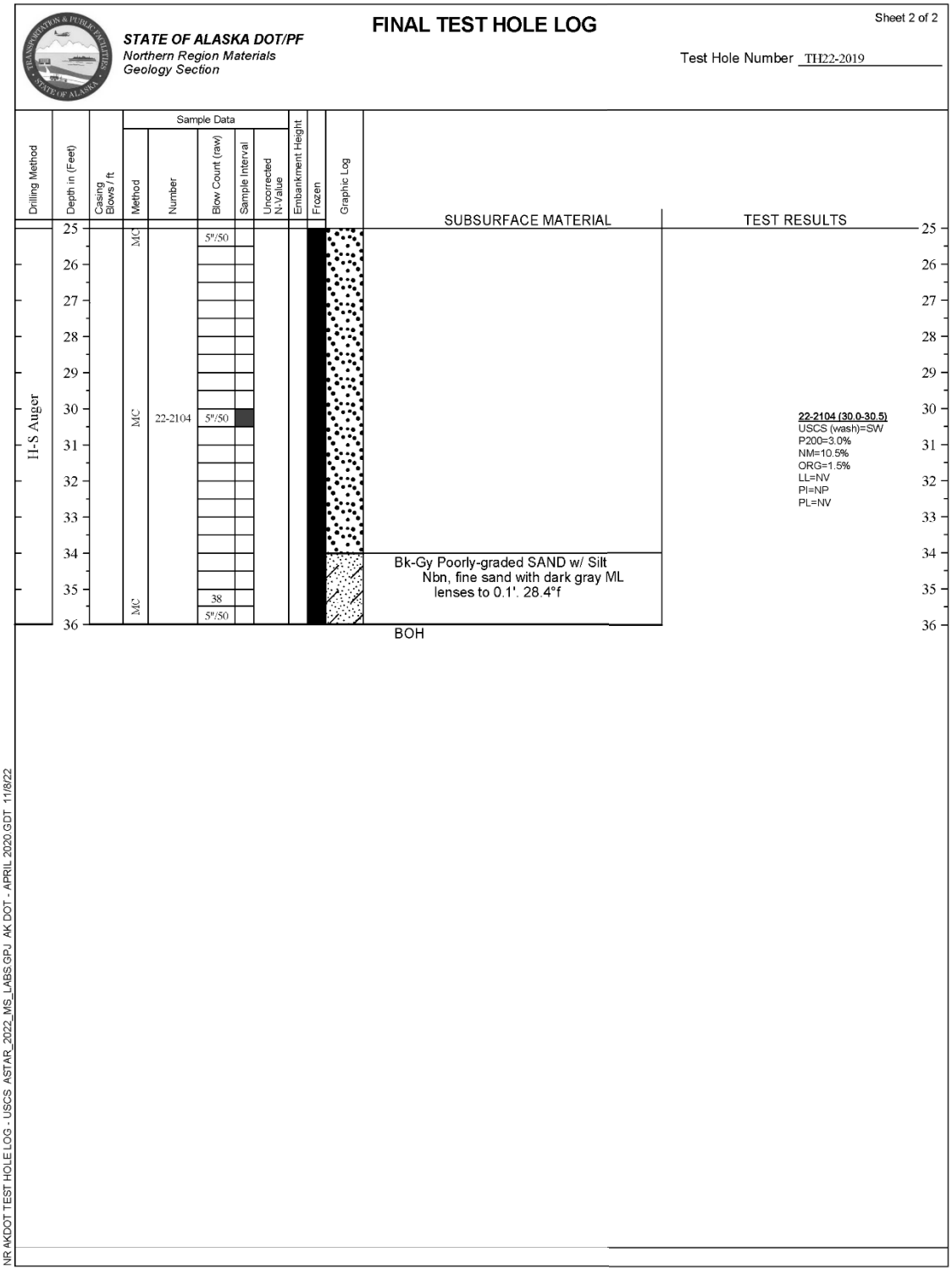
GENERAL COMMENTS:
MS target 7. CCR resistivity high and surface morphology suggest beach ridge.

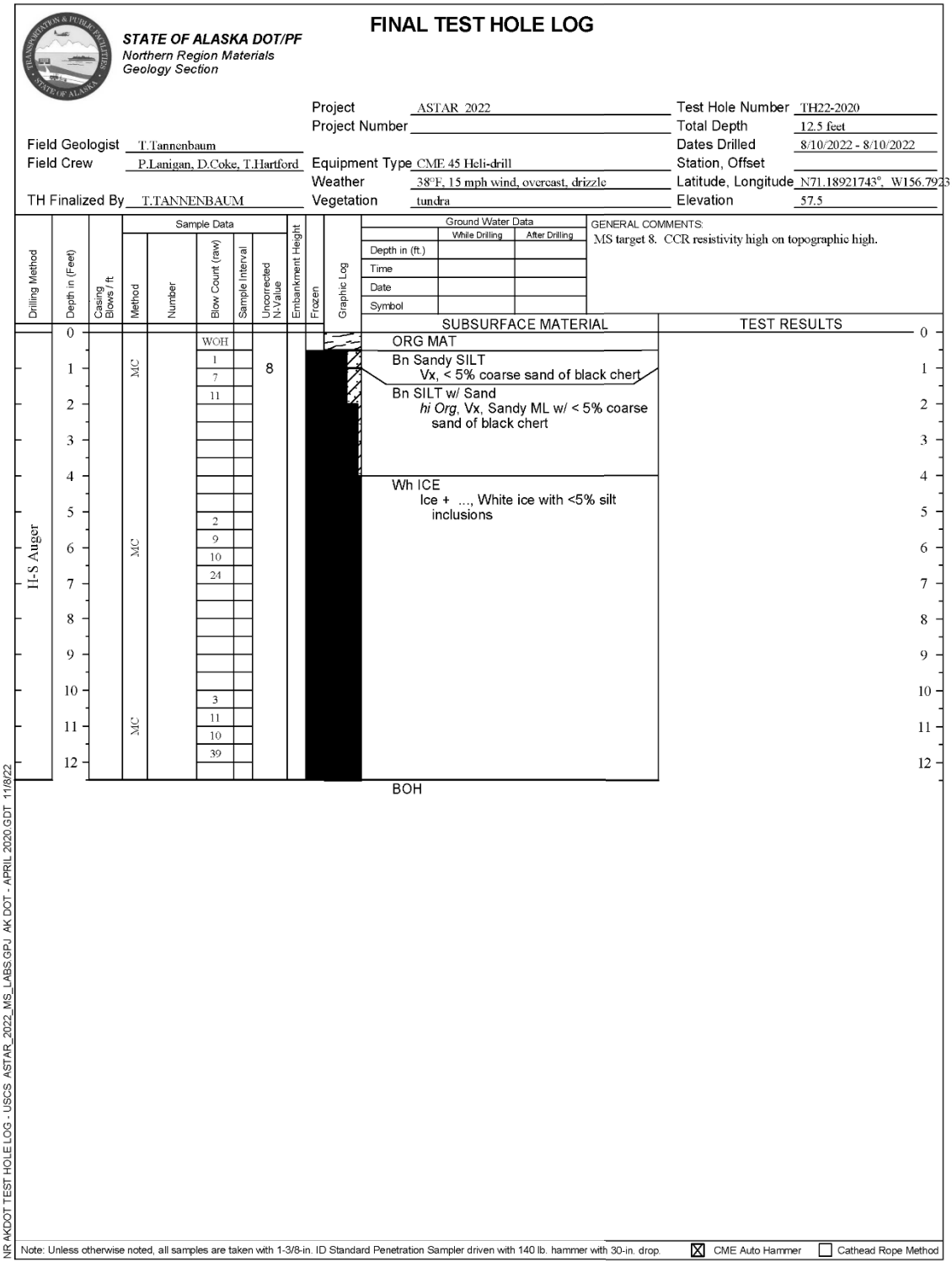
Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		WOH						Bn SILT moist, *hi Org*, <5% coarse sand	
					3							
	2				12						Bn SILT *hi Org*, Vx	
	3										Bn SILT Vx	
	4											
	5				6						Gy-Bn Silty SAND *Org*, Vx, interlayered gray SM and earthy brown organic SM. Rare coarse sand. 28.3°f	
	6		MC		12							
					13							
	7				17							
	8											
	9											
	10				8						Bn Silty SAND Nbn, laminated interlayered SM and sandy ML with 5% coarse sand of subrounded tan to black chert. 28.1°f	
	11		MC		15							
					13							
	12				16							
	13											
	14											
	15				16						Tn-Bn Sandy SILT Vx, ML with 5% coarse sand and rare fine gravel of subrounded tan - black chert. 29.5°f	**22-2103 (15.0-17.0)** USCS (wash)=ML P200=50.6% NM=33.1% ORG=4.2% LL=16 PI=1 PL=15
	16		MC	22-2103	20							
					20							
	17				25							
	18											
	19											
	20		MC		4"/50						Tn-Bn Well-graded SAND Nbn, lenses with up to 15% coarse sand and fine gravel with rare medium to coarse gravel. 31.3°f	
	21											
	22											
	23											
	24											
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop.

☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2019
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
11-S Auger
MC
22-2104
5"/50
38
Bk-Gy Poorly-graded SAND w/ Silt
Nbn, fine sand with dark gray ML
lenses to 0.1'. 28.4°f
22-2104 (30.0-30.5)
USCS (wash)=SW
P200=3.0%
NM=10.5%
ORG=1.5%
LL=NV
PI=NP
PL=NV
BOH
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



FINAL TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2020
Total Depth: 12.5 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/10/2022 - 8/10/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 38°F, 15 mph wind, overcast, drizzle
Latitude, Longitude: N71.18921743°, W156.79231
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 57.5

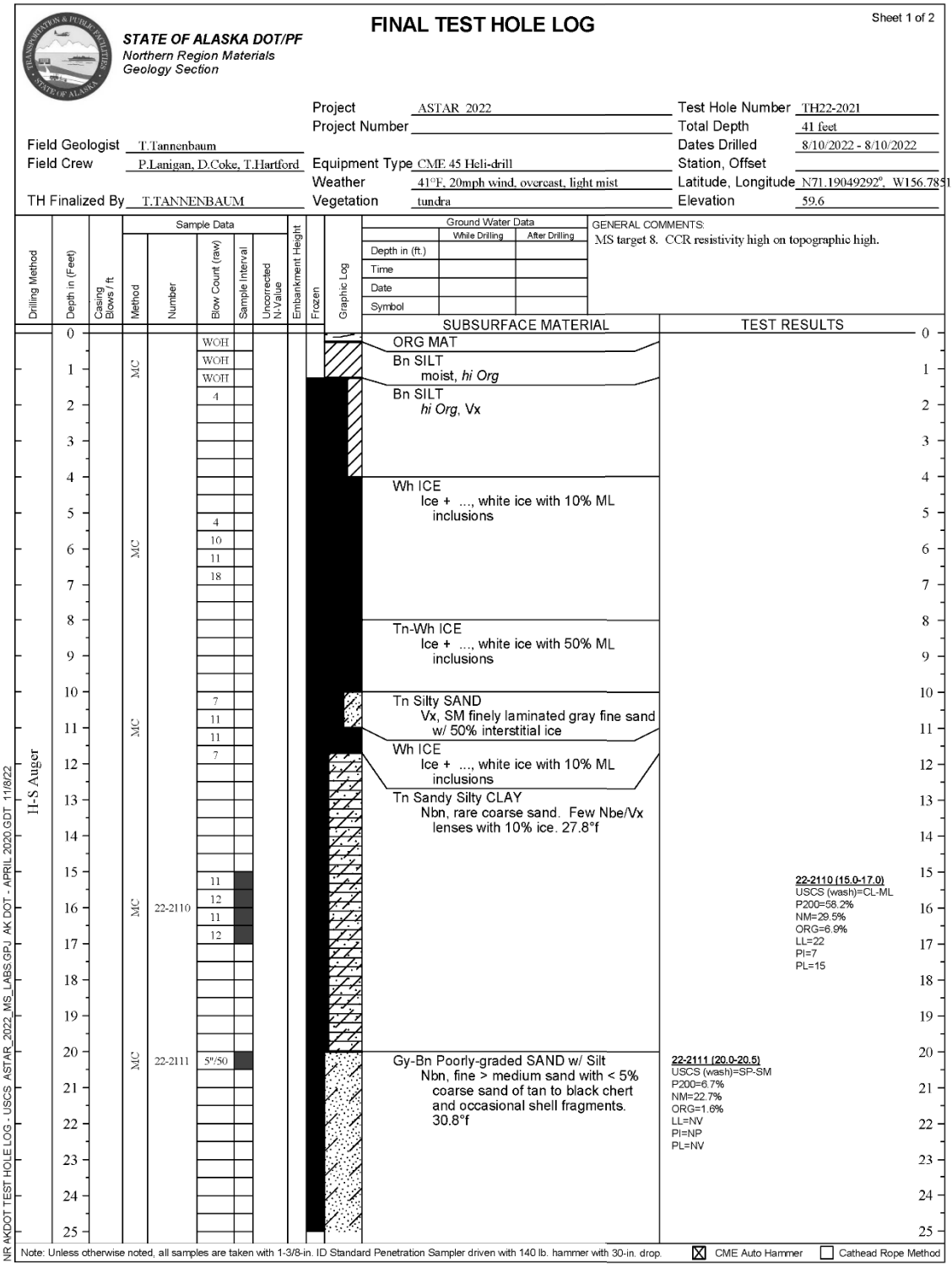
Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:
MS target 8. CCR resistivity high on topographic high.

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		1		8				Bn Sandy SILT Vx, < 5% coarse sand of black chert	
	2				7						Bn SILT w/ Sand *hi Org*, Vx, Sandy ML w/ < 5% coarse sand of black chert	
	3				11							
	4										Wh ICE Ice + ..., White ice with <5% silt inclusions	
	5				2							
	6		MC		9							
	7				10							
	8				24							
	9											
	10				3							
	11		MC		11							
	12				10							
					39						BOH	

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2021
Total Depth: 41 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/10/2022 - 8/10/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 41°F, 20mph wind, overcast, light mist
Latitude, Longitude: N71.19049292°, W156.78519°
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 59.6

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

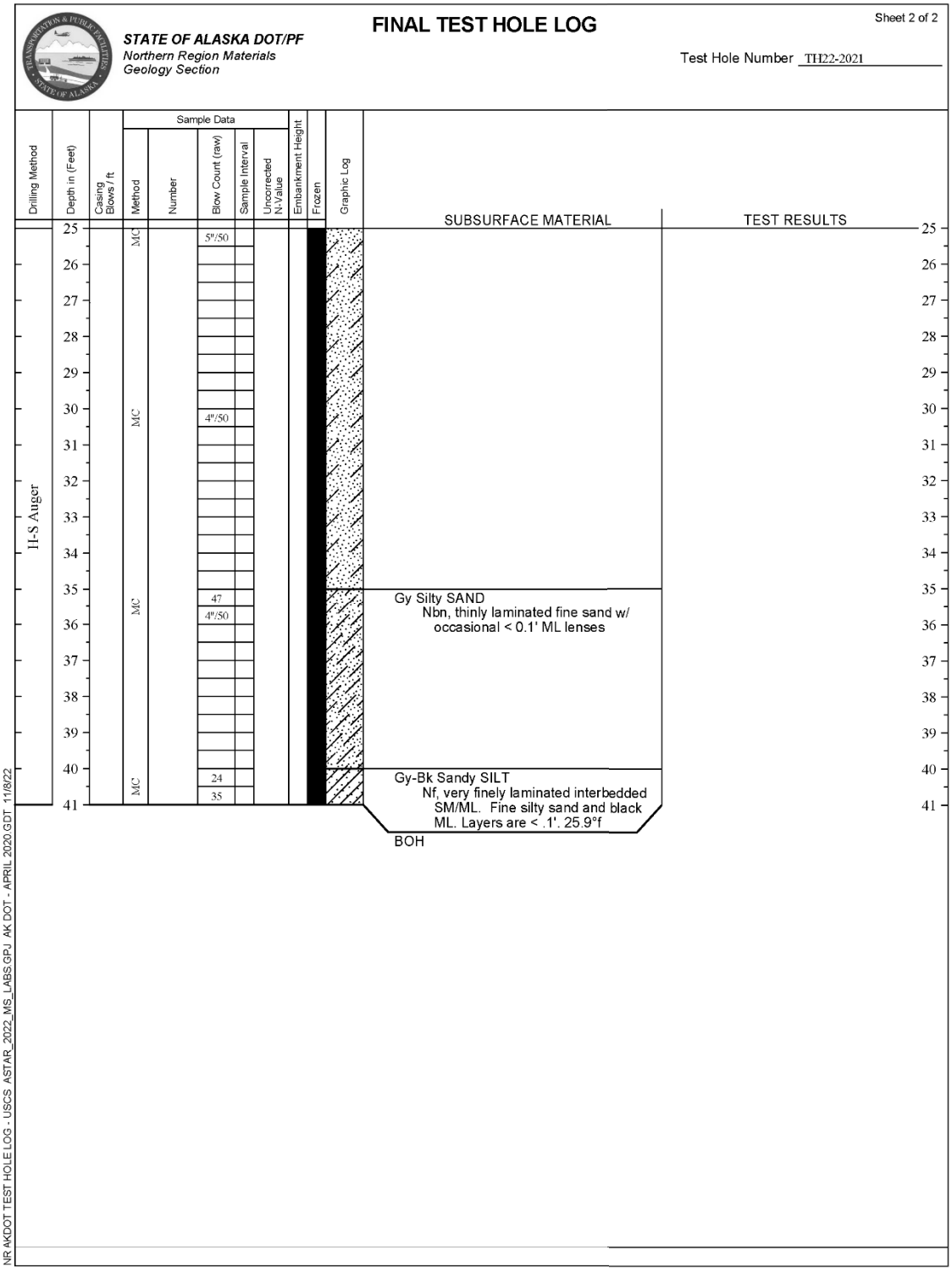
GENERAL COMMENTS:
MS target 8. CCR resistivity high on topographic high.

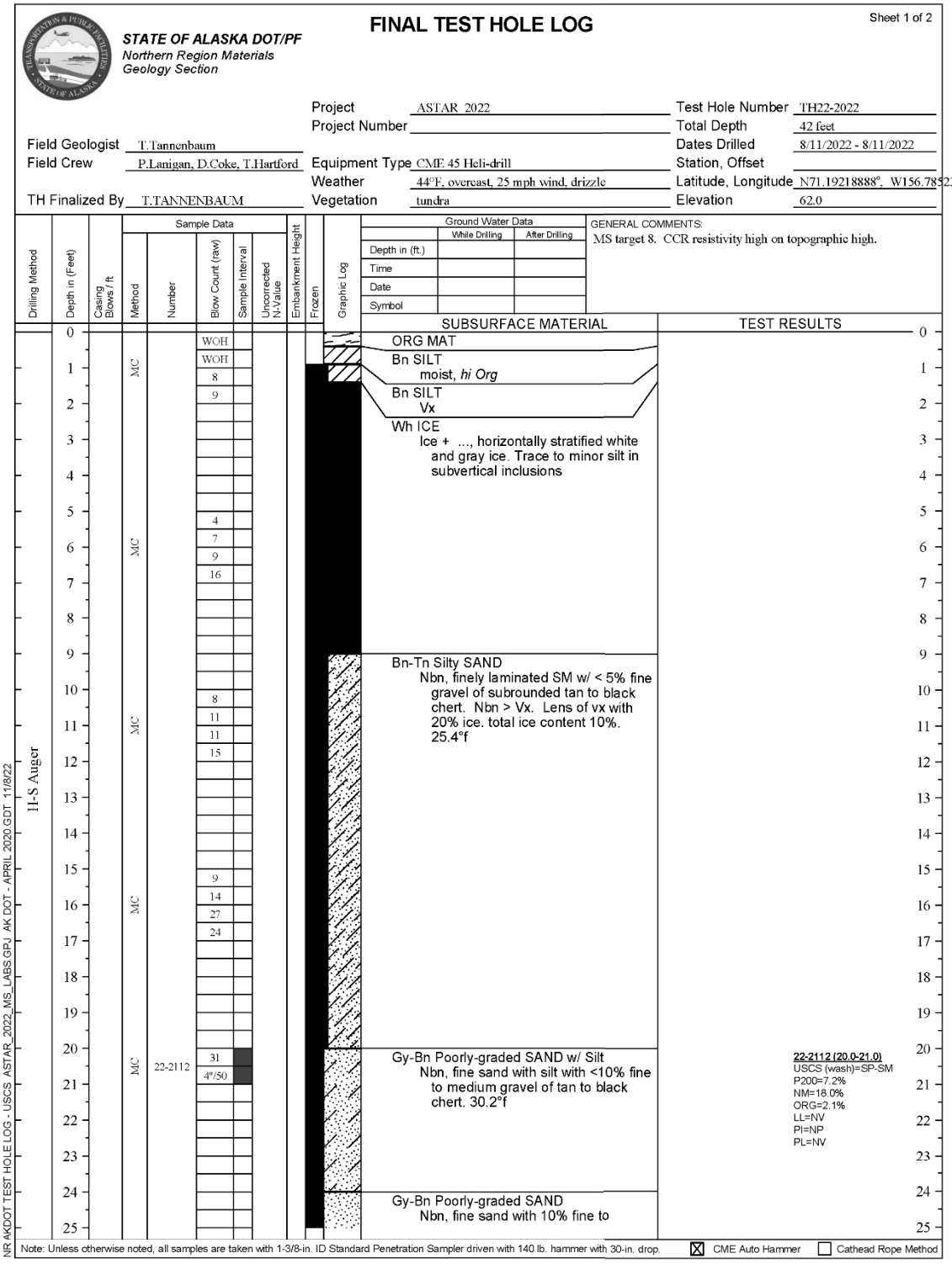
Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		WOH						Bn SILT moist, *hi Org*	
	2				WOH						Bn SILT *hi Org*, Vx	
	3				4							
	4										Wh ICE Ice + ..., white ice with 10% ML inclusions	
	5											
	6		MC		4							
	7				10							
	8				11						Tn-Wh ICE Ice + ..., white ice with 50% ML inclusions	
	9				18							
	10										Tn Silty SAND Vx, SM finely laminated gray fine sand w/ 50% interstitial ice	
	11		MC		7							
	12				11						Wh ICE Ice + ..., white ice with 10% ML inclusions	
	13				11						Tn Sandy Silty CLAY Nbn, rare coarse sand. Few Nbe/Vx lenses with 10% ice. 27.8°f	
	14				7							
	15											22-2110 (15.0-17.0) USCS (wash)=CL-ML P200=58.2% NM=29.5% ORG=6.9% LL=22 PI=7 PL=15
	16		MC	22-2110	11							
	17				12							
	18				11							
	19				12							
	20		MC	22-2111	5"/50						Gy-Bn Poorly-graded SAND w/ Silt Nbn, fine > medium sand with < 5% coarse sand of tan to black chert and occasional shell fragments. 30.8°f	22-2111 (20.0-20.5) USCS (wash)=SP-SM P200=6.7% NM=22.7% ORG=1.6% LL=NV PI=NP PL=NV
	21											
	22											
	23											
	24											
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop.

☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2021
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
11-S Auger
MC
5"/50
4"/50
47
4"/50
24
35
Gy Silty SAND
Nbn, thinly laminated fine sand w/ occasional < 0.1' ML lenses
Gy-Bk Sandy SILT
Nf, very finely laminated interbedded SM/ML. Fine silty sand and black ML. Layers are < .1'. 25.9°f
BOH
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2022
Total Depth: 42 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/11/2022 - 8/11/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 44°F, overcast, 25 mph wind, drizzle
Latitude, Longitude: N71.19218888°, W156.78523
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 62.0

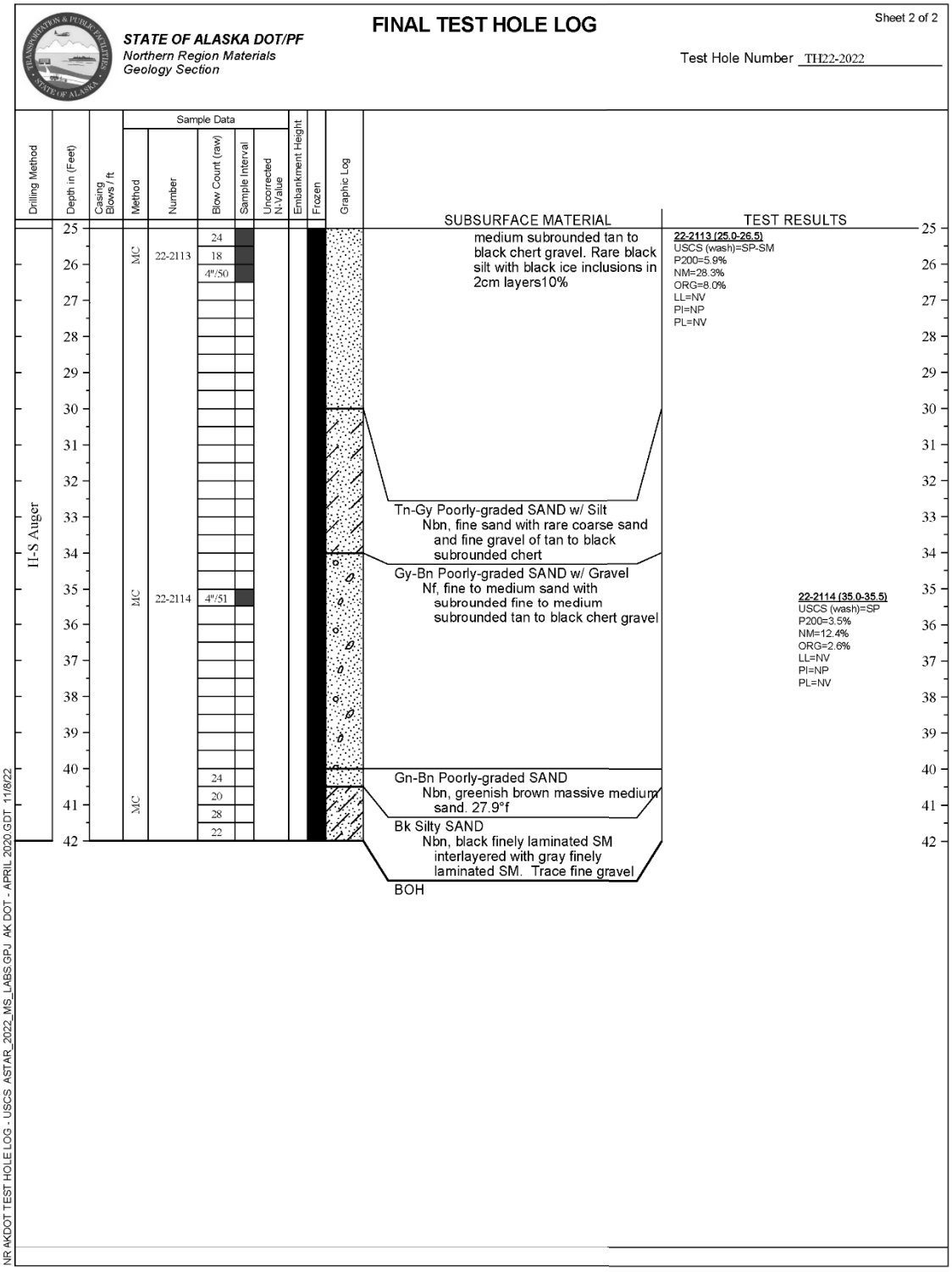
Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

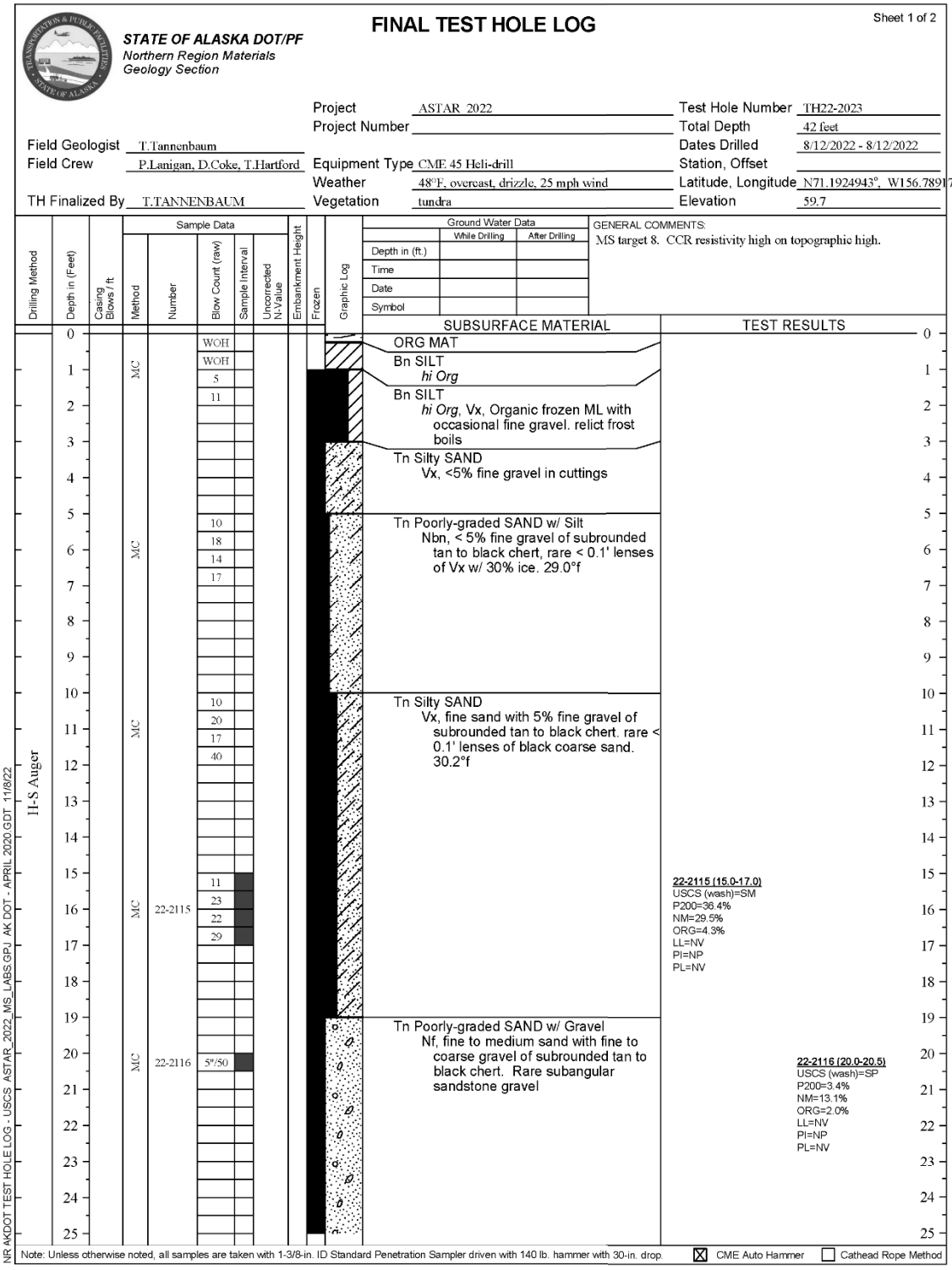
GENERAL COMMENTS:
MS target 8. CCR resistivity high on topographic high.

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		WOH						Bn SILT moist, *hi Org*	
	2				8						Bn SILT Vx	
	3				9						Wh ICE Ice + ..., horizontally stratified white and gray ice. Trace to minor silt in subvertical inclusions	
	4											
	5											
	6		MC		4							
	7				7							
	8				9							
	9				16							
	10										Bn-Tn Silty SAND Nbn, finely laminated SM w/ < 5% fine gravel of subrounded tan to black chert. Nbn > Vx. Lens of vx with 20% ice. total ice content 10%. 25.4°f	
	11		MC		8							
	12				11							
	13				11							
	14				15							
	15											
	16		MC		9							
	17				14							
	18				27							
	19				24							
	20		MC	22-2112	31						Gy-Bn Poorly-graded SAND w/ Silt Nbn, fine sand with silt with <10% fine to medium gravel of tan to black chert. 30.2°f	22-2112 (20.0-21.0) USCS (wash)=SP-SM P200=7.2% NM=18.0% ORG=2.1% LL=NV PI=NP PL=NV
	21				4"/50							
	22											
	23											
	24										Gy-Bn Poorly-graded SAND Nbn, fine sand with 10% fine to	
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2022
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
11-S Auger
MC
22-2113
24
18
4"/50
medium subrounded tan to black chert gravel. Rare black silt with black ice inclusions in 2cm layers10%
22-2113 (25.0-26.5)
USCS (wash)=SP-SM
P200=5.9%
NM=28.3%
ORG=8.0%
LL=NV
PI=NP
PL=NV
Tn-Gy Poorly-graded SAND w/ Silt
Nbn, fine sand with rare coarse sand and fine gravel of tan to black subrounded chert
Gy-Bn Poorly-graded SAND w/ Gravel
Nf, fine to medium sand with subrounded fine to medium subrounded tan to black chert gravel
MC
22-2114
4"/51
22-2114 (35.0-35.5)
USCS (wash)=SP
P200=3.5%
NM=12.4%
ORG=2.6%
LL=NV
PI=NP
PL=NV
MC
24
20
28
22
Gn-Bn Poorly-graded SAND
Nbn, greenish brown massive medium sand. 27.9°f
Bk Silty SAND
Nbn, black finely laminated SM interlayered with gray finely laminated SM. Trace fine gravel
BOH
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



FINAL TEST HOLE LOG

Sheet 1 of 2

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2023
Total Depth: 42 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/12/2022 - 8/12/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 48°F, overcast, drizzle, 25 mph wind
Latitude, Longitude: N71.1924943°, W156.7891794°
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 59.7

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

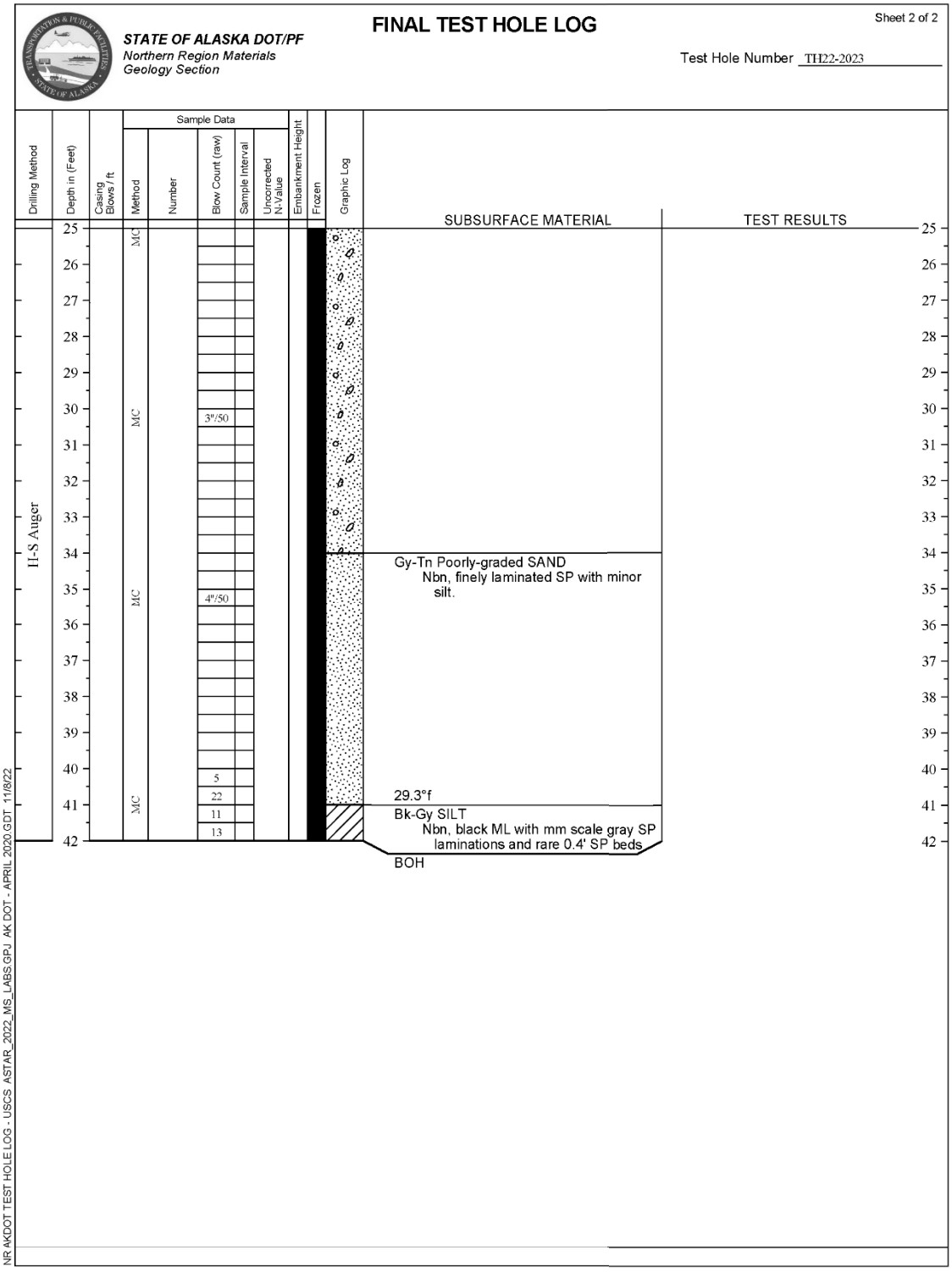
GENERAL COMMENTS:
MS target 8. CCR resistivity high on topographic high.

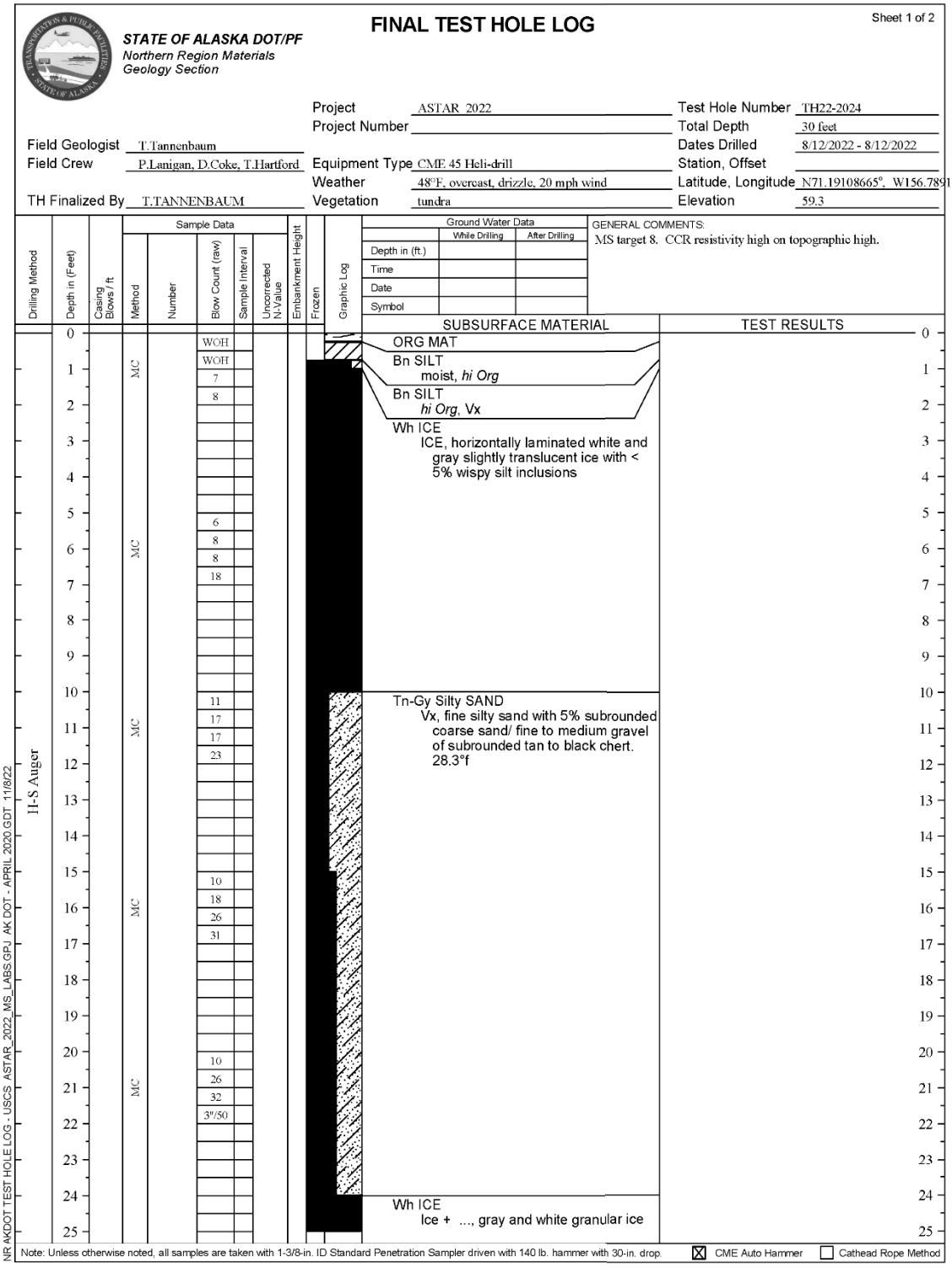
Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		WOH						Bn SILT *hi Org*	
	2				5						Bn SILT *hi Org*, Vx, Organic frozen ML with occasional fine gravel. relict frost boils	
	3				11							
	4										Tn Silty SAND Vx, <5% fine gravel in cuttings	
	5											
	6		MC		10						Tn Poorly-graded SAND w/ Silt Nbn, < 5% fine gravel of subrounded tan to black chert, rare < 0.1' lenses of Vx w/ 30% ice. 29.0°f	
	7				18							
	8				14							
	9				17							
	10											
	11		MC		10						Tn Silty SAND Vx, fine sand with 5% fine gravel of subrounded tan to black chert. rare < 0.1' lenses of black coarse sand. 30.2°f	
	12				20							
	13				17							
	14				40							
	15											
	16		MC	22-2115	11							**22-2115 (15.0-17.0)** USCS (wash)=SM P200=36.4% NM=29.5% ORG=4.3% LL=NV PI=NP PL=NV
	17				23							
	18				22							
	19				29							
	20											
	21		MC	22-2116	5"/50						Tn Poorly-graded SAND w/ Gravel Nf, fine to medium sand with fine to coarse gravel of subrounded tan to black chert. Rare subangular sandstone gravel	**22-2116 (20.0-20.5)** USCS (wash)=SP P200=3.4% NM=13.1% ORG=2.0% LL=NV PI=NP PL=NV
	22											
	23											
	24											
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop.

☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22


FINAL TEST HOLE LOG
Sheet 2 of 2
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section
Test Hole Number TH22-2023
Drilling Method
Depth in (Feet)
Casing Blows / ft
Sample Data
Method
Number
Blow Count (raw)
Sample Interval
Uncorrected N-Value
Embankment Height
Frozen
Graphic Log
SUBSURFACE MATERIAL
TEST RESULTS
11-S Auger
MC
3"/50
4"/50
5
22
11
13
Gy-Tn Poorly-graded SAND
Nbn, finely laminated SP with minor silt.
29.3°f
Bk-Gy SILT
Nbn, black ML with mm scale gray SP laminations and rare 0.4' SP beds
BOH
NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2024
Total Depth: 30 feet
Field Geologist: T.Tannenbaum
Field Crew: P.Lanigan, D.Coke, T.Hartford
Dates Drilled: 8/12/2022 - 8/12/2022
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 48°F, overcast, drizzle, 20 mph wind
Latitude, Longitude: N71.19108665°, W156.78918
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 59.3

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

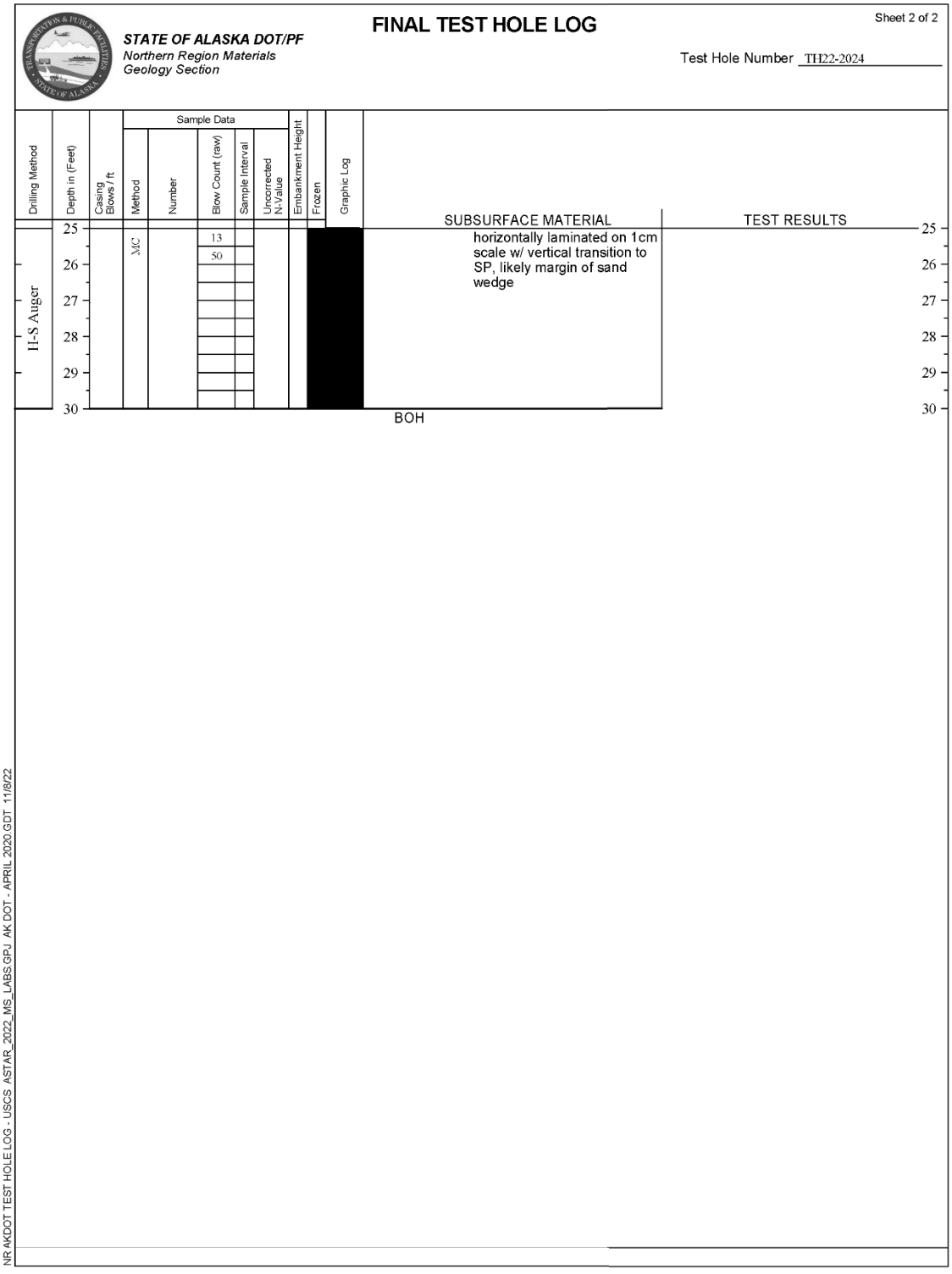
GENERAL COMMENTS:
MS target 8. CCR resistivity high on topographic high.

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		WOH						Bn SILT moist, *hi Org*	
	2				7						Bn SILT *hi Org*, Vx	
	3				8						Wh ICE ICE, horizontally laminated white and gray slightly translucent ice with < 5% wispy silt inclusions	
	4											
	5											
	6		MC		6							
	7				8							
	8				8							
	9				18							
	10											
	11		MC		11						Tn-Gy Silty SAND Vx, fine silty sand with 5% subrounded coarse sand/ fine to medium gravel of subrounded tan to black chert. 28.3°f	
	12				17							
	13				17							
	14				23							
	15											
	16		MC		10							
	17				18							
	18				26							
	19				31							
	20											
	21		MC		10							
	22				26							
	23				32							
	24				3"/50						Wh ICE Ice + ..., gray and white granular ice	
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop.

☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

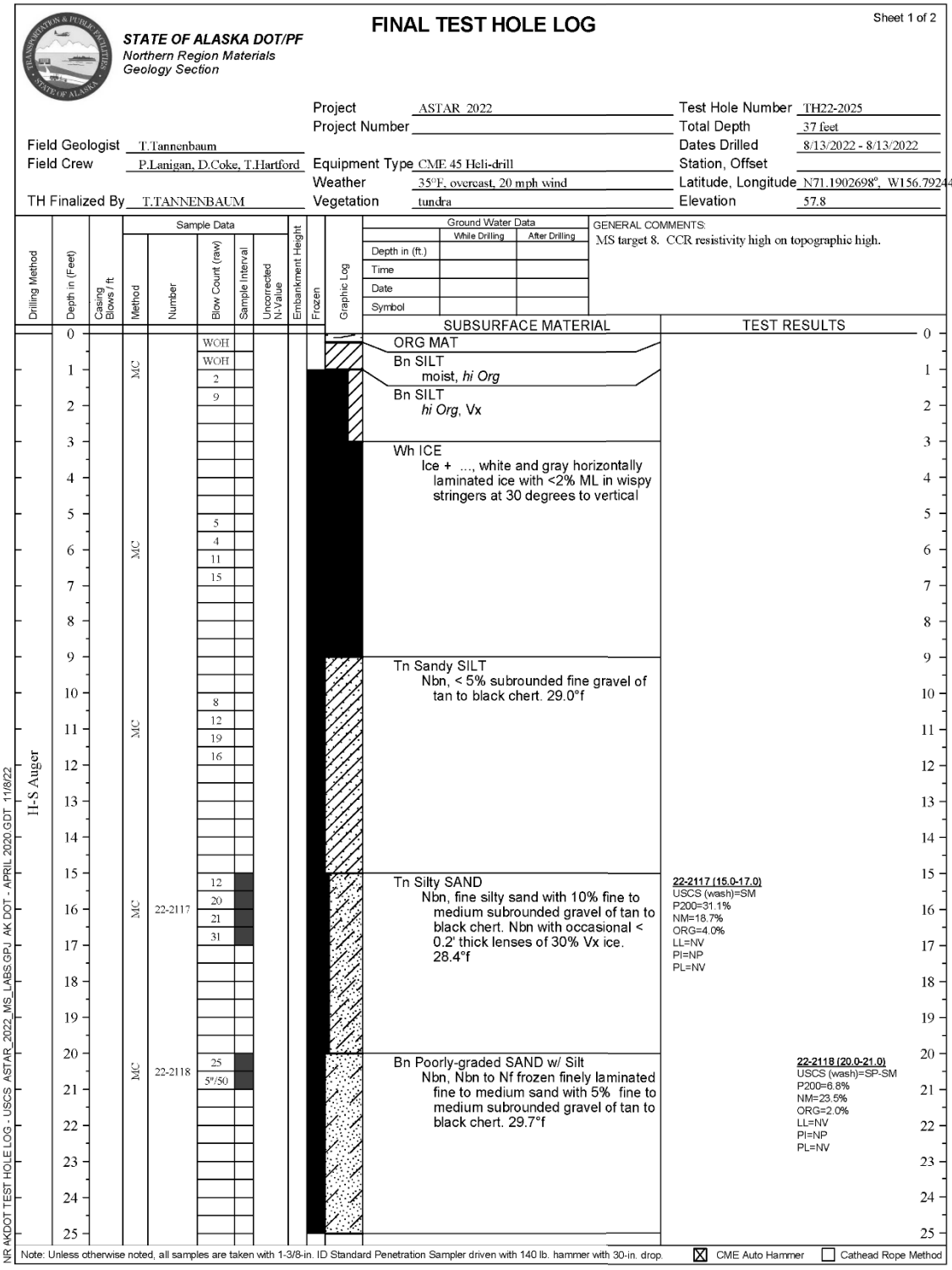
FINAL TEST HOLE LOG

Sheet 2 of 2

Test Hole Number TH22-2024

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Sample Data: Number	Sample Data: Blow Count (raw)	Sample Data: Sample Interval	Sample Data: Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
	25				13						horizontally laminated on 1cm scale w/ vertical transition to SP, likely margin of sand wedge	
	26		MC		50							
11-S Auger	27											
	28											
	29											
	30										BOH	

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 1 of 2

Project: ASTAR 2022
Project Number:
Test Hole Number: TH22-2025
Total Depth: 37 feet
Field Geologist: T.Tannenbaum
Dates Drilled: 8/13/2022 - 8/13/2022
Field Crew: P.Lanigan, D.Coke, T.Hartford
Equipment Type: CME 45 Heli-drill
Station, Offset:
Weather: 35°F, overcast, 20 mph wind
Latitude, Longitude: N71.1902698°, W156.7924468
TH Finalized By: T.TANNENBAUM
Vegetation: tundra
Elevation: 57.8

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

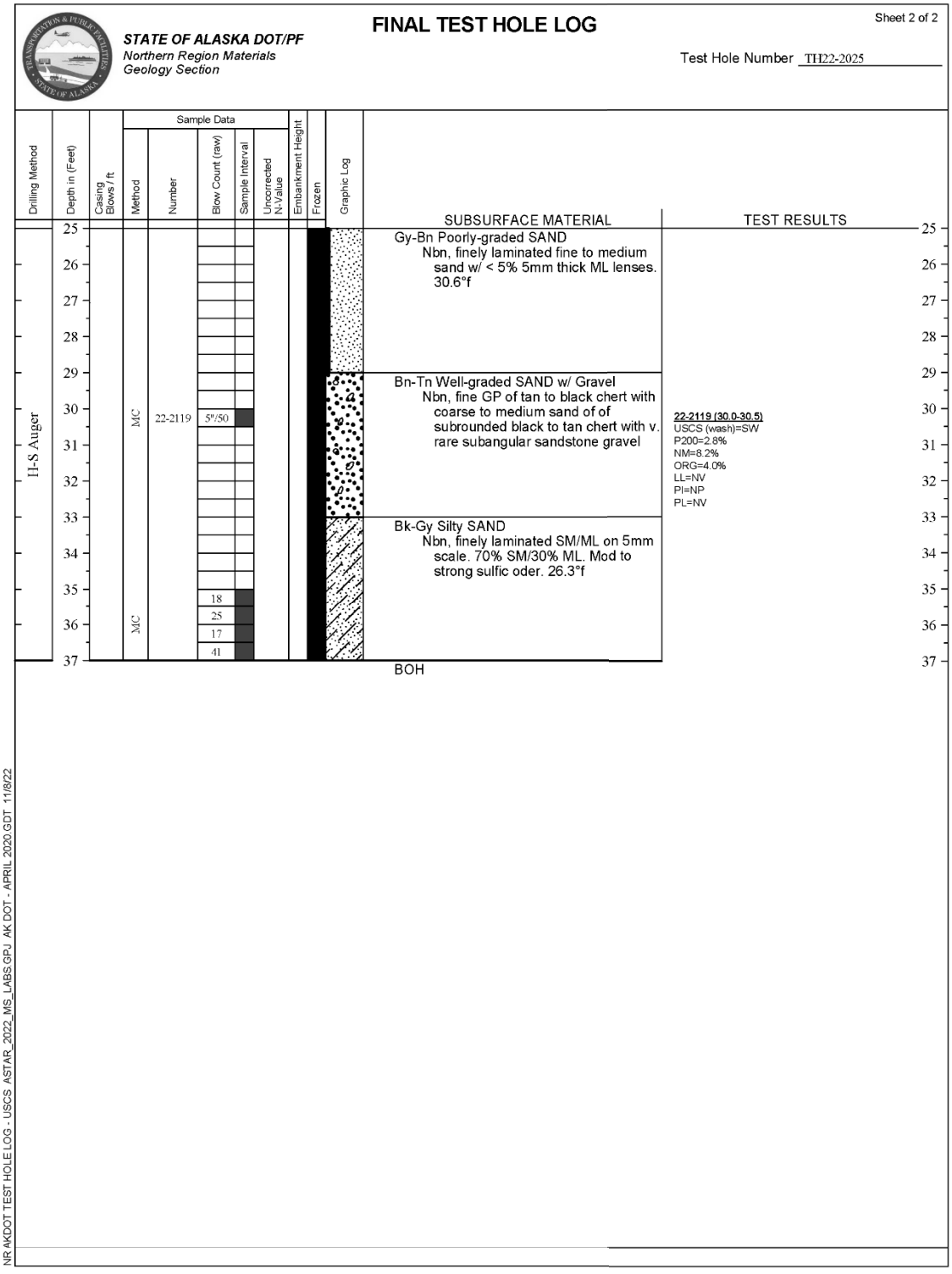
GENERAL COMMENTS:
MS target 8. CCR resistivity high on topographic high.

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count (raw)	Sample Interval	Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	0				WOH						ORG MAT	
	1		MC		WOH						Bn SILT moist, *hi Org*	
	2				2						Bn SILT *hi Org*, Vx	
	3				9							
	4										Wh ICE Ice + ..., white and gray horizontally laminated ice with <2% ML in wispy stringers at 30 degrees to vertical	
	5											
	6		MC		5							
	7				4							
	8				11							
	9				15							
	10				8						Tn Sandy SILT Nbn, < 5% subrounded fine gravel of tan to black chert. 29.0°f	
	11		MC		12							
	12				19							
	13				16							
	14											
	15				12						Tn Silty SAND Nbn, fine silty sand with 10% fine to medium subrounded gravel of tan to black chert. Nbn with occasional < 0.2' thick lenses of 30% Vx ice. 28.4°f	22-2117 (15.0-17.0) USCS (wash)=SM P200=31.1% NM=18.7% ORG=4.0% LL=NV PI=NP PL=NV
	16		MC	22-2117	20							
	17				21							
	18				31							
	19											
	20				25						Bn Poorly-graded SAND w/ Silt Nbn, Nbn to Nf frozen finely laminated fine to medium sand with 5% fine to medium subrounded gravel of tan to black chert. 29.7°f	22-2118 (20.0-21.0) USCS (wash)=SP-SM P200=6.8% NM=23.5% ORG=2.0% LL=NV PI=NP PL=NV
	21		MC	22-2118	5"/50							
	22											
	23											
	24											
	25											

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop.

☒ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22



STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

FINAL TEST HOLE LOG

Sheet 2 of 2

Test Hole Number TH22-2025

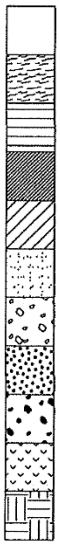
Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Sample Data: Number	Sample Data: Blow Count (raw)	Sample Data: Sample Interval	Sample Data: Uncorrected N-Value	Embankment Height	Frozen	Graphic Log	SUBSURFACE MATERIAL	TEST RESULTS
11-S Auger	25										Gy-Bn Poorly-graded SAND Nbn, finely laminated fine to medium sand w/ < 5% 5mm thick ML lenses. 30.6°f	
	26											
	27											
	28											
	29											
	30		MC	22-2119	5"/50						Bn-Tn Well-graded SAND w/ Gravel Nbn, fine GP of tan to black chert with coarse to medium sand of of subrounded black to tan chert with v. rare subangular sandstone gravel	22-2119 (30.0-30.5) USCS (wash)=SW P200=2.8% NM=8.2% ORG=4.0% LL=NV PI=NP PL=NV
	31											
	32											
	33											
	34											
	35				18						Bk-Gy Silty SAND Nbn, finely laminated SM/ML on 5mm scale. 70% SM/30% ML. Mod to strong sulfic oder. 26.3°f	
	36		MC		25 17							
	37				41						BOH	

NR AKDOT TEST HOLE LOG - USCS ASTAR_2022_MS_LABS.GPJ AK DOT - APRIL 2020.GDT 11/8/22

APPENDIX D: SYMBOLS AND DEFINITIONS

SYMBOLS AND DEFINITIONS

BASIC MATERIAL SYMBOLS



ASPHALT

PEAT

CLAY (Cl)

ICE

SILT (Si)

POORLY GRADED SAND (Sa)

POORLY GRADED GRAVEL (Gr)

WELL GRADED SAND

WELL GRADED GRAVEL

BEDROCK (Bx), soft(Type)

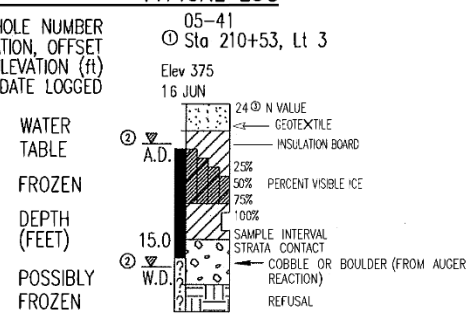
BEDROCK (Bx), hard(Type)

SOFT OR HARD BEDROCK BASED ON DRILLING RATE

NOTE

MAIN COMPONENT (UPPER CASE ... SOLID LINES)
MINOR COMPONENT (Title Case ... DASHED LINES OR SPARSER PATTERN)

TYPICAL LOG



① Station value may also be on centerline e.g. Sta 210+53, CL or lat–long format e.g. N64.56789°, W145.67890°
② W.D.= WHILE DRILLING, A.D.= AFTER DRILLING
③ "N VALUE" INDICATES STANDARD PENETRATION TEST (1.4" I.D., 2.0" O.D. SAMPLER DRIVEN WITH 140 LB. HAMMER, 30" FREE FALL) AND IS SUM OF 2nd AND 3rd 6" OF PENETRATION.

PLAN VIEW SYMBOLS

POWER AUGER TEST HOLE (TH)
HAND AUGER TEST HOLE (TH)
EXPOSED MATERIAL
PROBE
HAND DUG TEST PIT (TP)
DOZER/BACKHOE TEST TRENCH (TT)
BODY OF WATER
FLOW DIRECTION
WASTE BERM
BANK
SWAMP
TREELINE

USCS SIZE DEFINITIONS

BOULDERS (Boulders)	12"+
COBBLES (Cobbles)	3" TO 12"
GRAVEL	#4 TO 3"
ANGULAR FRAGMENTS	#10 +
SAND	#200 TO #4
SILT	#200 TO 0.005 mm
CLAY	MINUS 0.005 mm

TEST RESULTS

_._%–200	= % PASSING #200 SIEVE
NM _._%	= NATURAL MOISTURE
ORG _._%	= ORGANIC CONTENT
SSc _	= SODIUM SULFATE LOSS(coarse)
SSf _	= SODIUM SULFATE LOSS(fine)
LA _	= LOS ANGELES ABRASION
DEG _	= DEGRADATION
LL _	= LIQUID LIMIT (NV = no value)
PI _	= PLASTIC INDEX (NP = non–plastic)

MISC.

Tr	= TRACE
sl	= SLIGHTLY
hi	= HIGHLY
w/_	= WITH UNSPECIFIED AMOUNT
X'tls	= CRYSTALS
TH	= TEST HOLE
TT	= TEST TRENCH
TP	= TEST PIT

SOIL DENSITY/CONSISTENCY DESCRIPTORS

NON–COHESIVE		COHESIVE	
RELATIVE DENSITY	BLOWS/FOOT (N) VALUE	CONSISTENCY	BLOWS/FOOT (N) VALUE
VERY LOOSE	< 4	VERY SOFT	< 2
LOOSE	5–10	SOFT	2–4
MEDIUM DENSE	11–30	FIRM	5–8
DENSE	31–50	STIFF	9–15
VERY DENSE	> 50	VERY STIFF	16–30
		HARD	> 30

COLOR

Bk = BLACK	Gy = GRAY	Tn = TAN
Bl = BLUE	Or = ORANGE	Wh = WHITE
Bn = BROWN	Rd = RED	Yw = YELLOW
Gn = GREEN		

MOISTURE

dry	= < OPTIMUM*	DUSTY, DRY TO THE TOUCH
moist	~ OPTIMUM*	DAMP, NO VISIBLE WATER
wet	= > OPTIMUM*	VISIBLE FREE WATER

* OPTIMUM MOISTURE FOR MAXIMUM DENSITY

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DESCRIPTION AND CLASSIFICATION OF FROZEN SOILS

Part I Description of Soil Phase (a) (Independent of Frozen State)	Major Group		Sub-Group		Field Identification (6)	Pertinent Properties of Frozen Materials which may be measured by physical tests to supplement field identification. (7)	Guide for Construction on Soils Subject to Freezing and Thawing	
	Description (2)	Designation (3)	Description (4)	Designation (5)			Thaw Characteristics (8)	Criteria (9)
Part II Description of Frozen Soil	Segregated ice is not visible by eye (b)	N	Poorly Bonded or Friable	Nf	Identify by visual examination. To determine presence of excess ice, use procedure under note (c) below 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.	In-Place Temperature Density and Void Ratio a) In Frozen State b) After Thawing in Place Water Content (Total H_2O, including ice) a) Average b) Distribution Strength a) Compressive b) Tensile c) Shear d) Adfreeze Elastic Properties Plastic Properties Thermal Properties Ice Crystal Structure (using optional instruments.) a) Orientation of Axes b) Crystal size c) Crystal shape d) Pattern of Arrangement	Usually Thaw-Stable	The potential intensity of ice segregation in a soil is dependent to a large degree on its void sizes and may be expressed as an empirical function of grain size as follows: Most inorganic soils containing 3 percent or more of grains finer than 0.02 mm in diameter by weight are frost-susceptible. Gravels, well-graded sands and silty sands, especially those approaching the theoretical maximum density curve, which contain 1.5 to 3 percent finer than 0.02 mm by weight without being frost-susceptible. However, their tendency to occur interbedded with other soils usually makes it impractical to consider them separately. Soils classed as frost-susceptible under the above criteria are likely to develop significant ice segregation and frost heave if frozen at normal rates with free water readily available. Soils so frozen will fall into the thaw-unstable category. However, they ma also be classed as thaw-stable if frozen with insufficient water to permit ice segregation. Soils classed as non-frost-susceptible ("NFS) under the above criteria usually occur without significant ice segregation and are not exact and may be inadequate for some structure applications exceptions may also result from minor soil variations. In permafrost areas, ice wedges, pockets, veins, or other ice bodies may be found whose mode of origin is different from that described above. Such ice may be the result of long-time surface expansion and contraction phenomena or may be glacial or other ice which has been buried under a protective earth cover.
			No excess ice Well Bonded Excess ice	Nb n e				
	Segregated ice is visible by eye. (Ice 1 inch or less in thickness) (b)	V	Individual ice crystals or inclusions	Vx	For ice phase, record the following as applicable: Location Size Orientation Shape Thickness Spacing Pattern of arrangement Length Hardness } Structure } per part III Below Color } Estimate volume of visible segregated ice present as percent of total sample volume		Usually Thaw-Unstable	
			Ice coatings on particles	Vc				
			Random or irregularly oriented ice formations	Vr				
			Stratified or distinctly oriented ice formations	Vs				
Part III Description of Substantial Ice Strata	Ice (Greater than 1 inch in thickness)	Ice	Ice with soil inclusions	Ice + Soil Type	Designate material as ICE (d) and use descriptive terms as follows, usually one item from each group, as applicable: Hardness: Hard, Soft (mass not incl. crystals) Structure: Clear, Cloudy, Porous, Candled, Granular, Stratified Color: e.g. Colorless, Gray, Blue Admixtures: e.g. Contains Thin Silt Inclusions	Same as Part II above, as applicable, with special emphasis on Ice Crystal Structure.		
			Ice without soil inclusions	Ice				

DEFINITIONS:

Ice Coatings on Particles are discernible layers of ice found on or below the larger soil particles in a frozen soil mass. They are sometimes associated with hoarfrost crystals, which have grown into voids produced by the freezing action.

Ice Crystal is a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in a combination with other ice formations.

Clear ice is transparent and contains only a moderate number of air bubbles.(e)

Cloudy Ice is translucent, but essentially sound and non-pervious

Porous Ice 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.

Candled Ice is ice which has rotted or otherwise formed into long columnar crystals, very loosely bonded together.

Granular Ice is composed of coarse, more or less equidimensional, ice crystals weakly bonded together.

Ice Lenses are lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss and commonly in repeated layers

Ice Segregation is the growth of ice as distinct lenses, layers, veins and masses in soils, commonly but not always oriented normal to direction of heat loss.

Well-bonded signifies that the soil particles are strongly held together by the ice and that the frozen soil possesses relatively high resistance to chipping or breaking.

Poorly-bonded signifies that the soil particles are weakly held together by the ice and that the frozen soil consequently has poor resistance to chipping or breaking.

Friable denotes a condition in which material is easily broken up under light to moderate pressure.

Thaw-Stable frozen soils do not, on thawing, show loss of strength below normal, long-time thawed values nor produce detrimental settlement.

Thaw-Unstable frozen soils show on thawing, significant loss of strength below normal, long-time thawed values and/or significant settlement, as a direct result of the melting of the excess ice in the soil.

Modified from: Linell, K. A. and Kaplar, C. W., 1966, *Description and Classification of Frozen Soils*, Proc. International Conference on Permafrost (1963). Lafayette, IN, U.S. National Academy of Sciences, Publ. 1287, pp 481-487.

NOTES:

(a) When rock is encountered, standard rock classification terminology should be used.

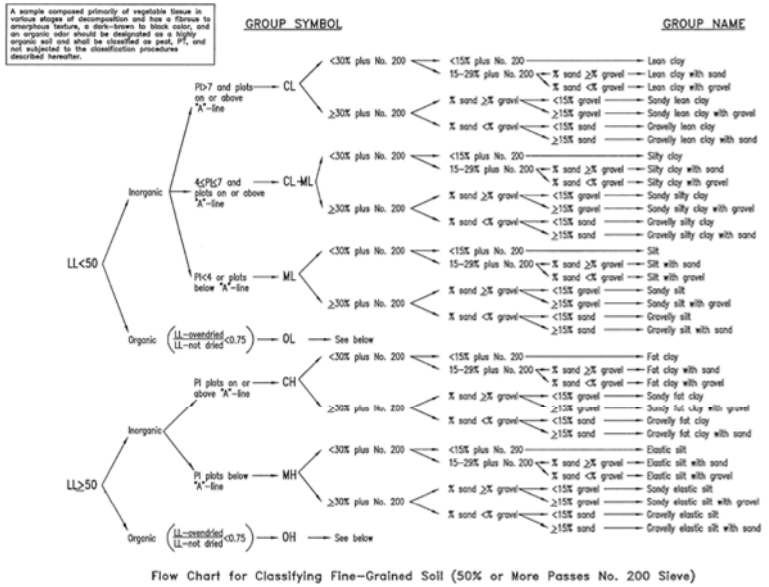
(b) Frozen soils in the N group may on close examination indicate presence of ice within the voids of the material by crystalline reflections or by a sheen on fractured or trimmed surfaces. However, the impression to the unaided eye is that none of the frozen water occupies space in excess of the original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

(c) When visual methods may be inadequate, a simple field test to aid evaluation of 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 percent of total volume.

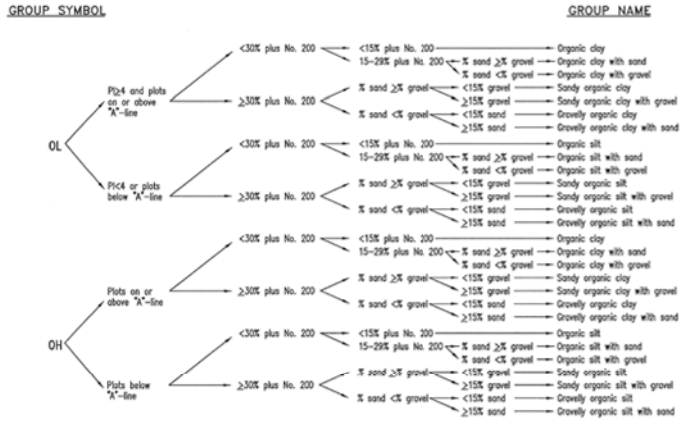
(d) Where special forms of ice, such as hoarfrost, can be distinguished, more explicit description should be given.

(e) Observer should be careful to avoid being misled by surface scratches or frost coating on the ice.

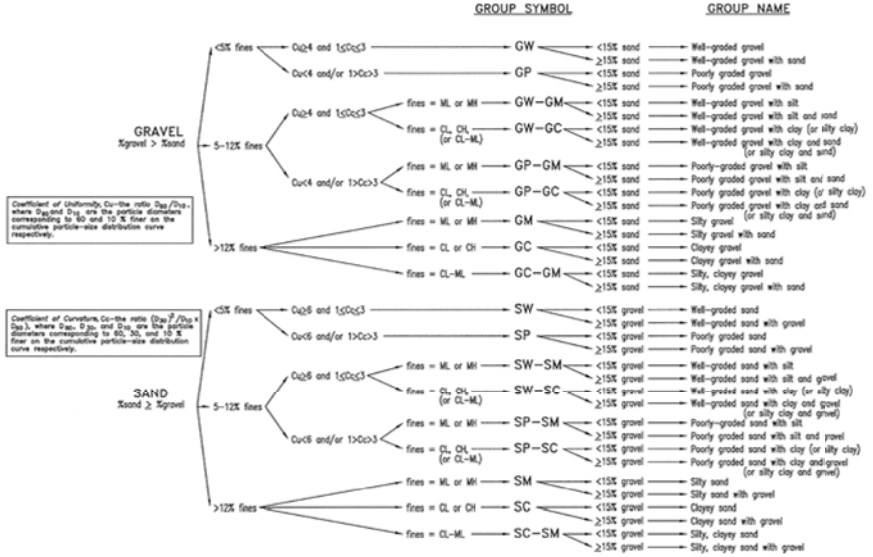
Classification of Soils for Engineering Purposes (Unified Soil Classification System)



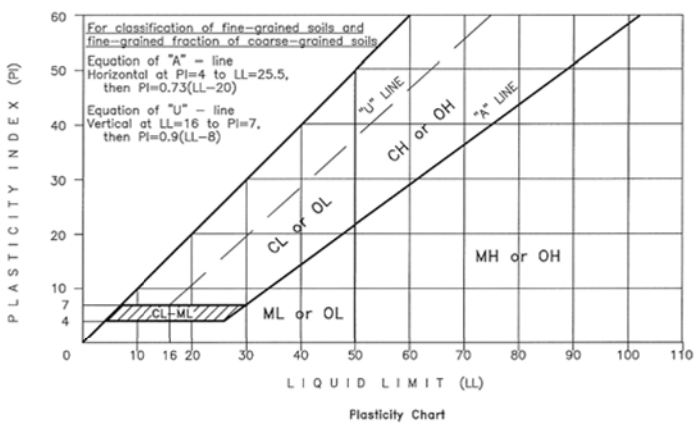
Flow Chart for Classifying Fine-Grained Soil (50% or More Passes No. 200 Sieve)



Flow Chart for Classifying Organic Fine-Grained Soil (50% or More Passes No. 200 Sieve)



Flow Chart for Classifying Coarse-Grained Soil (More Than 50% Retained on No. 200 Sieve)



Plasticity Chart

Peat and Organic Soil Classification System