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Alaska Department of Transporation & Public Facilities

R&M Consultants, Inc.

Investigation Report
Borings and Subsurface Instrumentation
Beach Road Landslide, Haines, Alaska

Professional Services Agreement No. 25213018
IRIS Program No. SDRER00317

LANDSLIDE TECHNOLOGY
A DIVISION OF CORNFORTH CONSULTANTS

INVESTIGATION REPORT
BORINGS AND SUBSURFACE INSTRUMENTATION
BEACH ROAD LANDSLIDE
HAINES, ALASKA

Professional Services Agreement No. 25213018
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March 18, 2022

Report To:

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1 INTRODUCTION

This report presents the results of geotechnical subsurface borings at the Beach Road Landslide in Haines, Alaska. Investigations were completed by Landslide Technology (LT), under subcontract with R&M Consultants, Inc. (R&M), between August 2021 and October 2021 for the Alaska Department of Transportation and Public Facilities (DOT&PF).

This work was performed by LT as NTP 3 of the geotechnical investigation program under the direction of Alaska DOT&PF, Southcoast Region as described in Agreement No. 25213018 (Task 5.3B Subsurface Investigation). The investigations included borings, subsurface instrument installation and monitoring, and laboratory testing. Landslide interpretation including delineation, site characterization, and slope stability will be reported in the Updated Findings Report.

2 BACKGROUND INFORMATION

The work summarized in this investigation report is part of the recommended additional investigation to supplement the Winter Reconnaissance – Preliminary Findings Report dated April 8, 2021, and the Spring Surface Reconnaissance Memo dated September 8, 2021. An understanding of subsurface conditions was recommended to refine landslide interpretations and develop slope stability models. Geologic hazard mechanisms, slide geometry, geologic stratigraphy, structural orientations, groundwater conditions, and material properties are key elements of a slope stability model.

3 SUBSURFACE INVESTIGATIONS: BORINGS

This phase of the subsurface investigation program consisted of drilling exploratory boreholes, sampling of subsurface materials, collection of oriented borehole imagery, installation and monitoring of subsurface geotechnical instrumentation, and preparation of boring logs. The Site Plan (Figure 1) shows the locations of the 12 exploratory borings, designated LT-1 through LT-12. Geotechnical instrumentation was installed in each boring to measure subsurface deformations and groundwater levels.

The subsurface investigations were performed by Discovery Drilling, Inc. of Anchorage, Alaska. Due to the steep and forested terrain, most of the borings (LT-1 through LT-10) necessitated limited tree clearing, drill pad preparation, and helicopter access to mobilize drilling equipment and supplies. Helicopter access was provided by Temsco Helicopters, Inc., of Skagway, Alaska. Performance of the work included coordination with DOT&PF, Haines Borough and residents. Tree clearing was performed by Holzfäller Tree Service. Work on state land was performed under permit from the State Department of Natural Resources, Division of Parks and Outdoor Recreation.

3.1 Details of drilling

Drilling operations began on August 28 and concluded on October 23, 2021. Between October 6 and October 21, 2021, a second drill rig was on site to assist drilling efforts. The borings are located within or adjacent to the Beach Road Landslide. Helicopter support was provided for 10 of the 12 borings to move drill rigs into position; and to provide daily support of the drill crew for access, drill water, and supplies. The two boreholes located within the Beach Road ROW were accessible by road and the drill rig was able to be moved into position on its tracks with the assistance of an excavator. Nine boring locations required clearing of trees in the immediate area of each borehole. Tree clearing was performed prior to mobilization of drilling equipment to each individual boring location. In addition, two of the drill pads were made into helicopter landing zones for crew and equipment transport (located at borings LT-2 and LT-8). Table 1 summarizes the location and ground surface elevation of each boring. Completed boring locations were surveyed by R&M Consultants, Inc. (R&M) on November 4 and 6, 2021.

Table 1: Boring Survey Locations and Elevation

Boring No.	Northing (ft)	Easting (ft)	Ground Surface Elevation (ft)
LT-1	2,701,522.02	2,359,503.25	781.5
LT-2	2,701,639.29	2,359,193.51	767.6
LT-3	2,701,724.16	2,359,014.78	738.7
LT-4	2,702,143.68	2,359,231.81	416.6
LT-5	2,702,076.66	2,358,927.94	480.9
LT-6	2,701,469.62	2,358,930.78	877.5
LT-7	2,701,535.81	2,358,955.39	858.1
LT-8	2,701,442.91	2,358,626.40	941.8
LT-9	2,701,872.92	2,358,594.82	712.5
LT-10	2,702,539.56	2,358,526.83	290.0
LT-11	2,703,171.36	2,359,168.08	105.8
LT-12	2,703,272.01	2,358,875.45	113.1

3.2 Sampling Methods

The exploratory borings were performed using track-mounted Geoprobe 6712DT drill rigs using casing advancer techniques to drill through the overburden soils and HQ3 wire-line core drilling techniques to collect rock samples.

In general, drilling activities were performed in accordance with ASTM D1586 and ASTM D2113-14. Standard Penetration Test (SPT) split-spoon samples were nominally obtained at 5-foot intervals until refusal conditions were encountered. SPTs were performed with an 18-inch long, 2-inch O.D. split-barrel sampler, with a recessed I.D. of 1.375-inches (without liners) and an automatic impact hammer weighing 140 pounds, falling 30 inches. Once refusal conditions were encountered, the drilling method was switched to HQ3 wire-line core drilling.

During the investigations, a representative from LT was present with each drill rig to coordinate the work, log the soil and rock core samples, and oversee the installation of geotechnical instrumentation. Details of the exploratory borings and core photographs are provided on the Summary Borings Logs (Appendix A) and Core Box Photographs (Appendix B).

3.3 Borehole Imaging

Oriented downhole imagery was conducted for 11 of the 12 borings (LT-1 through LT-10, and LT-12). Imagery was not collected at LT-11 due to complications with the casing that was used to maintain borehole stability. Oriented borehole logging was used for mapping of discontinuity azimuth and orientations.

The imaging equipment included a QL40-OBI-1G Optical Televiewer and QL40-ABI-1G Acoustic Televiewer rented from COLOG, Inc. of Denver, Colorado. The Optical Televiewer was used to produce high resolution images of the boreholes as well as determine discontinuity orientations using a 3-axis magnetometer and 3-axis accelerometer. The borehole was flushed to improve the clarity of the water for the optical imaging. In the event the water in the borehole was cloudy, the Acoustic Televiewer was also used, which emits an ultrasonic beam to detect and measure borehole wall irregularities. The Televiewers were lowered at a controlled rate of less than 5 feet per minute using an automated winch. Two individual passes were recorded in each boring for redundancy.

The borehole imagery was used to identify dip and dip direction of joints, fractures, and foliations observed in the rock as well as aperture (width of openings) on larger fractures. Healed fractures, partially open fractures, and foliation/bedding were also identified with dip and azimuth as noted. Imagery collected within approximately 5-10 feet of the bottom of casing was discarded from the images due to steel casing affecting the sensor's magnetic compass. Imagery collected from the oriented borehole logging is contained in Appendix C. Stereonets and analysis of the structure will be provided in the upcoming Updated Findings Report.

4 LABORATORY TESTING

Laboratory testing was performed on soil samples by R&M Consultants of Anchorage Alaska. Natural moisture contents were performed on all soil samples, which are presented on the Summary Boring Logs. Detailed laboratory test results are provided in Appendix D.

Laboratory testing was performed on representative rock samples by GeoTesting Express of Acton, Massachusetts and their subcontractor's K/T GeoServices, Inc. of Gunnison, Colorado and McLin Petrographics of Houston, Texas. The testing included: unconfined compressive strength (UCS) tests (ASTM D7012 Method D), X-Ray Diffraction (XRD), and petrographic analysis. The rock testing lab results are detailed and provided in Appendix D.

UCS testing was attempted on 19 representative samples selected from the rock core. Samples were trimmed (ends cut and ground flat) in the laboratory to fit the testing apparatus. Several of the samples yielded results that were lower than expected due to breaking along healed fractures. These healed fractures make an inherent plane of weakness in an otherwise hard to very hard rock, and tend to break along those lines of relative weakness. Five samples did not survive the trimming process due to numerous healed fractures noted in the samples. A summary of UCS testing results is provided in Table 2.

Table 2: Summary of Unconfined Compressive Strength (ASTM D7012 Method D) Testing

Boring No.	Run No.	Tested Depth (ft)	Bulk Density (pcf)	Compressive Strength (psi)	Young's Modulus (psi, millions)	Poisson's Ratio
LT-1	R-13	53.74 - 54.18	196	4,548	1.35 to 1.46	0.10 to 0.27
LT-3	R-6	35.00 - 35.44	205	9,714	2.21 to 2.66	0.20
LT-3	R-7	39.00 - 39.60	213	8,006	4.11 to 4.71	0.44
LT-3	R-14	63.27 - 63.71	197	4,802	1.87 to 2.72	0.14 to 0.33
LT-3	R-14	63.72 - 64.16	198	4,799	1.73 to 3.66	0.12
LT-4	R-3	27.62 - 28.06	210	14,353	3.79 to 5.37	0.24
LT-4	R-13	69.99 - 70.43	164	12,672	4.69 to 5.25	0.24 to 0.32
LT-5	R-8	38.80 - 39.40	198	4,374	1.53 to 1.86	0.08 to 0.11
LT-5	R-14	70.55 - 70.99	204	10,719	1.68 to 3.20	0.11 to 0.33
LT-6*	R-4	24.00 - 24.80	-	-	-	-
LT-7	R-5	21.20 - 21.80	198	12,088	2.52 to 3.08	0.05 to 0.21
LT-7	R-10	47.65 - 48.09	201	4,846	0.67 to 0.84	0.21 to 0.46
LT-8	R-3	16.51 - 16.95	212	7,969	2.36 to 3.63	0.14 to 0.30
LT-10*	R-8	45.50 - 46.40	-	-	-	-
LT-10*	R-10	56.90 - 57.60	-	-	-	-
LT-11*	R-2	28.50 - 29.80	-	-	-	-
LT-11	R-4	41.41 - 41.85	200	11,450	5.98 to 6.71	0.10 to 0.14
LT-12	R-6	31.93 - 32.37	210	2,691	1.77 to 2.32	0.12 to 0.34
LT-12*	R-7	36.40 - 37.10	-	-	-	-

* Denotes sample did not hold up to trimming and grinding preparation process.

Bulk only X-ray diffraction analysis can be used to rapidly determine mineral amounts in a powdered sample. The samples are cleaned of contaminants, disaggregated, split, and pulverized before being placed in a sample holder. XRD uses diffraction of X-rays across an angular range (typically five to sixty degrees two theta) and captures the diffracted pattern. These patterns are then compared against known patterns (Whole Pattern Fitting (WPF)) and uses refinement methods on the observed data to best fit the patterns against known minerals. A summary of the XRD analysis is presented in Table 3. Detailed results are provided in Appendix D.

Table 3: X-ray Diffraction Data (Weight Percent)

Boring No.	Run No.	Tested Depth (ft)	Quartz	Plagioclase	Amphibole	Pyroxene	Biotite	Muscovite	Calcite	Total Clay Minerals	Total
LT-1	R-13	53.64 - 53.73	0.6	0.0	1.9	73.5	23.4	0.0	0.0	0.6	100
LT-1	R-22	35.00 - 35.44	0.0	27.1	4.6	35.5	0.0	21.9	0.0	10.9	100
LT-3	R-14	63.71 - 63.26	0.0	3.6	17.4	54.8	22.5	0.0	0.0	1.7	100
LT-6	R-4	24.00 - 24.71	0.0	31.2	13.0	23.7	31.4	0.0	0.0	0.7	100
LT-7	R-1	11.24 - 11.60	24.1	48.5	0.0	3.5	0.0	15.9	0.0	8.0	100
LT-8	R-3	16.41 - 16.50	0.0	0.0	18.9	61.6	17.2	0.0	0.0	2.3	100
LT-8	R-11	55.20 - 55.83	1.3	63.7	6.3	6.2	16.0	0.0	5.9	0.6	100
LT-9	R-28	93.67 - 93.90	0.0	0.0	13.7	81.5	0.0	3.8	0.0	1.0	100
LT-11	R-2	28.58 - 28.67	0.0	0.0	58.3	0.0	18.0	0.0	20.4	3.3	100

Optical minerology and petrology used thin sections (a thin slice of rock) prepared in a laboratory and a polarizing petrographic microscope. A sample is prepared by slicing a thin sliver of rock from a sample, and grinding it down until it is optically flat. The sample is then mounted on a glass slide and ground smooth until the sample is approximately 30μm thick. The sample is viewed using the microscope to determine physical and optical properties of the minerals. A summary of samples with identified rock type, and dominant minerology is shown in Table 4. The full petrographic analysis is included in Appendix D.

Table 4: Petrographic Analysis Data

Boring No.	Run No.	Tested Depth (ft)	Rock Type	Dominant Minerology
LT-1	R-13	53.64 - 53.73	Clinopyroxenite	Clinopyroxene, biotite/phlogopite, hornblende, plagioclase feldspar, olivine, and magnetite
LT-1	R-22	35.00 - 35.44	Gabbro (heavily altered)	Plagioclase feldspar, olivine, and clinopyroxene with secondary alteration minerals.
LT-3	R-14	63.71 - 63.26	Clinopyroxenite	Clinopyroxene, biotite/phlogopite, hornblende, plagioclase feldspar, olivine, and magnetite
LT-6	R-4	24.00 - 24.71	Alkaline Lamprophyre	Plagioclase feldspar and augite-clinopyroxene
LT-7	R-1	11.24 - 11.60	Alkaline Lamprophyre	Plagioclase feldspar and augite-clinopyroxene
LT-8	R-3	16.41 - 16.50	Olivine Gabbro	Plagioclase feldspar, olivine, and clinopyroxene with secondary alteration minerals.
LT-8	R-11	55.20 - 55.83	Dolerite or Diabase	Plagioclase feldspar, augite-clinopyroxene, and hornblende.
LT-9	R-28	93.67 - 93.90	Clinopyroxenite	Clinopyroxene, biotite/phlogopite, hornblende, plagioclase feldspar, olivine, and magnetite
LT-11	R-2	28.58 - 28.67	Clinopyroxenite	Clinopyroxene, biotite/phlogopite, hornblende, plagioclase feldspar, olivine, and magnetite

5 INSTRUMENTATION

Geotechnical instrumentation was installed in each boring. An associate engineer and associate geologist from our firm finalized instrument installations and wiring in September and October 2021. To investigate groundwater conditions, measure pore pressures, and determine if slope movement is occurring, a Measurand ShapeArray® (consisting of continuous strings of MEMS displacement monitoring sensors) and two vibrating wire piezometers (VWP) were installed in each boring. The VWPs measure groundwater pressures at the sensor depths within the borehole and the MEMS strings measure subsurface deformation.

MEMs strings were installed inside of 1-inch diameter (nominal) PVC casing following protocol outlined by Measurand ShapeArrays® manual. In general, two Geokon model 4500S VWPs were installed attached on the outside of the PVC casing at specified depths, then tremie-grouted in place using a cement-bentonite mixture. At borehole locations LT-4, LT-5, and LT-7 through LT-12, the PVC casing was Schedule 40 (27 mm inner diameter). At borehole locations LT-1 through LT-3 and LT-6, the PVC casing was Schedule 80 (24 mm inner diameter). To accommodate the smaller inner diameter of the 1-inch Schedule 80 PVC casing, a two-foot, ½-inch diameter steel pipe nipple was attached to the distal end of the ShapeArray® to allow for the required compression of the sensor.

Installation of each ShapeArray® was verified in the field using a Portable Diagnostic Unit provided by Measurand. Pertinent data concerning installed instrumentation for each boring is summarized in Table 5. Calibration sheets for each VWP and Measurand ShapeArrays® are given in Appendix E, along with the installation verification photo exhibit.

Table 5: Summary of Instrument Installation and Elevations

Boring No.	Surface Elevation (ft)	PVC Depth (ft)	ShapeArray, Top and Bottom Elevation (ft) (S/N)	X-Mark Azimuth (deg)	VWP depth Shallow (S/N)	VWP depth Deep (S/N)
LT-1	781.5	119.8	781.9 to 663.7 (296321)	056	734.5 (2123117)	685.8 (2123112)
LT-2	767.6	121.8	766.0 to 647.8 (296822)	013	714.7 (2123115)	667.2 (2123109)
LT-3	738.7	119.7	739.2 to 621.0 (306386)	063	685.9 (2123114)	657.1 (2123111)
LT-4	416.6	100.3	415.1 to 316.3 (306398)	013	373.6 (2123106)	348.1 (2123102)
LT-5	480.9	99.7	480.0 to 381.2 (306399)	340	447.9 (2123097)	422.9 (2123105)
LT-6	877.5	121.0	877.1 to 758.5 (306387)	012	830.0 (2123108)	795.2 (2123095)
LT-7	858.1	122.0	857.1 to 736.1 (306396)	025	801.1 (2123104)	751.1 (2123107)
LT-8	941.8	119.6	940.6 to 822.2 (306400)	038	899.4 (2123098)	860.3 (2123099)
LT-9	712.5	120.6	710.5 to 591.9 (306401)	301	639.5 (2123100)	605.5 (2123101)
LT-10	290.0	102.1	287.2 to 187.9 (306402)	055	266.0 (2123116)	204.0 (2123096)
LT-11	105.8	38.6	106.2 to 67.2 (306397)	050	78.9 (2123094)	68.8 (2123103)
LT-12	113.1	39.9	112.6 to 73.2 (306404)	034	89.6 (2123113)	79.1 (2123110)

The VWPs and MEMs strings are connected to Measurement and Control Units (MCU) at each boring location to collect, store, and transmit data to a central server (base station). Each MCU consists of a data logger, vibrating wire interface, SAAV interface, radio and antenna. The data logging hardware is supplied and/or manufactured by Campbell Scientific, Inc. (CSI) of Logan, Utah. The SAAV interface was supplied by Measurand. Each data logger was programmed by Landslide Technology using CSI's proprietary programming language, CR Basic. A summary of the various data logging components is provided in Table 6.

Data logging components were installed inside of a polycarbonate enclosure that was mounted inside of a steel free-standing enclosure. The steel enclosures are secured to a 3-ft x 3-ft x 1-ft thick concrete pad. One 200W solar panel (27x65 in.) was mounted to the steel enclosure using 2-inch EMT, which powers the instrumentation through two 75 AH (Amp Hour) batteries.

Table 6: Summary of Data Logging Components

Component	Model
Data Logger	Campbell Scientific CR1000X
Vibrating Wire Interface	Campbell Scientific AVW200 2-channels
SAAV Interface	Measurand SAAV 232 ShapeArray Interface
Radio	Campbell Scientific RF451 900 MHz spread spectrum radio
Radio Antenna	900 MHz 3dBd Omnidirectional, Yagi directional (LT-3 only)
Cellular Modem	Sierra Wireless RV50, AT&T service
Cellular Antenna	8 dBd Yagi directional
Solar Regulator	Morningstar SunSaver 20L (12V, 20-amp load capacity)
Solar Panel	Newpowa 200W, 12V Monocrystalline
Batteries	Mighty Max 12 V, 75 AH x 2; connected in parallel for combined 150 AH. LT-6 has 75 AH x 3 for combined 225 AH
Free-Standing Enclosure	Saginaw Enviroline series, 60x24x18", freestanding, powder-coated steel, 3-point locking handle
Secondary Enclosure	Polycarbonate 18x16x10", Adalet Elite HFLL series, hinged, locking latch

The base station at LT-6 was additionally equipped with a Sierra Wireless RV50X industrial cellular gateway, which provides internet connectivity to the dataloggers. This base station is powered by three 75 AH batteries and a 200W solar panel. In addition to collecting VWP and MEMS data, the base station collects and transmits data collected from six surface extensometers previously installed in June 2020 (refer to Surface Extensometer Instrument Installation Memo, dated Aug 26, 2021). Photos of the typical instrument installation and base station installation are provided in the photo exhibit in Appendix E.

Data collection occurs automatically at each boring's MCU with data from VWPs collected every hour, and Measurand ShapeArray® data collected every six hours. All MCUs transmit data to the base station once each day (located at boring LT-6). The base station data logger is currently programmed to turn on the radio and/or modem at 12:00 p.m. and turn off at 2:00 p.m. (Alaska local time) daily to conserve power. Accumulated data is collected once each day and stored on Landslide Technology's servers. A cloud-based data server "Konect" hosted by CSI also connects and downloads the data from the base station daily.

Initial instrumentation data plots include ShapeArray® deflection versus depth, displacement versus time, and vector orientation are presented in Appendix *F*. VWP groundwater elevation data is presented, along with daily precipitation and snow depth for possible correlation. Daily precipitation and snow depth information are obtained from the Mount Riley weather station (MRWA2) hosted by Alaska Department of Natural Resources Geological and Geophysical Surveys.

LIMITATIONS IN THE USE AND INTERPREATATION OF THIS GEOTECHNICAL REPORT

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject facility and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive boring and test pit logs, cross-sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory borings, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory borings and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The boring logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at these boring locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borings or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.

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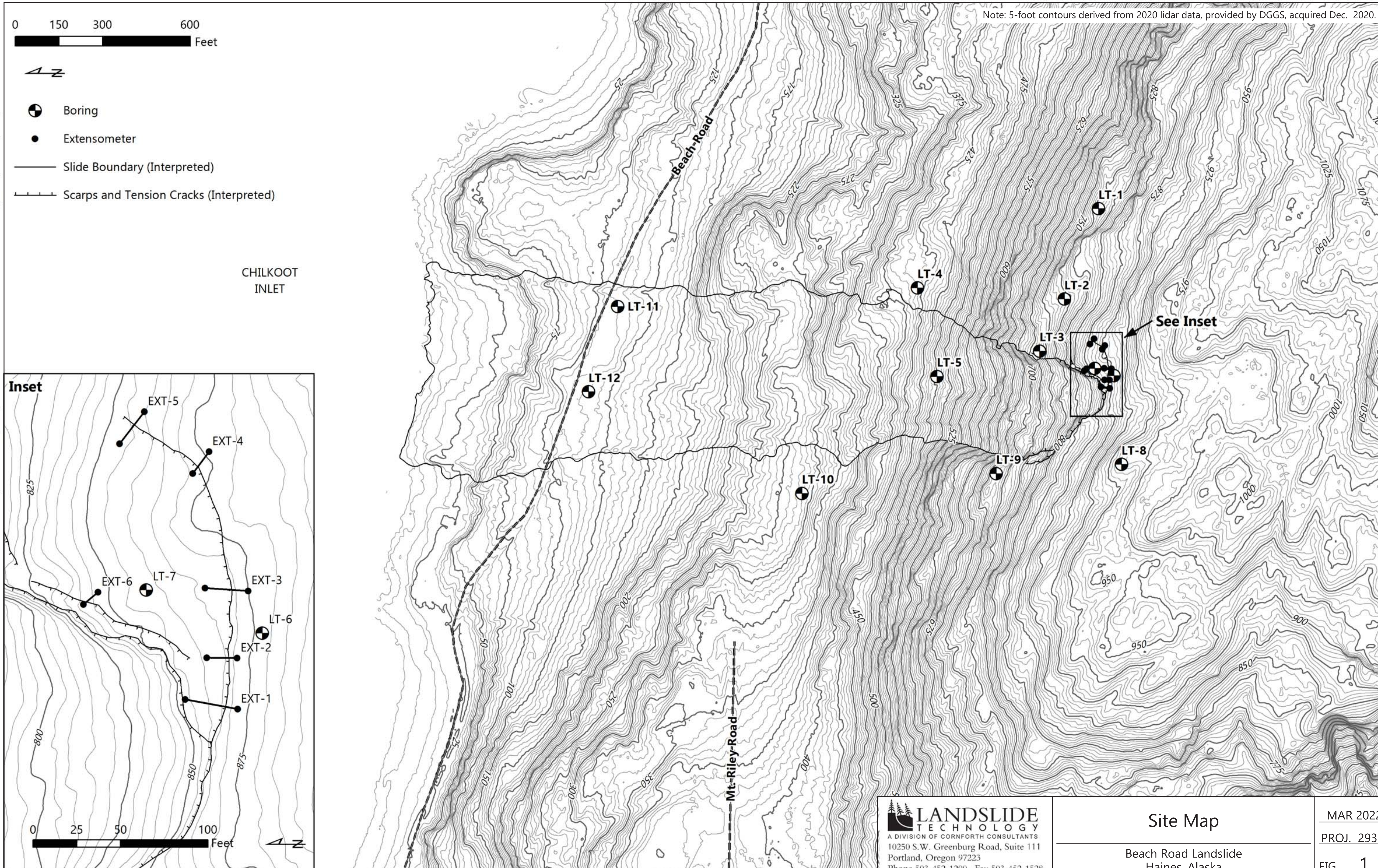

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Site Map

Beach Road Landslide
Haines, Alaska

MAR 2022
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FIG. 1