Project Report

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City and Borough of Sitka

Technical Memorandum No. 7 – Geotechnical Findings Report

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Executive Summary

Geotechnical investigations were carried out, during May through October, 2009, to obtain design parameters for to carry out design development and undertake final design for a proposed raising of the Blue Lake Dam. The project will entail raising the concrete arch dam from a height of 160 ft to 243 ft, construct a new power intake and intake tunnel, surge chamber, new penstock and powerhouse. These investigations included geological mapping at the dam, intake, upstream portal of the lower tunnel, surge chamber and powerhouse sites. The work also included drilling a total of 15 boreholes at the Project site, including 7 holes at the dam site as shown in Table 3.1. Four boreholes were drilled at the left abutment, two boreholes were drilled at the right abutment and one was drilled in the plunge pool. Seismic refraction testing was undertaken over a potential seepage path located to the west of the right abutment along the existing Blue Lake access road and at the powerhouse site. The purpose of the seismic refraction survey was to determine the depth to bedrock in these areas. In addition to the borehole, to validate the results of the seismic survey at the powerhouse site, six test pits were excavated.

The plunge pool was dewatered in late August to permit geological mapping and drilling of the borehole in the plunge pool immediately downstream of the arch dam.

The two main bedrock units underlying the project area belong to the Kelp Bay Group (Haeussler et al. 2004). The first unit occurs (north of STA 50+00 on the lower tunnel alignment and south of approximately STA 22+00 on the Lower Tunnel alignment. This unit is described by the U.S. Geological Survey (USGS) (Loney et al. 1964) as a Triassic to Jurassic-aged "greenstone, graywacke, greenschist, metachert, and phyllite". Based on the results of petrographic analyses of three samples of the core (two from the arch dam area and one from the surge chamber), the petrographic description of this unit is andesitic siltstone (sediments formed from the deposition of re-worded andesite clasts). This is generally consistent with the nomenclature used by the USGS and the U.S Bureau of Reclamation (USBR) (1954). As a result, this unit will be referred to as "greywacke" in this report. The unit located along most of the Lower Tunnel alignment between STA 22+00 and 50+00 is a Permian- to Triassic aged greenstone (metamorphosed volcanic rock, likely of andesitic composition).

The project components that will be affected by the raised lake level of the Project include the new intake tunnel, the arch dam and plunge pool, the South River Portal, the North River Portal, the Lower Portal, the proposed new surge chamber, and a new penstock and powerhouse. All of these areas are underlain by the graywacke.

The results of point load and Uniaxial Compressive Strength (UCS) testing indicate that the mean UCS for the graywacke is approximately 120 MPa (17,500 psi). A similar value was obtained for the greenstone, although a considerable smaller number of samples were analysed. Based on the results of laboratory testing on concrete core samples obtained from the within top 10 ft of Borehole DH09-04, (collared on the left abutment parapet) from the parapet at the UCS ranged from 34.6 MPa (5020 psi) to 55.3 MPa (8,024 psi).

Based on the results of geological mapping three major sets of discontinuities occur within the project area with the following orientations (Dip/Direction):

- Set 1 – 87°/300°
- Set 2 – 72°/214°
- Set 3 – 33°/320°

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Joint Set 1 is parallel to the channel walls at the arch dam and forms the steep exposures in the cliff above the powerhouse portal. Set 2 is parallel to bedding. Joint Set 3 is less well defined than Sets 1 and 2, except at the arch dam. In general, the joints have planar shape, have a smooth to rough surface, and are slightly weathered, and are generally tight. The joint spacing for Sets 1 and 2 is 0.7 – 2 ft and the spacing for Set 3 is 2 – 6 ft. The persistence of jointing in the project area typically ranges from 3 to over 30 ft; however, individual joints in the abutments of the arch dam and other steep exposures were observed to have persistences in excess of 50 – 60 ft. The average RQD from core from the seven boreholes drilled at the dam is 95%. The overall GSI at both the left and right abutments at the dam is estimated to be 65 – 70.

For the most part, the bedrock at the arch dam site was found to be relatively impermeable and most of the intervals tested have hydraulic conductivities less than 10 Lugeons. However, there were a few zones, approximately 10 – 20 ft in length, with higher takes in excess of 10 Lugeons. On the left abutment, these include a 21-ft long zone, are intersected by both DH09-01 and DH09-02. During drilling operations, a connection was noted between these two holes. DH09-04 also intersected a higher permeability zone with a hydraulic conductivity of 11 – 16 Lugeons. On the right abutment, DH09-07 and DH09-11 each intersected 10 ft zones with hydraulic conductivities of 12 Lugeons and 23 Lugeons, respectively. Borehole DH09-04 was drilled through the concrete into bedrock and the concrete-bedrock contact in this hole is bonded.

The dam is located of the top of an older stream channel that was excavated to el. 140 and filled with a concrete plug. It is suspected that the channel was originally cut, along an area of closely spaced jointing, by glaciation and infilled with glacial till, which was washed out as the glacier retreated, except possibly in a deep section, under the dam, where a small till deposit was wedged in place and could not be eroded. The channel was then subsequently infilled with talus and alluvium. This channel extends downstream into the plunge pool and is formed by Joint Set 1. DH09-08 was drilled through 21 ft of boulders and gravel and encountered a high permeability zone (calculated to be 192 Lugeons) in the top 10 ft of the bedrock. If this fractured rock is present under the dam, it would likely have been sealed by the grouting program implemented during dam construction. The RQD of the bedrock obtained from this zone was indicative of poor to fair quality rock (30% to 62%). The remainder of the borehole passed through excellent quality rock (RQD of 96% to 100%). A vibrating wire piezometer was installed in this borehole, and based on the data collected to October 31, 2009, appears to be working as expected.

There are several closely jointed zones in the intake area, 6 ft to 30 ft wide and oriented parallel to the bedding (Joint Set 2) that could potentially intersect the intake tunnel alignment. In addition there are also several lined sections along the existing tunnel that are inferred to correspond with zones of weaker, closely jointed and/or sheared rock. The majority of the Upper Tunnel is unlined with no support and the rockmass rating (RMR) is estimated to be greater than 65 (“good” to “very good”).

The drilling results in the intake area generally confirm the results obtained from the geological mapping. The RMR values obtained for the rock drilled by DH09-12 varied from 40 to 60 (“fair”) for the top 15 ft of bedrock, improving to 60 – 70 (“good”) for the remainder of the borehole. In DH09-10, the RMR values were slightly higher, ranging from 60 to over 80 (“good” to “very good”). The RMR values for DH09-09 in the top 15 ft of the bedrock were between 42 and 57 (“fair”). The RMR values for the remainder of the borehole ranged from 60 to 84 (“good” to “very good”).

The USBR (1954) investigation results indicated the presence of a narrow topographic depression up to 60 ft deep in the right abutment area, and generally following the existing access road. The results of the seismic refraction surveys and drilling of DH09-05 and DH09-06 obtained similar results, indicating that the original

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USBR interpretation is credible. The overburden materials are classified as a silty sand to sandy silty clay or silty sand with gravel, indicative of glacial till. The overburden materials were found to have a low permeability (hydraulic conductivity 5.9 x 10^{-9} ft/s to 2.3 x 10^{-8} ft/s. The results of packer testing in Boreholes DH09-05, DH09-06, DH09-09, DH09-10, and DH09-12, plus the observations regarding groundwater inflow into the Upper Tunnel and into the right abutment adit, indicate that the bedrock in this area has low permeability. As a result seepage from the elevated lake along this pathway is unlikely to be an issue. It should be noted that the static water levels in these boreholes could not be obtained as a result of the low permeability of the rock.

The slope above the South River Portal of the Lower Tunnel is steep and rocky with a discontinuous layer of colluvium. There are numerous talus piles at the base of the slope, near the tunnel portal. The contact between the graywacke and the greenstone occurs at approximately STA 50+00 along the tunnel alignment. This portion of the tunnel was inspected and the RMR for the unlined sections was estimated to be greater than 75 ("good" to "very good"). The groundwater inflow conditions encountered were "damp" to "dry". DH09-13 was drilled to a depth of 58 ft (el. 259) in the bedrock. The RMR values obtained, for this hole, range from 60 to 76, indicative of "good" rock conditions. The rock mass was found to have low permeability. A piezometer was installed to monitor the ground water levels on the slope and compare over the longer term (at least one year) with the changes in lake levels. The initial piezometer readings to October 31, 2009) indicated that the ground water levels were between el. 292 and el. 296 and that the piezometer was working as planned.

The bedrock of the proposed surge chamber and the powerhouse sites is the graywacke unit. Based on the results of the tunnel inspection and the results of the drilling DH09-14, RMR values between 60 and 70 would be anticipated for most of the surge chamber, the exception being the top 20 ft, where RMR values between 40 and 60 (indicative of "fair rock") were obtained. The permeability of the bedrock is low.

Bedrock is exposed in the powerhouse and lower penstock area at the Lower Portal, immediately downstream of the timber crib wall, and along the existing access road. The remainder of this area is covered by unstratified fill, comprised of angular rock up to 3 ft in diameter as well as sand, gravel and rounded boulders. The results of the test pit excavation. drilling of DH09-15, and seismic refraction tests carried out in this area indicate that the depth to bedrock in the vicinity of the proposed powerhouse site is generally within 10 to 12 ft. The depth to bedrock at the timber crib wall is likely more than 20 ft. The seismic refraction survey did not correlate well with the test pit results in the northwest portion of the powerhouse site near the intersection of Seismic Lines SL-3A and SL-6; however, this area is currently located outside of the area that would be affected by the Project.

The results of the direct shear testing indicate that the basic friction angle for the both the concrete-rock and the rock–rock contacts at the dam should be 30 degrees.

The results of the reservoir rim study indicate that reservoir rim stability arising from the inundation of Blue Lake to el. 425 is not a concern in terms of reservoir rim stability.

The results of the laboratory analyses for acid rock drainage prediction indicate the potential for acid rock drainage from the site is expected to be low. Nonetheless, a waste rock management plan that addresses the identification, segregation, and treatment of potentially acid generating materials should be developed in accordance with applicable environmental regulatory requirements.

The investigations have produced geotechnical design parameters for the proposed raising of the arch dam in terms of the strength and quality of rock in the dam abutments, rock conditions for the intake and intake tunnel, surge chamber, foundation conditions for the new powerhouse, reservoir rim stability and increased water pressures in the existing tunnels.

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Based on the results of the geotechnical investigations, the following are recommended:

- The City should continue to collect the piezometric data from the piezometers installed in the plunge pool (DH09-08) and on the slope above the South River Portal (DH09-13). The piezometric data for the plunge pool should be compared to determine the relationship between the pressure data measured in the borehole, the plunge pool water level and the reservoir levels to determine if there is any evidence of excessive seepage under the dam. The piezometric data obtained from DH09-13 should also be compared with precipitation data and the reservoir levels to determine the relationship between these parameters.
- It is anticipated that the only further site investigations needed to carry out final design would be additional test pitting to obtain confirmation of bedrock depths in certain areas at the powerhouse site, depending on the development of the powerhouse and penstock layout during final design; and
- It may be desirable to obtain additional concrete cores with a diameter of at least 0.5 ft from the arch dam and undertake unconfined compressive and splitting tensile strength testing.

Recommendations regarding the tunnel and surge chamber lining requirements, the erodibility of the plunge pool, seepage under the dam, and the foundation rock parameters are provided in Technical Memoranda Nos. 2, 5, 23, 24, and 25, respectively.

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1. Introduction

1.1 Background

The Blue Lake Project, owned and operated by the City and Borough of Sitka ("the City"), was commissioned in 1961 and is located about five miles east of the Sitka city centre. The current project consists of a 160-ft high arch dam, at the outlet of Blue Lake on Sawmill Creek, with a spillway crest at el. 342 ft, two tunnel segments, two penstock segments, and three powerhouses. The three powerhouses include the 2x3 MW Blue Lake powerhouse, the 0.67 MW Fish Valve Unit (FVU) and the 0.87 MW Pulp Mill Feeder Unit (PMFU). The general arrangement is shown in **Figure 1**.

Water is conveyed to three powerhouses from the intake, located to the west of the arch dam in Blue Lake at invert el. 210 ft, via the 1445-ft long Upper Tunnel that daylights on the north side of Sawmill Creek. Sawmill Creek is spanned by a 610-ft long penstock crossing over the creek and a 4922-ft long tunnel which daylights at invert el. 73-ft adjacent to the water treatment plant. Downstream of the Upper Tunnel, there is a wye branch that conveys water to the FVU. Water would be conveyed from the Lower Tunnel portal to the proposed site via a 9-ft diameter steel pipe. The existing Blue Lake power plant and the PMFU would be decommissioned.

The Blue Lake Hydroelectric Expansion Project (Project) is comprised of the following elements:

- A dam raise by 83 ft;
- Three new 5.3-MW generating units (the existing units must operate at a higher head and will likely be replaced rather than upgraded);
- A new powerhouse, housing the new generating units;
- A modification to the existing intake (e.g. a new intake tunnel and gate shaft located to the South of the present alignment);
- A new downstream surface penstock segment from the Lower Tunnel;
- A new surge chamber; and
- A new switchyard.

Figure 1 also shows the proposed new intake, intake tunnel, surge chamber, and new lower penstock and powerhouse sites.

Task Order 1 engineering services included Phase 1 final feasibility and design development studies. This work also included a detailed geotechnical investigation program that was developed to evaluate the tunneling and foundation conditions at the site and determine the properties of the materials that are required for design.

1.2 Previous Work

Previous geotechnical investigations by others for this project included geological mapping and drilling of 17 boreholes in 1952-53 (USBR 1954). This work was undertaken in support of the design and construction of the existing project components. Geotechnical drilling included drilling 11 boreholes in the vicinity of the existing dam site, two boreholes in the low saddle separating Beaver Lakes from Blue Lake, and four boreholes at the possible spillway area on the right abutment. All of the borehole

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locations, except for the boreholes at the Beaver Lakes are shown on Figures 3 and 5. It should be noted, however, that the fields of rock mechanics, rock mass classification, engineering geology, and drilling technology have advanced considerably since the 1950s when these investigations were carried out. As a result, the quality and type of data collected during that time would be insufficient to permit classification of the foundation materials in accordance with the current practice.

Additional studies include carrying out Periodic and Part 12 Safety Inspections (de Rubertis 2004; Duke Engineering and Services 1999; Bowes 1994; R.W. Beck and Associates 1989, 1984, 1974) as per the requirements of the Federal Regulatory Energy Commission (FERC); Plunge Pool Surveys were carried out in 1968, 1983 and 1997 (Duke Engineering and Services 1997; R.W. Beck and Associates 1983); and a geotechnical reconnaissance was carried out in 2006 to examine the feasibility of connecting the water conveyance structure to a new powerhouse (de Rubertis and McArthur 2006).

1.3 Scope of Work

A detailed investigation program was developed to evaluate the tunnelling and foundation conditions at the site and to determine the properties of the materials that are required for design. Geotechnical data for the site was required prior to designing the proposed new project components, including: the arch dam raise; new intake gate and tunnel; the lower tunnel portals; surge chamber; penstock alignment; and powerhouse.

The 2009 geotechnical field investigations included the following components:

- Topographic surveys;
- Tunnel inspection and geological mapping;
- Preparation of a geotechnical exploration plan for submittal to the Federal Energy Regulatory Commission (FERC);
- Seismic refraction surveys and excavation of test pits;
- Dewatering and surveying the plunge pool and monitoring the rate of re-fill;
- Geotechnical drilling and permeability testing;
- Installation of two piezometers; and
- Laboratory testing.

This report describes the methods used to the carry out the geotechnical investigations and the presents the results. Interpretation of the geotechnical investigation results are presented in the following technical memoranda:

- Technical Memorandum No. 2 – Tunnel and Tunnel Linings;
- Technical Memorandum No. 5 – Surge Shaft Lining and Constructability Assessment;
- Technical Memorandum No. 23 – Plunge Pool Analysis;
- Technical Memorandum No. 24 – Dam Foundation Seepage Analysis; and
- Technical Memorandum No. 25 – Dam Foundation Rock Properties and Dam Abutment Assessment.

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2. Regional Geology

2.1 Surficial Geology

Blue Lake occupies the west end of a broad glacial U-shaped valley. The lower end of the lake is bounded by bedrock cliffs up to 300 ft in height. The cliffs are steepest on the west and north shores of the lake and less steep on the south shore. The valley slopes are mantled with colluvium and talus deposits of variable thickness with bedrock outcrops exposed on the steeper slopes. The results of the USBR (1954) investigation indicate that there are some remnants of glacial till in the areas, in particular in the saddle in the right abutment of the dam. In addition, glacial errata, primarily of igneous origin have been deposited in the in the stream channel of Sawmill Creek and on the valley floor.

As shown on **Figure 2**, Blue Lake Dam is located where Sawmill Creek enters a steep canyon that extends down to the Fish Valve Unit (FVU) powerhouse site where there is a Forest Service Campground. At this location, where the canyon ends, the valley widens considerably for an approximately 0.5 miles before entering a second narrow section, which discharges into Sawmill Cove near the Blue Lake Powerhouse site.

2.2 Bedrock Geology

Figure 2 shows the general project layout and regional geology. There are two distinct lithologies within the Project area, both of which are included in the Kelp Bay Group described by Haeussler et al. (2004). The first is described as "a series of intricately folded, fractured, and re-cemented phyllite, graywacke, and argillite beds and lenses" (USBR 1954). The United States Geological Survey (USGS) (Loney, et al. 1964) describes this unit as a Triassic- and Jurassic-aged unit of greenstone, greywacke, greenschist, metachert, and phyllite. Within the Project area, these beds dip sub-vertically towards that southwest and extend approximately 0.5 miles downstream of the lake. Three samples, obtained during the 2009 Investigations from drill core from three of the boreholes (DH09-02, DH09-04, and DH09-14), were submitted for petrographic analyses as described in Sections 3 and 4. This unit will be referred to as "greywacke".

Overlying the graywacke is a unit described by the USBR (1954) as a greenstone which extends for approximately another further 0.5 miles downstream. The color and texture of the greenstone is described (USBR 1954) as varying "… from fine-grained and light greenish gray at the bottom to almost black in places near the top of the section. "Several 1 – 2 ft wide andesite dikes cut through the greenstone and greywacke-phyllite – argillite. The dikes are light grey in color and fine grained. Bedding planes are practically non-existent in the outcrops examined". This unit is described by the Loney, et al. 1964) as a Permian to Triassic-aged amphibolite and greenschist; subordinate phyllite and schist. It should be noted that Haeussler et al. (2004) show a narrow sliver of Jurassic aged diorite within the boundaries of the greenstone. However, for the sake of simplicity in this report, the lithological term used for the unit between the two sequences of greywacke will be "greenstone"

As shown on **Figure 2**, the contact between greenstone and the graywacke on the ground surface is at approximately STA 50+00 along the Lower Tunnel alignment (Figure 2).

The USGS classifies the bedrock between STA 20+00 and 25+00 along the Lower Tunnel alignment, and extending down to the powerhouse site as being part of the Triassic- and Jurassic-aged unit of

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greenstone, graywacke, greenschist, metachert, and phyllite unit that occurs in the northern portion of the project area. The downstream contact between the graywacke and the greenstone is gradational.

Major faulting has occurred throughout the area, and the faults can be divided into two main groups; one northwest-trending, and the other east-west trending (USBR 1954). The USBR mapped three major potential faults in the vicinity of the project area; one parallel to the upper channel of Sawmill Creek at the dam site, another thought to pass through the Beaver Lakes and a third parallel to the shoreline at Herring Cove. None of these faults are considered active.

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3. Site Investigation Program Methodology

3.1 Reservoir Rim Stability Assessment

This work was carried out by R&M Consultants Ltd. (R&M) and the report outlining the methods and results of the assessment is included in **Appendix A**. Interpretation of aerial photographs was carried out initially to delineate surficial materials and geological features. The aerial photographs consisted of stereo pairs at scale of 1:30,000 flown on August 6, 2003 by Delta Aerial Surveys. The aerial photo interpretation was followed up by a field inspection of the existing reservoir rim by boat and helicopter, carried out on September 8, 2009. The results are summarized in Section 4.1.

3.2 Topographical Surveys

The topographical and survey database used for the project is based on LIDAR data acquired from September 22 – 29, 2009 by Aero-Metric Anchorage, at a height of 1,000 m (3,281 ft) above mean terrain with a nominal point spacing of 0.56 m (1.83 ft). The map projection is based on Alaska State Plane Zone 1 as expressed in US Survey Feet. The accuracy is within 15 cm (0.5 ft).

A component of the field investigations for this project included additional ground-level topographic surveys carried out by O'Neill Surveying and Engineering Ltd., based in Sitka Alaska, between May and October, 2009, which included:

- re-establishing dam survey monuments at the crest of the existing dam;
- a detailed survey of the proposed new powerhouse area, including establishment of Temporary Bench Marks (TBM's);
- detailed survey of existing services and utilities in the proposed powerhouse area that would be affected by construction; and
- survey of the borehole and test pit locations and the endpoints of all of the seismic lines.

In addition, the tunnel was surveyed during the dewatering period from May 5 – 7, 2009 to verify the lengths and locations of the lined sections as well as the tunnel geometry shown on the as-built drawing (see TM-02, Tunnel Evaluation). The plunge pool was also surveyed after it had been dewatered as described in Section 3.5.

3.3 Geological Mapping and Tunnel Inspection

Geological mapping has been undertaken in the following areas:

- existing dam site, left and right abutments, and plunge pool;
- proposed locations for a new intake structure and the intersection of the gate shaft and the existing tunnel; and
- the area covering the proposed surge chamber location, Lower Tunnel alignment, penstock alignments and powerhouse site.

Geological mapping of the arch dam area was carried out by Hatch during May 7 – 10, 2009 and June 16 – 20, 2009. The dewatered plunge pool was mapped during August 29 – 31, 2009.

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The geological mapping involved the assessment and geological conditions at the above-listed areas, including delineating bedrock outcrops, identifying the thickness and type of surficial materials and potentially unstable slopes, noting major bedrock structures or linear structural features and describing detailed discontinuity data from selected outcrops. Discontinuity type, orientation, and engineering characteristics as a type of surface shape, spacing, and persistence (continuity), and aperture were noted in selected outcrops. The discontinuity data were analyzed using the DIPS Software, developed by RocScience (2009), and plotted on lower hemisphere stereoplots (pole and contour). Based on the results of the geological mapping, a detailed subsurface investigation program, which included geotechnical drilling, test pit excavation and seismic refraction surveys, was developed.

Horizontal survey control during the geological mapping was undertaken using a Garmin Etrex GSX 60 GPS receiver. The receiver was calibrated to provide Universal Transverse Mercator (UTM) Coordinates for NAD 83. The horizontal accuracy of the coordinates provided by the GPS receiver was ± 5 to 10 m (15 to 30 ft). In site-specific areas, such as the dam, survey control for the geological mapping was undertaken using a compass and measuring tape to tie into a known landmark.

The results of the geological mapping are described in Section 4 and shown on **Figures 3** to **12**. Site Photographs are provided in **Appendix B**.

An inspection of the dewatered tunnels was undertaken by D. Brox (Hatch Mott McDonald), P. Friz (Hatch), accompanied by Dean Orbison (City of Sitka), and J. Morrison and B. Roberds, (Redpath) on May 5 – 6, 2009 to confirm the conditions of the exposed rock in the unlined sections, conditions of installed tunnel support, and quality/condition of the existing concrete liners. This inspection included the entire Upper Tunnel and the portions of the Lower Tunnel, between the Lower Portal at STA 4+32 and STA 21+00; and between STA 45+00 and the South River Portal. As part of the tunnel inspection, the lengths of the various rock and concrete-line sections were measured using a tape as a check to the existing as-built drawings. Schmidt hammer testing was also undertaken on the various concrete-lined sections to obtain an assessment of the concrete condition.

The results of the tunnel inspection are described in a project memorandum, provided in **Appendix C**.

3.4 Geotechnical Exploration Plan, Quality Control Inspection Plan and Permitting

The City was responsible for obtaining all regulatory permits and approvals for the geotechnical subsurface investigation program. This included various environmental permits obtained through the Coastal Zone Management Review process.

In addition to the environmental permits, approval for the subsurface investigation program, based on its technical objectives and merits, was also required from FERC. Hatch prepared a Geotechnical Exploration Plan based on the results of the geological mapping and the tunnel inspection. A 95% submittal of the Geotechnical Exploration Plan was prepared, submitted, and presented for review to the FERC and the Board of Consultants at a meeting held in Sitka, Alaska, during July 8-10, 2009. The meeting was attended by key team member from Hatch, the City, members of the Board of Consultants and FERC staff from the Portland Regional Office.

The geotechnical exploration plan outlined the results of the geological mapping carried out to-date and provided the rationale for the proposed subsurface investigations, which included excavation of test pits, seismic refraction surveys, and a geotechnical drilling program.

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After incorporating the comments received from the FERC and the Board of Consultants, Hatch provided the City with a 100% submittal of the Geotechnical Exploration Plan. This plan also included a Quality Control Inspection Program (QCIP), a Temporary Emergency Action Plan (outlines the communication protocols to identify and address hazards during drilling operations), and an Erosion Control Plan. The 100% submittal plan was provided by the City to FERC for final approval, which was obtained on August 19, 2009.

3.5 Plunge Pool Dewatering and Survey

The plunge pool was dewatered by the City during the week of August 21 – 28, 2009. At this time, the Sitka area was experiencing heavy rainfall. Therefore, to ensure access to the plunge pool for geological mapping and allow the drilling contractor to set up equipment at Borehole DH09-08, the City continued to pump water from the plunge pool until September 2, 2009. The plunge pool infill rate was monitored from September 3 until September 24, 2009, when the Howell Bunger valve (low-level outlet) was opened and the plunge pool was filled to spill level.

The plunge pool water levels were measured by installing a staff gauge at the deepest point of the plunge pool, extending up to the ledge above the pool. Water level readings were carried out daily and the precipitation was monitored by using the rain gauge at the powerhouse, located approximately 2 miles from the plunge pool. To assess the potential for seepage under the dam through the bedrock, the water balance for the plunge pool was calculated between September 3-24, 2009 during drilling of boreholes DH09-01 through DH09-04, DH09-07 and DH09-11. The drillers utilized the water from the reservoir upstream of the dam. Since the drill water was being discharged downstream of the dam during this period, this water had to be accounted for in calculating the water balance. The drill water pumped into the plunge pool was estimated based on the capacity of the pump and the number of hours per day it was in use. The results of the water balance are presented in Technical Memorandum TM-24, Dam Foundation Seepage Analysis. As described in this memorandum, the estimated seepage rate is very low.

The dewatered plunge pool was surveyed by O'Neill Surveying and Engineering Ltd. along the same cross sections that were surveyed in 1997 and 1983 to measure any differences in scour, which are described in Technical Memorandum TM-23, Plunge Pool Analysis.

3.6 Seismic Refraction Surveys and Test Pit Excavations

Seismic refraction testing was performed between September 18 and 23, 2009, along six lines shown in **Figures 3** and **11**. The surveys were performed by MACTEC Engineering and Consulting Inc. (MACTEC) and the seismic refraction survey report is provided in **Appendix D**. Lines SL-1A, SL-1B and SL-2 were undertaken in the vicinity of a suspected buried channel along the originally proposed right abutment spillway. Based on a review of the results of 1950s investigations (USBR 1954), the bedrock elevation along this channel could be at el. 400 ft. With the reservoir level expected to rise to el. 428 ft, there was a concern that raising the dam, and subsequently the lake levels could result in the creation of a seepage path around the raised dam through this saddle. As a result, the depth of bedrock and the type and nature of the overburden materials in the vicinity of the originally proposed right abutment spillway was analyzed to establish permeability potential. Test pits were not excavated in this area because anticipated depth to bedrock was expected to range from 20 to 60 ft, which is beyond the reach of a standard excavator.

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The three seismic refraction survey line segments (SL-1A, SL-1B and SL-2) are shown in **Figure 3**. These lines are located in the vicinity of several boreholes, two (DH09-05 and DH09-06) drilled as part of the 2009 investigations, as described in Section 3.7, as well as Boreholes DH14 through DH17, drilled in 1953. Boreholes DH09-05 and DH09-06 were drilled to validate the results of the seismic refraction survey.

The main geotechnical issue in the vicinity of the penstock alignment and at the powerhouse site was to determine the depth to bedrock where it is not exposed. To do this, a seismic refraction testing and excavation of test pits were carried out in the area between the steep slope above the downstream tunnel portal and the powerhouse site to determine the depth to rock within this area. **Figure 11** shows the location of the seismic refraction survey lines and test pits.

A total of six test pits were excavated in the locations shown on **Figure 11**. The text pits were excavated using a track excavator and were excavated to either to its maximum reach of 18 ft or to refusal (i.e. hit bedrock). The test pit logs, which included descriptions of the depths and type of subsurface materials encountered in each test pit, were prepared using gINT software and are provided in **Appendix E**.

3.7 Geotechnical Drilling

The geotechnical drilling program was performed from September 1, 2009, through October 5, 2009. A total of 15 boreholes, totalling 1,854 ft, were drilled. A summary of drilling data is provided in **Table 3.1**. The drilling contractor was Crux Subsurface Inc., based in Spokane, Washington.

Four different types of drills were used on this project.

Boreholes DH09-01, DH09-05, DH09-07, DH09-08, DH09-09, DH09-10, DH09-12, and DH09-14 were drilled using a Burley 4500 Geotechnical Drill and DH09-02, DH09-04, DH09-06, DH09-11, DH09-13 and DH09-15 were drilled using a Burley 2500 Geotechnical Drill.

A Eurocopter "A-Star" B3 was used to transport the drill rigs to borehole locations DH09-01 through DH09-0404, DH09-08, DH09-13, and DH09-14. Boreholes DH09-05 through DH09-07, DH09-09 through DH09-12, and DH09-15 were accessed by road by placing both the Burley 2500 and 4500 on a track undercarriage.

DH09-03 was drilled into the vertical rock face using a 1 ton drill rig set on a platform suspended from 4 16-ft long anchors, installed into rock at the top of the left abutment near DH09-01 and DH09-02.

The anchors used were ASTM A615 #18 Grade 75 All-thread rebar. The rock anchors were installed six days prior to setting the platform at the boring location. The hole for the rock anchors were drilled using a rock bolt percussion drill rig. The platform was attached to the anchors using rigging and then lowered into place in front of the borehole location using the helicopter. Once the platform was set by the helicopter and supported by the rigging, the drill crews accessed the platform and made adjustments to position and level. The drill equipment was placed on the platform using the helicopter.

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Table 3.1 Summary of Borehole Data

Borehole	Elevation (ft)	Length (ft)	Location	Date Drilled	Azimuth (deg)	Inclination (deg)	Depth in Overburden (ft)	Depth in Rock (ft)	Type of Down-hole Testing and Surveys	Remarks
DH09-01	441.7	84.0	Left Abutment	Sept 14 – 16, 2009	305	70	4	80	Packer testing, COBL	Overburden only
DH09-02	440.5	118.5	Left Abutment	Sept 12 - 16, 2009	240	70	1.3	117.2	Packer testing, COBL	
DH09-03	385.3	62.0	Left Abutment	Sept 8 – 11, 2009 (anchor installation); Sept 17 - 22, 2009 (Platform setup and drilling)	120	30	0	62	Packer testing, COBL	
DH09-04	345.6	95.8	Left abutment	September 4 – 7, 2009	150	60	0.0	86.0	Packer testing, COBL	Top 9.8 ft of borehole drilled in concrete
DH09-05	442.1	30.8	Right abutment on Blue Lake access road	Sept 25 – 26, 2009	n/a	90	10.0	20.8	SPT/split spoon, Packer testing	
DH09-06	450.9	71.4	Right abutment on Blue Lake access road	Sept 28 – 30, 2009	n/a	90	41.4	70.4	SPT/split spoon, Packer testing	
DH09-07	468.1	168.8	Right Abutment	Sept 21 – 25, 2009	050	60	4.0	1118.8	Packer testing, COBL	

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Borehole	Elevation (ft)	Length (ft)	Location	Date Drilled	Azimuth (deg)	Inclination (deg)	Depth in Overburden (ft)	Depth in Rock (ft)	Type of Down-hole Testing and Surveys	Remarks
DH09-08	155.2	81.0	Plunge Pool	Sept 3 – 6, 2009	n/a	90	21.2	59.8	SPT/split spoon; Packer testing	Vibrating wire piezometer installed at depth of 20.5 ft.
DH09-09	392.1	250.0	Intersection of intake tunnel and existing upper tunnel	Oct 2 – 5, 2009	095	60			Packer testing, COBL	
DH09-10	421.5	211.7	Intake tunnel at the intake gate	Sept 26 – 29, 2009	060	60	3.3	208.4	Packer testing, COBL	
DH09-11	484.6	170.8	Left Abutment	Sept 23 – 26, 2009	120	70	0.0	170.8	Packer testing, COBL	
DH09-12	413.1	120.7	Intake Area	Sept 30 – Oct 1, 2009	060	60	1.7	119.0	Packer testing, COBL	
DH09-13	317.3	57.9	Slope above the upper portal, lower tunnel (South River Portal)	Sept 17 – 20, 2009	n/a	90	17.9	40.0	Packer testing, COBL	Vibrating wire piezometer installed at depth of 57.3 ft
DH09-14	479.5	301.0	Surge Chamber	Sept 7 – 13, 2009	025	80	2.0	299.0	Packer testing, COBL	
DH09-15	28.6	30.7	Powerhouse Site	Oct 1 – 2, 2009	n/a	90	7.7	23.0	Packer testing,	

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HQ-3-sized (2.4 in. diameter) drill core was produced by the three core rigs. The triple tube method was used in order to minimize the disturbance to the drill core during drilling. The drill was advanced through the overburden to bedrock using a NWT Casing Advancer. Near the bedrock contact, the holes were drilled using the diamond bit and casing was advanced after each run was drilled. Standard penetration tests (SPTs) and collection of split spoon samples were attempted where deemed possible in Boreholes DH09-06 and DH09-08. In DH09-06, continuous SPT/split spoon sampling was undertaken in the top 5 ft and subsequently attempted at 5-ft intervals until bedrock was hit at a depth of 41.7 ft. In DH09-08, the drill advanced through 21 ft of overburden materials prior to hitting bedrock; however, only the top two split spoon samples were attempted due to two large boulders, which took up most of the drill length in the overburden within these materials.

The boreholes were oriented using the Crux Oriented Borehole Logging (COBL) system to provide a continuous detailed and oriented color image of the borehole wall using a OBI 40 slimhole optical televiewer. This system was used to obtain the azimuth and dip of the boreholes as well as the orientation of planar geological features, including bedding or discontinuities that intersect the borehole. The orientations of the geological features obtained from the COBL System were compiled on the discontinuity logs as described below. Based on the downhole measurements obtained using the COBL system, the deviations from the target azimuths and inclinations for each borehole were found to be within +/-5 degrees and +/- 2.5 degrees, respectively.

Drill core was logged at the Project site between September 1 and October 9, 2009. Two sets of drill logs were prepared; a lithological log and a discontinuity log. The lithological logs of the bedrock included the following information.

- Elevation/depth of interval;
- Bedrock description, including lithology, alteration, and general discontinuity orientations, field estimates of the uniaxial compressive strength (UCS), and results of laboratory analyses of core samples, including point load tests and UCS tests;
- Results of permeability testing;
- Core recovery (%) for each core run;
- Rock Quality Designation (RQD) (%) for each core run (determined by summing up the lengths of core greater than 10 cm long within a drill run and presenting this total as a percentage of the length of the drill run); and
- Estimate of the Geological Strength Index (GSI) based visual inspection of the core, in accordance with Hoek and Marinos (2000).

The discontinuity logs included detailed data on each discontinuity in the bedrock including:

- Depth;
- Angle to core axis;
- Dip and dip direction (from COBL system);

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- Type (i.e. joint, vein, or bedding);
- Roughness;
- Shape;
- Infilling;
- Weathering; and
- Alteration.

In addition, for boreholes DH09-09, DH09-10, DH09-12, DH09-13, and DH09-14, which were drilled in the vicinity of either existing or proposed underground structures, the rockmass rating (RMR) (Bieniawski 1989) was estimated for each core run to classify the rock mass.

Appendix E includes the lithological and discontinuity logs for all of the boreholes, as well as the COBL images showing the oriented wrapped and unwrapped view of the borehole, along with all dip/dip direction notations for the identified geological features. In addition, for Boreholes DH09-09, DH09-10, DH09-12, DH09-13, and DH09-14, tables are provided showing the data used to calculate the RMR values for each core run as well as plots of the RMR vs. depth. Core photographs are provided in **Appendix F**.

To estimate the hydraulic conductivity of the overburden materials, three falling head tests were undertaken within the overburden materials in DH09-06. The falling head test was carried out by filling the casing with water and measuring the change in water level in the casing over a period of ten minutes. The results are provided in **Appendix G**.

Permeability in rock was measured using the 5-stage Lugeon test procedure. In a given test, water was injected at a pressure on the order of approximately 0.5 psi/ft of depth at 1/3, 2/3, full, 2/3, and 1/3 of full pressure at a constant rate for a minimum of 5 minutes per stage until the flow rates stabilized. A double packer system was utilized to carry out the tests, except for tests carried out at the bottom of the borehole where a single packer system was utilized. For the boreholes in the vicinity of the arch dam and the South River Portal, the test were carried out over the entire length of the borehole at an interval of approximately 10 ft. For the remaining boreholes, the tests were carried out over approximately 20 ft intervals. For the longer boreholes, including DH09-09, DH09-10 and DH09-14, representative sections of the boreholes were tested as described in Section 4. In areas where the cover was limited and low maximum pressures had to be utilized (i.e. 10 psi or less) a five-stage Lugeon test was not possible and the tests were carried out in 3 stages (½, full, ½), or even 1 stage (full). The bedrock permeability test results are provided in **Appendix G**.

Water levels were measured at each borehole, using a water level probe. The measurements were typically obtained prior to each drilling shift to allow the water levels to settle overnight and obtain results that were more representative of the actual static water levels. However, due to the generally low permeability of the rock, in most cases, these water levels are likely a measurement of the depth to residual drill water and therefore often do not represent the static water levels in the rockmass. These measured water levels are provided on the notes page of each borehole logs (**Appendix E**) and included in the permeability test results for each hole provided in **Appendix G**.

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3.8 Piezometer Installation

Two vibrating wire piezometers supplied by RST Instruments were installed, one each in Boreholes DH09-08 (Model VW2100-2.0; range of 290 psi) and DH09-13 (Model VW-2100.1.0; range of 145 psi).

Both piezometers were installed using the fully grouted method where the piezometer was lowered to the desired depth in each borehole by attaching the piezometer to the rigid tremie pipe, which was left in the borehole. In DH09-13, the bottom of the piezometer tip was installed at depth of 57.3 ft. The borehole was backfilled, using the procedure recommended by the supplier, which involves backfilling the hole with a grout mix with an approximately water-cement-bentonite ratio (by weight) of 2.7:1.0:0.3 (94 lbs of Type II Portland Cement, 30 gallons of water, and 25 lbs of bentonite).

At DH09-08, the casing was left in the hole to a depth of 20.5 ft. However, due to the high permeability of the alluvium and bedrock in the top 31 ft of this hole, the hole was backfilled with a thick grout mix to a depth of 26 ft. The remainder of the borehole was filled with the 2.7:1.0:0.3 grout mix.

3.9 Laboratory Analyses

3.9.1 Petrographic Analyses

Three representative core samples were submitted to Vancouver Petrographics Ltd., located in Langley, British Columbia, Canada, for thin section preparation and petrographic examination and classification based on the mineralogical composition using a polarizing microscope. The results of the petrographic analyses are described in Section 4.2.1.

3.9.2 Gradational Analyses

Selected samples, collected from drilling of DH09-06 and from the overburden materials in one of the test pits (TP-3) near the powerhouse site, were submitted for gradational analyses, including hydrometer determinations in accordance with ASTM D 422 to Hatch's geotechnical laboratory in Niagara Falls, Ontario, including hydrometer determinations. The materials were classified in accordance with the Unified Soil Classification System. The results are provided in **Appendix H** and summarized in Section 4.2.3 and 4.2.6.

3.9.3 Point Load and Uniaxial Compressive Strength Testing

Selected rock and concrete cores sampled for uniaxial compressive strength (UCS) and point load tests. The UCS tests were undertaken in accordance with ASTM D 2938 by Hatch's geotechnical laboratory in Niagara Falls. The point load tests were undertaken using a point load test machine in Hatch's Vancouver office in accordance with the procedures recommended by the International Society for Rock Mechanics (ISRM 1985).

The results are provided in **Appendix H** and summarized in Section 4.2.1.

3.9.4 Direct Shear Tests

The direct shear tests were undertaken on three rock core samples and three concrete core samples in accordance with ASTM D5607. Slices were cut from the cores by diamond saw. The diamond saw has a tendency to polish the surface of the slices, and this can result in erroneously low friction angle measurements. Thus, each saw cut surface was roughened by hand to expose the natural texture of the material, without producing a grooved, stepped or non-planar surface.

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The resultant slices were set in standard direct shear molds. A total of 4 series of tests were conducted on the following combinations:

- Rock on rock (1 series); and
- Concrete on rock (3 series).

Tests were conducted at 100 kPa (15 psi), 300 kPa (45 psi) and 600 kPa (90 psi) to cover the range of normal loads at the concrete/bedrock contact at the left abutment thrust block. Overall, a total of 12 individual direct shear tests were completed. Horizontal travel, vertical dilation, and shear force data were automatically data logged during the shear test, which was run starting from 0 mm/minute to a final rate of up to 0.25 mm/minute. Results were corrected for any dilation/compression noted during the tests. Corrections were also made for increasing normal load as the test progressed, due to sample offset and the corresponding reducing contact area. All tests were conducted on wet core slices.

Results from the four series of tests are summarized in Section 4 and provided in **Appendix H**.

3.9.5 Acid-Generating Potential

Metal Leaching/Acid Rock Drainage (ML/ARD) assessments have been undertaken on six of the fifteen boreholes drilled during the September 2009 investigation program and a total of eight samples were tested:

- Two in the left abutment (DH09-03);
- Two near the intake (DH09-10 and DH09-12);
- One near the intersection of the new intake tunnel and existing tunnel (DH09-09);
- One at the proposed powerhouse (DH09-15); and
- Two at the surge chamber (DH09-14).

Samples were selected to represent the general rock conditions in each borehole, except in DH09-03 and DH09-14, where two composite samples were obtained from each hole. For each sample, small pieces, approximately 30 – 50 grams (1 – 2 oz) each of characteristic rock core were removed every five to fifteen feet in order to obtain a total sample size of approximately 2.5 – 5.0 lbs. Two samples were taken from DH09-14, the deepest hole in the drilling program, in order to accurately represent rock conditions for the entire length of the hole (301 ft). Two smaller (2.5 lbs) samples were taken in DH09-03 due to variations in rock conditions at depth.

Each sample test has included analysis of total sulphur and sulphate, as well as pH and major element analyses. Both neutralization potential and carbonate content were determined for each sample. Neutralization Potentials (NP) were determined using the standard Sobek et al. (1978) method. The NP calculated from carbonate content was converted to equivalent NP units (kg $CaCO^3$/tonne).

The Acid Potential for each sample (AP) was calculated from sulphide sulphur, which was estimated as the difference between total sulphur and sulphate sulphur. If sulphate sulphur was not detected it was assumed to be absent and AP was based on total sulphur.

The acid generating potential was predicted by calculating the NP/AP ratio and comparing with the Acid Base Accounting Screening Criteria provided in the "Draft Guidelines and Recommended Methods for

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Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (Price 1997). The laboratory test results are provided in **Appendix H** and summarized in Section 4.3.

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4. Results

The geotechnical parameters derived from the data discussed in this section are presented in the technical memoranda listed in Section 1.3. This report is limited to presenting the site investigation and test data.

4.1 Reservoir Rim Stability Assessment

The reservoir rim stability assessment was undertaken by R&M (2009) and provided in **Appendix A**.

The results of the study showed that the majority of the proposed new shoreline at el. 425 is either exposed bedrock or bedrock covered by a thin layer of overburden. The results of the reservoir rim assessment indicated that the slopes were generally stable and only a few minor shallow soil failures were observed. There was no evidence of thick medium to fine grained soil deposits that could become unstable when inundated. Following inundation of the reservoir, there is expected to be some erosion of overburden soils for several years, and localized soil failures may occur above the new high water elevation, but are not expected to be extensive.

There is also an extensive complex of talus slopes and fans at the south shore at the east end of the lake that will be inundated. The talus deposits are comprised of well drained coarse grained angular gravel, cobbles and boulders, and therefore are expected to be stable.

Alluvial deposits occurring on generally level ground, upstream of the lake were inundated when the reservoir was originally constructed. Similar alluvial materials will be inundated with the proposed reservoir expansion. These materials are not a stability concern since they do not occur on steep slopes.

Normal reservoir operations lower the pool level at an approximate rate of 1 ft per day, which is sufficiently slow that the free draining soils are around the reservoir rim are not expected to be become unstable due to changes in the water level.

4.2 Site Geological Conditions

This section describes the geological conditions for the following areas:

- Proposed intake, intake tunnel, and existing Upper Tunnel (on surface and inside the tunnel);
- Arch dam area, including the left and right abutments and plunge pool;
- Slope above the upstream portal (South River Portal) of the Lower Tunnel and the dewatered tunnel between the South River Portal and STA 45+00;
- Surge chamber and tunnel construction adit and the Lower Tunnel between the downstream portal (Lower Portal) and approximately STA 16+00; and
- Proposed and existing powerhouse sites and penstock alignment.

As previously indicated, the site photographs are provided in **Appendix B**.

The borehole logs, including lithological logs, discontinuity logs, borehole images, and plots of the RMR with depth (for Boreholes DH09-09, DH09-10, DH09-12, DH09-13, DH09-14).

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Figures 3 to **12** display the site geology for the project area. **Figure 3** provides the geological plan for the intake, arch dam, and Upper Tunnel areas. **Figure 4** provides cross sections along a suspected buried valley/seepage path. **Figure 5** shows the detailed geological plan for the left and right abutments and the plunge pool. **Figure 6** provides the contour stereoplots of the discontinuity measurements collected during geological mapping and from the oriented discontinuities in the boreholes. **Figures 7** to **9** show sections along the boreholes in the left and right abutments of the arch dam. **Figure 10** shows the geological plan for the slope above the South River Portal of the Lower Tunnel. **Figure 11** shows the geological plan at the powerhouse site, and **Figure 12** shows a cross section along Seismic Line SL-3B at the powerhouse site.

4.2.1 General Bedrock Lithology, Structures and Rock Strength

As discussed in Section 2 and on **Figure 2**, there are two differentiated geological units of the Kelp Bay Group (Haeussler, et al. 2004) occurring within the Project area. The bedrock in the upstream portion of the project area extending from Blue Lake to approximately STA 50+00 on the tunnel alignment (near the South River Portal) is described by the USGS (Loney et al. 1964) as a "greenstone, greywacke, greenschist, metachert, and phyllite and referred to as a "graywacke" in this report. From 50+00 to approximately STA 22+00 along the lower the lower tunnel alignment, the bedrock is comprised of the greenstone described in Section 2. Below this point and extending down to the powerhouse site, the bedrock grades back into the graywacke unit.

Three variations of the graywacke were noted in the drill core obtained from the Project area. The petrographic descriptions for each are provided by Vancouver Petrographics Ltd (2009) and are based on a microscopic analysis of thin sections cut from each rock sample as described in **Appendix H**. One sample (R1-PL), obtained from the left abutment of the arch dam from Borehole DH09-04, is described as a metamorphosed carbonaceous andesitic siltstone/mudstone. The dominant mineral is plagioclase feldspar, and there are numerous veins and veinlets containing primarily calcite, quartz, potassium feldspar and chlorite with some pyrite occurring in a few of the veinlets. There are also lenses or irregular patches of carbonate opaques (as seen in thin section) up to less than 0.25 in size.

A second sample, R3-PL, obtained the borehole at the surge chamber site (DH09-14), is described as a metamorphosed bedded andesitic siltstone. This sample contained two main sedimentary zones: a coarser andesitic siltstone dominated by plagioclase feldspar with lesser biotite, and quartz fragments; and a finer, carbonaceous andesitic siltstone/mudstone with a similar mineralogical composition as the coarse andesitic siltstone, with graded beds.

Sample R5-PL is described as a metamorphosed fragmental andesitic siltstone and was obtained from Borehole DH09-02, which was drilled into the left abutment of the dam. This sample contains fragments, 0.5 to 5 mm in size, of coarser grained siltstone in a groundmass of finer grained siltstones/mudstone. The dominant mineral is plagioclase feldspar with much less abundant biotite, sericite and quartz.

The petrographic description of metamorphosed andesitic siltstone is consistent with the USGS nomenclature (graywacke, etc.) used to describe this unit. As a result, the USGS nomenclature will be used in the text and the figures, but the petrographic descriptions will be used on the borehole logs shown in Appendix E.

The greenstone does not occur within any of the areas where new structures for the Project will be constructed, and therefore none of the boreholes intersected this unit. As a result rock samples of the

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greenstone were not submitted for petrographic analyses. The mineralogy of the greenstone is described by the USBR (1954) as a 7000-ft thick unit, likely of volcanic origin (andesite) with no visible bedding planes. The greenstone is very hard and dense in unweathered exposures and weathered surfaces are light gray in color.

Geological mapping was undertaken throughout the Project area, in particular, at the base of the dam and within the plunge pool, the intake area, the slope above the South River Portal, and in the vicinity of the surge chamber and powerhouse areas. The geological mapping included collecting detailed discontinuity data from selected outcrops within the area. Detailed data were collected for a total of 479 discontinuities from surface bedrock exposures throughout the project area. An additional 394 discontinuities were obtained from all of the boreholes except for DH09-05, DH09-06, DH09-08 and DH09-15 using the COBL system.

In general, the jointing is consistent throughout the entire Project area. **Figure 6** shows two stereoplots: one for the entire Project area and the other for the arch dam site. As shown on **Figure 6** and **Table 4.1**, there are three main discontinuity sets. This table also displays the discontinuity characteristics for each joint set.

Table 4.1 Summary of Discontinuity Sets

Discontinuity Set	Surface	Shape	Spacing	Persistence (ft)	Weathering	Orientation (Dip/Dip Direction
1	Smooth to rough	planar	0.7 – 2	3 - >30	Slight	87/300
2	Smooth to rough	planar	0.7 – 2	3 - >30	Slight	72/214
3	Smooth	planar	2 – 6	3 - >30	Slight	33/322

Discontinuity Set 1 is parallel to the channel walls at the arch dam and forms the steep exposures in the cliff above the Lower Portal. Set 2 is parallel to bedding. Joint Set 3 and it is particular evident at the dam site. Elsewhere in the Project area, Set 3 is less well defined than Sets 1 and 2.

In general, the discontinuity Sets 1 and 2 have planar shape, have a smooth to rough surface, spacing of 0.7 to 2 ft, and are slightly weathered. The joints in Set 3 are more widely spaced and have a smoother surface than is the case for Sets 1 and 2. The range of the joint roughness coefficient (JRC) for Sets 1 and 2 is estimated to be between 5 and 10. Since the discontinuity surfaces for Set 3 are generally smoother the JRC range is estimated to be between 5 and 8. The persistence of jointing in the Project area, typically, is between 10 ft and 30 ft; however, individual joints in the abutments of the arch dam and other steep exposures were observed to persist for more than 50 – 60 ft. Most of the joints are tight and unfilled; however, there are a few open joints associated with Sets 1 and 3.

Point load testing was undertaken on a total of 21 samples (**Appendix H**) collected from bedrock exposed in surface outcrops and the Upper and Lower Tunnel walls with 16 of these samples from the graywacke, 4 from the greenstone, and 1 from an altered seam of the graywacke from within the Lower Tunnel near the South River Portal. Point load tests were also undertaken on an additional 15 samples of

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drill core, all from the Kelp Bay Group graywacke. Based on results of the point load testing on the graywacke, the UCS varied from 41 MPa (6000 psi) to 236 MPa (34,000 psi) with a mean value of approximately 120 MPa (17,500 psi). The point load test results on the four greenstone samples indicated a UCS range from 79 MPa (11,500 psi) and 200 MPa (30,000 psi) with a mean value of 127 MPa. Since none of the boreholes intersected the greenstone, core samples of this unit were not obtained.

A total of eight samples obtained from drill cores of the graywacke were submitted for UCS testing and the results are provided in **Appendix H**. The UCS ranged from 69 MPa (10,000 psi) to 198 MPa (28,700 psi) with the mean UCS being 117 MPa (17,000 psi).

4.2.2 Arch Dam Area

Figure 5 displays the geological plan for the arch dam area, and **Figure 6** displays the stereoplots for the discontinuities measured from surface outcrops and from downhole measurements using the COBL system. As indicated by the contour stereoplot, Discontinuity Sets 1 – 3 are well defined at the arch dam. **Photo 1** displays the base of the arch dam.

Plunge Pool

During the geotechnical investigations carried out in 1952-53, a narrow debris-filled stream channel was identified under the centre of the arch dam. The presence of this feature was identified from drilling Boreholes DH-3, DH-4, DH-12, and DH-13. The feature was estimated to be approximately 45 ft deep and 30 – 45 ft wide. This feature is thought to be associated with a fault mapped by the USBR (1954). During construction, the debris was removed from this channel and a base plug was cast from el. 140 to el. 210. The base plug was shored up by a temporary timber crib construction at the downstream side. Construction photos indicate that the base plug was poured directly on alluvial material of up to 20 feet thickness to the top of the bedrock.

The material in the channel was interpreted by the USBR (1954) to be comprised of talus and alluvium and is described on the 1954 drill logs as primarily sand and gravel, although a layer of silt and fine sand was noted on the borehole log for DH-3. The USBR interpretation was that at one time the level of the stream was approximately 45 ft lower than at present time (prior to dam construction) and had been filled with boulders and gravel from the cliffs above and from stream deposits and surface runoff. Prior to the dewatering of the plunge pool in 2009, there had been dewaterings in 1968, 1983, and 1997. No evidence of seepage under the dam was observed during any of these dewaterings or throughout the operation of the dam. As result, given the depth of the channel, and the lack of measurable seepage under the dam, it is possible that there could be a remnant deposit of low-permeability glacial till that could not be eroded.

This channel is also present downstream of the dam in the plunge pool area **Photos 2** and **3**).

It should be noted that since the dam was constructed, based on the results of periodic dam safety inspections including several dewaterings and surveys of the plunge pool, there has been no evidence of significant seepage through the foundations. Nonetheless, information regarding the type and permeability of the debris material filling the stream channel and the permeability of the foundation rock below is required to carry out the engineering work associated with the dam raise.

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As described in Section 3, the plunge pool was dewatered in August 2009, to allow for geological mapping and surveying of the normally submerged portion. **Photos 4** and **5** display the upstream and downstream views of the dewatered plunge pool. Discontinuity Set 1 plays a major role in forming the plunge pool as joints from this discontinuity set form the narrow channel walls near the arch dam. As shown on **Figure 5** and **Photos 2** and **3**, there is an area with a closely spaced jointing at the southeast corner of the plunge pool. This zone is located along strike with the channel forming the plunge pool and extends under the dam centerline. The width of the plunge pool varies from 10 ft to 40 ft.

Figure 5 also shows the substrate for the plunge pool. The upstream portion is comprised primarily of angular boulders up to 5 ft in diameter. There is a very large boulder, approximately 10 – 12 ft in diameter shown in **Photo 4**, which appears to hold the other boulders in place. The substrate in the middle portion is comprised of cobbles and boulders, generally less than 2 ft in diameter. A 25 ft long section of bedrock is exposed near the exit portion of the pool (shown in **Photo 5**). The exit portion of the plunge pool is comprised of angular boulders 4 – 8 ft in diameter. Many of these boulders appear to be wedged in place and buried amongst the other boulders.

Borehole DH09-08 had initially been planned to be drilled through the debris at the base of the dam (shown on **Photo 1**) through approximately 60 ft of boulder fill material and another 60 ft into the bedrock. However, during late August 2009, the Sitka area experienced high rainfall and the Blue Lake levels were within 7 ft of spill. At this point, the City had determined that for safety reasons, any drilling activity at the base of the dam would have to be terminated once the lake levels were within 3 ft of spill. As a result, the borehole collar was moved to the top of the aforementioned large boulder (shown in **Photo 6**), to expedite the drilling of this borehole.

DH09-08 is a vertical borehole and extended to a depth of 81 ft from its collar (el 155) at the top of the large boulder. The borehole intersected 21.2 ft (el 134) of alluvium comprised primarily of boulders and some cobbles. A constant head test was attempted at a depth of 12.3 ft, but the permeability of the material was too high to allow the water pump being used to supply drill water to maintain constant head.

The bedrock encountered in this borehole is the Kelp Bay Group graywacke, described on the drill logs (Appendix E) as a metamorphosed bedded to fragmental andesitic siltstone. Between depths of 21 ft and 36 ft (el 119), the RQD ranged from 30% to 62%. This correlated with a hydraulic conductivity of 192 Lugeons. The RQD values obtained for the remainder of the borehole were between 96% and 100% and the packer test results indicate that the bedrock below a depth of 31 ft has a low permeability. The average discontinuity spacing encountered in this borehole was between 1 and 3 ft. The joints are planar, smooth and slightly weathered. Most of the joints, except within the upper 10 ft of bedrock, are tight.

During drilling, it was noted that the water levels, measured in the borehole, corresponded to the gradually rising water levels in the plunge pool (due to infill from precipitation and runoff as described in TM-24), which were below el. 150 for the duration of the drilling and piezometer installation

A vibrating wire piezometer was installed in DH09-08, with the bottom of the tip set at a depth of 20.5 ft, immediately above the top of bedrock. The purpose of the piezometer was to intercept the highly permeable alluvium immediately above the bedrock. The piezometer readings were obtained between September 10 and October 31 and are provided in **Appendix I** and indicate that the piezometer is working properly and the readings are measuring the elevation of the plunge pool.

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Left Abutment

As shown in **Photos 7** and **8**, Discontinuity Sets 1 and 3 are prominent in the left abutment as Set 1 forms the channel walls and Set 3 forms the shallower joints that are also inclined into the channel. Set 2 is also visible in the left abutment. All of these joints may persist for up to 50 ft to 60 ft. It was also noted in the USBR Preliminary Geology Report, that there are three zones of closely spaced jointing on the left abutment, which were also noted during the geological mapping (**Figure 5**). **Photo 9** shows one of the zones located immediately downstream of the dam and **Photo 10** displays the zone immediately upstream of the dam. These zones are between 10 and 15 ft wide.

Four boreholes were drilled at the left abutment. DH09-04 (**Photo 11**) was inclined at 60 degrees, had an azimuth of 150 degrees, and was drilled through the concrete into the rock to a depth of 95.8 ft. The top 9.8 ft of this borehole passed through concrete. The concrete was in good condition and the concrete-bedrock contact was bonded. Three uniaxial compressive strength tests were undertaken and values of 34.6 MPa (5,022 psi), 42.7 MPa (6,197 psi) and 55.5 MPa (8,026 psi) were obtained. During final design phase, it may be desirable to obtain additional concrete core samples and undertake tensile strength tests (ASTM 3967) as well as elastic modulus testing (ASTM D 7012) on selected rock cores.

DH09-03 (**Photos 12** and **13**) was collared at the bedrock face at el. 385.6 approximately 40 ft above DH09-04. This hole was drilled to a depth of 62 ft into the rock face at an inclination of 30 deg and had an azimuth of 120 deg. Boreholes DH09-01 and DH09-02 were drilled from the top of the left abutment and (**Photo 14**) were carefully aligned to avoid hitting the rock anchors, which were installed 16 ft into the bedrock at the top of the abutment, and used to support the drilling platform for DH09-03. DH09-02 (**Photo 15**) was drilled to a depth of 118.5 ft, had an azimuth of 240 degrees and was inclined at 70 degrees. DH09-01 (**Photo 16**) was inclined at 70 degrees, had an azimuth of 305 degrees and was drilled to a depth of 84 ft.

Average RQDs of 90% to 97% were obtained for Boreholes DH09-01, DH09-02, DH09-03, and DH09-04 with the lower RQD zones generally being near the top of the bedrock. The bedrock in the left abutment is comprised of Kelp Bay Group graywacke (bedded, fragmental and carbonaceous andesitic siltstones). **Figures 7** and **8** show the sections along these boreholes, only a few high permeability (hydraulic conductivity greater than 10 Lugeons) zones were noted in the four boreholes. As shown in **Figure 7**, there is a high permeability zone (53 – 109 Lugeons) between El. 425 and 415, in DH09-02. There is also a high permeability zone (hydraulic conductivity of 90 to 126 Lugeons) at approximately the same elevation in DH09-01. In fact, since these holes were drilled at the same time by two separate drill rigs, it was noted that the two boreholes are connected and likely intersected the same zone. These zones are associated with numerous open joints in both holes. DH09-03 did not intersect any high permeability zones as the maximum hydraulic conductivity obtained from the packer testing was 4.5 Lugeons. DH09-4 intersected a zone with a hydraulic conductivity of 11 Lugeons to 16 Lugeons between depths of 64.5 m (el. 291) and 75.3 ft (el. 272) (**Figure 8**). Water levels were measured at a depth of approximately 37 ft in both DH09-01 and DH09-02. Due to the very low permeability of the rock below a depth of 39 ft, it is likely that these water levels are the measured depth of residual drill water in the boreholes rather than static water levels within the rockmass. For Boreholes DH09-03 (drilled into the rockface on the left abutment) and DH09-04 (drilled into the concrete on the left abutment parapet), the static water levels were assumed to be equivalent to the reservoir level.

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The overall GSI for the bedrock in the left abutment area is typically estimated as 65 – 70, indicative of a blocky structure (formed by three discontinuity sets) and good discontinuity surface conditions (rough surfaces, slight weathered, iron stained).

Based on the drilling results, the joint spacing in the left abutment area varies from 1 ft to 3 ft. The joints tend to be planar and smooth and are slightly weathered with iron staining on the discontinuity surfaces.

Right Abutment

In May and June, 2009, geological mapping was undertaken at the base of the channel walls between the base of the arch dam and the plunge pool at both the left and right abutments as well as from exposed outcrops, above el. 440, on the left abutment. Discontinuity data were collected from exposed outcrops on the left and right abutments. In addition, there is an adit (**Photo 17**) with an entrance located approximately 135 ft downstream of the right abutment of the dam. Discontinuity data were also collected from the walls of this adit which extends 60 ft upstream before hitting a concrete plug. Prior to the installation of the plug, this adit served as a diversion tunnel during the construction of the dam. The dimensions of the adit vary from 10.8 ft wide by 7.6 ft high near the entrance to 6.2 ft wide by 2.6 ft high at the concrete plug. The upstream portion of the adit is infilled with coarse sediment (**Photo 18**). The ground water conditions in the adit were "damp" to "dripping" except for the downstream section extending approximately 10 ft upstream from the adit entrance, which was dry.

As shown on **Figure 5**, there is a 10-ft wide closely spaced joint zone on the right abutment, immediately downstream of the dam.

The presence of the three aforementioned major joint sets was confirmed during the geological mapping (see **Figure 5**). Sets 1 and 3, in particular, were noted to contain highly persistent joints (up to 50 - 60 ft in length) (Set 3 shown in **Photo 17**) and are exposed in the right abutment.

Boreholes DH09-07 and DH09-11 were drilled from the top of the right abutment. The average RQD for these boreholes was between 95 and 98%. The bedrock exposed in the right abutment is comprised of the graywacke (fragmental andesitic siltstone). In DH09-07, a 2-ft wide andesite dyke was intersected at a depth of 91.4 ft (el. 388.9 ft). In DH09-11, a carbonaceous andesitic siltstone is interlayered with the fragmental andesitic siltstone between depths of 65.8 ft (el 427) and 81.9 ft (el. 413.1). The carbonaceous layer is intruded by an andesite dyke between depths of 72.5 ft (el, 421.3) and 76.6 ft (el. 427.8). Discontinuity spacing in these boreholes averaged between 1 and 4 ft and the discontinuities were predominantly smooth and planar. The discontinuity surfaces were slightly weathered and iron-stained. The overall GSI for the bedrock in right abutment area is estimated to be 65 – 70, indicative of a block structure and good discontinuity surface conditions.

The results of packer testing indicate that most of the rockmass drilled by the two boreholes is tight. However, Boreholes DH09-07 and DH09-11 each intersected an interconnected higher permeability zone (**Figures 7** and **9**). As shown in **Figure 9**, in DH09-07, a zone with a hydraulic conductivity of 11.7 Lugeons was intersected at a depth of 77.2 ft (el. 401 ft) and DH09-11 intersected a zone with a hydraulic conductivity of 23 Lugeons at a depth of 54.5 ft (el. 436.9 ft). These zones were noted to be interconnected as water exited DH09-07 while this interval was being tested. Both of these zones are each associated with two or three open joints as shown on **Figures 7** and **9**.

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4.2.3 Intake and Intake Tunnel Area

The current intake is located in the lake at el. 210 below a slope comprised of colluvium and/or reworked glacial till overlying bedrock. The City has commented that debris from this slope accumulates in the lake in front of the intake gate. The existing access road switchbacks from DH09-06 across the base of this slope down to the lakeshore.

A new water intake structure will be constructed for the Project and is expected to be located between the existing intake and the dam at an elevation below the existing high water elevation (el 342). This location is expected to minimize, if not eliminate, the amount of slope debris collecting in front of the new intake and allow for the removal of the material that does collect on the racks to be more easily removed. The preferred design includes a downward sloping intake tunnel with an intake gate shaft located about 100 feet downstream of a submerged trashrack structure. The intersection between the two tunnels is dependent upon the gradient of the decline intake tunnel. At the time of the drilling, gradients of 55% and 17% were under consideration, however, after drilling was completed, the alternative with the 17% gradient was recommended as the preferred alternative for final design and is the one shown on **Figure 3**.

Figure 3 displays the results of geological mapping in the vicinity of the intake and intake tunnel area. As indicated in Section 3, the entire Upper Tunnel was inspected in May 2009. The results are presented in **Appendix C** (Tunnel Inspection Memo). Generally, with the exception of a few lined sections, which are inferred to correlate with zones of broken rock associated with faulting or shearing, the rock is strong to very strong and of "good" to "very good" quality. Most of the existing tunnel is unsupported. In the Upper Tunnel, the ground water conditions were "wet" to "dripping" with minor "dry" areas. The RMR for the unlined sections of the Upper Tunnel was estimated to be greater than 65, indicative of "good" to very good' rock.

Geological mapping was focused in the vicinity of the new intake site, the intake gate shaft site and the tunnel intersection. The graywacke is exposed in the vicinity of the intake as shown in **Photo 20**. There are several closely spaced joint zones in the intake area ranging in width from 6 to 30 ft wide (**Figure 3**). These zones are generally parallel to bedding and steeply inclined to the southwest and could potentially intersect of the potential intake tunnel alignments. In addition, **Figure 3** shows the aforementioned concrete lined sections along the tunnel that are inferred to correspond with zones of weaker, closely jointed and/or sheared rock, including a tunnel section immediately upstream of the North River Portal (e.g. outlet portal of Upper Tunnel shown in **Photo 21**). The rock in this section appears to be slightly weathered with some open jointing at the surface.

To obtain an indication of the bedrock quality in the vicinity of the intake, Borehole DH09-10 was drilled in the vicinity of the proposed intake gate shaft, and Borehole DH09-12 was drilled to target the general intake area. DH09-12 had an azimuth of 060 degrees, was inclined at 60 degrees and drilled to a depth of 120 ft. The top 5.9 feet passed through overburden materials, which were not sampled. The borehole intersected "Fair" rock with RMR values of 40 to 60, to a depth of 20 ft. The remainder of the borehole passed through "good rock" with RMR values generally between 60 and 70. The graywacke unit encountered in this borehole is comprised of interlayered carbonaceous and fragmental variations of andesitic siltstone. The rockmass generally has a very low permeability (less than 1 Lugeon), the exception being between depths of 21.5 and 42.1 ft and at the bottom of the hole below a depth of 96.5 ft (el. 330), where the rock is of low permeability (9.5 Lugeons and 17.4 Lugeons, respectively). The water level in the borehole was measured at a depth of 40 ft. Although there are some open joints at the bottom of the hole, the Blue Lake water level at the time of drilling would have been higher than the

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elevation of the top of the open joint zone (el 330) and it is therefore likely that the measured water level may have been the depth of residual drill water. The rock is tight between the two sets of open joints. The average discontinuity spacing in DH09-12 was approximately 1 ft. Generally, the discontinuity surfaces have a planar shape and smooth surface and are iron-stained, and the GSI is estimated to be 60 – 65, indicative of a blocky structure and good discontinuity surface conditions.

DH09-10 was drilled to a depth of 210 ft to provide information on the rock conditions for a steeply-inclined intake tunnel option (gradient of 55%) as opposed to the 900-ft long intake tunnel (gradient of a maximum of 17%) currently shown on the drawings. This borehole had an azimuth of 060 degrees and was inclined at 60 degrees. The variation of the graywacke encountered in this borehole is a fine grained to coarser grained fragmental andesitic siltstone. Generally "good" to "very good" rock conditions were encountered in this borehole (RMR ranges from 60 to over 86). Based on the results of permeability testing of representative sections of the borehole, the bedrock in this location was found to be tight. The water level in the borehole was measured at a depth of 26.8 ft, but given the impermeability of the rock, this is likely the measured depth of residual drill water. A GSI of 60 – 65 is estimated for the top 60 ft of the borehole. The GSI of the rock intersected by the remainder of the borehole is estimated at 70 – 75, indicative of a blocky structure and good to very good (very rough, fresh, unweathered surfaces).

Based on the results of drilling Boreholes DH-14 through DH-17 (see **Figure 3**); the USBR suggested that a buried valley, parallel to Sawmill Creek and up to 60 ft deep, underlies the upper portion of the current access road to Blue Lake.

A review of the USBR drill logs shows the top of the bedrock to be at el. 430 at DH-17 and as low as el. 400 ft at DH-15. The issue of whether this buried valley could become a seepage path if Blue Lake were raised required investigation. This is due to the fact that estimated bedrock elevations (by USBR) in this area were based on the topographic survey data obtained the 1950s, which was undertaken using a local grid rather than State Plane coordinates. As a result, there was some uncertainty of the subsurface bedrock elevations in this area. From the USBR drill logs, the overburden materials are described as glacial till with rock fragments, sand and clay; boulders; gravel; and clay. The results of percolation tests indicated that there was no water loss. Boreholes DH09-05 and DH09-06 were drilled in the vicinity of this potential buried depression, and seismic refraction surveys were undertaken along lines SL-1A, SL-1B and SL-2 to validate the USBR results and interpretation regarding the type, depth and permeability of the subsurface materials. The boreholes were drilled in close proximity to the seismic lines to corroborate the bedrock depths obtained from the seismic refraction survey.

Seismic lines SL-1A and SL-1B were installed over top of the suspected buried channel oriented subparallel to Sawmill Creek. SL-2 was established perpendicular to SL-1A and SL-1B through a topographic low point where a possible seepage path could potentially turn towards the southeast. The results of the seismic refraction survey are described by MACTEC (2009) and provided in **Appendix D**. Based on the results of the seismic refraction survey, the possible depth to bedrock varied from up to 66 ft at the north end of SL-1B in the vicinity of the unstable slope to just below the ground surface at the south end of SL-1A. At SL-2, the survey results indicate that depth to bedrock varies from 13 ft on the slope on the west side of the road to 46 ft at the east end of SL-2, on the cliff face above Sawmill Creek.

Borehole DH09-06 was drilled on the access road immediately above the slope heading down towards the reservoir. This borehole was a vertical borehole and extended to a depth of 71.4 ft. The overburden materials are comprised of a silty sand, sandy silty clay, or silty sand with gravel and extend to a depth of

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41 ft. All of the SPTs attempted below a depth of 15 ft hit refusal (50 blows) after advancing less than 2 ft - likely due to the presence of boulders in the overburden materials. The three falling head tests undertaken at depths of 10.2 ft, 20.2 ft, and 40.2 ft had corresponding hydraulic conductivities of 5.9 x 10^{-9} ft/s, 2.3 x 10^{-8} ft/s, and 7.4 x 10-^{9} ft/s, respectively, indicating that permeability of this material is very low RQDs of 100% were obtained for the entire section (30 ft long) of this hole drilled in bedrock, comprised of Kelp Bay Group graywacke (andesitic siltstone) indicating excellent quality rock. Based on the low number of discontinuities intersected by this borehole, the discontinuity spacing is considered to be wide. The GSI was estimated to be between 65 and 70. The results of the packer testing indicate that the bedrock is tight as there was no take from any of the packer tests carried out in this borehole. As a result of the very low permeability of the bedrock, a static water level could not be determined.

As shown on **Figure 3**, Borehole DH09-05 was drilled near the intersection of the Seismic Lines SL-1 and SL-2, approximately 20 ft south of SL-2. This borehole also had a vertical inclination. Bedrock in this borehole was encountered at a depth of 10.0 ft. However, it should be noted that these channels are quite narrow and the borehole may have missed the deepest point of the buried channel. The results of drilling indicate that the overburden materials are comprised primarily of gravel and boulders. The quality of the Kelp Bay Group graywacke (bedded to fragmental andesitic siltstone) is excellent, based on RQD values of 100% between for nearly the entire section of the borehole drilled within the rock. The discontinuities are widely spaced and are iron-stained and the GSI is estimated at 65 – 70. The results of packer testing at this location indicate that the bedrock is tight. Due to the very low permeability of the rock, a static water level could not accurately be determined.

Figure 4 displays sections along seismic lines SL-1A and SL-1B and SL-2. The bedrock surface was estimated based on the data from the boreholes and seismic refraction surveys. As indicated on **Figure 4**, and concluded by MACTEC (2009), given the presence of large, angular boulders, the top of the bedrock surface has been interpreted to correspond to a seismic velocity of 10,000 ft/s. These results indicated that the original USBR interpretation regarding the presence of a buried valley is reasonable.

DH09-09 was drilled near the intersection of the intake tunnel and existing tunnel approximately 1000 ft downstream of the intake. DH09-09 was drilled targeting el. 175 ft (the elevation of the tunnel intersection). The borehole azimuth was orientated in the direction of the tunnel alignment at this location. The rock is classified as "fair" in the top 15 ft of this borehole, with an RMR ranging from 41 to 56. The RMR generally improves with depth with values from 64 to 80 between 15 ft and 55 ft. Throughout the remainder of the borehole, the RMR varies from 70 to over 80, indicative of "very good" rock conditions. Permeability testing was undertaken on the bottom 100 ft of the borehole and, based on the results of packer testing; the permeability is very low (less than 0.1 Lugeons). Due to the low permeability of the rock at depth, the static water level could not be determined.

4.2.4 Lower Tunnel – South River Portal Area

The penstock crosses Sawmill Creek immediately downstream of the Fish Valve Unit (**Figure 10**, **Photo 22**).

The surficial materials on the slope above the South River Portal are comprised of a thin layer of colluvium, likely less than 10 ft thick, overlying bedrock (**Figure 10**). The exception is where there are talus piles possibly at least 20 ft thick (**Photos 23** and **24**) below steep bedrock exposures (**Photo 25**). There are several locations where structural lineaments initially identified on the orthophotos were examined in the field and steep, narrow gulleys or steep rock outcrops were noted in these areas. Deposits of talus and boulders were also noted to be infilling narrow gulleys. During the mapping of this

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slope, seepage was noted to be daylighting at its base between el. 220 and el. 200, however, it could not be determined whether the source of this seepage is from runoff percolating down slope through the colluvium from the top of the ridge, or from groundwater.

The portion of Upper Tunnel between the South River Portal and approximately STA 45+00 was inspected in May, 2009. As previously indicated, the results of the inspection are provided in **Appendix C**. The RMR for the unlined sections of the Lower Tunnel was estimated to be greater than 75, indicative of "good" to "very good" rock conditions. The groundwater conditions encountered were "dry" to "damp" with minor dripping areas.

The upstream contact between the greenstone and graywacke is gradational, and occurs approximately at STA 50+00.

At both the Lower and South River portals of the Lower Tunnel, an adequate cover is required to avoid the requirement for a steel liner, as described in TM-2. While the rock mass in the tunnel at the South River Portal does appear quite competent with no indications of high in-situ permeability, the amount of surficial weathering and the characteristics of the rock mass over its entire thickness were not known. As a matter of sound engineering practice, given that the internal pressure in the tunnel will increase when the reservoir level is raised, specific investigations were undertaken to verify that adequate competent rock cover exists. Borehole DH09-13 was drilled in the location shown in **Figure 10**. To obtain information regarding the groundwater levels on this slope, to obtain a further indication of the permeability of the rock, and to determine whether there is any correlation between Blue Lake level and the groundwater level, a vibrating wire piezometer was installed in this borehole.

Borehole DH09-13 is a 57.9 ft long vertical borehole collared at el. 317 on the slope immediately over the tunnel alignment. The top 17.9 ft of the borehole intersected a layer of overburden materials comprised of boulders, rock fragments and sand. The remainder of the borehole intersects the bedrock with average discontinuity spacing (as encountered within the borehole) of 2.5 ft. The discontinuities encountered in this borehole are primarily smooth and planar with iron staining on the discontinuity surfaces. The RMR varies from 60 to 76 for most of this borehole, indicative of "Good" rock conditions. The permeability of the bedrock was less than 10 Lugeons. The static water level was measured at a depth of 23.5 ft.

A vibrating wire piezometer was installed in this borehole at depth of 57.4 ft. The initial readings (September 20 – October 31, 2009) for the piezometer are provided in **Appendix I** and indicate that the depth to the static water level over the piezometer varies from 21 ft (el. 296) to 25 ft (el. 292). The piezometer was installed using the fully grouted method described in Section 3.8 using an approximate water/cement/bentonite ratio (by weight) of 2.7:1.0:0.3. Over this same period, Blue Lake levels were within 10 feet of spillway crest el. 342.

4.2.5 Lower Tunnel – Surge Chamber Area

The surge chamber will be located to the left (east) of the existing tunnel as shown on **Figure 11**. The primary issue with the location of the surge chamber is the limited access to its top (helicopter requirement). The surge chamber would be located above a steep rock face (**Photo 26**).

The surficial materials on this slope include steep bedrock exposures and deposits of colluvium varying in thickness. On the bench where the surge chamber is to be located, there is very little exposed

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bedrock; however, the colluvium is generally less than 10 ft thick as small bedrock outcrops become exposed in locations where large trees have fallen over.

The exposed bedrock in this area is part of the Kelp Bay Group graywacke (andesitic siltstone) similar to the one mapped at the South River Portal area, at the North River Portal area, at the intake, and at the arch dam site. Mapping of the outcrops in the vicinity of the surge chamber locations indicate that Joint Sets 1 and 2 predominate here as well, and it should be noted that Joint Set 3 is less well-defined in this area. The results of the tunnel inspection in the portion of the Lower Tunnel between STA 4+32 and 21+00 indicate the fine unlined section are characterized by "good" to "very good" quality rock conditions with a rock mass rating generally above 75 and groundwater conditions generally "dry" to "damp" with minor dripping areas and no significant inflow at any location.

Borehole DH09-14 was drilled in the vicinity of the surge chamber to obtain an indication of the bedrock conditions to a depth of 300 ft in this location. The borehole azimuth was oriented at 030 degrees, parallel to the Lower Tunnel, and inclined at 80 degrees. Bedrock was encountered at a depth of 2.0 ft and the materials were not sampled. The rock type encountered in this borehole is a series of carbonaceous (top 15 ft) and bedded andesitic siltstones belonging to the graywacke unit of the Kelp Bay Group. The RMR values obtained for this borehole were between 40 and 60, indicative of "fair" rock, for the top 20 ft. For the remainder of the borehole were generally between 60 and 70, indicative of "good" rock. The results of packer testing in bedrock indicate that the rockmass in this location has a low permeability as the hydraulic conductivities ranging from 0 to 3.5 Lugeons were obtained.

4.2.6 Powerhouse Site

The site geology of the powerhouse area is shown on **Figure 11**. Bedrock is exposed at the existing lower tunnel portal (**Photo 27**) as well as the slope above the PMFU. Bedrock is also exposed on the downstream side of the timber crib wall (**Photos 28** and **29**) and on the other side of the water treatment plant (**Photo 30**) along the access road. Most of the overburden materials in the area are comprised of fill, except for the lower portion of the slope above the pulp mill feeder unit, which is covered with colluvium up to 20 ft thick.

A test pitting and seismic refraction survey program was carried out in this area. Borehole DH09-15 was drilled within the proposed new powerhouse footprint. A total of six test pits were excavated and seismic refraction testing was undertaken along seven seismic line segments as shown on **Figure 11**. The Test Pit Logs are provided in **Appendix E**. **Figure 12** shows a geological section oriented along Seismic Line SL-3B. This section was prepared using the data for the seismic refraction survey (**Appendix D**), the data from Borehole DH09-15 (**Photo 31**), and, to a lesser extent, Test Pits TP-1 and TP-2, which are offset from SL-3B. The depth to bedrock on the southern portion of the section is 10 ft or less. At approximate chainage 150 ft on the section, the bedrock appears to slope to the north, and there appears to be approximately over 40 ft of fill along the remainder of the section. The depths to bedrock in Test Pits TP-1 and TP-2 were 10.5 ft and 11.0 ft, respectively.

Bedrock was encountered in DH09-15 at a depth of 7.7 ft. The quality of the bedrock in this location is good to excellent with RQDs ranging from 80% to 100%. The average discontinuity spacing encountered within the borehole is 1 – 2 ft and discontinuities are primarily smooth and planar and slightly to moderately weathered. The results of the packer testing indicate the bedrock has a low permeability (less than 1 Lugeon).

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The overburden materials encountered in TP-1 are comprised of a brown layer angular to subrounded boulders, gravel and sand overlying a poorly consolidated layer of grey sand, gravel and boulders. In TP-2, the overburden materials are comprised of an unstratified layer of boulders and gravel with a silty sand matrix. For TP-3, the layer of unstratified rockfill extended to a depth of 14.0 ft where a layer of grey silty sand with gravel was encountered. Water entered the pit at a depth of 14 ft. The test pit was excavated to a depth of 16 ft and bedrock was not encountered. TP-4 was excavated near the PMFU, and two layers of unstratified rock fill are comprised of boulders, gravel and sand, ash and contain pieces of metal. The bottom of the pit extended to a depth of 18.0 ft; however, bedrock was not encountered. TP-5 was excavated near the intersection of SL-3A and SL-6 and bedrock, which is overlain by unstratified fill, was encountered at a depth of 7.5 ft. TP-6 was excavated along the access road to the PMFU, near the midpoint of SL-4A and the test pit was excavated through angular pieces of blast rock up to 3 ft in diameter. The top of bedrock was encountered at a depth of 5.5 ft.

The results of the seismic testing at the powerhouse site generally correlate with the results of the test pit excavation, the exception being within the vicinity of TP-5. In this area, the seismic test results indicate that the depth to bedrock is below 35 ft. However, the MACTEC report makes reference to interference with its readings in this area and also with the 30-ft gap in data caused by the background vibrations from the penstock. In addition, the seismic test results indicated that the depth to bedrock varies from 22 ft along the timber crib wall to over 35 ft at the west end of the line. This correlates with the data obtained from TP-4, at the timber crib wall, but not at TP-5, where the depth to bedrock was found to be 5.5 ft.

Along SL-4A and 4B, the depth to bedrock varied from 4 ft to 22 ft, which correlates somewhat with the results obtained from TP-5, which is offset by 20 ft. Along SL-5A, the depth to bedrock ranged from 19 to 22 ft and along SL-5B, the depth to bedrock is between 14 and 25 ft. The gap between SL-5A and SL-5B is a result of the background vibrations from the powerhouse and tailrace area causing interference leading to insufficient data for this area.

Depending on the development of the layout during final design, additional test pits may be required in order to obtain additional locations where the depth to bedrock is confirmed.

4.3 Laboratory Analyses

The results of petrographic analyses, gradational testing of overburden samples, and point load and UCS test on rock and concrete cores have been described previously in Section 4.2. As a result, this section covers the results of direct shear and acid generating potential tests.

4.3.1 Direct Shear Tests

Table 4.2 details the sections of core (three of concrete, and three of rock) from which slices were taken. A total of 4 series of tests were conducted on the following combinations:

- Rock on rock (1 series); and
- Concrete on rock (3 series).

Table 4.2 Prepared Samples Taken from Concrete and Bedrock Cores

Sample	Location	Type	Diameter	Area (cm^2)	Test

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			(cm)		
R-2	DH09-04, depth of 16.4 – 17.1 ft	Rock core – graywacke	6.08	29.1	Direct shear
R-6	DH09-01, Depth of 78.2 – 79.0 ft	Rock core – graywacke	6.08	29.1	Direct Shear, UCS
R-12	DH09-03, depth of 11.2 – 12.0 ft	Rock core – graywacke	6.08	29.1	Direct Shear,
C1	DH09-04, depth of 0.3 – 0.9 ft.	Concrete core	6.08	29.1	Direct Shear, UCS
C2	DH09-04, depth of 3.4 – 4.1 ft.	Concrete core	6.08	29.1	Direct Shear, UCS
C3	DH09-04, depth of 7.2 – 7.8 ft	Concrete core	6.08	29.1	Direct Shear, UCS

Tests were conducted at 100 kPa (15 psi), 300 kPa (45 psi) and 600 kPa (90 psi) to cover the range of normal loads at the concrete/bedrock contact at the proposed left abutment thrust block site. Overall, a total of 12 individual direct shear tests were completed. Horizontal travel, vertical dilation, and shear force data were automatically data logged during the shear test, which was run starting from 0 mm/minute to a final rate of up to 0.25 mm/minute. Results were corrected for any dilation/compression noted during the tests. Corrections were also made for increasing normal load as the test progressed, due to sample offset and the corresponding reducing contact area. All tests were conducted on wet core slices.

Results from the four series of tests are summarized in **Figures 13** and **14** and provided in **Appendix H**. Interpretations of the basic friction angles are given in **Table 4.3.**

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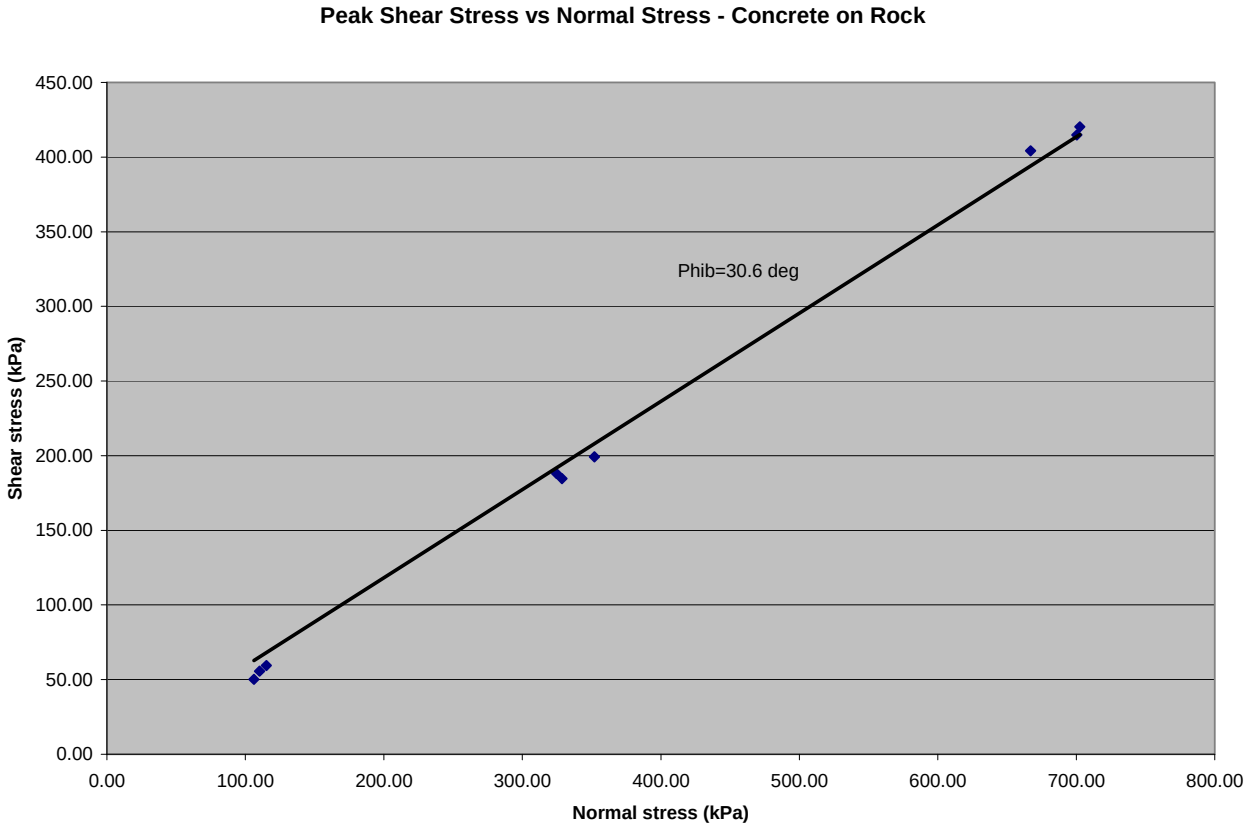

Figure 13 Basic Friction Angle – all concrete – rock series

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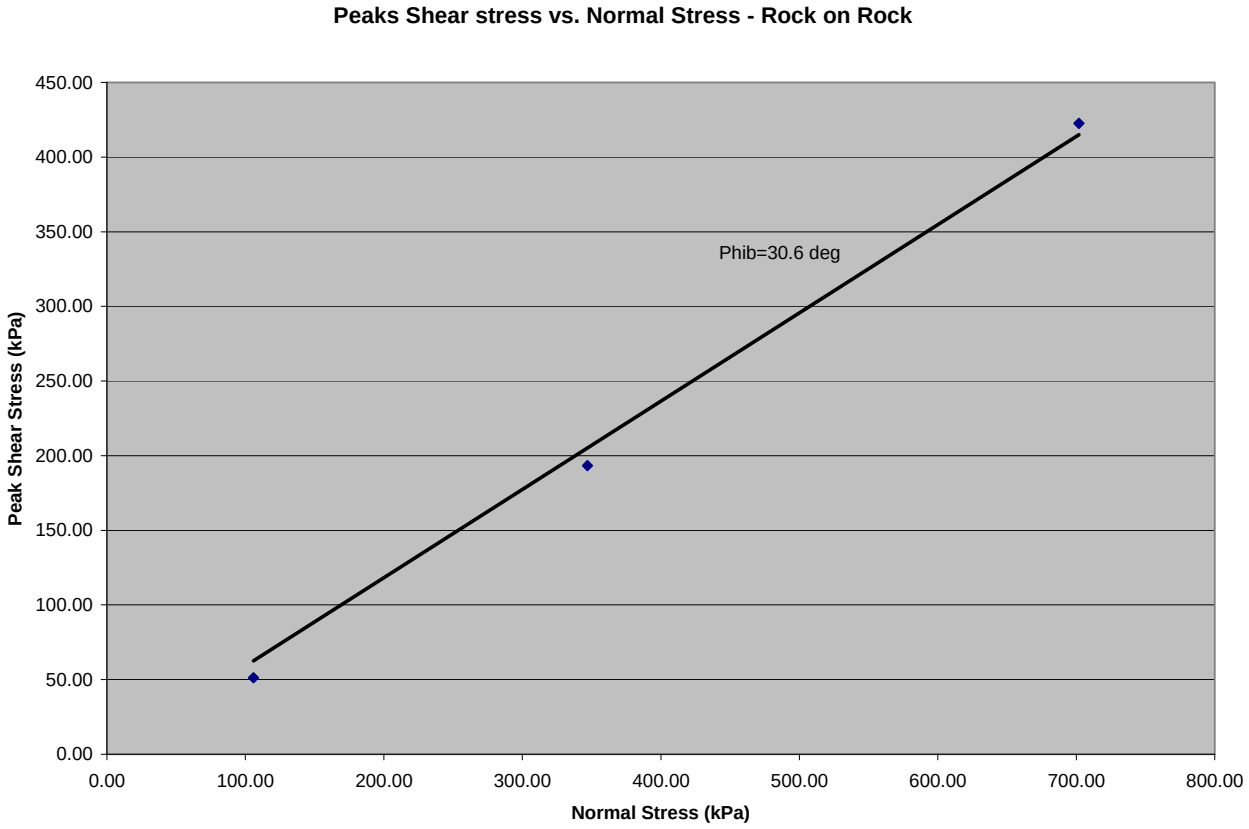

Figure 14 Basic Friction angle (rock – rock series)

Table 4.3 Results of Direct Shear Testing

Surface	Test Series	Basic Friction Angle (degrees)	Comments
Rock on rock	R6/R12	25.8 – 31.1	Higher angle at higher normal load.
Concrete on rock	C1/R2	27.3 – 30.9	Higher angle at higher normal load
Concrete on rock	C2/R6	26.8 – 30.6	Higher angle at higher normal load.
Concrete on rock	C3/R12	25.3 – 31.2	Higher angle at higher normal load; sample surfaces began to bind up then quickly release at a higher normal load.

Since the test results for each individual series tested displayed some variability, the peak shear stress was plotted against the normal stress for all of the concrete-concrete series, rock-to-rock series, and concrete to rock series, respectively, as shown in **Figures 13** and **14**. The base friction angles using this approach for both the rock-to-rock and concrete-to-rock surfaces 30.6 degrees.

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As result, a basic friction angle of 30 degrees is recommended. The total friction angle is the sum of the basic friction angle and the roughness component as described Technical Memorandum No. 25, which also recommends the total friction angle for the concrete-rock and the rock-rock surfaces.

4.3.2 Acid Generation Potential

Table 4.4 provides geochemical data obtained for 8 samples during the investigation. For complete petrographic analyses and descriptions of the rock, see Section 4.2.1.

Generally, NP/AP ratios below 1 indicate potential for ARD (PAG – potentially acid generating), whereas ratios above 2 indicate negligible potential for ARD (non-PAG). Ratios between 1 and 2 indicate uncertainty. At low sulfur concentrations, interpretation of ARD potential using NP/AP ratios is not meaningful because oxidation of small concentrations of sulfide produces low amounts of acid which are readily neutralized by many rock components in addition to carbonate. A sulfur concentration of 0.1% was selected to represent low sulfur concentrations. Below this level, rock was classified as non-PAG regardless of the NP/AP.

Table 4.5 provides a summary of the acid-generating potential for the 8 samples.

The results of the ABA testing, indicated that 7 samples had NP/AP ratios greater than 2, indicating negligible potential for acid generation and one sample had an NP/AP ratio of 1.5 indicating an uncertain potential due to a higher sulfide concentration than what is present in the other samples. Typically, graywacke unit contains some pyrite on joint surfaces; however, the pyrite was typically associated with quartz-carbonate veins, veinlets, and stockworks. The greywacke is primarily classified as non potentially-acid-generating. Nonetheless, the presence of pyrite mineralization shows that the spoil materials should be monitored for ARD potential in accordance with applicatory regulatory requirements.

Table 4.6 provides trace element quantities for each of the 8 samples. Typically significantly elevated concentrations of copper, lead zinc, arsenic and cadmium are often associated with potentially acid generating sites. Element scans completed on the samples indicated that these elements generally occur within or below the normal range of the typical global concentrations (Price, 1997).

Overall, potential for metal leaching and acid rock drainage is considered negligible to low for the Project. However, due to the observation of occasional presence of pyrite noted in the drill core, the City should develop a waste rock management plan to identify and if necessary, segregate any potentially acid generating rock exposed during excavation.

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Table 4.4 Geochemical Data for ARD samples for 8 Blue Lake Hydro (332360) samples - November 2009

Sample ID	Hole #	Hole Depth (ft)	Sample Length (ft)	General Location	Rock Type	Dry Sample Wt. (Kg)	Average Spacing of Pieces (ft)	Veining	Pyrite Content
ARD COMP-1	DH09-14 (0-150 ft)	301.0	150.0	Surge Chamber	Kelp Bay Group - Graywacke (metamorphosed bedded andesitic siltstone)	2.05	14.1	Quartz and calcite; veinlets throughout; stockwork veins	Disseminated grains on joint surfaces and in veins
ARD COMP-2	DH09-14 (150-301 ft)	301.0	151.0	Surge Chamber	Kelp Bay Group – Graywacke (metamorphosed bedded andesitic siltstone)	2.01	15.2	Quartz and calcite; veinlets throughout; stockwork veins	Disseminated grains on joint surfaces and in veins
ARD COMP-3	DH09-10	211.7	211.7	Intake	Kelp Bay Group – Graywacke (metamorphosed fragmental andesitic siltstone)	2.12	17.4	Calcite veinlets throughout; some wide Quartz bands	Iron staining, few disseminated grains
ARD COMP-4	DH09-15	30.7	30.7	Powerhouse	Kelp Bay Group – Graywacke (metamorphosed fragmental andesitic siltstone)	1.99	4.9	Calcite; veinlets throughout; 4 thick (5mm) veins at 14.7ft	Iron staining, very few disseminated grains
ARD COMP-5	DH09-12	120.7	120.7	Intake	Kelp Bay Group – Graywacke (metamorphosed fragmental andesitic siltstone)	1.60	12.2	Calcite; veinlets throughout; some wider veins at depth	Iron staining, few disseminated grains
ARD COMP-6	DH09-09	250.0	250.0	Tunnel Alignment	Kelp Bay Group – Graywacke (metamorphosed fragmental andesitic siltstone)	3.14	13.2	Calcite; veinlets throughout; occasional wider veins	Very little iron staining, very few disseminated grains
ARD COMP-7	DH09-03	62.0	38.0	Left Abutment	Kelp Bay Group –	1.17	3.0	Quartz and calcite;	Disseminated

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	(0-38 ft)				Graywacke (metamorphosed bedded andesitic siltstone)			veinlets throughout; occasional wide (8mm) carbonate veins	grains on joint surfaces and in veins
ARD COMP-8	DH09-03 (38-62 ft)	62.0	24.0	Left Abutment	Kelp Bay Group - Graywacke (metamorphosed carbonaceous andesitic siltstone)	1.00	5.5	Quartz and calcite; veinlets throughout; occasional wide (8mm) carbonate veins	Disseminated grains on joint surfaces and in veins

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Table 4.5 ABA Test Results for 8 Blue Lake Hydro (332360) samples - November 2009

Sample ID	Hole #	General Location	Total Sulfur	Sulfate Sulfur	Sulfide Sulfur*	Maximum Potential Acidity (AP)**	Neutralization Potential (NP)	Net Neutralization Potential (NNP)***	Fizz Rating	NP/AP
			(Wt.%)	(Wt.%)	(Wt.%)	(Kg $CaCO_3$/ Tonne)	(Kg $CaCO_3$/ Tonne)	(Kg $CaCO_3$/ Tonne)		
ARD COMP-1	DH09-14	Surge Chamber	0.19	0.01	0.18	5.6	22.4	16.8	Slight	4.0
ARD COMP-2	DH09-14	Surge Chamber	0.09	<0.01	0.09	2.8	20.8	18.0	Slight	7.4
ARD COMP-3	DH09-10	Intake	0.15	<0.01	0.15	4.7	67.5	62.8	Moderate	14.4
ARD COMP-4	DH09-15	Powerhouse	0.38	<0.01	0.38	11.9	105.0	93.1	Strong	8.8
ARD COMP-5	DH09-12	Intake	0.08	<0.01	0.08	2.5	30.3	27.8	Slight	12.1
ARD COMP-6	DH09-09	Tunnel Alignment	0.28	<0.01	0.28	8.8	145.0	136.3	Strong	16.6
ARD COMP-7	DH09-03	Left Abutment	0.10	<0.01	0.10	3.1	71.3	68.1	Moderate	22.8
ARD COMP-8	DH09-03	Left Abutment	0.50	<0.01	0.50	15.6	23.6	7.9	Slight	1.5
Detection Limits			*0.02*	*0.01*	*0.02*	*0.6*				

Calculations:

*Sulfide sulfur is based on difference between total sulfur and sulfate sulfur.

**MPA (Maximum Potential Acidity) is based on sulfide sulfur.

*** NNP (Net Neutralization Potential) is based on difference between Neutralization Potential (NP) and MPA.

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Table 4.6 Trace Metal Concentrations for Blue Lake Hydro (332360) samples - November 2009

S. No.	Sample ID	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Ni ppm	Co ppm	Mn ppm	Fe %
1	ARD COMP-1	4.0	33.5	4.2	104	<0.1	34.0	16.6	484	4.16
2	ARD COMP-2	3.1	26.8	3.4	102	<0.1	28.9	15.0	467	4.05
3	ARD COMP-3	3.5	54.7	1.6	93	<0.1	42.3	19.8	968	4.45
4	ARD COMP-4	4.1	39.8	4.5	85	<0.1	27.7	14.5	854	3.94
5	ARD COMP-5	4.3	54.2	2.0	92	<0.1	59.9	19.9	903	4.47
6	ARD COMP-6	2.3	73.1	1.2	112	<0.1	64.6	43.6	1221	6.32
7	ARD COMP-7	2.1	40.1	0.9	74	<0.1	21.6	15.1	761	3.89
8	ARD COMP-8	3.2	69.4	3.9	103	0.1	29.3	15.2	656	4.23
Typical Concentrations*		**2.6**	**45.0**	**20.0**	**95**	**0.07**	**68.0**	**19.0**	**850**	**4.72**

S. No.	Sample ID	As ppm	U ppm	Au ppb	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm
1	ARD COMP-1	3.9	0.5	<0.5	1.8	38	0.2	0.2	0.2	137
2	ARD COMP-2	11.1	0.5	0.8	1.8	51	0.1	0.1	0.1	121
3	ARD COMP-3	3.0	0.1	<0.5	0.4	27	<0.1	0.1	<0.1	99
4	ARD COMP-4	8.0	0.7	1.8	2.2	41	0.1	0.4	<0.1	121
5	ARD COMP-5	4.0	0.1	0.8	0.5	20	<0.1	<0.1	0.1	97
6	ARD COMP-6	19.5	<0.1	<0.5	0.1	46	<0.1	<0.1	<0.1	150
7	ARD COMP-7	0.8	<0.1	<0.5	0.3	27	<0.1	0.1	<0.1	87
8	ARD COMP-8	2.1	0.1	<0.5	0.3	105	<0.1	<0.1	0.2	123
Typical Concentrations*		**13.0**	**3.7**	**n/a**	**1.4**	**300**	**0.3**	**1.5**	**n/a**	**130**

S. No.	Sample ID	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %
1	ARD COMP-1	0.62	0.08	4.0	86	1.55	471	0.22	<20	2.66
2	ARD COMP-2	0.57	0.08	4.0	83	1.50	242	0.19	<20	2.52
3	ARD COMP-3	1.09	0.07	2.0	110	1.94	489	0.23	<20	2.75
4	ARD COMP-4	2.26	0.12	4.0	84	1.61	112	0.14	<20	2.11
5	ARD COMP-5	0.73	0.10	2.0	109	2.22	423	0.20	<20	2.93
6	ARD COMP-6	2.09	0.12	<1	151	1.54	620	0.27	<20	3.08
7	ARD COMP-7	1.03	0.07	2.0	58	1.51	263	0.17	<20	2.29
8	ARD COMP-8	0.55	0.09	2.0	76	1.83	770	0.19	<20	2.65
Typical Concentrations*		2.21	0.07	92.0	90	1.50	580	0.46	100	8.00

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S. No.	Sample ID	Na %	K %	W ppm	Hg ppm	Sc ppm	Tl ppm	Ga ppm	Se ppm	
1	ARD COMP-1	0.04	1.40	0.1	<0.01	7.2	0.3	9.0	<0.5	
2	ARD COMP-2	0.03	0.84	0.1	<0.01	6.2	0.2	9.0	<0.5	
3	ARD COMP-3	0.02	0.99	<0.1	<0.01	2.5	0.2	7.0	0.7	
4	ARD COMP-4	0.03	0.25	0.3	<0.01	5.8	0.1	8.0	0.8	
5	ARD COMP-5	0.02	0.89	0.2	<0.01	1.5	0.1	8.0	<0.5	
6	ARD COMP-6	0.02	1.54	<0.1	<0.01	7.1	0.4	10.0	<0.5	
7	ARD COMP-7	0.02	0.60	0.2	<0.01	1.3	0.1	7.0	<0.5	
8	ARD COMP-8	0.03	1.62	0.2	<0.01	2.4	0.2	8.0	1.1	
Typical Concentrations*		0.96	2.66	1.8	0.4	13.0	n/a	19.0	0.6	

* Typical Concentrations for shales (closest rock type to a siltstone), Price 1997 (Appendix 3)

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5. Conclusions and Recommendations

5.1 Conclusions

Based on our review and analysis of the geotechnical data collected from the geotechnical investigation program conducted in 2009, the following conclusions are made:

1. The bedrock underlying the project area north of STA 50+00 on the Lower Tunnel alignment and south of approximately STA 22+00 on the Lower Tunnel alignment is a Triassic to Jurassic-aged graywacke of the Kelp Bay Group. The unit located along most of the Lower Tunnel alignment between STA 22+00 and 50+00 is a Permian- to Triassic-aged greenstone (and possibly containing a sliver of Jurassic-aged diorite). Both rock types appear to be of similar quality. The greenstone does not underlay any of the new Project elements, and no drilling was undertaken within this rock type.

2. The results of point load and UCS testing indicate that the mean UCS for the graywacke is approximately 120 MPa (17,500 psi). A similar value was obtained for the greenstone, although a considerably smaller number of samples were tested. Based on the results of UCS testing on concrete samples obtained from DH09-04, a mean UCS of 44.3 MPa (6429 psi) was obtained.

3. Based on the results of geological mapping three, major sets of discontinuities occur within the Project area with the following orientations (Dip/Direction):

   - Set 1 – 87°/300° (parallel to channel walls at arch dam), forms plunge pool;
   - Set 2 – 72°/214° (parallel to bedding); and
   - Set 3 – 33°/322° (well defined at arch dam).

4. In general, the joints have planar shape, have a smooth to rough surface, and are slightly weathered. Sets 1 and 2 are spaced between 0.7 and 2 ft and Set 3 is spaced between 2 and 6 ft. The persistence of jointing in the Project area typically is 10 to 30 ft; however, individual joints in the abutments of the arch dam and other steep exposures were observed to have persistence in excess of 50 – 60 ft. The overall GSI for the bedrock at the dam site is estimated to be 65 – 70. Based on the results of the tunnel inspection, the RMR was estimated to generally range from 60 to over 80 ("good" to "very good") for the unlined sections of the Upper Tunnel and Lower Tunnel (at the South River Portal and surge chamber locations). The lined sections of the tunnels were inferred to be generally associated with zones of closely spaced jointing or weak rock.

5. Generally the bedrock along the tunnel alignment and at the arch dam has a very low permeability (less than 1 Lugeon). Local zones (10 to 20 ft in length) of higher permeability (ranging from 10 to over 100 Lugeons) were encountered. These zones are located notably, at the arch dam near the top of left abutment, in the top 10 ft of bedrock drilled in the plunge pool, in the right abutment, and at the intake.

6. The results of the seismic refraction surveys and drilling of DH09-05 and DH09-06 indicate that the original USBR interpretation, regarding the presence of buried valley, up to 60 ft deep, at the right abutment under the current access road, is credible. The results of the falling head test indicate that the materials infilling the valley have a very low permeability. In addition, the results of packer testing, plus the observations regarding groundwater inflow into the Upper Tunnel and into the right

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abutment adit, indicate that the bedrock in this area has low permeability. As a result seepage through this pathway from a raised Blue Lake to el 425 is not considered to be an issue.

7. Bedrock is exposed in the powerhouse and lower penstock area at the Lower Portal, immediately downstream of the timber crib wall, and along the existing access road. The remainder of this area is covered by unstratified rock fill. The results of the test pit excavation and drilling of DH09-15, and seismic refraction tests carried out in this area indicate that the depth to bedrock in the vicinity of the proposed powerhouse site is generally within 10 to 12 ft. The depth to bedrock at the timber crib wall is likely more than 20 ft.

8. The results of the direct shear testing indicate that the basic friction component of the shear resistance angle is 30 degrees for the concrete-rock and rock-rock surfaces. The basic friction angle is added to the roughness component to obtain the total shear resistance angle, provided in Technical Memorandum No. 25. The concrete-bedrock contact intersected in DH09-04 is bonded.

5.2 Recommendations

Based on the results of the geotechnical investigations, the following are recommended:

1. The City continue to collect the piezometric data from the piezometers installed in the plunge pool (DH09-08) and on the slope above the South River Portal (DH09-13) for at least one year. The pressure data measured in Borehole DH09-08 should be correlated with the water levels in the plunge pool and the reservoir. The piezometric data obtained from DH09-13 should be compared with precipitation data and the reservoir levels to determine if there is a relationship between these factors.

2. Depending on the development of the powerhouse and penstock layout during final design, additional test pits may be required to obtain additional confirmation of bedrock depths at the powerhouse site. It is not anticipated that any other subsurface geotechnical investigations will be required to carry out final design for the Project.

3. It may be desirable to obtain additional concrete samples from the dam using a portable hand held concrete coring drill and carry out additional unconfined compressive strength and tensile strength testing (ASTM 3967).

Recommendations regarding the tunnel and surge chamber lining requirements, the erodibility of the plunge pool, assessment of seepage under the dam, and the foundation rock parameters and abutment assessment, are provided in Technical Memoranda Nos. 2, 5, 23, 24, and 25, respectively.

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Figures

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Appendix A

Reservoir Rim Survey

(R&M Consultants Inc.)

© Hatch 2006/03 ⌘

Appendix B

Site Photographs

Working Together SAFELY
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Appendix C

Tunnel Inspection Memo

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Appendix D

Seismic Refraction Survey

(MACTEC Engineering and Consulting Inc.)

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Appendix E

Borehole Logs

Working Together SAFELY
© Hatch 2006/03 ⌘

Appendix F

Core Photographs

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Appendix G

Permeability Test Results

WorkingTogether SAFELY
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Appendix H

Laboratory Test Results

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Appendix I

Piezometer Data

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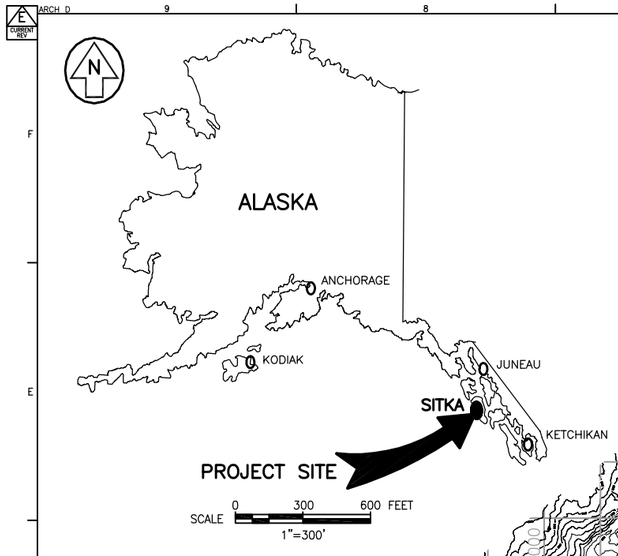

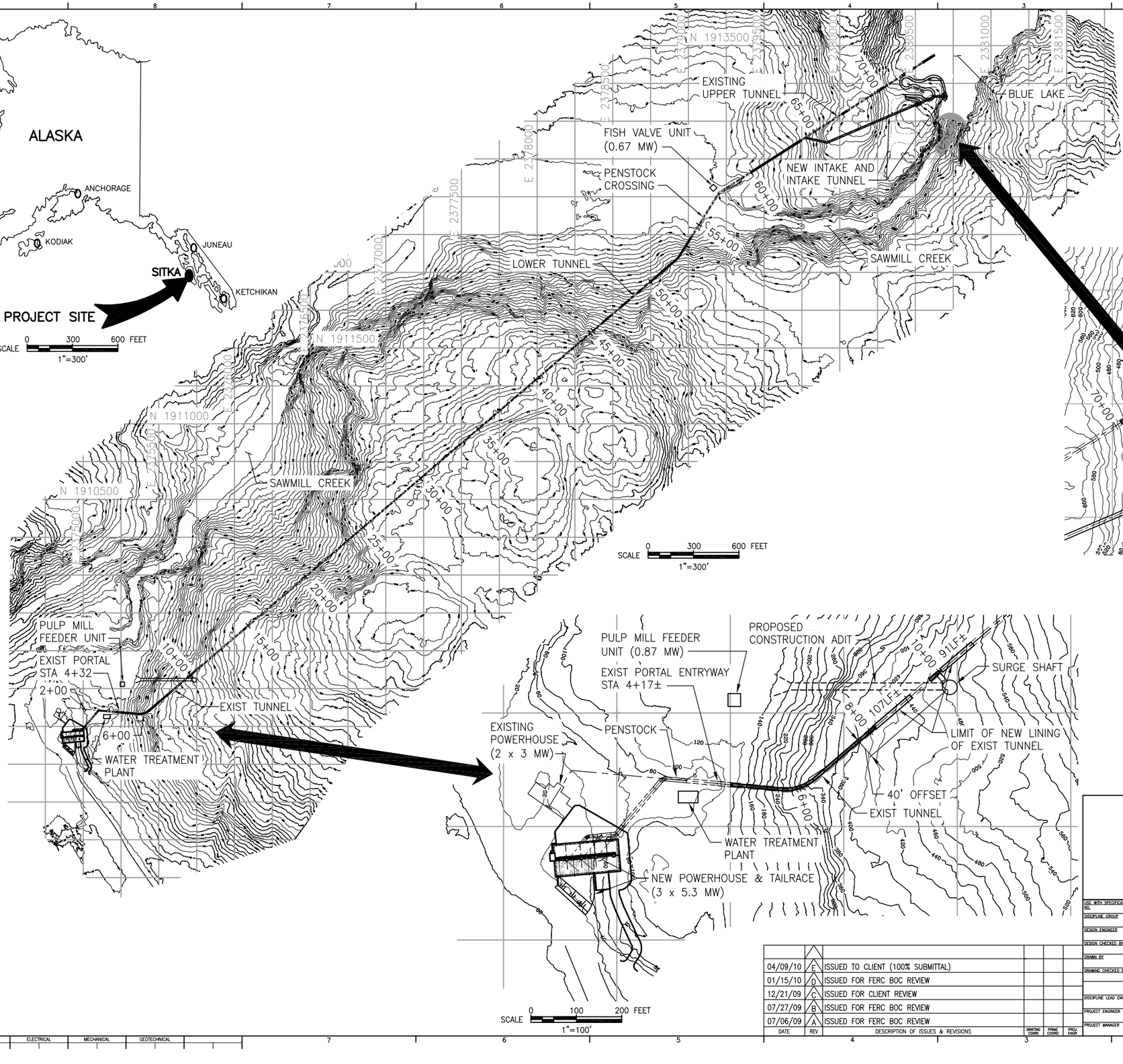

DATE	REV	DESCRIPTION OF ISSUES & REVISIONS	DRAFTING COORD	PRIME COORD	PROJ ENGR
04/09/10	E	ISSUED TO CLIENT (100% SUBMITTAL)			
01/15/10	D	ISSUED FOR FERC BOC REVIEW			
12/21/09	C	ISSUED FOR CLIENT REVIEW			
07/27/09	B	ISSUED FOR FERC BOC REVIEW			
07/06/09	A	ISSUED FOR FERC BOC REVIEW			

USE WITH SPECIFICATION NO.
DISCIPLINE GROUP
DESIGN ENGINEER DATE
DESIGN CHECKED BY DATE
DRAWN BY DATE CREATED
DRAWING CHECKED BY DATE
DISCIPLINE LEAD ENGINEER DATE
PROJECT ENGINEER DATE
PROJECT MANAGER DATE

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BLUE LAKE HYDROELECTRIC EXPANSION PROJECT

CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL FINDINGS REPORT LOCATION PLAN AND GENERAL ARRANGEMENT

DRAWING NUMBER
FIGURE 1

E CURRENT REV

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

SAVED: 04-06-2010_4:51pm By ramo113002

PLOTTED: 04-06-2010_4:51PM
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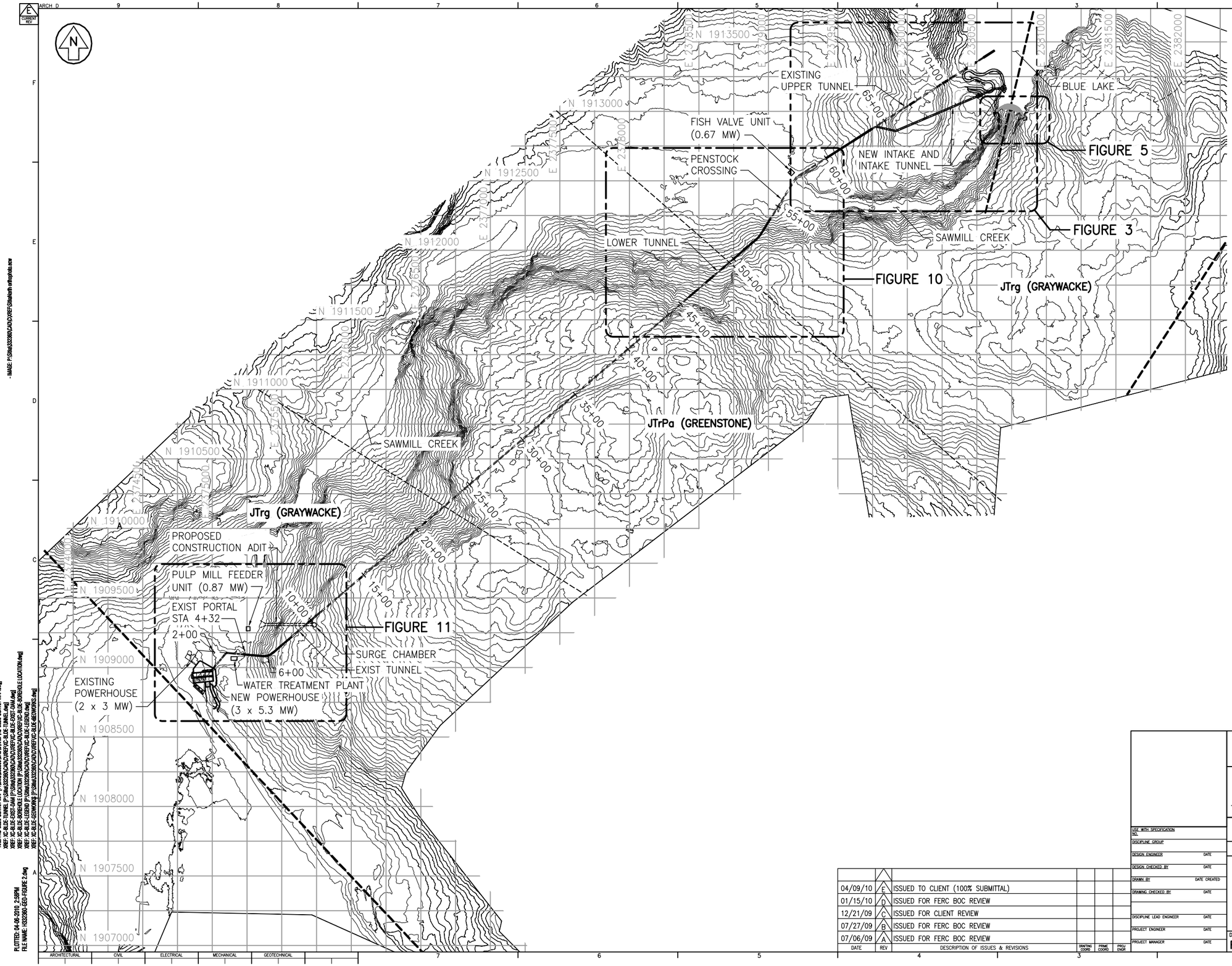

LEGEND

-------- GEOLOGICAL CONTACT (APPROXIMATE)

– – – – FAULT (FROM USBR GEOLOGY MAP, 1953)

JTrg – KELP BAY GROUP– TRIASSIC–JURASSIC AGED GREENSTONE, GRAYWACKE, GREENSCHIST, METACHERT, AND PHYLLITE. (Andesitic Siltstone)

JTrPa – KELP BAY GROUP PERMIAN–JURASSIC AGED AMPHIBULITE AND GREENSCHIST. (GREENSTONE)

NOTES

1. GEOLOGICAL CONTACTS BASED ON FIELD OBSERVATIONS BY HATCH.
2. BEDROCK LITHOLOGY BASED ON LONEY et. al (1964) AND HAEUSSLER P. J. et al (2004).

SCALE 0 300 600 FEET

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07/27/09	B	ISSUED FOR FERC BOC REVIEW			
07/06/09	A	ISSUED FOR FERC BOC REVIEW			

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DISCIPLINE GROUP
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DESIGN CHECKED BY DATE
DRAWN BY DATE CREATED
DRAWING CHECKED BY DATE
DISCIPLINE LEAD ENGINEER DATE
PROJECT ENGINEER DATE
PROJECT MANAGER DATE

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BLUE LAKE HYDROELECTRIC EXPANSION PROJECT

CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL FINDINGS REPORT REGIONAL GEOLOGY

DRAWING NUMBER
FIGURE 2

CURRENT REV: E

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

PLOTTED: 04-06-2010 2:58PM
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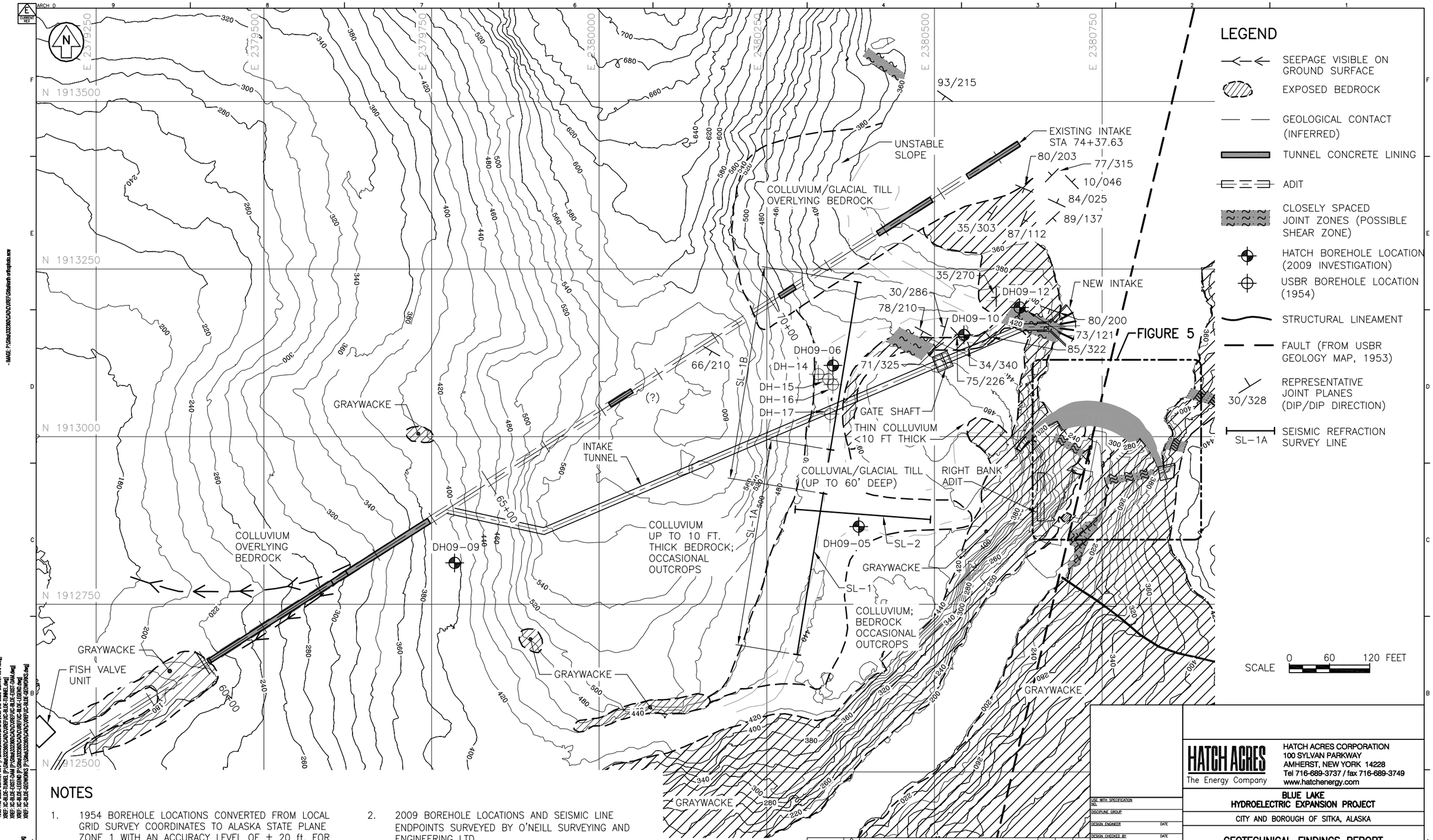

NOTES

1. 1954 BOREHOLE LOCATIONS CONVERTED FROM LOCAL GRID SURVEY COORDINATES TO ALASKA STATE PLANE ZONE 1 WITH AN ACCURACY LEVEL OF ± 20 ft. FOR EXAMPLE, DH-16 IS SHOWN ON THE WEST SIDE OF SL-1B , HOWEVER, SINCE IT WAS COLLARED IN BEDROCK IT IS MORE LIKELY THAT ITS ACTUAL LOCATION IS EAST OF SL-1B.
2. 2009 BOREHOLE LOCATIONS AND SEISMIC LINE ENDPOINTS SURVEYED BY O'NEILL SURVEYING AND ENGINEERING LTD.

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07/27/09	B	ISSUED FOR FERC BOC REVIEW			
07/06/09	A	ISSUED FOR FERC BOC REVIEW			

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USE WITH SPECIFICATION NO.
DISCIPLINE GROUP
DESIGN ENGINEER DATE
DESIGN CHECKED BY DATE
DRAWN BY DATE CREATED
DRAWING CHECKED BY DATE
DISCIPLINE LEAD ENGINEER DATE
PROJECT ENGINEER DATE
PROJECT MANAGER DATE

BLUE LAKE
HYDROELECTRIC EXPANSION PROJECT

CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL FINDINGS REPORT
GEOLOGICAL PLAN
INTAKE AREA/DAM AND UPPER TUNNEL

DRAWING NUMBER
FIGURE 3
E CURRENT REV

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

SAVED: 04-06-2010_3:02pm By ramo113002

PLOTTED: 04-06-2010_3:02PM
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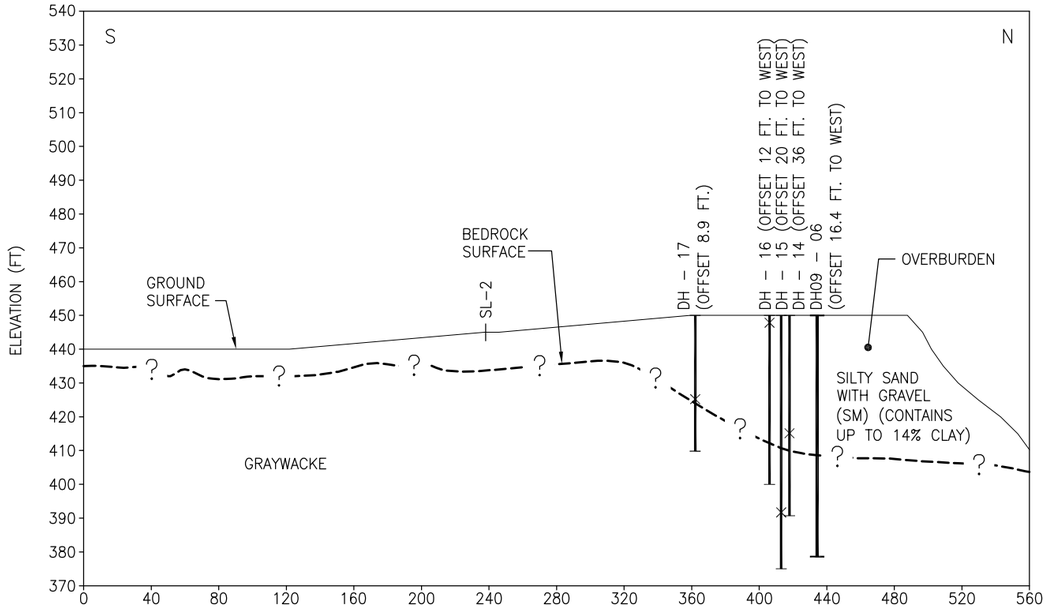
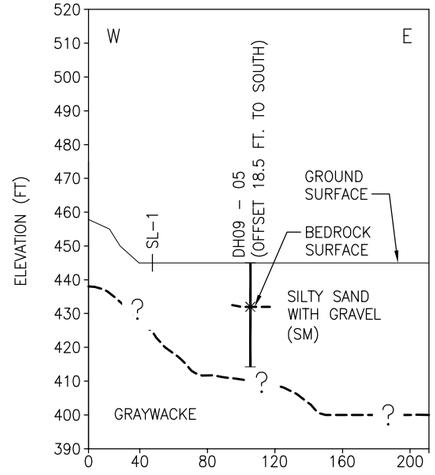


SL-1



SL-2

NOTES

1. INFERRED BEDROCK CONTACT PLANE BASED ON SEISMIC REFRACTION SURVEY RESULTS AND BOREHOLE DATA.
2. TOP OF BEDROCK IS ASSUMED TO BE AT A P-WAVE VELOCITY OF 10,000 ft/s.
3. LOCATIONS OF U.S.B.R. BOREHOLES DH-14 TO DH-17 SHOWN WERE ESTIMATED. LOCATIONS WERE CONVERTED FROM LOCAL GRID TO ALASKA STATE PLANE SYSTEM TO AN ACCURACY LEVEL OF ±20 FT.

LEGEND

- APPROXIMATE BEDROCK SURFACE
- BOREHOLE
- APPROXIMATE BEDROCK DEPTH ENCOUNTERED IN THE BOREHOLES (OFFSET FROM SECTION)

VERTICAL SCALE 40 0 40 80 FT

HORIZONTAL SCALE 80 0 80 160 FT

DATE	REV	DESCRIPTION OF ISSUES & REVISIONS	DRAFTING COORD	PRIME COORD	PROJ ENGR
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LOC WITH SPECIFICATION NO.
DISCIPLINE GROUP
DESIGN ENGINEER DATE
DESIGN CHECKED BY DATE
DRAWN BY DATE CREATED
DRAWING CHECKED BY DATE
DISCIPLINE LEAD ENGINEER DATE
PROJECT ENGINEER DATE
PROJECT MANAGER DATE

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BLUE LAKE HYDROELECTRIC EXPANSION PROJECT

CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL EXPLORATION GEOLOGICAL SECTIONS SEISMIC LINES SL-1 & SL-2 INTAKE SITE

DRAWING NUMBER
FIGURE 4

CURRENT REV: C

ARCH D | ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

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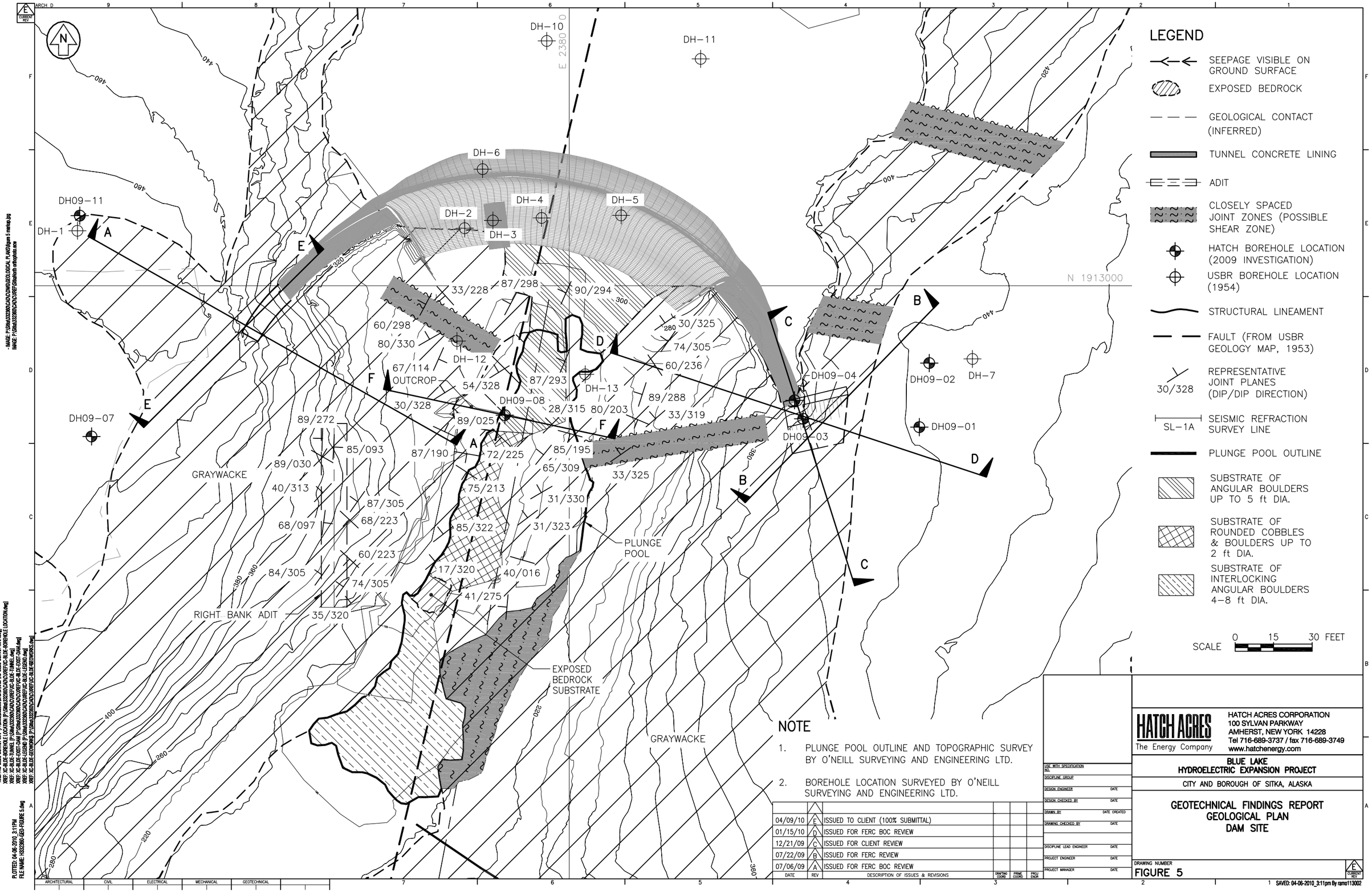
SAVED: 04-06-2010_3:09pm By ramo113002



LEGEND

- SEEPAGE VISIBLE ON GROUND SURFACE
- EXPOSED BEDROCK
- GEOLOGICAL CONTACT (INFERRED)
- TUNNEL CONCRETE LINING
- ADIT
- CLOSELY SPACED JOINT ZONES (POSSIBLE SHEAR ZONE)
- HATCH BOREHOLE LOCATION (2009 INVESTIGATION)
- USBR BOREHOLE LOCATION (1954)
- STRUCTURAL LINEAMENT
- FAULT (FROM USBR GEOLOGY MAP, 1953)
- 30/328 REPRESENTATIVE JOINT PLANES (DIP/DIP DIRECTION)
- SL-1A SEISMIC REFRACTION SURVEY LINE
- PLUNGE POOL OUTLINE
- SUBSTRATE OF ANGULAR BOULDERS UP TO 5 ft DIA.
- SUBSTRATE OF ROUNDED COBBLES & BOULDERS UP TO 2 ft DIA.
- SUBSTRATE OF INTERLOCKING ANGULAR BOULDERS 4-8 ft DIA.

SCALE 0 15 30 FEET

NOTE

1. PLUNGE POOL OUTLINE AND TOPOGRAPHIC SURVEY BY O'NEILL SURVEYING AND ENGINEERING LTD.
2. BOREHOLE LOCATION SURVEYED BY O'NEILL SURVEYING AND ENGINEERING LTD.

DATE	REV	DESCRIPTION OF ISSUES & REVISIONS	DRAFTING COORD	PRIME COORD	PROJ ENGR
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07/22/09	B	ISSUED FOR FERC REVIEW			
07/06/09	A	ISSUED FOR FERC BOC REVIEW			

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BLUE LAKE
HYDROELECTRIC EXPANSION PROJECT

CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL FINDINGS REPORT
GEOLOGICAL PLAN
DAM SITE

DRAWING NUMBER
FIGURE 5

CURRENT REV: E

USE WITH SPECIFICATION NO.
DISCIPLINE GROUP
DESIGN ENGINEER DATE
DESIGN CHECKED BY DATE
DRAWN BY DATE CREATED
DRAWING CHECKED BY DATE
DISCIPLINE LEAD ENGINEER DATE
PROJECT ENGINEER DATE
PROJECT MANAGER DATE

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

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PLOTTED: 04-06-2010_3:11PM
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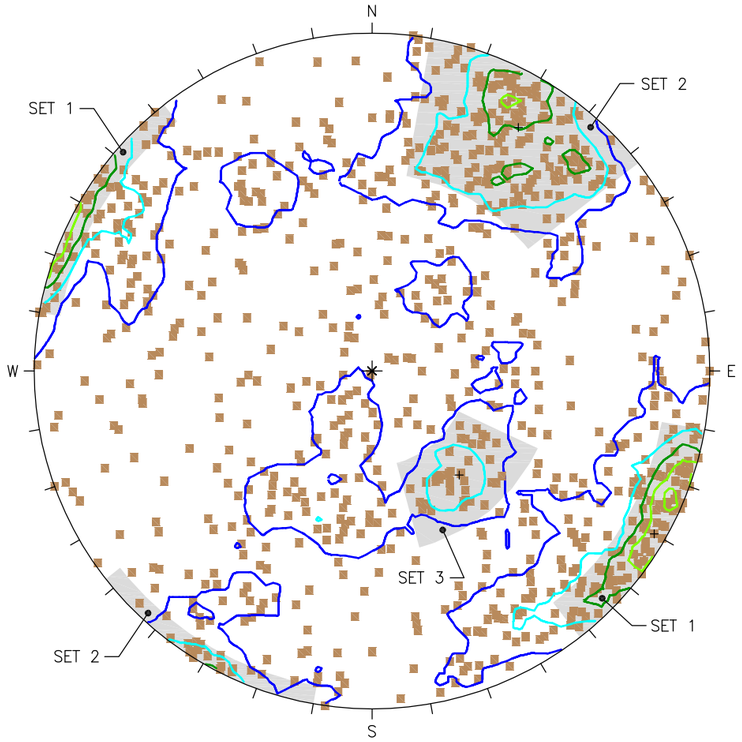
A) ENTIRE PROJECT AREA



SCHMIDT
CONCENTRATIONS
% OF TOTAL PER 1.0 % AREA

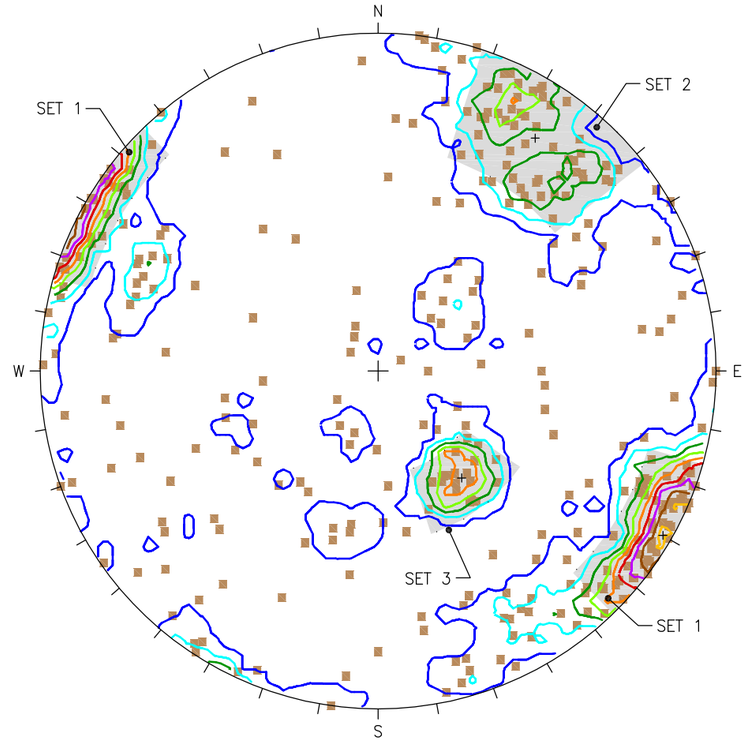
1.00 %
2.00 %
3.00 %
4.00 %
5.00 %
6.00 %
7.00 %
8.00 %
9.00 %

NO BIAS CORRECTION
MAX. CONC. = 5.3837%

EQUAL AREA
LOWER HEMISPHERE
873 POLES

JOINT SET	MEAN ORIENTATION
1	86/300
2	73/211
3	33/320

B) ARCH DAM SITE



NO BIAS CORRECTION
MAX. CONC. = 9.4512%

EQUAL AREA
LOWER HEMISPHERE
328 POLES

JOINT SET	MEAN ORIENTATION
1	87/300
2	72/214
3	33/322

NOTES:

1. STEREOPLOTS OF DISCONTINUITIES FOR ENTIRE PROJECT AREA ARE BASED ON FIELD MEASUREMENT OF DISCONTINUITIES FROM BEDROCK OUTCROPS AT VARIOUS LOCATIONS SHOWN ON FIGURES 3, 5, 7 AND 8.

2. STEREOPLOTS OF DISCONTINUITIES FOR ARCH DAM SITE ARE BASED ON FIELD MEASUREMENTS OF DISCONTINUITIES FROM BEDROCK OUTCROPS AND FROM ORIENTED CORE IN BOREHOLES DH09-01 TO 04, DH09-07 AND DH09-11.

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HYDROELECTRIC EXPANSION PROJECT

CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL FINDINGS REPORT
REGIONAL GEOLOGY
STEREOPLOT OF DISCONTINUITIES

DRAWING NUMBER
FIGURE 6

C CURRENT REV

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

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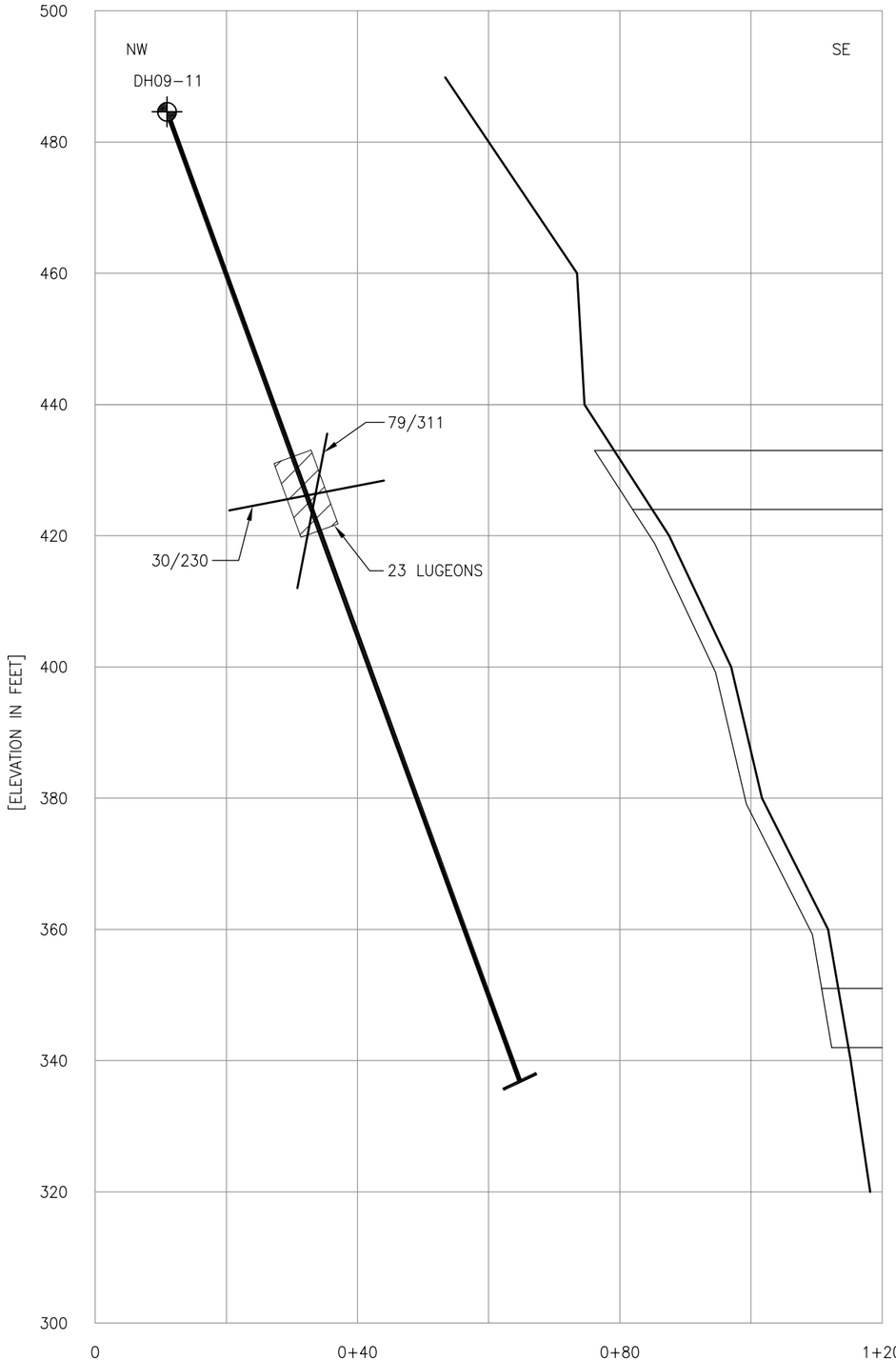
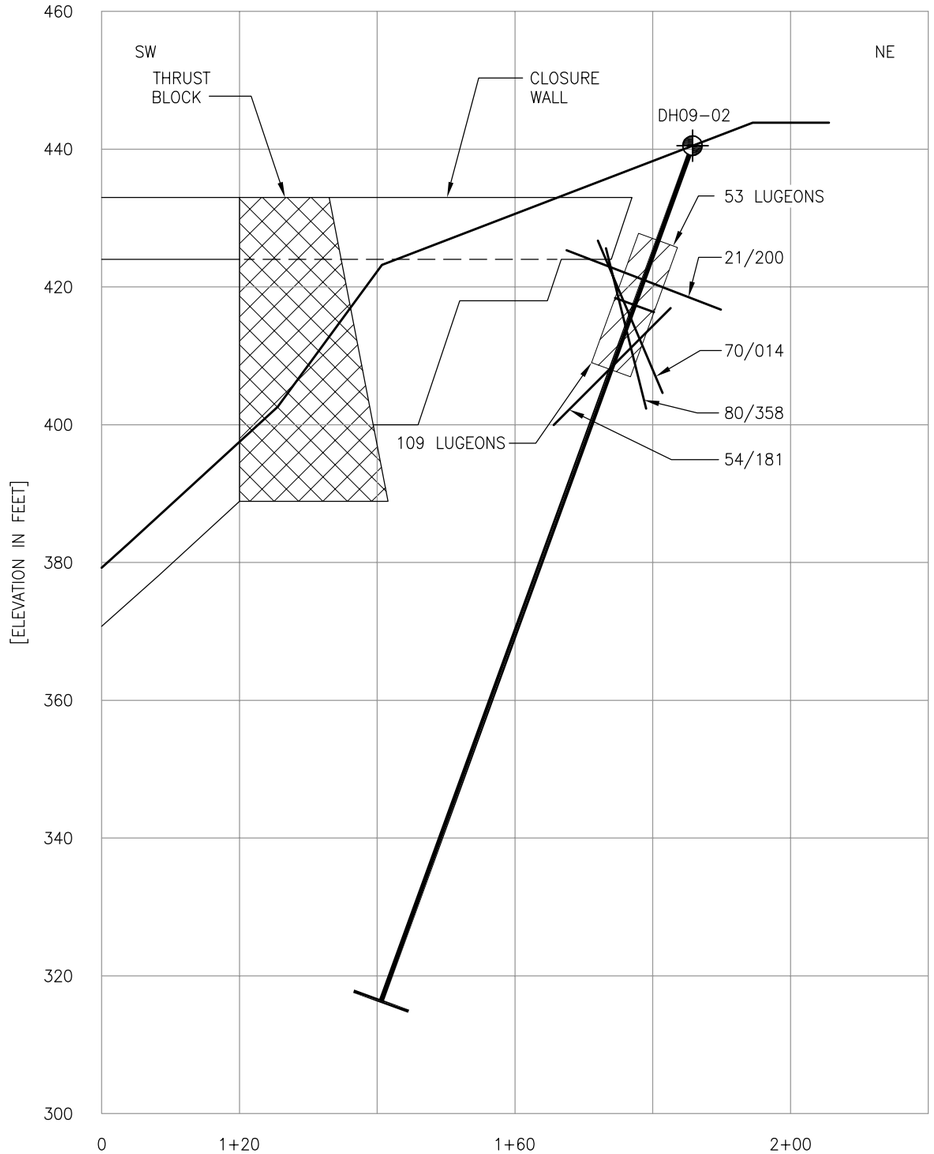
SAVED: 04-06-2010_4:52pm By ramo113002



SECTION A
(FROM FIGURE 5)



SECTION B
(FROM FIGURE 5)

LEGEND

HIGH PERMEABILITY ZONE (>10 LUGEONS)

OPEN JOINT IN VICINITY OF WITH HIGH PERMEABILITY ZONE (>10 LUGEONS)

79/311 JOINT ORIENTATION (DIP/DIRECTION)

NOTE

1. JOINT TRACES ARE SHOWN AS THE APPARENT DIPS IN THE PLANE PARALLEL TO THE BOREHOLE AZIMUTHS. THE INDICATED DIP AND DIRECTION (NUMERICAL VALUES) SHOWN FOR EACH DISCONTINUITY IS THE TRUE DIP/DIP DIRECTION.

SCALE 0 10 20 FEET

DATE	REV	DESCRIPTION OF ISSUES & REVISIONS	DRAFTING COORD	PRIME COORD	PROJ ENGR
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BLUE LAKE
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CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL EXPLORATION
ARCH DAM
BOREHOLE SECTIONS

DRAWING NUMBER
FIGURE 7

CURRENT REV E

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

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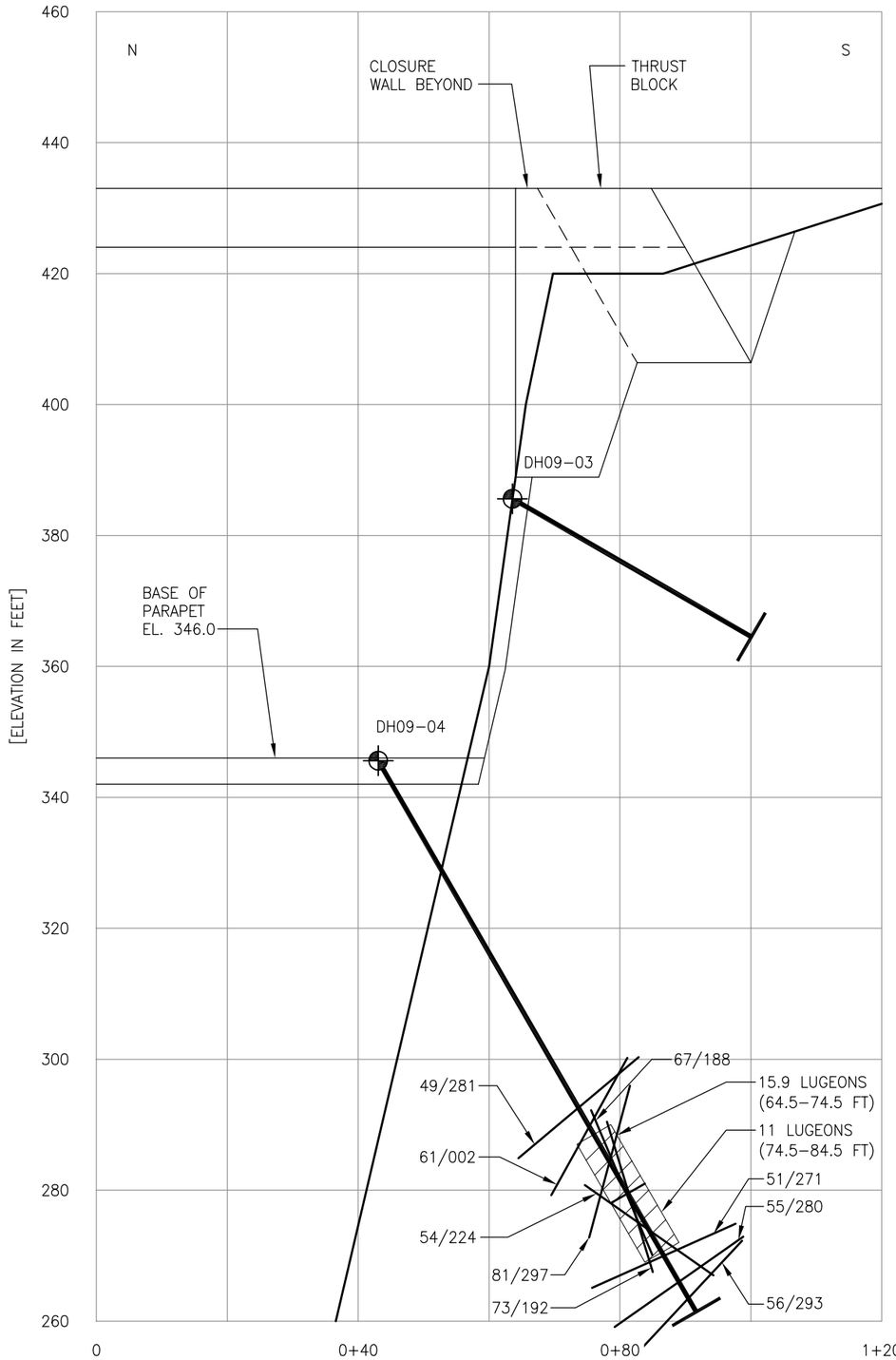
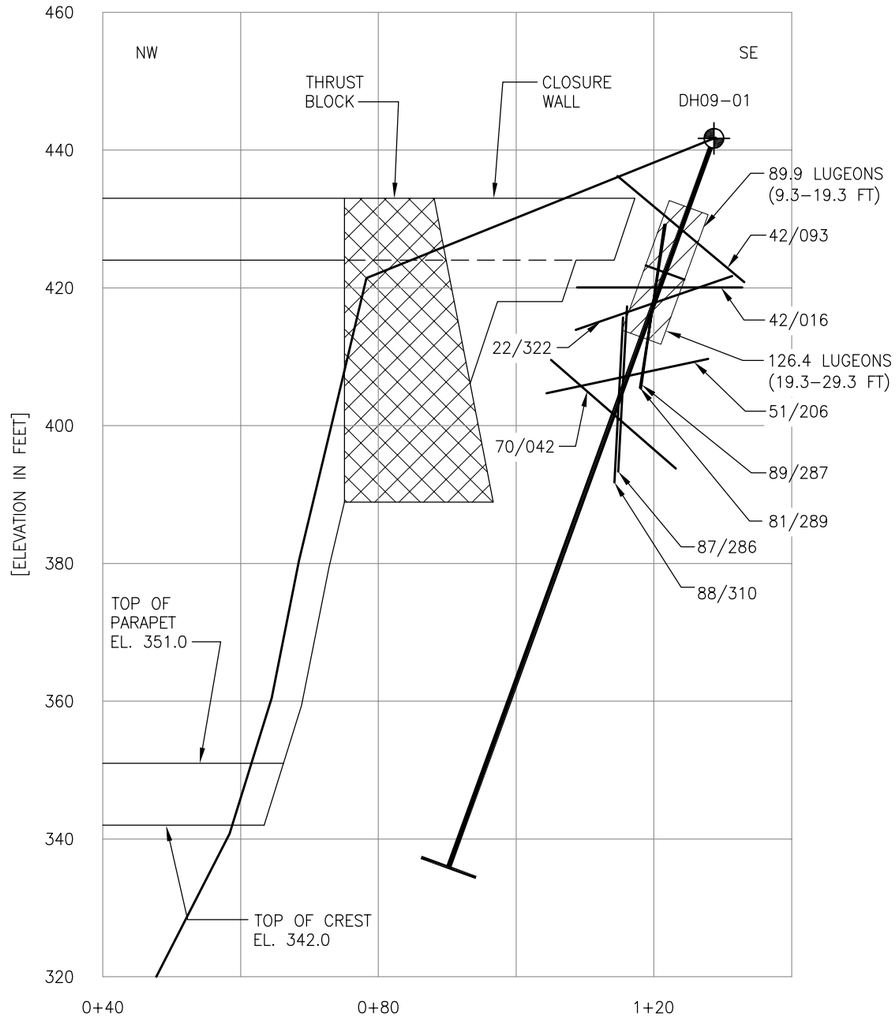
SAVED: 04-06-2010_4:53pm By ramo113002



SECTION C
(FROM FIGURE 5)



SECTION D
(FROM FIGURE 5)

LEGEND

HIGH PERMEABILITY ZONE (>10 LUGEONS)

OPEN JOINT IN VICINITY OF WITH HIGH PERMEABILITY ZONE (>10 LUGEONS)

88/310 JOINT ORIENTATION (DIP/DIRECTION)

NOTE

1. JOINT TRACES ARE SHOWN AS THE APPARENT DIPS IN THE PLANE PARALLEL TO THE BOREHOLE AZIMUTHS. THE INDICATED DIP AND DIRECTION (NUMERICAL VALUES) SHOWN FOR EACH DISCONTINUITY IS THE TRUE DIP/DIP DIRECTION.

SCALE 0 10 20 FEET

DATE	REV	DESCRIPTION OF ISSUES & REVISIONS	DRWTNG COORD	PRIME COORD	PROJ ENGR
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12/21/09	C	ISSUED FOR CLIENT REVIEW			
07/22/09	B	ISSUED FOR FERC BOC REVIEW			
07/06/09	A	ISSUED FOR FERC BOC REVIEW			

LOC WITH SPECIFICATION NO.	
DISCIPLINE GROUP	
DESIGN ENGINEER	DATE
DESIGN CHECKED BY	DATE
DRAWN BY	DATE CREATED
DRAWING CHECKED BY	DATE
DISCIPLINE LEAD ENGINEER	DATE
PROJECT ENGINEER	DATE
PROJECT MANAGER	DATE

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CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL EXPLORATION
ARCH DAM
BOREHOLE SECTIONS

DRAWING NUMBER
FIGURE 8

CURRENT REV: E

ARCH D

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

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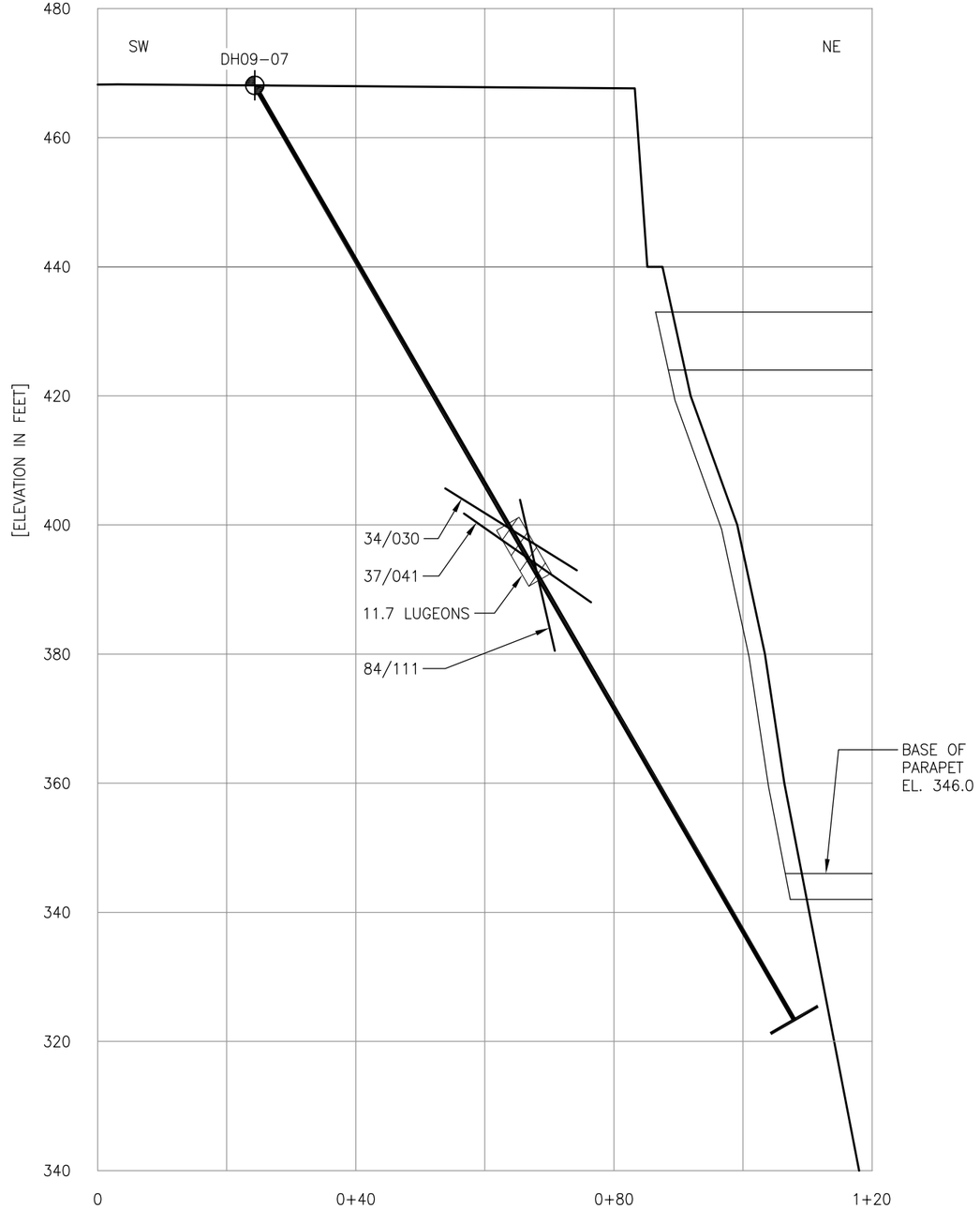
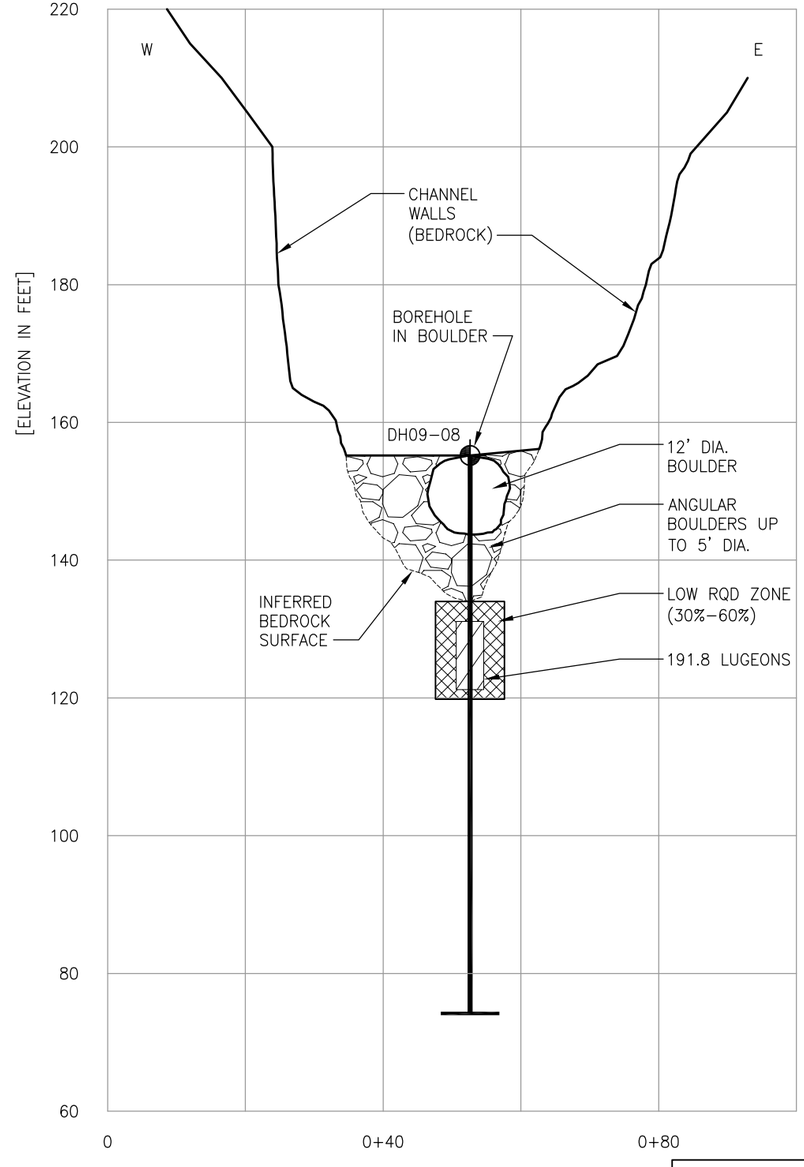
FILE NAME: H322369-SEC-FIGURE 8.dwg

SAVED: 04-06-2010_4:54pm By ramo113002



SECTION E
(FROM FIGURE 5)



SECTION F
(FROM FIGURE 5)

LEGEND

- HIGH PERMEABILITY ZONE (>10 LUGEONS)
- LOW RQD ZONE
- OPEN JOINT IN VICINITY OF WITH HIGH PERMEABILITY ZONE (>10 LUGEONS)
- 34/030 JOINT ORIENTATION (DIP/DIRECTION)

NOTE

1. JOINT TRACES ARE SHOWN AS THE APPARENT DIPS IN THE PLANE PARALLEL TO THE BOREHOLE AZIMUTHS. THE INDICATED DIP AND DIRECTION (NUMERICAL VALUES) SHOWN FOR EACH DISCONTINUITY IS THE TRUE DIP/DIP DIRECTION.
2. THE PROFILE SHOWN IN SECTION F IS BASED ON THE TOPOGRAPHIC SURVEY DATA PROVIDED BY O'NEILL SURVEYING AND ENGINEERING LTD AS WELL AS MEASUREMENTS OF THE CHANNEL WIDTH CARRIED OUT BY HATCH DURING THE GEOLOGICAL MAPPING OF PLUNGE POOL.

SCALE 0 10 20 FEET

DATE	REV	DESCRIPTION OF ISSUES & REVISIONS	DRAFTING COORD	PRIME COORD	PROJ ENGR
04/09/10	E	ISSUED TO CLIENT (100% SUBMITTAL)			
01/15/10	D	ISSUED FOR FERC BOC REVIEW			
12/21/09	C	ISSUED FOR CLIENT REVIEW			
07/22/09	B	ISSUED FOR FERC BOC REVIEW			
07/06/09	A	ISSUED FOR FERC BOC REVIEW			

USE WITH SPECIFICATION NO.
DISCIPLINE GROUP
DESIGN ENGINEER DATE
DESIGN CHECKED BY DATE
DRAWN BY DATE CREATED
DRAWING CHECKED BY DATE
DISCIPLINE LEAD ENGINEER DATE
PROJECT ENGINEER DATE
PROJECT MANAGER DATE

HATCH ACRES
The Energy Company
HATCH ACRES CORPORATION
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AMHERST, NEW YORK 14228
Tel 716-689-3737 / fax 716-689-3749
www.hatchenergy.com

BLUE LAKE
HYDROELECTRIC EXPANSION PROJECT
CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL EXPLORATION
ARCH DAM
BOREHOLE SECTIONS

DRAWING NUMBER
FIGURE 9
CURRENT REV

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

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FILE NAME: HS3298-GEO-FIGURE 9.dwg

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ARCH D

CURRENT REV: E

E 2378000
E 2378250
E 2378500
E 2378750
E 2379000
E 2379250
E 2379500

N 1912500
N 1912250
N 1912000
N 1911750
N 1911500

FISH VALVE UNIT
GRAYWACKE
SEEPAGE
55+00
82/320
GRAYWACKE
DH09-13
70/310
83/208
TALUS (~20 FT THICK)
COLLUVIUM; < 10 FT THICK BEDROCK OUTCROPS
LIMITS OF ROCKFALL/ OPEN TALUS SLOPE
57/202
68/014
85/032
62/325
50+00
20/170
80/034
GRAYWACKE
75/318
GREENSTONE
COLLUVIUM < 10 FT THICK BEDROCK OUTCROPS
45+00

LEGEND

- SEEPAGE VISIBLE ON GROUND SURFACE
- EXPOSED BEDROCK
- GEOLOGICAL CONTACT (APPROXIMATE)
- TUNNEL CONCRETE LINING
- HATCH BOREHOLE LOCATION (2009 INVESTIGATION)
- USBR BOREHOLE LOCATION (1954)
- STRUCTURAL LINEAMENT
- FAULT (FROM USBR GEOLOGY MAP, 1953)
- 30/328 REPRESENTATIVE JOINT PLANES (DIP/DIP DIRECTION)

NOTE

1. ONLY THE OUTCROPS WHERE DETAILED DISCONTINUITY MEASUREMENTS WERE OBTAINED ARE SHOWN.
2. BOREHOLE LOCATION SURVEYED BY O'NEILL SURVEYING AND ENGINEERING LTD.

SCALE 0 60 120 FEET

1"=60'

DATE	REV	DESCRIPTION OF ISSUES & REVISIONS	DRAFTING COORD	PRIME COORD	PROJ ENGR
04/09/10	E	ISSUED TO CLIENT (100% SUBMITTAL)			
01/15/10	D	ISSUED FOR FERC BOC REVIEW			
12/21/09	C	ISSUED FOR CLIENT REVIEW			
07/27/09	B	ISSUED FOR FERC BOC REVIEW			
07/06/09	A	ISSUED FOR FERC BOC REVIEW			

USE WITH SPECIFICATION NO.
DISCIPLINE GROUP
DESIGN ENGINEER DATE
DESIGN CHECKED BY DATE
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DRAWING CHECKED BY DATE
DISCIPLINE LEAD ENGINEER DATE
PROJECT ENGINEER DATE
PROJECT MANAGER DATE

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BLUE LAKE
HYDROELECTRIC EXPANSION PROJECT

CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL FINDINGS REPORT
GEOLOGICAL PLAN
SOUTH RIVER PORTAL

DRAWING NUMBER
FIGURE 10

CURRENT REV: E

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

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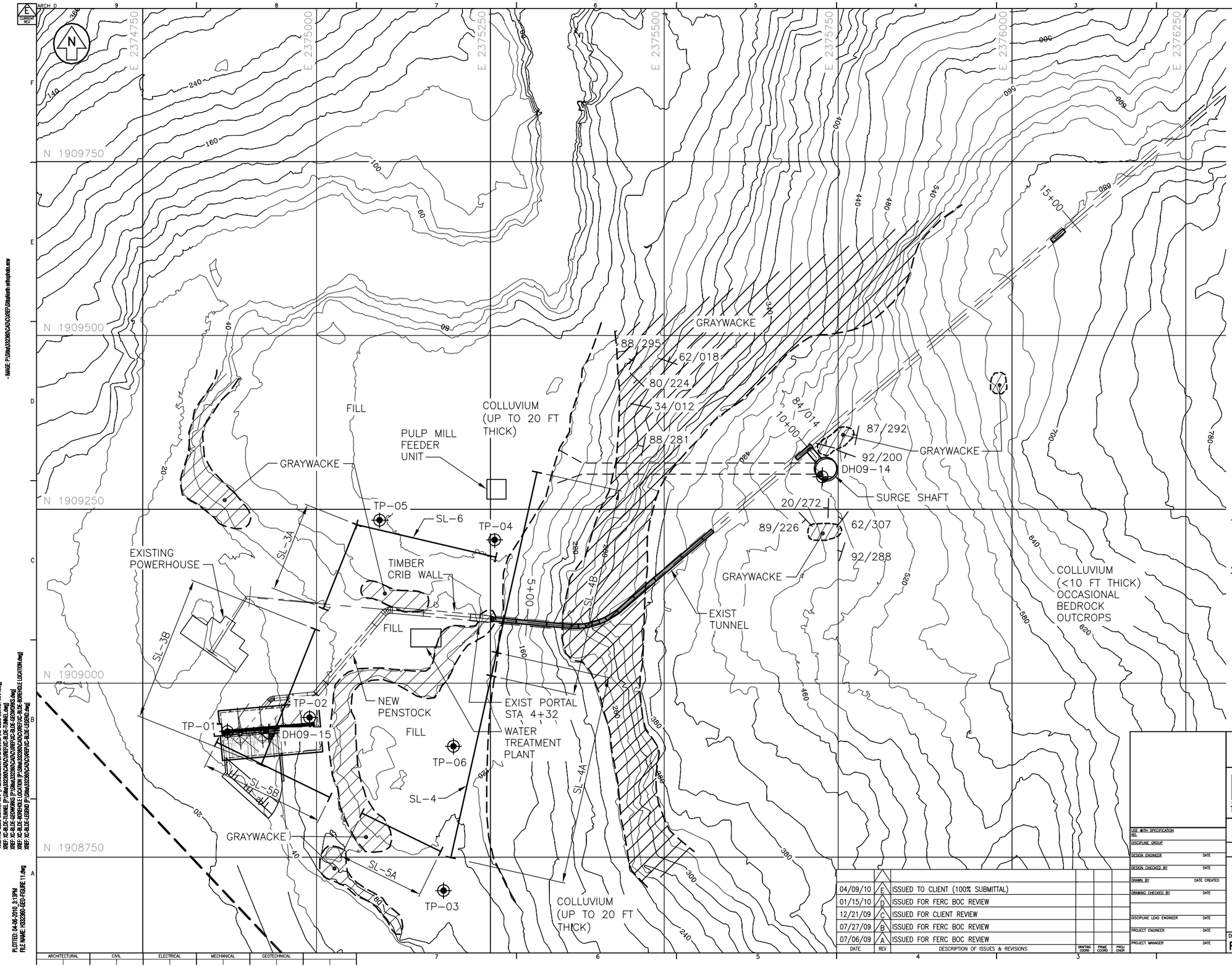
PLOTTED: 04-06-2010_3:12PM
FILE NAME: H322060-GEO-FIGURE 10.dwg

- XREF: XC-BLUE-SURVEY MAP [P:\Sitka\322060\CAD\OVERS\XC-BLUE-SURVEY MAP.dwg]
XREF: XC-BLUE-BOREHOLE LOCATION [P:\Sitka\322060\CAD\OVERS\XC-BLUE-BOREHOLE LOCATION.dwg]
XREF: XC-BLUE-TUNNEL [P:\Sitka\322060\CAD\OVERS\XC-BLUE-TUNNEL.dwg]
XREF: XC-BLUE-GEOWORKS [P:\Sitka\322060\CAD\OVERS\XC-BLUE-GEOWORKS.dwg]
XREF: XC-BLUE-LEGEND [P:\Sitka\322060\CAD\OVERS\XC-BLUE-LEGEND.dwg]



LEGEND

- SEEPAGE VISIBLE ON GROUND SURFACE
- EXPOSED BEDROCK
- GEOLOGICAL CONTACT
- TUNNEL CONCRETE LINING
- ADIT
- CLOSELY SPACED JOINT ZONES (POSSIBLE SHEAR ZONE)
- HATCH BOREHOLE LOCATION (2009 INVESTIGATION)
- USBR BOREHOLE LOCATION (1954)
- TEST PIT LOCATION
- STRUCTURAL LINEAMENT
- FAULT (FROM USBR GEOLOGY MAP, 1953)
- 30/328 — REPRESENTATIVE JOINT PLANES (DIP/DIP DIRECTION)
- SL-1A — SEISMIC REFRACTION SURVEY LINE

NOTES

1. BOREHOLE, TEST PIT AND SEISMIC LINE ENDPOINTS SURVEYED BY O'NEILL SURVEYING AND ENGINEERING LTD.
2. THE GAPS SHOWN BETWEEN SEISMIC LINES SL-3A, SL-3B & SL-5A, SL-5B ARE DUE TO GAPS IN THE VELOCITY MODEL WHERE INSUFFICIENT SEISMIC DATA WAS OBTAINED DUE TO BACKGROUND VIBRATIONS FROM THE POWERHOUSE OR PENSTOCK.

SCALE 0 60 120 FEET
1"=60'

DATE	REV	DESCRIPTION OF ISSUES & REVISIONS	DRAFTING COORD	PRIME COORD	PROJ ENGR
04/09/10	E	ISSUED TO CLIENT (100% SUBMITTAL)			
01/15/10	D	ISSUED FOR FERC BOC REVIEW			
12/21/09	C	ISSUED FOR CLIENT REVIEW			
07/27/09	B	ISSUED FOR FERC BOC REVIEW			
07/06/09	A	ISSUED FOR FERC BOC REVIEW			

USE WITH SPECIFICATION NO.
DISCIPLINE GROUP
DESIGN ENGINEER DATE
DESIGN CHECKED BY DATE
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DRAWING CHECKED BY DATE
DISCIPLINE LEAD ENGINEER DATE
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BLUE LAKE
HYDROELECTRIC EXPANSION PROJECT

CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL FINDINGS REPORT
GEOLOGICAL PLAN
POWERHOUSE
SURGE CHAMBER SITE

DRAWING NUMBER
FIGURE 11

E CURRENT REV

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

SAVED: 04-06-2010_3:13pm By ramo113002

- IMAGE: P:\Sitka\332260\CAD\OVERFLOW\Sitka North orthophoto.dwg
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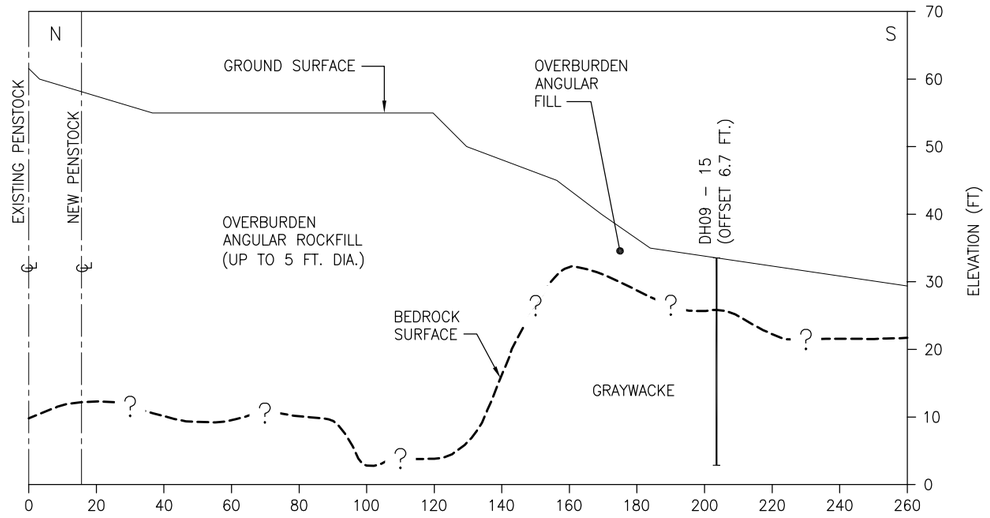
XREF: XC-BLDE-TUNNEL [P:\Sitka\332260\CAD\OVERFLOW\XC-BLDE-TUNNEL.dwg]
XREF: XC-BLDE-SEDIWORKS [P:\Sitka\332260\CAD\OVERFLOW\XC-BLDE-SEDIWORKS.dwg]
XREF: XC-BLDE-BOREHOLE LOCATION [P:\Sitka\332260\CAD\OVERFLOW\XC-BLDE-BOREHOLE LOCATION.dwg]
XREF: XC-BLDE-LEGEND [P:\Sitka\332260\CAD\OVERFLOW\XC-BLDE-LEGEND.dwg]
PLOTTED: 04-06-2010_3:13PM
FILE NAME: H332260-GEO-FIGURE 11.dwg



SL–3A & 3B

NOTES

1. INFERRED BEDROCK CONTACT PLANE BASED ON SEISMIC REFRACTION SURVEY (APPENDIX D), BOREHOLE AND TEST PIT DATA.
2. TOP OF BEDROCK IS ASSUMED TO BE AT A P–WAVE VELOCITY OF 10,000 ft/s.

LEGEND

- ? — APPROXIMATE BEDROCK SURFACE
- I — BOREHOLE

VERTICAL SCALE 20 0 20 FEET

HORIZONTAL SCALE 40 0 40 FEET

DATE	REV	DESCRIPTION OF ISSUES & REVISIONS	DRAWING COORD	PRIME COORD	PROJ ENGR
04/09/10	C	ISSUED TO CLIENT (100% SUBMITTAL)			
01/15/10	B	ISSUED FOR FERC BOC REVIEW			
12/21/09	A	ISSUED FOR CLIENT REVIEW			

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BLUE LAKE
HYDROELECTRIC EXPANSION PROJECT

CITY AND BOROUGH OF SITKA, ALASKA

GEOTECHNICAL EXPLORATION
GEOLOGICAL SECTIONS
SEISMIC LINES SL–3A & SL–3B
POWERHOUSE SITE

DRAWING NUMBER
FIGURE 12

CURRENT REV C

ARCHITECTURAL | CIVIL | ELECTRICAL | MECHANICAL | GEOTECHNICAL

PLOTTED: 04-06-2010_3:14PM
FILE NAME: H332360-GEO-FIGURE 12.DWG

SAVED: 04-06-2010_3:14pm By ramo113002

FINAL SUBMITTAL

BOUNDARY RIM STABILITY SURVEY
BLUE LAKE HYDROELECTRIC PROJECT

SITKA, ALASKA

CONTRACT NO. H-332360

Prepared for:

HATCH ACRES CORPORATION
6 Nickerson Street, Suite 101
Seattle, Washington 98109

Prepared by:

R&M CONSULTANTS, INC.
9101 Vanguard Drive
Anchorage, Alaska 99507

November 23, 2009

BOUNDARY RIM STABILITY SURVEY
BLUE LAKE HYDROELECTRIC PROJECT

SITKA, ALASKA

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1.3 Project Description 1
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2.1 Aerial Photo Interpretation 2
2.2 Site Reconnaissance 2
3.0 SITE CONDITIONS 3
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3.2 Talus Slopes 3
3.3 Alluvial Deposits 4
4.0 CONCLUSIONS 5
5.0 CLOSURE 6

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BOUNDARY RIM STABILITY SURVEY
BLUE LAKE HYDROELECTRIC PROJECT

SITKA, ALASKA

1.0 INTRODUCTION

1.1 Purpose and Scope-of-Work

R&M Consultants Inc. (R&M), under contract with Hatch Acres Inc. (Hatch), undertook reconnaissance-level geotechnical investigation for the proposed expansion of the Blue Lake Hydroelectric Project, in Sitka, Alaska. This investigation included a surficial survey over the boundary rim of the reservoir at the new proposed inundation level of Elev. 425. The purpose of the survey was to check for potential soil instability or slide areas which may be activated or worsened when inundated by the reservoir expansion. This report presents the results of our investigation.

1.2 Contract Authorization

This work was completed under the terms of Agreement No. H-332360 between Hatch and R&M. Measurements presented in this report are generally reported in United States customary units.

1.3 Project Description

The proposed expansion of Blue Lake will raise the reservoir level by 83 feet (Drawing 1). It is understood that minimal site preparation of the inundation area will be performed prior to raising the reservoir level. The area will be logged, with the trees cut at about waist height. The timber will be removed, but brush and slash may be left in place, or burned. Stumps and soil will be left undisturbed. This is understood to be the same general procedure that was followed for the original construction of the Blue Lake Reservoir. It is expected that wave action will erode the overburden soil washing it along with slash and many of the stumps into the lake.

2.0 METHODOLOGY

R&M's approach to this study consisted of aerial photo interpretation and field observations to identify areas that could become unstable when inundated. The effort was focused on identifying existing slope failures at or above the current reservoir rim, and identifying soil deposits which could become unstable. The primary criteria used to determine if a soil deposit was potentially unstable were thickness and grain-size. For a soil deposit to be considered potentially unstable, it would need to be relatively thick, and medium to fine-grained. A thick, coarse-grained deposit such as talus is not likely to become unstable because the angular coarse particle would be resistant to erosion and would give the soil high shear strength. Thin soil deposits even if they are fine-grained and easily eroded by wave action were not considered problematic because any resulting instability or failure would be localized. Examples of the types of soil deposits which could be a concern are fine-grained glacial till, hanging delta deposits, and terrace deposits. These types of deposits can consist of thick, medium to fine-grained soil, and can be encountered in steep terrain.

2.1 Aerial Photo Interpretation

An aerial photo interpretation process was undertaken to identify geological features and geotechnical conditions that would affect the stability of the new reservoir rim. The interpretation process consisted of delineating surface materials and geological features and conditions in the project area. The first step involved a review of the literature concerning the geology of the Blue Lake area. This created a regional terrain framework which aided in the interpretation of the aerial photos. Major terrain divisions identified on the published maps and reports were then used as an aerial guide for identification of potential unstable terrain.

It should be noted that the aerial photo interpretation process is a generalized study which is intended to collect geological and geotechnical data for a very large area. There are inherent limitations to the data and interpretations. The engineering characteristics of the features observed can only be generalized and described qualitatively. When evaluating the properties of a soil for analysis, the actual properties of that unit must be identified by additional on-site subsurface investigation, sampling, and laboratory testing.

The aerial photos used for this project consisted of stereo pairs at a scale of 1:30,000. The photos were flown on August 6, 2003 by Delta Aerial Surveys Ltd.

2.2 Site Reconnaissance

The site reconnaissance was one-day trip to the project by Bob Pintner, P.E. Senior Geotechnical Engineer, and consisted of a visual survey of the existing reservoir rim by boat and helicopter. The boat was provided and operated by the City of Sitka. The helicopter was on-site to support the geotechnical drilling operations being performed by Hatch Acres Corporation. At the time of the site visit, the reservoir level was about 9 feet below the current spillway.

3.0 SITE CONDITIONS

Blue Lake is situated in a broad U-shaped glacial valley. The lower end of the lake is bounded by rock cliffs as high as 300 feet. The cliffs are steepest on the west and north shores of the lake. On the south shore the slope of the rock is generally less steep. Most of the rock surrounding the lake is phyllite and graywacke. Recent alluvium covers the valley floor upstream of the lake. The slopes above the lake are bare rock, or at most covered with thin overburden, except where talus deposits fill small drainage channels[1]. The aerial photo interpretation and site reconnaissance did not reveal the presence of any thick, medium to fine-grained soil deposits within the proposed inundation area. Three general geologic terrains will be inundated; 1) rock slopes with thin soil overburden, 2) talus slopes, and 3) alluvial deposits.

3.1 Rock Slopes with Thin Soil Overburden

A majority of the existing shoreline and the proposed new shoreline can be characterized as either exposed bedrock, or bedrock covered with a thin layer of overburden. Where the existing reservoir inundated this terrain, the fine-grained fraction of the overburden soil has washed away leaving scattered cobbles and boulders and exposing bedrock. Many stumps remain anchored to the rock (Figure 1).

Some shallow slope failures and slumping of the thin overburden soils were observed along the existing shoreline (Figure 2). In all cases these failures did not extend more than 20 to 30 feet above the high-water elevation, and were limited in depth by the shallow bedrock. Several small streams flow into Blue Lake. With the exception of the main inlet at the head of the lake, most of these streams appear to flow on bedrock surfaces (Figure 3).

3.2 Talus Slopes

Talus slopes and fans were common along the existing shoreline particularly on the north side of the lake. The material in these slopes appeared to consist of angular gravel, cobbles, and boulders. No slope failures were observed in talus material along the existing shoreline (Figure 4). Along the proposed new south shore at the east end of the lake, an extensive complex of talus slopes and fans will be inundated (Figure 5). These slopes, like those observed along the existing shoreline are expected to consist of coarse-grained, angular material, and are therefore expected to be generally stable.

[1] U.S. Department of the Interior, Bureau of Reclamation, "Preliminary Report on the Geology of the Blue Lake Project, Sitka, Alaska" March, 1954.

3.3 Alluvial Deposits

Alluvial deposits upstream of the lake were inundated when the reservoir was originally constructed. These deposits consisted of fluvial and delta deposits on generally level ground. Figure 6 shows the existing shoreline at the east end of the lake where alluvial deposits were inundated. Similar alluvial materials will be inundated with the proposed reservoir expansion. These materials are not expected to be a stability concern, because they are not deposited on steep slopes.

Delta deposits often consist of loose, poorly graded sediments, which make them susceptible to becoming unstable during strong seismic events. During the 1964 Great Alaska Earthquake, submarine landslides occurred in submerged delta deposits in Seward, Valdez, and other coastal areas. These failures resulted in waves which caused damage on-shore. The evaluation of the seismic stability of submerged delta deposits in Blue Lake is beyond the scope of this study.

4.0 CONCLUSIONS

The following conclusions are based on data collected from the office and field efforts. Existing and gathered geotechnical data for the Blue Lake site reveal that:

1. The shoreline of the existing reservoir appeared to be generally stable. Only a few minor, shallow soil failures were observed.

2. R&M observed no evidence of thick, medium to fine-grained soil deposits which could become unstable when inundated.

3. Erosion of overburden soils and slash into the reservoir will occur for several years following the reservoir expansion. Localized shallow soil failures may occur above the new high water elevation. These failures are not expected to be extensive.

4. The only significant soil deposits identified on slopes in the project area other than overburden soils were talus deposits. Talus deposits on slopes are expected to be generally stable.

5. The alluvial deposits in the project area occurred in flat-lying areas, and therefore pose little risk of instability.

5.0 CLOSURE

The conclusions presented in this report are based on our understanding of the project requirements, our limited rim stability survey, and other pertinent information listed herein. Significant alteration of any of these concepts or site locations could substantially alter the foregoing conclusions. We would, therefore, appreciate having the opportunity to review and evaluate the final design, and where necessary, present any required changes to our present conclusions. Additionally, because surface and subsurface characteristics can change significantly within a given area, and with the passing of time, the possibility exists that important conditions not disclosed during our current investigation may be discovered during any future investigation or construction. Should this situation occur, the influence of the new information on the present interpretations should be evaluated without delay.

R&M Consultants, Inc. performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. This report is intended for use only in accordance with the purposes of study described within.

We have appreciated the opportunity to perform this rim stability survey. Should you require further information concerning the investigation or this report, please contact us at your convenience.

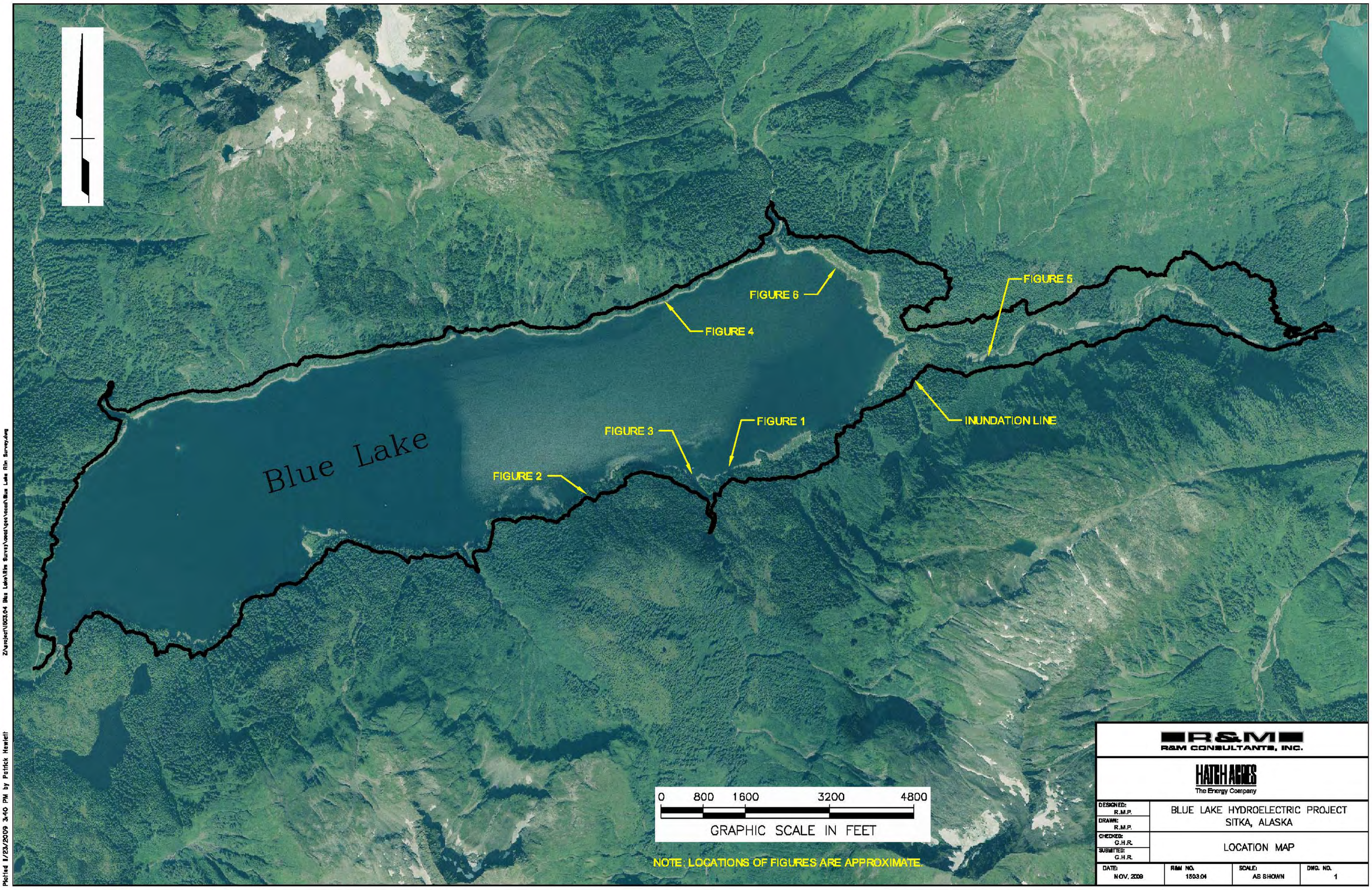
Very truly yours,

R&M CONSULTANTS, INC.

Charles H. Riddle, C.P.G.
Senior Vice President

Robert M. Pintner, P.E.
Senior Geotechnical Engineer

RMP:chr



R&M CONSULTANTS, INC.

HATCH ACRES
The Energy Company

DESIGNED: R.M.P.	BLUE LAKE HYDROELECTRIC PROJECT SITKA, ALASKA
DRAWN: R.M.P.	
CHECKED: C.H.R.	LOCATION MAP
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
NOV. 2009	1503.04	AS SHOWN	1

Plotted 11/23/2009 3:40 PM by Patrick Hewlett
Z:\project\1503.04 Blue Lake\Rim Survey\Land\geo\Vasch Blue Lake Rim Survey.dwg

Figure 1: Stump anchored to bedrock along existing shoreline. Overburden soil is completely washed away.

Figure 2: Slope failures in thin overburden soil along the south shore of Blue Lake. The maximum height is estimated at about 30 feet. Bedrock was exposed in these slide scarps.

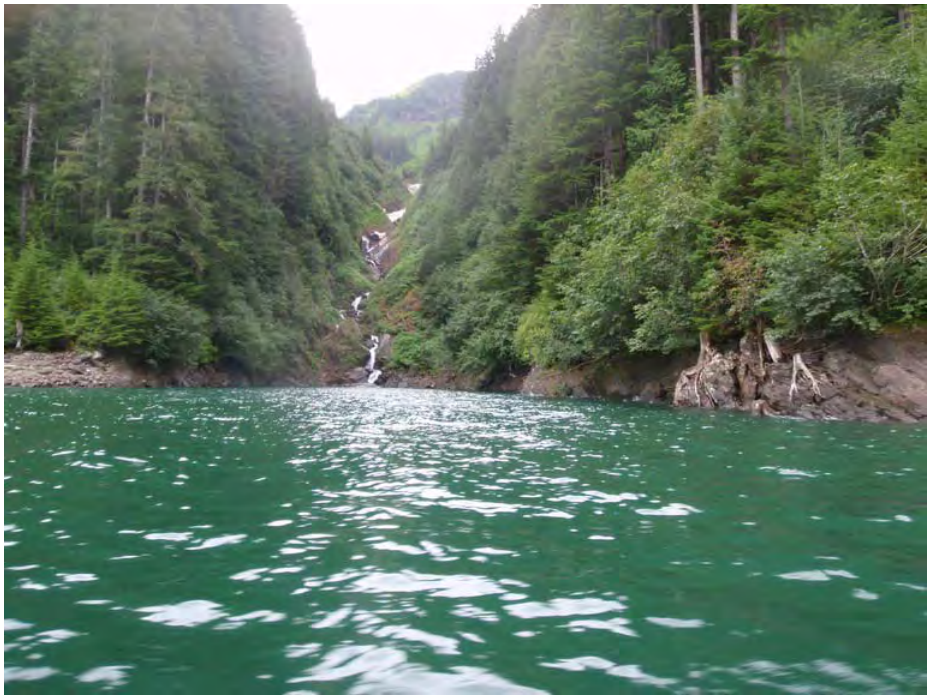


Figure 3: Tributary stream flowing on bedrock, on south shore.

Figure 4: Talus slope along north shoreline.

Figure 5: Talus slope at the east end of the lake.

Figure 6: Inundated alluvial deposits at the east end of the lake.

Photo 1 Base of arch dam with the plunge pool in the foreground.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 2 Plunge pool at base of dam viewed from the right abutment at the top of the existing concrete dam (EL. 346)

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 3 Plunge pool at base of dam viewed from the left abutment at the top of the existing dam (El. 346).

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 4 Dewatered plunge pool at base of dam.
Borehole DH09-08 was collared on the top of the boulder circled in red.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 5 View of the downstream portion of plunge pool.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 6 Drill rig (Burley 4500) at DH09-08.

Working Together SAFELY
© Hatch 2006/03 ⌘

Photo 7 Bedrock exposed above left abutment of the existing dam.

Working Together SAFELY
© Hatch 2006/03 ⌘

Photo 8 Left abutment shows joints comprising the moderately dipping discontinuity Set 3 with a main orientation of 33º/324º.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 9 Closely spaced discontinuity zone in left abutment.

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© Hatch 2006/03 ⌘

Photo 10 Closely spaced discontinuity zone upstream of dam on left bank.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 11 Left abutment of existing dam.
DH09-04 was drilled in the area indicated (red circle).

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 12 Setting up slope protection mesh prior to installing platform for DH09-03

Working Together SAFELY
© Hatch 2006/03 ⌘

Photo 13 Drilling of DH09-03 located on the rock face above the left abutment.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 14 View of the top of the left abutment where DH09-01 and DH09-02 were drilled.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 15 Burley 2500 drill rig at DH09-02 on the top of the left abutment (EL. 440.5).

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 16 Burley 4500 drill rig at DH09-01 on top of the left abutment (El. 441.7).

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 17 Photo of right abutment. Note the adit entrance.

Working Together SAFELY
© Hatch 2006/03 ⌘

Photo 18 Right bank adit looking upstream showing the concrete plug.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 19 View of the right abutment.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 20 View of the bedrock outcrop in the vicinity of the proposed new intake area.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 21 View of the downstream portal for the upper tunnel.

Working Together SAFELY

© Hatch 2006/03 ⌘

Photo 22 Penstock crossing over Sawmill Creek.

Working Together SAFELY

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Photo 23 Slope on the south side of Sawmill Creek, approximately 500 ft west of the south river portal. Note the steep rocky slope and talus piles below (circled).

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Photo 24 Close up of Talus pile shown on Photo 23.

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Photo 25 Close up of steep outcrops on the slope on the south side of Sawmill Creek.

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Photo 26 View of the slope above the pulp mill feeder unit. The top of the surge chamber will be on top of this slope.

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Photo 27 Downstream portal of the lower tunnel.

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Photo 28 Timber crib wall at the downstream portal at the lower tunnel.

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Photo 29 View of the timber crib wall from above the lower tunnel portal looking downstream.

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Photo 30 Outcrop in the vicinity of the downstream portal of the lower tunnel.

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Photo 31 View of proposed powerhouse site.

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Photo 32 View of test pit TP-1.

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Photo 33 View of test pit TP-3.

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Photo 34 Test pit TP-4

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Photo 35 Test pit TP-5

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Photo 36 Test pit TP-6.

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Appendix C

Tunnel Inspection Memo

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Hatch Mott MacDonald

TECHNICAL MEMO

To Steve Hart, PE., Hatch Acres, Seattle

From Dean Brox, P.Eng.

Date May 12, 2009

Project # Blue Lake Hydroelectric Project

Reference PM259050.002 – Blue Lake Expansion Project – Tunnel Inspection Observations

Blue Lake Expansion Project – Tunnel Inspection Observations

1. Introduction

An inspection of the power tunnel at the Blue Lake Hydropower Plant was undertaken on Tuesday May 5, 2009 and Wednesday May 6, 2009 by Messrs. Dean Orbison, City of Sitka, Dean Brox of Hatch Mott MacDonald, Peter Friz of Hatch Acres, and Jason Morrison and Ben Roberds of Redpath. At the time of the tunnel inspection a survey team was undertaking a survey traverse of key areas within the tunnel.

This technical memorandum presents observations and comments on the general condition of the tunnel, tunnel stability, rock mass conditions and quality, and conditions of the concrete lined sections.

2. Tunnel Inspection Survey

The tunnel inspection was undertaken according to the following itinerary:

Date	Time Period	Tunnel
Tuesday May 5, 2009	Morning	Upper Tunnel (without Redpath)
	Afternoon	Northern section of Lower Tunnel
Wednesday May 6, 2009	Morning	Southern section of Lower Tunnel
	Afternoon	Upper Tunnel – re-visit with Redpath

As part of the tunnel inspection survey the lengths of the various rock (R) and concrete (C) lined areas were measured using a tape in the Upper (U) and Lower (L) Tunnels as a check to the detailed survey. The measured lengths of the various sections are presented in the table below.

Transportation and Tunnels
Suite 1010, 1066 West Hastings Street, British Columbia, Canada V6E 3X2 **T** 604.629-1736
F 604.639.1191 www.hatchmott.com

Measured Lengths of Rock and Concrete Sections

Tunnel Section	Length, ft
Intake Gate Bifurcation Wall	10
UC1	90
UR1	61
UC2	95
UR2	145
UC3	30
UR3	263
UC4	40
UR4	303
UC5	145
Sawmill Creek Penstock	600
LC6	392
LR5	83
LC7	35
LR6	69
LC8	80
LR7	76
LC9	84
Non-inspected section	2947
LC4	23
LR3	600
LC3	25
LR2	454
LC2	30
LR1	136
LC1	367
Lower Tunnel Portal	0

3. Tunnel Conditions and Stability

3.1 Upper Tunnel

The following observations were made from the inspection of the Upper Tunnel:

- Tunnel size larger than expected at 16.5 ft wide by about 18 ft high suggesting significant overbreak occurred during excavation, this is supported by large outlook angles on many drill holes
- Stable tunnel profile
- No large wedge blocks/fall-outs released and present upon the tunnel floor
- No fresh rock surfaces that would otherwise suggest fall-out of rock from the unwatering process
- Variable amounts of accumulated rock debris along tunnel floor with fine material deposited at deep pools immediately downstream of concrete lined sections, and a limited amount of moderate size rock blocks (10”), maximum size block observed was about 12”
- Very limited areas of “hollow” sounding rock representing potential loosening
- Variable amounts of half-barrels presents ranging from 30% - 50%
- Organic sludge coating present over entire rock, concrete, and steel penstock surfaces of approximately thickness of 3-5 mm (Figure 6).

3.2 Lower Tunnel

The following observations were made from the inspection of the Lower Tunnel:

- Tunnel size larger than expected at 10.7 ft wide by about 12 ft high suggesting minimal overbreak occurred during excavation which is consistent with the better quality of rock in the Lower Tunnel in comparison to the Upper Tunnel
- Stable tunnel profile
- No large wedge blocks/fall-outs released and present upon the tunnel floor
- No fresh rock surfaces that would otherwise suggest fall-out of rock from the unwatering process
- Variable amounts of accumulated rock debris along tunnel floor with fine material deposited at deep pools immediately downstream of concrete lined sections
- Very limited areas of "hollow" sounding rock representing potential loosening
- Variable amounts of half-barrels presents ranging from 30% - 50%

4. Rock Mass Conditions and Quality

4.1 Upper Tunnel

The following observations were made of the rock conditions of the Upper Tunnel:

- Interbedded greywacke and phylitte rock types dipping steeping downstream and perpendicular to tunnel axis
- Good quality rock conditions with Rock Mass Rating (RMR) ranging from about 65 to 75 (Figure 1)
- Very strong rock with strength over 30,000 psi estimated using a field hammer

- Rock joints predominantly smooth and planar with persistence greater than tunnel size
- Three (3) main joint sets (J1: 75/120, J2: 66/210, J3: 36/337, Rock section UR2)
- No infilling materials with majority rock joints
- Minor erosion/pitting of limited greywacke rock surfaces (maximum scour size of 0.5" and depth of about ¼")
- A limited number of infilled veins/joints
- Single vein/joint, infilled with grey-whitish material, 6" wide, oriented sub-parallel to tunnel in roof, eroded (Figure 3) to full width and extending about 3 ft into tunnel roof over 3' long section, no concern of tunnel stability due to this feature (Figure 3)
- No signs of sulphides in rock (eg. Pyrite etc)
- Groundwater conditions generally "wet" to "dripping", with minor "dry" areas, no significant inflows at any locations
- Sulfur gas odour emanating along southern section of Upper Tunnel, not present along northern section of Upper Tunnel

4.2 Lower Tunnel

The following observations were made of the rock conditions of the Lower Tunnel:

- Predominantly Greenstone with sections of interbedded greywacke and phylitte rock types dipping steeping downstream and perpendicular to tunnel axis (Figure 4)
- Very Good to Good quality rock conditions with Rock Mass Rating (RMR) generally above about 75
- Very strong rock with strength over 30,000 psi estimated using a field hammer

- Rock joints predominantly smooth and planar with persistence greater than tunnel size
- Four (4) main joint sets (J1: 75/135, J2: 45/135, J3: 75/045, J4: 65/225, Rock Section LR2 - Surge Shaft location)
- No infilling materials with majority rock joints
- A limited number of infilled veins/joints (Figure 5)
- No signs of sulphides in rock (eg. Pyrite etc)
- Groundwater conditions generally “dry” to “damp”, with minor ”dripping” areas, no significant inflows at any locations

5. Concrete Lining Conditions

5.1 General

Upon review of the Carey and Kramer Drawings 5806-11 and 5806-12 dated 1958 it is now understood that concrete lining was installed for both confinement near the portal areas as well as along areas of poor quality rock where timber set support was installed duirng tunnel excavation. The use of timber set support was common practice at the time of construction.

5.2 Conditions and Testing of Concrete Linings

The following observations were made of the concrete linings in both the Upper and Lower Tunnels:

- No signs of deterioration/degradation
- No significant cracking
- Groundwater inflows occurring at a few locations at construction joints

Schmidt Hammer testing (Figure 2) was conducted on several concrete lined sections. The results of these tests are presented in the table below.

Concrete Section	Length, Ft	Schmidt Hammer Values	psi
UC1	90	LHS – 13,17,12 RHS – 13,26,16	<1220 <1480
UC2	95	LHS – 21,19,18 RHS – 30,20,24	<1370 <2920
UC3	30	LHS – 25,17,15 RHS – 22,20,20	<2010 <1520
UC4	40	LHS – 24,30,16 RHS – 17,18,24	<2920 <1830
UC5	145	Upper Area LHS – 28,29,33 RHS – 28,26,25	 <2720 <2550
		Middle Area LHS – 26,28,24 RHS – 20,24,19	 <2550 <1830

		Lower Area LHS – 15,16,19 RHS – 22,18,16	 <1220 <1520
UC6	392	LHS – 29,30,25 RHS – 23,22,19	<2920 <1680
UC7	35	pLHS – 20,25,21 RHS – 24,21,19	<2010 <1830

CITY AND BOROUGH OF SITKA

BLUE LAKE HYDRO PROJECT

POWER TUNEL
TUNNEL INSPECTION
UPPER TUNNEL - ROCK CONDITIONS

HATCH energy

PROJECT NO.	REF	REV.
259050	1	A

FIGURE 1

CITY AND BOROUGH OF SITKA

BLUE LAKE HYDRO PROJECT

POWER TUNEL

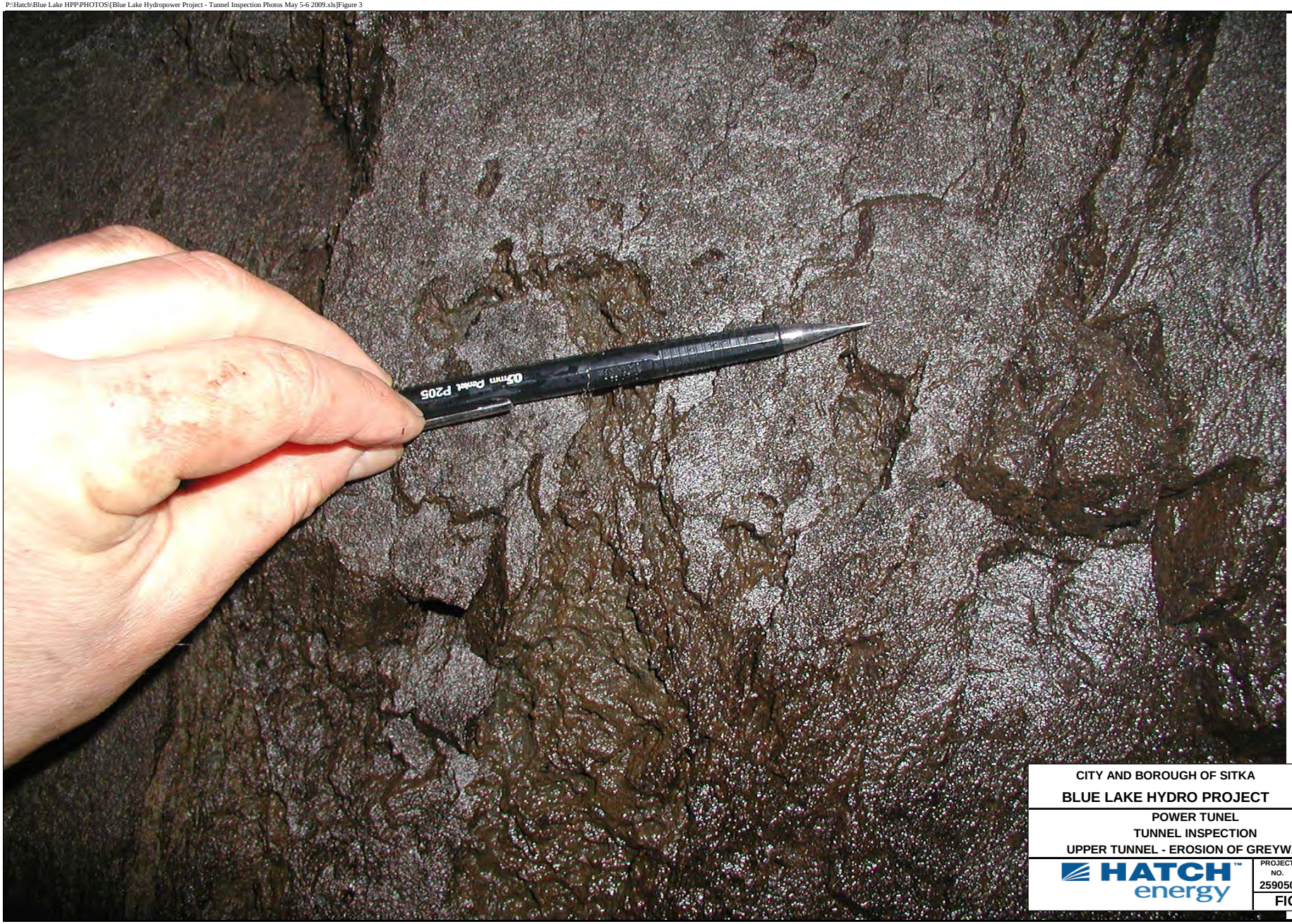
TUNNEL INSPECTION

UPPER TUNNEL - SCMIDT HAMMER TESTING

HATCH energy

PROJECT NO.	REF	REV.
259050	1	A

FIGURE 2



CITY AND BOROUGH OF SITKA

BLUE LAKE HYDRO PROJECT

POWER TUNEL

TUNNEL INSPECTION

UPPER TUNNEL - EROSION OF GREYWACKE

HATCH energy

PROJECT NO.	REF	REV.
259050	1	A

FIGURE 3

CITY AND BOROUGH OF SITKA

BLUE LAKE HYDRO PROJECT

POWER TUNEL

TUNNEL INSPECTION

LOWER TUNNEL - ROCK CONDITIONS

HATCH energy

PROJECT NO.	REF	REV.
259050	1	A

FIGURE 4

CITY AND BOROUGH OF SITKA

BLUE LAKE HYDRO PROJECT

POWER TUNEL

TUNNEL INSPECTION

LOWER TUNNEL - WEAK VEIN/JOINT INFILLING

HATCH energy

PROJECT NO.	REF	REV.
259050	1	A

FIGURE 5

CITY AND BOROUGH OF SITKA

BLUE LAKE HYDRO PROJECT

POWER TUNEL

TUNNEL INSPECTION

LOWER TUNNEL - SLUDGE COATING ON PENSTOCK

HATCH energy

PROJECT NO.	REF	REV.
259050	1	A

FIGURE 6

FINAL DATA REPORT OF SEISMIC COMPRESSION (P) WAVE VELOCITY MEASUREMENTS BY SEISMIC REFRACTION

BLUE LAKE HYDROELECTRIC EXPANSION
SITKA, ALASKA

Prepared For:

CITY AND BOROUGH OF SITKA ELECTRIC DEPARTMENT

Sitka, Alaska

Prepared By:

MACTEC ENGINEERING AND CONSULTING, INC.

MACTEC Project Number 4036090008

December 2, 2009

MACTEC
engineering and constructing a better tomorrow

December 2, 2009

Mr. Dean T. Orbison, P.E.
City and Borough of Sitka Electric Department
105 Jarvis Street
Sitka, AK 99835

Subject: **Final Data Report of Seismic Compression (P) Wave Velocity Measurements by Seismic Refraction**
Blue Lake Hydroelectric Expansion – Sitka, Alaska
MACTEC Project No. 4036090008

Dear Mr. Orbison:

MACTEC Engineering and Consulting, Inc. (MACTEC) is pleased to provide this Final Data Report of Seismic Compression (P) Wave Velocity Measurements by Seismic Refraction for the proposed Blue Lake Hydroelectric Expansion project in Sitka, Alaska. Our services were provided in accordance with our Proposal PROP09ANCH.46 authorized by you on September 11, 2009.

The purpose of the seismic refraction surveys was to obtain information regarding the depth to bedrock and the nature and type of overburden materials along a potential seepage path in the right abutment area to assist with a project to raise the dam height by 83 feet. Similar information was also required in the vicinity of a proposed new Powerhouse site and penstock alignment.

We thank you for the opportunity to provide our professional geophysical services during this phase of your project. Please contact us with questions regarding this report.

Sincerely,

MACTEC ENGINEERING AND CONSULTING, INC.

Timothy P. Quigley
Geotechnical Professional

Jeffrey R. Keaton, P.E., P.G., Ph.D.
VP, Senior Principal Engineering Geologist

Sean P. Thomas, RES
Managing Principal – Alaska

cc: Mr. Peter Friz – HATCH

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1.0 PROJECT DESCRIPTION

Project information was provided to MACTEC in the Blue Lake Hydroelectric Expansion Seismic Survey Request for Proposal dated August 14, 2009, prepared by HATCH for the City and Borough of Sitka (the City) as well as from correspondence with HATCH. We understand that the City anticipates a significant load growth in electrical demand in the near future. The City has determined that the best alternative to meet this demand is through increasing the dam height by 83 feet at Blue Lake near Sitka, Alaska and constructing a replacement Powerhouse at the downstream end of the power conduit.

As part of the design of this expansion project, geotechnical investigations, including geologic mapping, geotechnical drilling, seismic refraction surveys, and test pit excavations are to be performed. The services provided by MACTEC are restricted to seismic refraction surveys at six locations. The purpose of the seismic refraction surveys is to obtain seismic-velocity information that can be interpreted to indicate the depth to bedrock and some aspects of the nature and type of overburden materials along a potential seepage path in the right abutment area of the dam. Similar subsurface information is also required in the vicinity of the proposed new Powerhouse site and penstock alignment.

2.0 SITE EXPLORATION

Seismic refraction testing was performed between September 18 and 23, 2009 at six locations shown on Figures 1 and 2, designated as Seismic Lines SL-1 through SL-6. The locations of the six seismic survey lines were chosen by in the field by Mr. Peter Friz of HATCH acting as a representative for the City. The RFP had requested seven seismic surveys to be performed; however, one of the locations was eliminated in the field by Mr. Friz and SL-5 was performed in two segments due to a steep, nearly vertical, rock slope along the middle of its alignment.

Due to the lengths of these six seismic survey lines and local site conditions that limited their lengths (steep/near vertical drop-offs and large, above ground diameter penstock pipes), some of the seismic lines were performed in two segments, for a total of 10 seismic line segments along the 6 designated seismic lines, as listed in Table 1. Upon completion of field testing for each seismic line segment, MACTEC left labeled pin flags at the individual segment end points for survey location by others.

MACTEC performed approximately 2256 linear feet of seismic surveys at the approximate locations depicted on Figures 1 and 2. SL-1 and SL-2 were performed to the west of the existing dam structure and south of Blue Lake. SL-3 through SL-6 was performed in the area of the existing Powerhouse and Filter Plant located approximately 1 mile to the southwest of the existing dam structure.

The lengths of the individual seismic refraction line segments were between 115 feet and 345 feet, as listed in Table 1. Energy was introduced into the ground at “shot points” located at several locations along each seismic line utilizing a sledgehammer striking a metal plate. Shot points utilizing a seismic shotgun (a mechanism holding a blank 8-gauge shotgun shell), where conditions permitted, or a sledgehammer striking a metal plate were performed in line with the seismic survey line but away from the end points to provide greater depth of interpretation for the subsurface investigation. Approximate relative elevations of the geophones and shot points along the seismic lines were determined with an engineer’s level and rod and measuring tape or measuring tape and engineer’s rod with levels on steep/rugged terrain.

Seismic investigations reported herein were conducted using a 24-channel digital enhancement seismograph with a linear array of 24 geophones that were uniformly spaced. The geophones measure vertically oriented particle velocity at a frequency of 10 Hz and are fixed into the ground with metal spikes. Measurements consisted of time history traces (waveforms) from which the arrival times of the

seismic energy were determined to allow calculation of compression wave (P-wave) velocities and depths to layers of increasing seismic velocity. Compression wave velocity is related to the physical characteristics of subsurface materials, primarily stiffness or modulus, which can be used to interpret a geotechnical profile of shallow soil materials and probable depth to bedrock.

The geophones are very sensitive to vibrations and significant interference was experienced from background vibrations at the site, notably vibrations from the Powerhouse and the water supplying the Powerhouse from the penstock. Electrical interference was experienced to a lesser extent. The interference provided noise which affected the seismic velocity time history traces and masked some of the first arrivals of P-wave energy. This was particularly the case for the seismic lines performed closer to the Powerhouse and penstock (SL-3A, SL-3B, SL-5B,and SL-6). This interference reduced the data quality as well as the depths to which the subsurface conditions were able to be modeled.

3.0 SEISMIC REFRACTION METHOD

The time history trace data were processed using SeisOpt® software to produce a two-dimensional average P-wave velocity structure to a depth on the order of about one-fourth to one-third the length of the seismic line of geophones and offset shot points. Certain mechanical properties of soil and rock, primarily density and rigidity, can be characterized and profiled in terms of seismic P-wave velocity. In the seismic refraction method, an elastic wave pulse is generated at a point on the ground surface or at shallow depth and propagates radially into the subsurface. On encountering boundaries between media having contrasting mechanical properties and consequently seismic velocity, the incident wave pulse is partially refracted toward the ground surface and partially transmitted into underlying strata. The so-called ray-path of the incident-transmitted pulse is bent or refracted at the boundary in accordance with Snell's law. In particular, if seismic velocity increases across the boundary, the ray-path is refracted toward the boundary. As the angle of incidence increases, so does the angle of refraction until for some critical incidence angle is reached, depending on the relative seismic velocities, the refracted wave pulse travels along the boundary within the faster medium while sending some seismic energy back to the surface. These so-called head waves ultimately reach the surface where their arrival is detected by a linear array of vibration sensitive detectors known as geophones. By identifying the first arrival of seismic energy from the waveforms measured at each geophone, the travel times of the critically refracted seismic signal (from source to each geophone receiver) are measured. Relatively straight-forward graphical analysis and associated simple calculations historically were used to yield estimates of layer velocities and thicknesses. However, more refined interpretations are obtained efficiently via modern computer-based techniques.

The seismic velocity of water-saturated granular sediments is approximately 4,200 to 5,000 feet per second, and seismic refraction surveys have been effective in detecting the top of saturation in granular deposits. The seismic velocity of saturated dense granular sediments or bedrock needs to be higher than 6,000 feet per second to be distinguished from saturated granular sediments of lower density. A discussion of the anticipated P-wave velocities for the overburden and bedrock materials present at the test locations at this site is provided in greater detail in Section 5.0.

4.0 SEISMIC DATA REDUCTION AND RESULTS

The field data were analyzed using Vscope software by Seismic Source Co., and SeisOpt software (SeisOpt 2D) by Optim Software, LLC. Vscope software is used to select first-arrival times of seismic energy. SeisOpt software is a velocity optimization process using the first-arrival times for each geophone based on energy input from each shot points. Like the older manual methods of data analysis, it uses P-wave first-arrival times (observed data) to model the subsurface velocity structure. However, numerous

test models are then created through which travel times are calculated and compared to the observed data. The velocity model that has the smallest discrepancy with the observed data while exhibiting adequate raypath coverage and containing the fewest modeling artifacts was selected for the final result. The result, therefore, may reveal details of seismic stratigraphy and strong lateral velocity gradients that would be challenging or impossible to discern by older analysis methods. The compression wave results reveal variations in depth and velocity along the length of the seismic line, and are thus termed two-dimensional.

The compression wave results are depicted graphically on Figures 3 through 12 with some pertinent annotations. Surveyed ground surface elevations of each seismic line end point were provided to MACTEC by Mr. Peter Friz of HATCH via electronic mail dated November 3 and 6, 2009. Elevation changes between the surveyed end points along the length of the seismic lines were determined based on the field measurements of the geophone and energy source locations.. Therefore elevations and elevation changes along the length of the seismic lines shown on the attached Figures 3 through 12 should be considered approximate; however they are sufficient for the purpose of this report.

5.0 INTERPRETATION OF SEISMIC P-WAVE VELOCITIES

Geologic information relative to the project site was provided to MACTEC in the *Preliminary Report on the Geology of the Blue Lake Project* by the United States Department of the Interior Bureau of Reclamation (BOR) dated March 1954. Additionally preliminary subsurface information relative to the recent geotechnical drilling and test pit excavations was also provided by HATCH. Based on this information we understand that the bedrock is predominately classified as a series of greywacke, phyllite, and argillite beds, described in petrographic analyses as andesitic siltstones , that are highly fractured and steeply dipping. Boring logs in the 1954 report include notes that the cored rock is sound and hard.

The overburden materials, where present, were heterogeneous in nature and classified as glacial till consisting of clay with rock fragments, sand, gravel, and boulders as well as colluvial (landslide/rock fall material) and fill materials to depths of at least 58 feet in the vicinity of seismic line SL-1B.

Figures 3 through 12 show the two-dimensional seismic compression P-wave velocities indicated by color variations and contour intervals. Pertinent annotations specific to the individual seismic line segments are also provided on these figures. The following sections provide guidance relative to the site specific subsurface conditions, published experience and our experience relative to P-wave velocities.

5.1 Anticipated P-wave Velocities for Bedrock

Based on the results of our seismic surveys, review of the available subsurface data and geology, published values (NAVFAC Design Manual 7.02), and our own experience, the depth to which bedrock is first encountered corresponds to a P-wave velocity in the range of 10,000 ft per sec to12,000 ft per sec, with 10,000 ft per sec as the typical velocity value for the top of bedrock surface. This range of P-wave velocity was selected partly because the bedrock is described as sound and hard, and partly because of the likely presence of boulders of bedrock materials in surficial deposits. Boulders in surficial deposits can contribute to P-wave velocities that approach the lower range of P-wave velocities in bedrock in some geologic settings.

5.2 Anticipated P-wave Velocities for Overburden Materials

Due to the heterogeneous nature of the overburden materials the P-wave velocities will be highly variable and dependent on the composition of these materials. These overburden materials can be expected to have P-wave velocities less than 10,000 ft per sec with layers that contain a larger percentage of large boulders

and rock having P-wave velocities greater than those containing a lower percentage of these materials or loose unconsolidated fill material.

The P-wave velocity of saturated sediments tends to be controlled by the groundwater, and seismic refraction surveys are effective at determining the depth of the water table. The P-wave velocity is dominated by saturated conditions until the geologic materials have P-wave velocities that are substantially greater than saturated sediments (i.e., good quality bedrock).

The resulting P-wave velocities for overburden materials in these conditions should be interpreted with caution as they may be substantially higher than if they were to be measured in the unsaturated condition.

5.3 Estimated Depth to Bedrock for Individual Seismic Survey Lines

The following sections describe the estimated range of depths from the existing ground surface elevation to the top of bedrock surface based on a top of bedrock P-wave velocity of 10,000 ft per sec as well as other discussions specific to the individual seismic line segment. The P-wave velocity profiles in Figures 3 through 12 show the profiles in greater detail.

Intake/Dam Area Seismic Lines

SL-1A — Seismic Line SL-1A was performed along the gravel road providing access to Blue Lake. The estimated depth to top of bedrock based on P-wave velocities along the seismic line, as shown in Figure 3, ranged between just below the existing ground surface at the southern end of the seismic line to a depth of approximately 10 feet at the northern end.

SL-1B — The estimated depth to top of bedrock along the seismic line, as shown in Figure 4, ranged from approximately 32 feet to 2 feet below the existing ground surface along the southern portion of the seismic line. At the end of the gravel access road to Blue Lake, approximately 150 feet from the southern end of the seismic line, and just before the downward slope towards Blue Lake a rapid, nearly vertical slope in the buried bedrock surface from 10 feet to 66 feet was modeled. Additionally, a concrete retaining wall was observed during the field exploration at a location corresponding to the high velocity feature of 10,000 ft per sec located at 220 feet along the seismic line. The P-wave velocities located near this concrete retaining wall should be interpreted with caution as they are likely a modeling artifact and not representative of the actual subsurface conditions in this area.

Groundwater was encountered during the 1954 BOR field exploration in drill hole DH-14 at a depth of 35.5 feet below the ground surface at the time of drilling. This depth was 0.6 feet into the bedrock that was cored. Based on this water level depth and location below the overburden material the P-wave velocities measured in the overburden material in the velocity model should not be effected by the presence of groundwater.

SL-2 — Seismic line SL-2 was performed in the open area west of the gravel access road to Blue Lake and southwest of the right dam abutment. Along seismic line SL-2, Figure 5, the estimated bedrock elevation sloped downward to the east from a depth of approximately 13 feet below the existing ground surface at the western portion of the line to a depth of 46 feet at the eastern portion.

Powerhouse Area Seismic Lines

SL-3A — Seismic line SL-3A, Figure 6, was performed along a slope from the filter plant area down to the penstock supplying water to the Powerhouse. Significant interference was experienced from background vibrations from the water supplying the Powerhouse from the penstock located at the

southern end of the seismic line. The interference provided noise which affected the seismic velocity time history traces and masked some of the first arrivals of P-wave energy. This reduced the data quality as well as reduced the depths and length along the seismic line to which the subsurface conditions were able to be modeled. This also resulted in a gap in the velocity model from approximately 80 to 110 feet along the length of the seismic line in which not enough first arrival data was available for the SeisOpt velocity optimization program to produce a P-wave velocity profile. However, the estimated top of bedrock is below the maximum modeling depth of approximately 35 feet in the northern portion. ***SL-3B*** — Seismic line SL-3B, Figure 7, was performed closest to the existing Powerhouse. The anticipated depth to bedrock ranged from 50 feet below the existing ground surface in the northern portion to 5 feet in the southern portion of the line.

Background vibrations from the Powerhouse and river flowing near the southern end of the seismic line masked some of the first arrivals of P-wave energy recorded by the geophones along the southern end of the line. The resulting velocity model in the southern portion should be interpreted with caution as the high velocity region modeled could potentially be as a result of some errors in first arrival picking due to this interference or could be indicative of cobbles and boulders, such as the surficial ones observed in this area during the field exploration.

SL-4A — Seismic line SL-4A, Figure 8, was performed along the gravel road providing access to the filter plant. The estimated depth to top of bedrock based on P-wave velocities along the seismic line ranged from 4 feet at the southern portion of the line to 18 feet along the northern portion of the line.

SL-4B — Seismic line SL-4B, Figure 9, was performed east of the Filter Plant building and along the gravel road providing access to it. The estimated depth to top of bedrock based on P-wave velocities along the seismic line ranged from 5 feet at the southern portion of the line to 22 feet along the northern portion of the line.

SL-5A — Seismic line SL-5A, Figure 10, was performed from the access road to the filter plant near the end point of SL-4A and ran west. The estimated depth to top of bedrock based on P-wave velocities along the seismic line ranged from 22 feet at the eastern portion of the line to 19 feet along the western portion of the line.

The velocity model from 0 to 30 feet should be interpreted with caution as this area consistently showed a lack of raypath coverage during the modeling iterations, meaning the optimization program will interpolate the velocity model in this area from adjacent areas in which raypath coverage existed. This may be indicative of an area of low velocity material in the subsurface or an area in which not enough data was available to be used in the velocity model.

SL-5B — Seismic line SL-5B, Figure 11, was performed to the south of the existing Powerhouse and running to the east. The estimated depth to top of bedrock based on P-wave velocities along the seismic line ranged between 14 feet and 25 feet below the existing ground surface.

Groundwater was encountered just above the bedrock elevation at a depth of 10.5 feet below the existing ground surface in Test Pit TP-01 located near the southern end of the seismic line. The presence of groundwater in this area, at saturated sediments, may elevate the P-wave velocities and would not be representative of the actual P-wave velocity of this in-place material in the unsaturated condition. The P-wave velocity is dominated by saturated conditions until the geologic materials have P-wave velocities that are substantially greater than saturated sediments (i.e., good quality bedrock).

Background vibrations from the Powerhouse and river flowing near the seismic line masked some of the first arrivals of P-wave energy recorded by the geophones and did not provide enough data to model the P-wave velocity of the eastern end of the line from approximately 120 to 184 feet.

SL-6 — Seismic line SL-4B, Figure 12, was performed to the south of the filter plant and north of the timber crib wall. The estimated depth to top of bedrock based on P-wave velocities along the seismic line ranged from 22 feet to 35 feet along the length of the seismic survey line.

Additional soil test borings and rock coring could be performed to confirm the subsurface conditions and further correlate the individual seismic lines, particularly for the seismic lines performed in the Powerhouse area (SL-3 through SL-6) where only test pit excavations were performed.

6.0 TEST METHOD LIMITATIONS

Geologic Conditions

The heterogeneous nature of the overburden material previously discussed as well as shallow or perched groundwater levels could potentially limit the effectiveness of the seismic refraction method in determining the depth to the underlying bedrock material as well as the P-wave velocity of the overburden materials. A high-velocity layer masks all lower velocity layers that are deeper, as may be the case along the lengths of the seismic lines performed where shallow groundwater exists or layers with large percentages of dense gravel and boulders overly layers with lesser percentages of these materials.

The P-wave velocity of saturated sediments tends to be controlled by the groundwater, and seismic refraction surveys are effective at determining the depth of the water table. The P-wave velocity is dominated by saturated conditions until the geologic materials have P-wave velocities that are substantially greater than saturated sediments (i.e., good quality bedrock). It appears that the P-wave velocities in deeper layers along the seismic lines surveyed at the Blue Lake site are consistently higher than they are in shallower layers; this condition is necessary for the seismic refraction method to produce useful results.

7.0 QUALIFICATION OF REPORT

The seismic P-wave measurement results in this report represent estimates of subsurface properties within the area in which the seismic line was performed. Error in the first arrival time picks, and consequently the resulting P-wave velocity estimates, could result from difficulty in estimating the first arrival times caused by background vibrations and interfering waveforms from local energy sources, such as the existing Powerhouse and penstock.

The seismic refraction method, while useful, should not be relied upon without an adequate number of test borings. It is recommended that test borings with rock coring be made throughout the Powerhouse area to verify the subsurface profiles in seismic lines SL-3 through SL-6.

LIST OF TABLES

Table 1 – Seismic Refraction Line Test Locations and Lengths

Table 1: Seismic Refraction Segment Test Locations and Lengths

Seismic Line ID	Test Location	Segment Length (feet)
SL-1A	Southern Portion of SL-1	345
SL-1B	Northern Portion of SL-1	299
SL-2	SL-2	163
SL-3A	Northern Portion of SL-3	138
SL-3B	Southern Portion of SL-3	207
SL-4A	Southern Portion of SL-4	299
SL-4B	Northern Portion of SL-4	299
SL-5A	Eastern Portion of SL-5	115
SL-5B	Western Portion of SL-5	184
SL-6	SL-6	207

Prepared By: TPQ
Checked By: JRK

LIST OF FIGURES

Figure 1 – Seismic Refraction Survey Location Plan - Intake Area/Dam (SL-1A and SL-2)

Figure 2 – Seismic Refraction Survey Location Plan - Powerhouse (SL-3A through SL-6)

Figure 3 – P-Wave Velocity Profile for Seismic Refraction Line SL-1A

Figure 4 – P-Wave Velocity Profile for Seismic Refraction Line SL-1B

Figure 5 – P-Wave Velocity Profile for Seismic Refraction Line SL-2

Figure 6 – P-Wave Velocity Profile for Seismic Refraction Line SL-3A

Figure 7 – P-Wave Velocity Profile for Seismic Refraction Line SL-3B

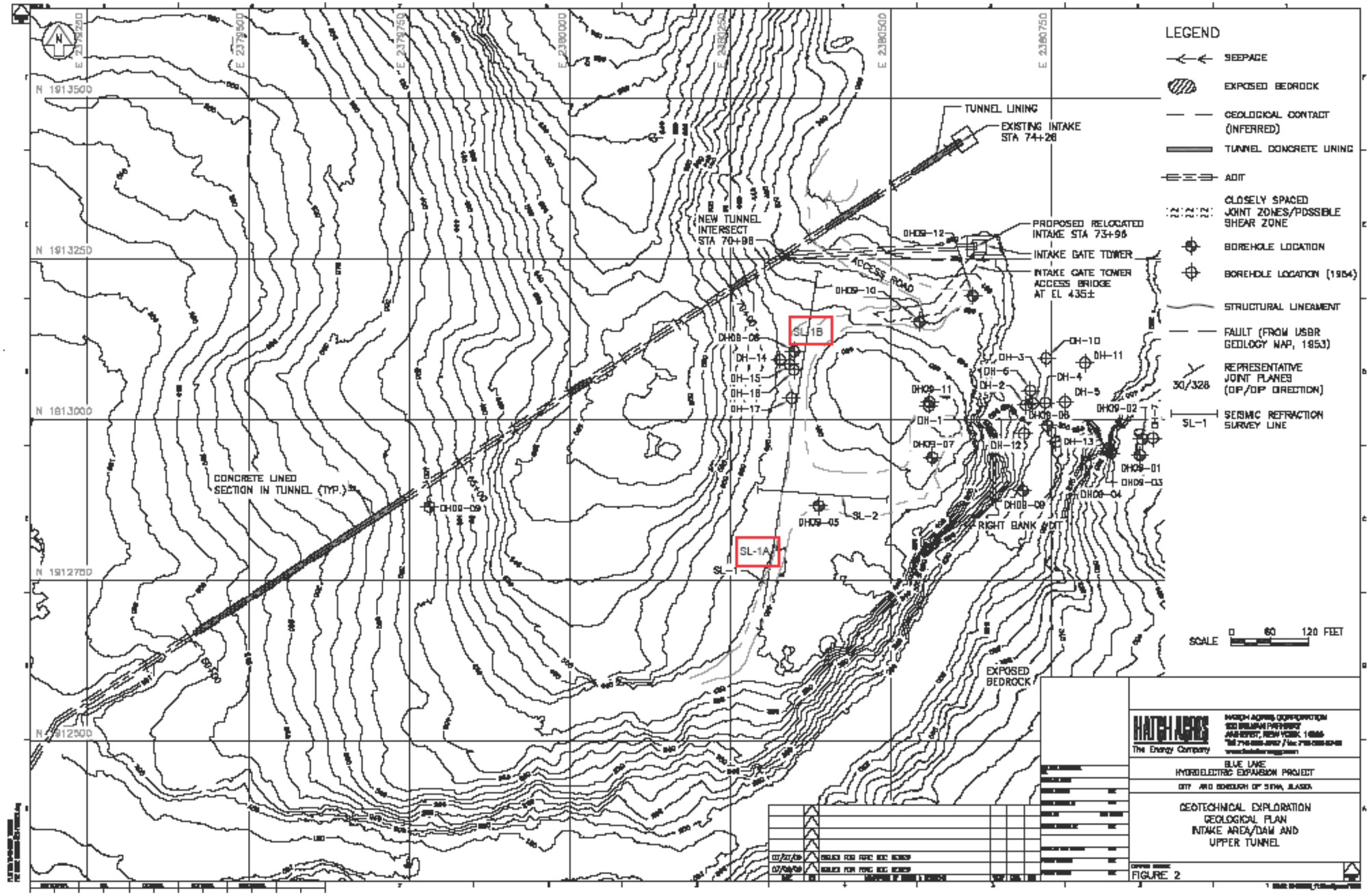
Figure 8 – P-Wave Velocity Profile for Seismic Refraction Line SL-4A

Figure 9 – P-Wave Velocity Profile for Seismic Refraction Line SL-4B

Figure 10 – P-Wave Velocity Profile for Seismic Refraction Line SL-5A

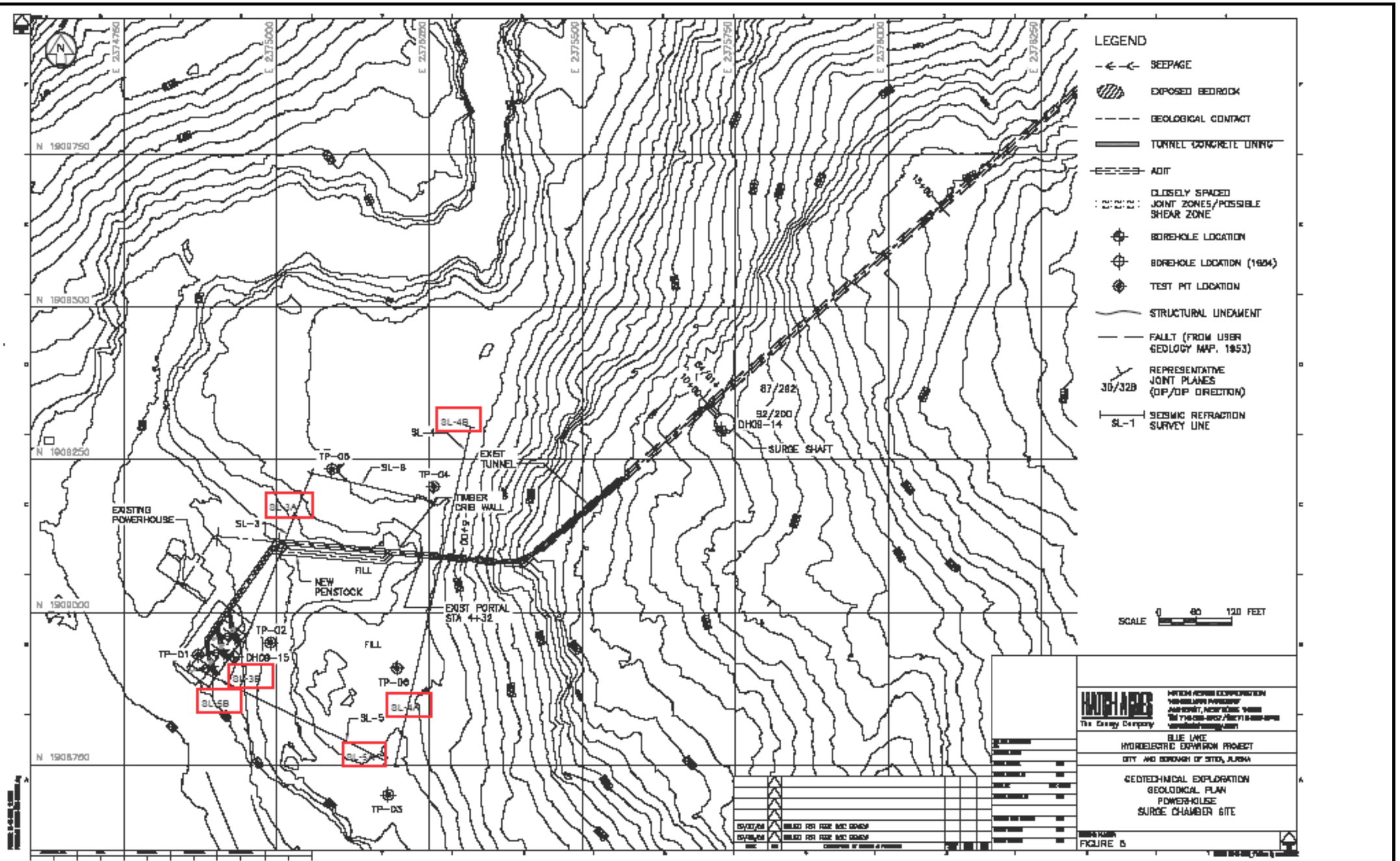
Figure 11 – P-Wave Velocity Profile for Seismic Refraction Line SL-5B

Figure 12 – P-Wave Velocity Profile for Seismic Refraction Line SL-6



Location Plan provided by Peter Friz of HATCH ACRES on October 16, 2009.

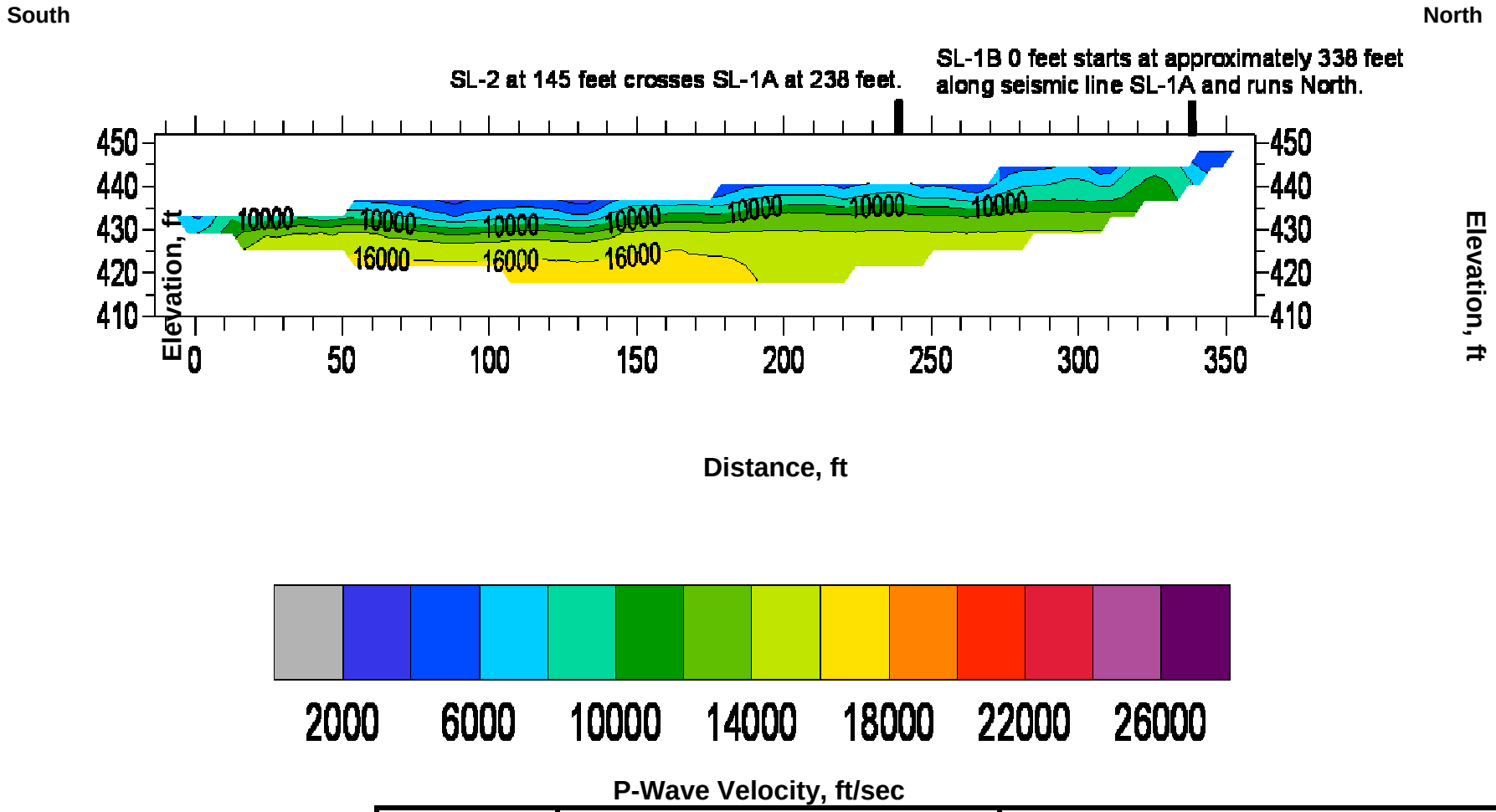
City and Borough of Sitka **Sitka, Alaska**	MACTEC		**Seismic Refraction Test Location Plan (SL-1 and SL-2)** Blue Lake Hydroelectric Expansion Sitka, Alaska		
Prepared by: TPQ	**Date:** 10/2009	**Checked By:** JRK	**Date:** 10/2009	**Project No.** 4036090008	**Figure 1**



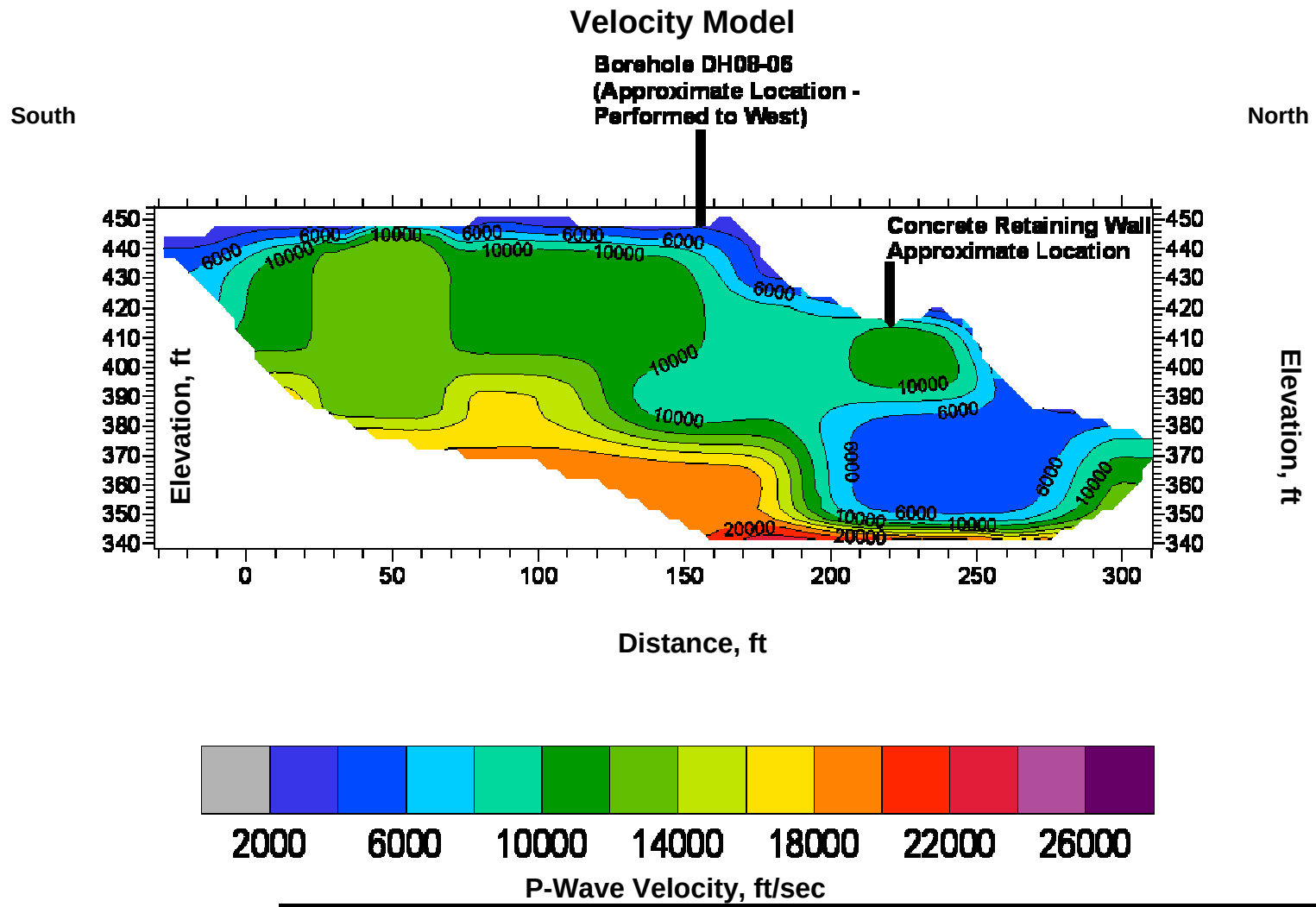
Location Plan provided by Peter Friz of HATCH ACRES on October 16, 2009.

City and Borough of Sitka **Sitka, Alaska**	MACTEC		**Seismic Refraction Test Location Plan (SL-3 through SL-6)** Blue Lake Hydroelectric Expansion Sitka, Alaska		
Prepared by: TPQ	**Date:** 10/2009	**Checked By:** JRK	**Date:** 10/2009	**Project No.** 4036090008	**Figure 2**

Velocity Model

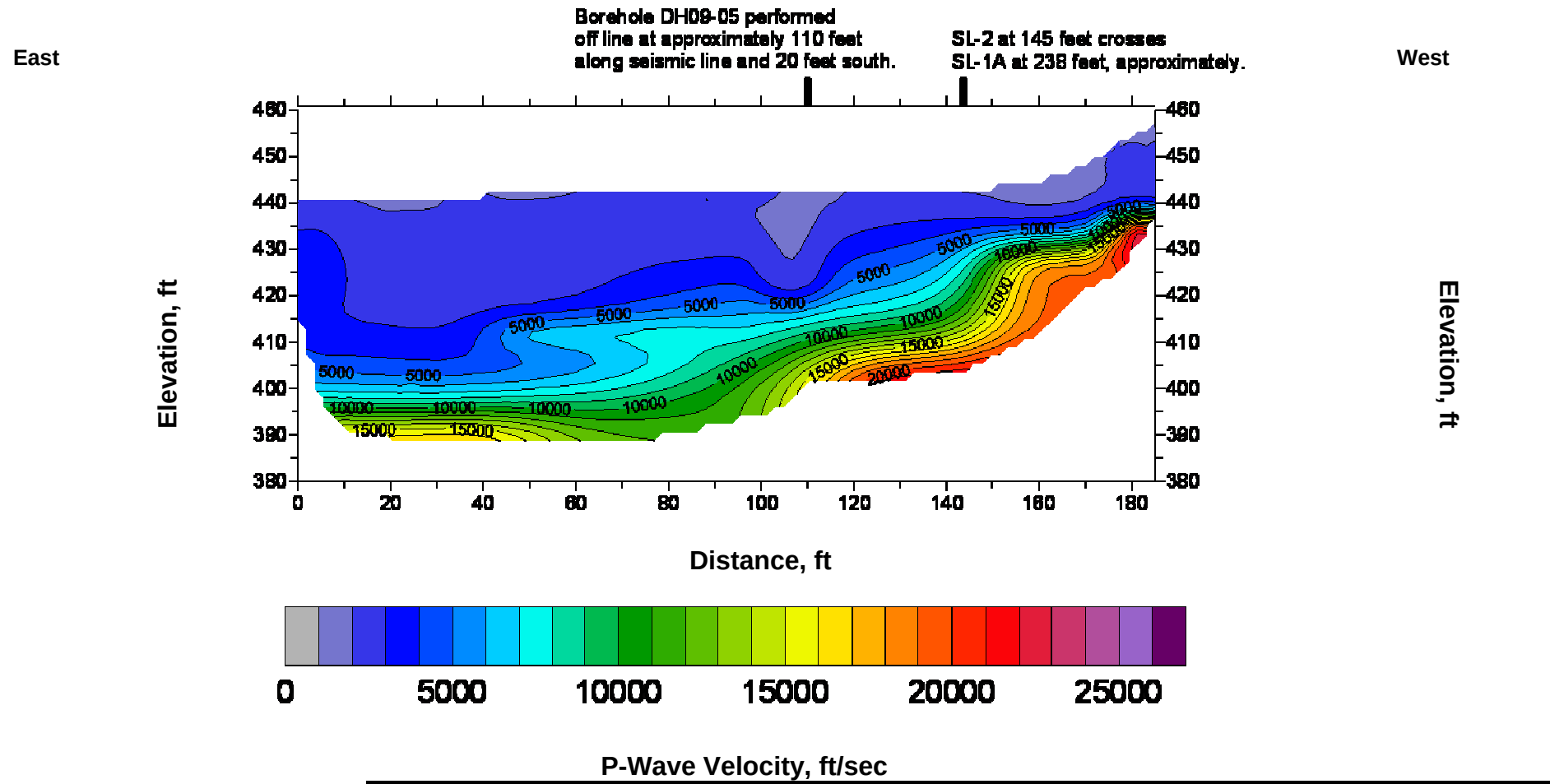


Velocity Contour Interval = 2000ft/s **Ground Surface Elevations are Approximate** **Seismic line endpoint elevations surveyed by others and provided by HATCH.**	**City and Borough of Sitka** **Sitka, Alaska**	MACTEC	**P-Wave Velocity Model for Seismic Refraction Survey Line SL-1A** Blue Lake Hydroelectric Expansion Sitka, Alaska			
	Prepared by: TPQ	**Date:** 12/2009	**Checked By:** JRK	**Date:** 12/2009	**Project No.** 4036090008	**Figure 3**



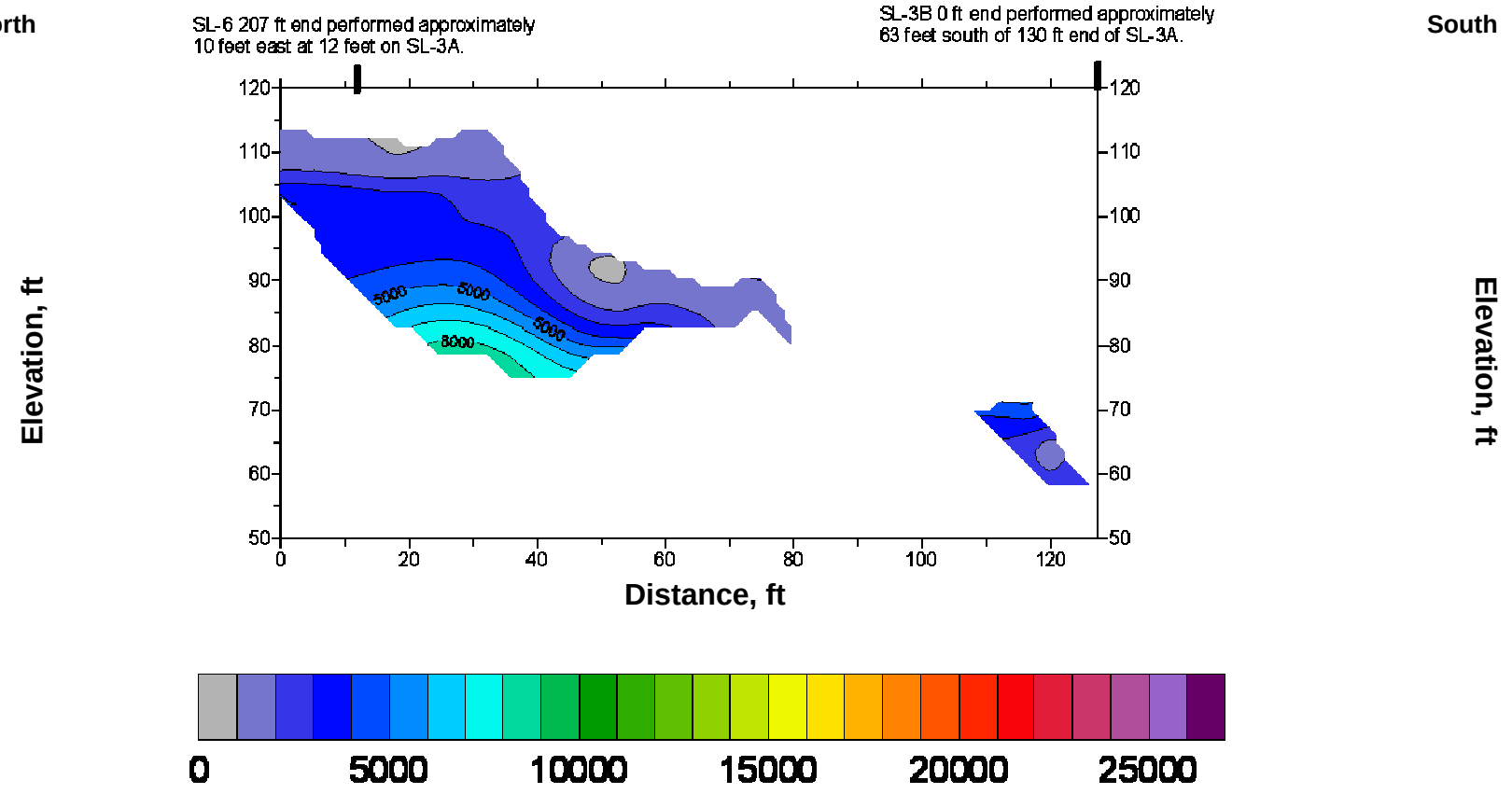
Velocity Contour Interval = 2000ft/s **Ground Surface Elevations are Approximate** **Seismic line endpoint elevations surveyed by others and provided by HATCH.**	**City and Borough of Sitka** **Sitka, Alaska**	MACTEC	**P-Wave Velocity Model for Seismic Refraction Survey Line SL-1B** Blue Lake Hydroelectric Expansion Sitka, Alaska			
	Prepared by: TPQ	**Date:** 12/2009	**Checked By:** JRK	**Date:** 12/2009	**Project No.** 4036090008	**Figure 4**

Velocity Model



Velocity Contour Interval = 1000ft/s **Ground Surface Elevations are Approximate** **Seismic line endpoint elevations surveyed by others and provided by HATCH.**	**City and Borough of Sitka** **Sitka, Alaska**	MACTEC		**P-Wave Velocity Model for Seismic Refraction Survey Line SL-2** Blue Lake Hydroelectric Expansion Sitka, Alaska		
	Prepared by: TPQ	**Date:** 12/2009	**Checked By:** JRK	**Date:** 12/2009	**Project No.** 4036090008	**Figure 5**

Velocity Model



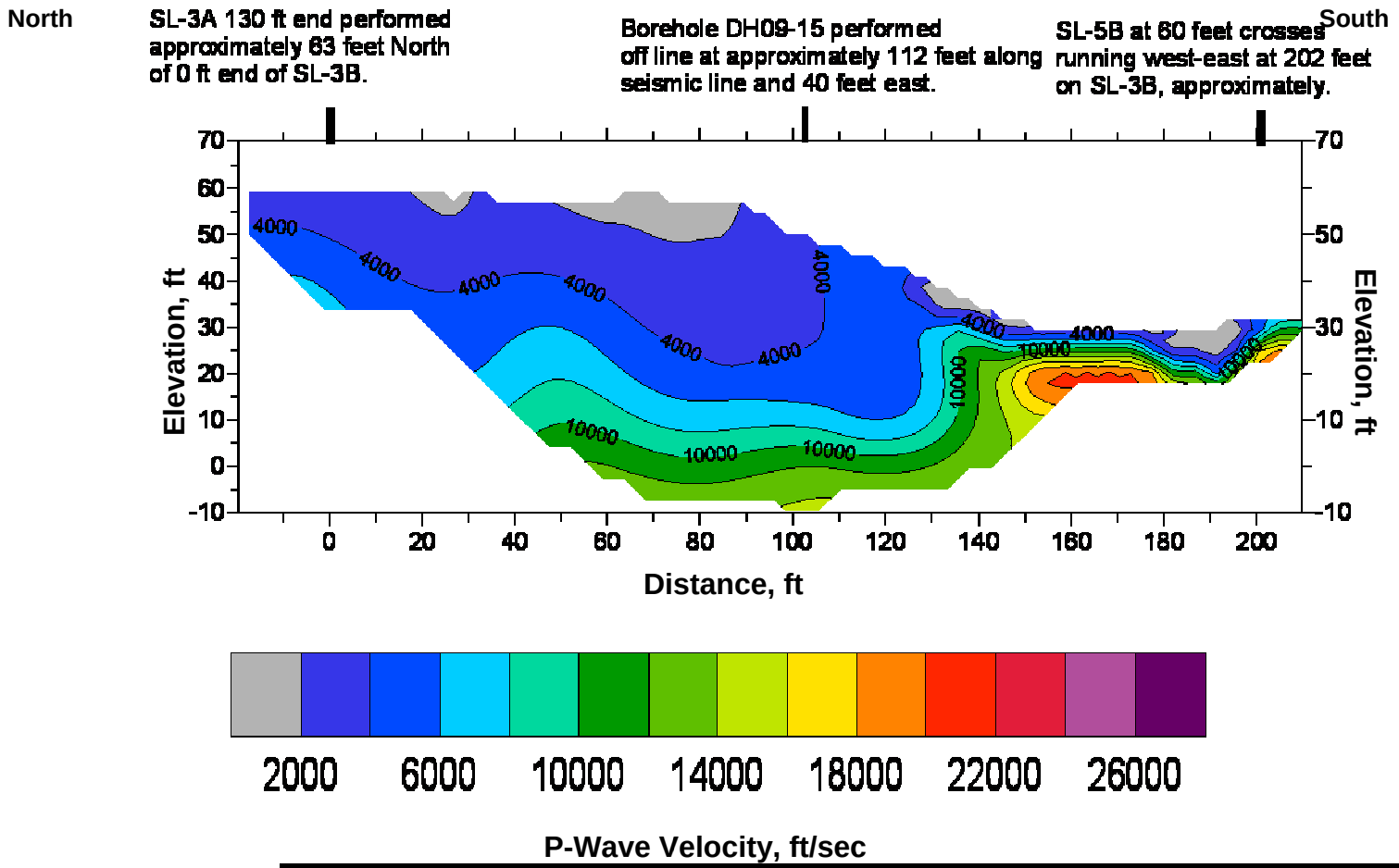
Velocity Contour Interval = 1000ft/s

Ground Surface Elevations are Approximate

Seismic line endpoint elevations surveyed by others and provided by HATCH.

City and Borough of Sitka Sitka, Alaska	MACTEC		**P-Wave Velocity Model for Seismic Refraction Survey Line SL-3A** Blue Lake Hydroelectric Expansion Sitka, Alaska		
Prepared by: TPQ	**Date:** 12/2009	**Checked By:** JRK	**Date:** 12/2009	**Project No.** 4036-09-0008	**Figure 6**

Velocity Model



Velocity Contour Interval = 2000ft/s

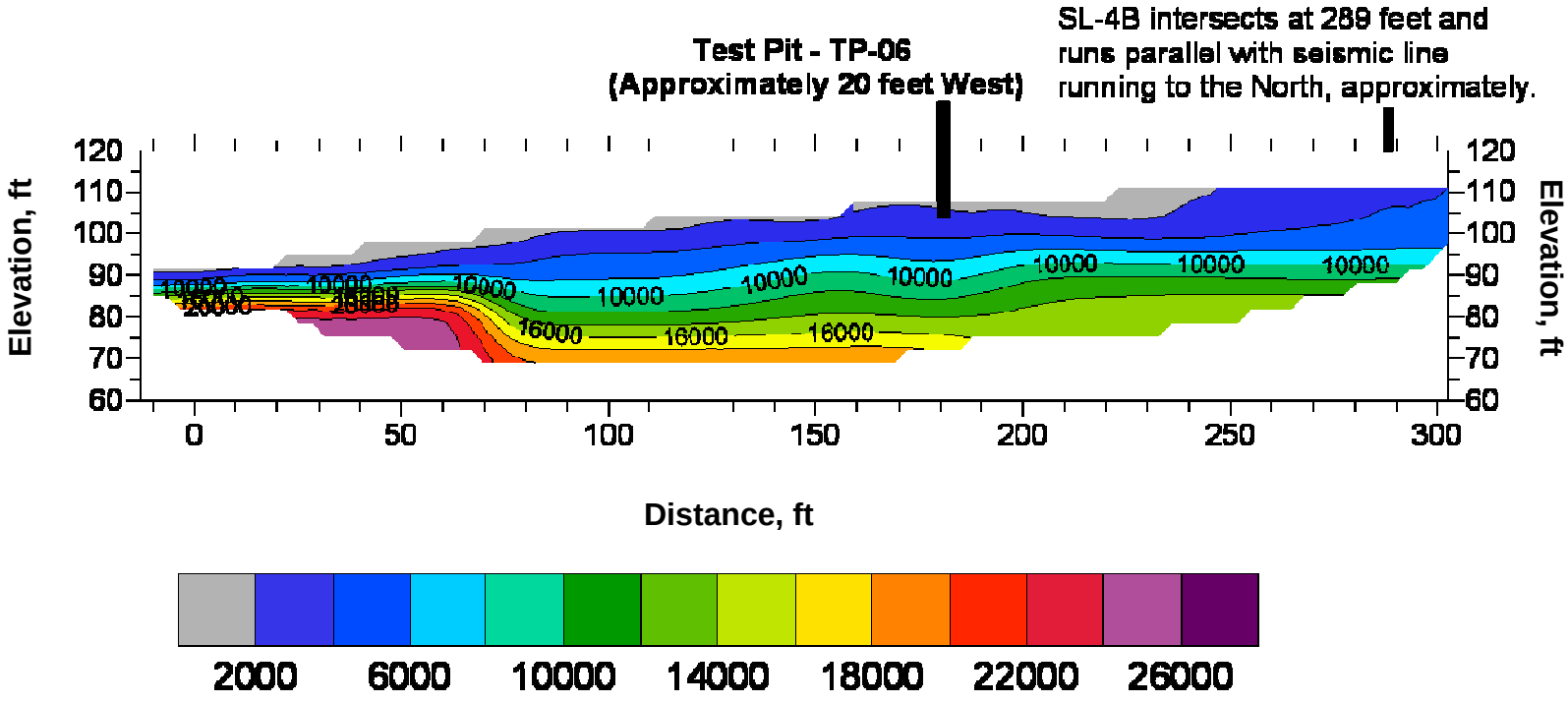
Ground Surface Elevations are Approximate

Seismic line endpoint elevations surveyed by others and provided by HATCH.

City and Borough of Sitka Sitka, Alaska	MACTEC		P-Wave Velocity Model for Seismic Refraction Survey Line SL-3B Blue Lake Hydroelectric Expansion Sitka, Alaska		
Prepared by: TPQ	**Date:** 12/2009	**Checked By:**	**Date:** 12/2009	**Project No.** 4036-09-0008	**Figure 7**

Velocity Model

South **North**



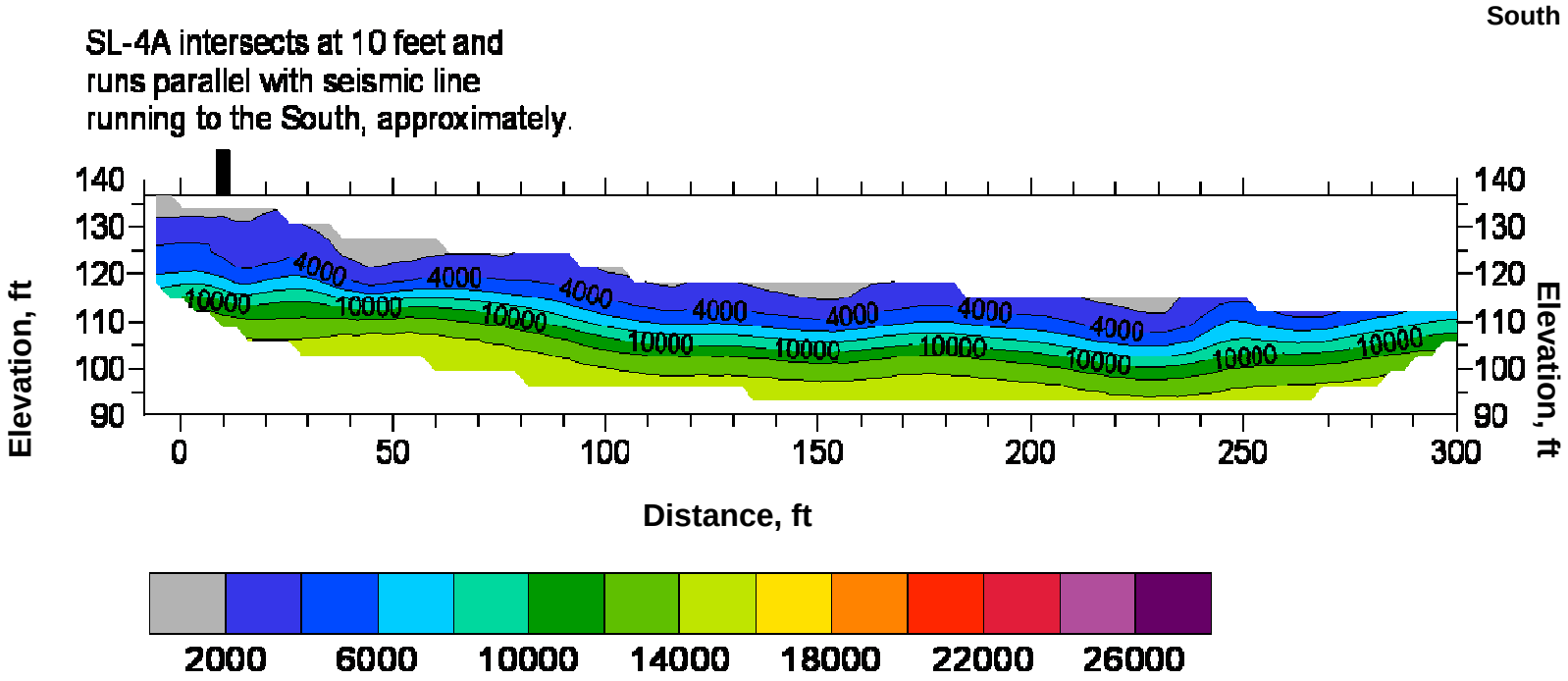
Velocity Contour Interval = 2000ft/s

Ground Surface Elevations are Approximate

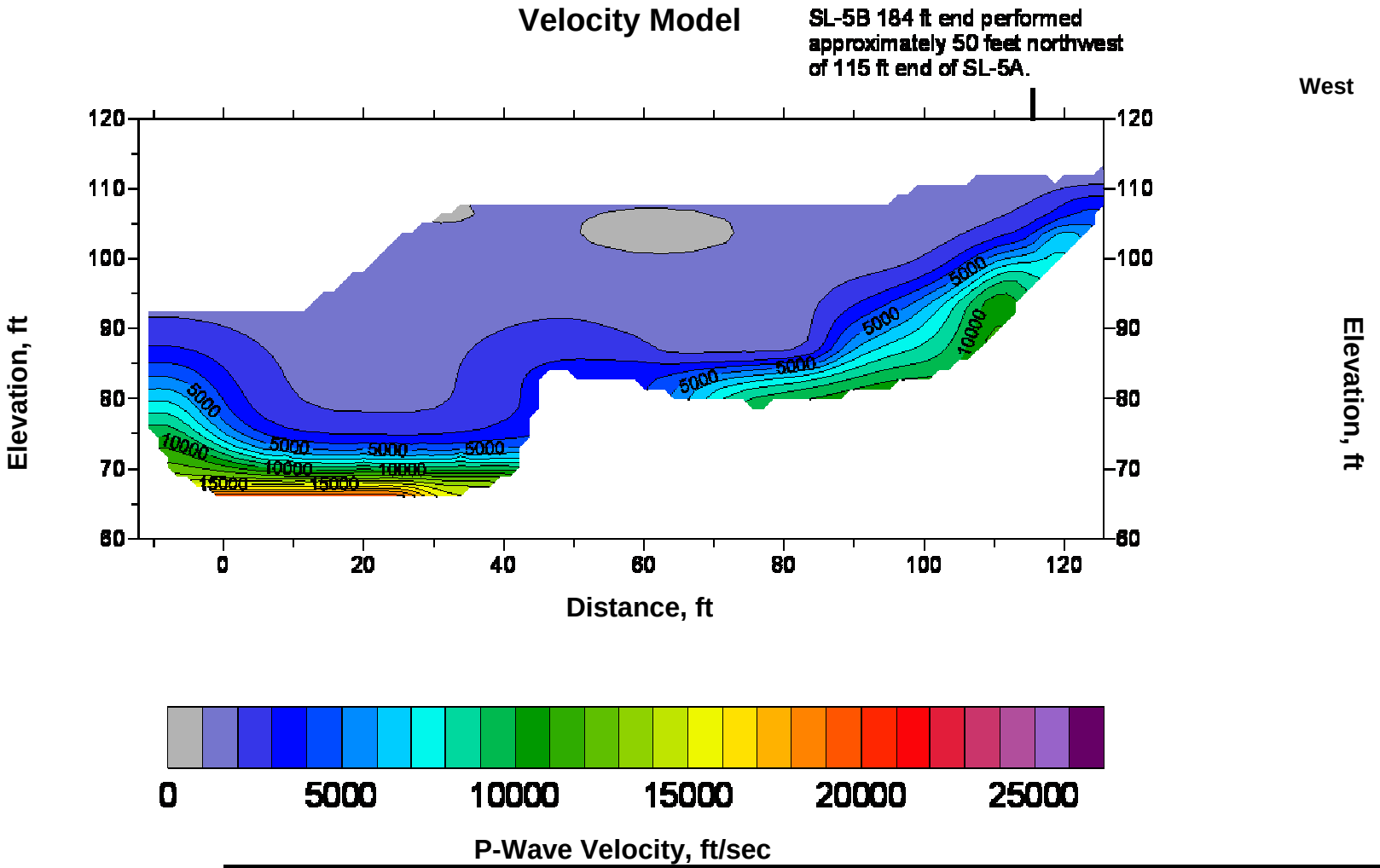
Seismic line endpoint elevations surveyed by others and provided by HATCH.

City and Borough of Sitka Sitka, Alaska	MACTEC		**P-Wave Velocity Model for Seismic Refraction Survey Line SL-4A** Blue Lake Hydroelectric Expansion Sitka, Alaska		
Prepared by: TPQ	**Date:** 12/2009	**Checked By:** JRK	**Date:** 12/2009	**Project No.** 4036-09-0008	**Figure 8**

Velocity Model



Velocity Contour Interval = 2000ft/s **Ground Surface Elevations are Approximate** **Seismic line endpoint elevations surveyed by others and provided by HATCH.**	**City and Borough of Sitka** **Sitka, Alaska**	MACTEC		**P-Wave Velocity Model for Seismic Refraction Survey Line SL-4B** Blue Lake Hydroelectric Expansion Sitka, Alaska		
	Prepared by: TPQ	**Date:** 12/2009	**Checked By:** JRK	**Date:** 12/2009	**Project No.** 4036-09-0008	**Figure 9**



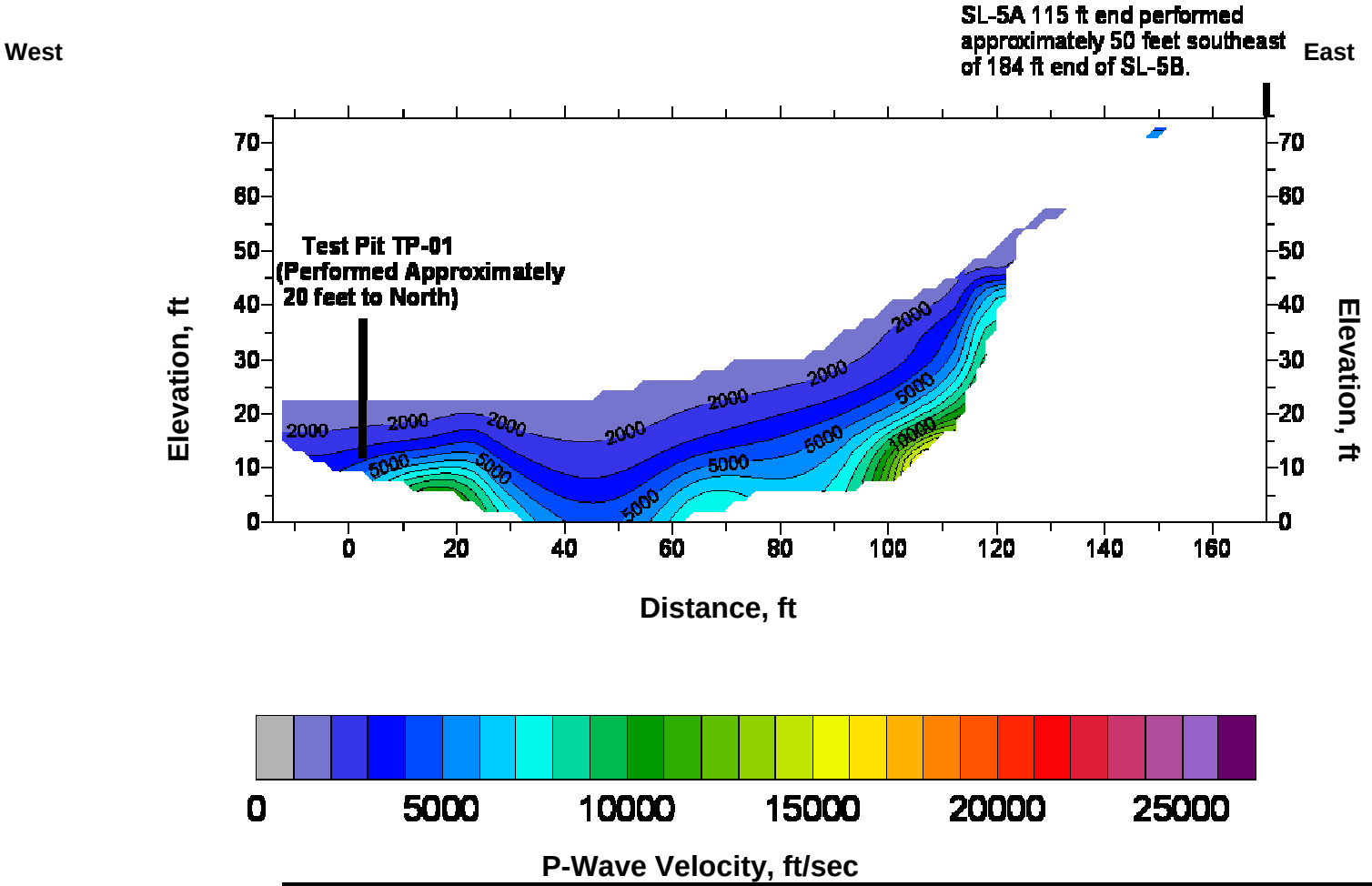
Velocity Contour Interval = 1000ft/s

Ground Surface Elevations are Approximate

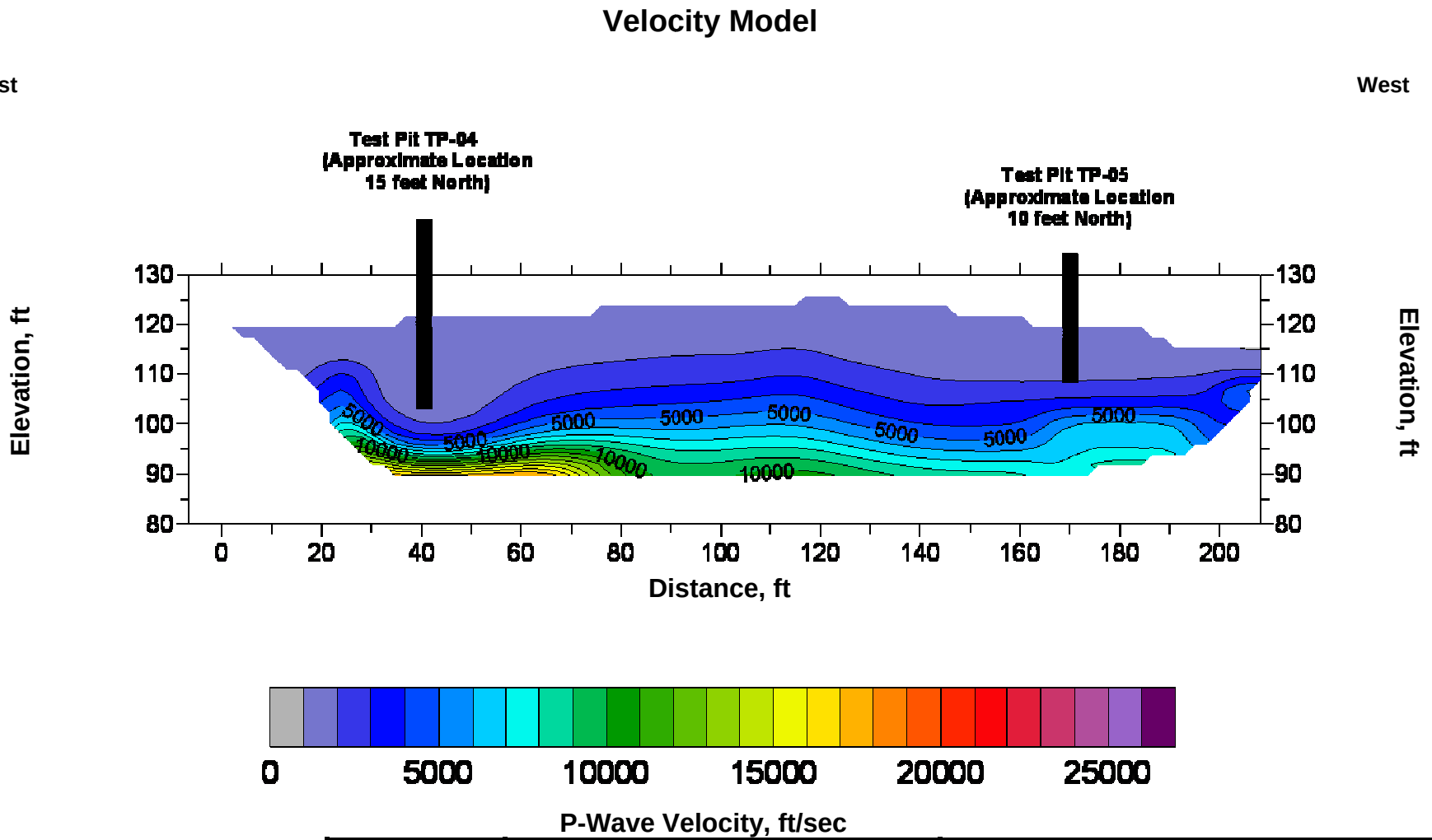
Seismic line endpoint elevations surveyed by others and provided by HATCH.

City and Borough of Sitka Sitka, Alaska	MACTEC		**P-Wave Velocity Model for Seismic Refraction Survey Line SL-5A** Blue Lake Hydroelectric Expansion Sitka, Alaska		
Prepared by: TPQ	**Date:** 12/2009	**Checked By:** JRK	**Date:** 12/2009	**Project No.** 4036-09-0008	**Figure 10**

Velocity Model



Velocity Contour Interval = 1000ft/s **Ground Surface Elevations are Approximate** **Seismic line endpoint elevations surveyed by others and provided by HATCH.**	**City and Borough of Sitka** **Sitka, Alaska**	MACTEC		**P-Wave Velocity Model for Seismic Refraction Survey Line SL-5B** Blue Lake Hydroelectric Expansion Sitka, Alaska		
	Prepared by: TPQ	**Date:** 12/2009	**Checked By:** JRK	**Date:** 12/2009	**Project No.** 4036-09-0008	**Figure 11**



Velocity Contour Interval = 1000ft/s **Ground Surface Elevations are Approximate** **Seismic line endpoint elevations surveyed by others and provided by HATCH.**	**City and Borough of Sitka** **Sitka, Alaska**	MACTEC		**P-Wave Velocity Model for Seismic Refraction Survey Line SL-6** Blue Lake Hydroelectric Expansion Sitka, Alaska		
	Prepared by: TPQ	**Date:** 12/2009	**Checked By:** JRK	**Date:** 12/2009	**Project No.** 4036-09-0008	**Figure 12**

DISTRIBUTION

Final Data Report of Seismic Compression (P) Wave Velocity Measurements by Seismic Refraction
Blue Lake Hydroelectric Expansion – Sitka, Alaska
MACTEC Project No. 4036090008

December 2, 2009

1 PDF (via E-Mail) 1 Hard Copy	Mr. Dean T. Orbison, P.E. City and Borough of Sitka Electric Department 105 Jarvis Street Sitka, AK 99835
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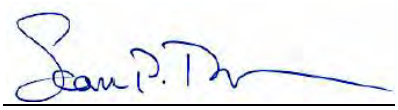
Quality Control Reviewer



Sean P. Thomas, RES

Reg. Env. Scientist - 5173

SPT/KAH/A0596DF

Appendix E

Borehole Logs

Working Together SAFELY
© Hatch 2006/03 ⌘

Borehole DH09-01

Working Together SAFELY

© Hatch 2006/03 ⌘

BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-01***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 9

SITE: Left Abutment

COORDINATES: 1912944.90 N, 2380886.50 E
DIP DIRECTION: 305
DIP: 70

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 441.7
END OF HOLE: 362.8

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 4500
METHOD SOIL: HWT Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 09/14/09
FINISHED: 09/16/09
INSPECTOR: P. Nolan
LOGGED BY: P. Friz
REVIEWED: S. Perkins

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) □ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN. (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
441.7													
0.0		0.0 - 4.0 ft: Overburden Soil and woody debris - material not sampled	0	1				1.0 2.0 3.0 4.0					
		4.0 ft TOP OF BEDROCK see next sheet						5.0					

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT | NATURAL MOISTURE CONTENT | LIQUID LIMIT
W_P W_N W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-01**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
437.94		4.0 - 13.8 ft: Metamorphosed Andesitic Siltstone Light to dark grey, fine grained, very strong (100 - 250 MPa), light/dark flow banding @ 45 deg to core axis; some calcite veinlets; Iron staining on joint surfaces; Average discontinuity spacing of 0.08 ft; GSI = 60 - 65.		4.3 ft. - 5.2 ft: FRAGMENTED ZONE In this hole the following general discontinuity characteristics were noted: 56% of the discontinuities are smooth, 27% slightly rough, and 17% rough. 93% of the discontinuities are planar. 40% of the discontinuities have hematite staining. For data on each discontinuity, see the detailed discontinuity log.		2	100	70	5 6 7 8 9	20 40 60 80	0.1 1 10 100 (cm/sec) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						3	100	100	10 11 12 13 14				
428.7 13.8		13.8 - 16.4 ft: Metamorphosed Andesitic Siltstone Light/dark grey, fine grained, very strong (100 - 250 MPa), very little flow banding; some calcite veinlets; No jointing;							15				

SAMPLING METHOD

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K - Slotted

SHIPPING CONTAINER

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P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost — RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-01**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
426.3 / 16.4		GSI = 60 - 65.											
		16.4 - 29.6 ft: Metamorphosed Bedded Andesitic Siltstone Light to dark grey, fine grained, very strong (100 - 250 MPa), flow banding @ 45 deg to core axis; some calcite veinlets up to 50 mm thick; Iron staining on joint surfaces; Average discontinuity spacing of 2.0 ft; GSI = 60 - 65.				4	100	100	17 18 19	20 40 60 80	0.1 1 10 100 (cm/sec) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						5	100	96	20 21 22 23 24				
		23.0 ft: Lost drill water circulation. 25.0 ft: 10-15 mm wide calcite vein ~ 15 deg to core axis				6	100	100	25 26 27				

SAMPLING METHOD

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P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-01**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
413.9 / 29.6		28.6 ft: 5 mm wide quartz vein ~80 deg to core axis							29	20 40 60 80	0.1 1 10 100 / No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
		29.6 - 39.3 ft: Metamorphosed Andesitic Siltstone Light to dark grey, fine grained, very strong (100 - 250 MPa), less prominent light and dark flow banding @ 45 deg to core axis; few calcite veinlets; Iron staining on joint surfaces; Average discontinuity spacing of 1.2 ft; GSI = 60 - 65.				7	100	100	30				
									31				
									32				
									33				
									34				
									35				
									36				
						8	100	96	37				
									38				
									39				
404.8 / 39.3		39.3 - 57.8 ft: Metamorphosed Andesitic Siltstone - Carbonaceous											

SAMPLING METHOD

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Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-01**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		Andesitic Siltsone/Mudstone Grey to Black color, conglomeratic texture with fine grained flow-banded matrix and mostly small (<0.25") clasts, some up to 0.5 - 1.0 " in size; calcite veinlets occur less frequently; Iron staining on joint surfaces; Average discontinuity spacing of 2.2 ft; GSI = 65 - 70.		42.8 ft. - 44.0 ft: FRAGMENTED ZONE		9	100	76	41 42 43 44 45 46 47 48 49 50 51				
						10	100	94					
						11	100	96					

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

PERMEABILITY (cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

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Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-01**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
387.4 / 57.8		57.8 - 75.3 ft: Metamorphosed Andesitic Siltstone - Metamorphosed Carbonaceous Andesitic Siltstone/Mudstone Grey to Black color, fine grained; flow banding @ 45 deg to core axis; very strong (100 - 250 MPa); few calcite veinlets; Iron staining on joint surfaces; GSI = 65 - 70.				12	100	88	53 54 55 56 57 58 59 60 61 62 63	20 40 60 80	0.1 1 10 100 (lugeons); No take; 10^{-6} 10^{-5} 10^{-4} 10^{-3} (cm/sec)		
						13	100	100					

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-01**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 7 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
				64.3 ft. - 1.5 ft: Longitudinal joints parallel to core axis.					65	20 40 60 80	0.1 1 10 100 / No take 10^-6 10^-5 10^-4 10^-3		
		65.2 - 70.0 ft: Calcite veins/veinlets occur less frequently.							66				
				66.6 ft. - 66.9 ft: FRAGMENTED ZONE		14	100	90	67				
									68				
									69				
		70.0 - 75.3 ft: Light to dark grey color; fine grained; very strong (100 - 250 MPa); less prominent light/dark flow banding @ 30 deg to core axis; some calcite veinlets.				15	100	100	70				
									71				
									72				
									73				
									74				
370.9 / 75.3		75.3 - 84.0 ft: Metamorphosed Fragmental Andesitic							75				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-01**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 8 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		Siltstone Grey-Black colors; conglomeratic texture with fine grained flow-banded matrix and mostly small (<0.25") clasts, some up to 0.5 - 1.0 " in size; very few calcite veins/veinlets; Iron staining on joint surfaces; Average discontinuity spacing of 4.3 ft; GSI = 65 - 70. 77.8 - 78.2 ft: Sample R6-PL = 83.71 MPa 78.2 - 79.0 ft: Sample R6-UCS = 198.0 MPa				16	100	100	77 78 79	20 40 60 80	0.1 1 10 100 (cm/sec) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						17	100	100	80 81 82 83				
362.8 84		**END OF BOREHOLE**							84				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-01

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 9 **OF:** 9

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at 37.2 ft. on September 16, 2009.
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-01
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Left Abutment
Azimuth (Deg) 235
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
4.3	5.2			x	Fragmented zone																
5.2					Joint	40						x		x			H		S			O
5.7					Joint	40						x		x					S			
5.8					Joint	40						x		x			H		S			
6.5					Joint	80							x			x	H		S			
6.5					Joint	45					x			x			H		S			
6.9					Drill Break																	
7.4					Joint	45					x			x			H		S			
7.8					Joint						x			x								
8.8					Joint		84	316				x				x	H	S	S			O
8.9					Joint		84	303			x			x			H	S	S			O
8.9					Joint	50							x	x			H		S			O
9.0					Drill Break																	
12.6					Joint	55	42	93			x			x								O
13.2					Hammer Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Left Abutment
Azimuth (Deg) 235
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
13.8					Hammer Break																
14.0					Drill Break																
15.4					Drill Break																
16.9					Joint	55					x			x			H	C	S		P	O
18.2					Joint	70					x			x			H		S			O
19.0					Drill Break																
20.3					Drill Break																
21.4					Joint	30						x		x			H		S			O
21.6					Joint	30	42	16				x		x			H		S			O
22.3					Hammer Break																
23.2					Hammer Break																
24.0					Joint		22	322			x			x			H		S			O
24.5					Joint	10	81	289			x			x			H	Q	S		P	O
24.6					Joint		82	287			x			x			H	Q	S		P	O
24.9					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

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Drilling Report (Discontinuities)

Borehole: DH09-01
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Left Abutment
Azimuth (Deg)	235
Inclination (Deg)	70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
25.9					Joint		89	287					x			x	H		S			O
26.0					Drill Break																	
26.8					Hammer Break																	
27.4					Hammer Break																	
29.0					Drill Break																	
31.3					Hammer Break																	
34.0					Drill Break																	
35.3					Joint	40	51	206			x			x			H		S			H
35.8					Drill Break																	
36.3					Joint	40	20	4			x			x			H		S			H
36.5					Drill Break																	
37.3					Joint	45	87	286					x	x			H		S			H
37.5					Joint	45							x	x			H		S			H
39.0					Joint	30	88	310			x			x			H	C	S		P	H
40.5					Joint	60							x	x			H		S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

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Drilling Report (Discontinuities)

Borehole: DH09-01
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Left Abutment
Azimuth (Deg) 235
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
41.2					Joint	30	70	42			x			x			H	C	S		P	H
41.5					Joint	30					x			x			H	C	S		P	H
42.8	44.0			x	Fragmented zone		56	223			x			x			H		S			
46.0					Joint	35					x			x			H		S			
46.1					Joint	30							x	x			H		S			
46.8					Joint	35	30	239				x		x			H		S			
47.0					Drill Break																	
47.4					Drill Break																	
47.7					Joint	45					x			x								
47.9					Drill Break																	
48.3					Drill Break																	
48.8					Joint	15						x		x			H		S			
49.0					Drill Break																	
50.4					Drill Break																	
50.9					Hammer Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

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S-slightly; M-moderately; H-highly

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Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Left Abutment
Azimuth (Deg) 235
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
51.6					Joint	40					x			x			H		S			
51.7					Joint	40	61	217				x		x			H		S			
51.8					Joint	40	48	239			x			x			H		S			
52.5					Drill Break																	
54.0					Drill Break																	
54.7					Joint	30	82	215				x		x			H		S			
55.3					Drill Break																	
55.8					Drill Break																	
56.0					Drill Break																	
56.4					Joint	25					x			x			H		S			
56.8					Joint	50						x		x			H		S			
57.1					Joint	30						x		x			H		S			
57.6					Joint	30	54	221			x			x			H		S			
57.9					Joint		44	204			x			x			H		S			
58.2					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

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S-slightly; M-moderately; H-highly

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Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Left Abutment
Azimuth (Deg) 235
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
59.0					Drill Break																
59.2					Drill Break																
60.0					Joint	40	37	273				x		x			H		S		
60.6					Drill Break																
61.1					Hammer Break																
61.8					Hammer Break																
62.8					Drill Break																
63.5					Drill Break																
63.8					Drill Break																
64.0					Drill Break																
64.2					Joint	25					x			x			H		S		
64.3	65.8				Longitudinal Joint	5						x		x			H		S		
65.8					Joint	45					x			x			H		S		
66.6	66.9			x	Fragmented zone		74	212													
67.3					Joint		69	218													

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

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S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-01
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 235
Inclination (Deg): 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
67.4					Joint	15	82	219														
67.6					Drill Break																	
68.2					Drill Break																	
69.0					Joint	30	90	124			x			x			H		S			
69.8					Hammer Break																	
70.7					Drill Break																	
70.8					Drill Break																	
72.6					Drill Break																	
73.7					Drill Break																	
73.9					Drill Break																	
74.0					Drill Break																	
74.9					Drill Break																	
75.9					Drill Break																	
76.7					Calcite Vein		46	245		x				x				C			P	
77.7					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Left Abutment
Azimuth (Deg) 235
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
78.1					Drill Break																	
79.0					Drill Break																	
79.8					Drill Break																	
80.4					Drill Break																	
80.6					Drill Break																	
80.7					Joint	45					x			x			H		S			
81.2					Joint	45	26	296			x			x			H	C	S		P	
84.0					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

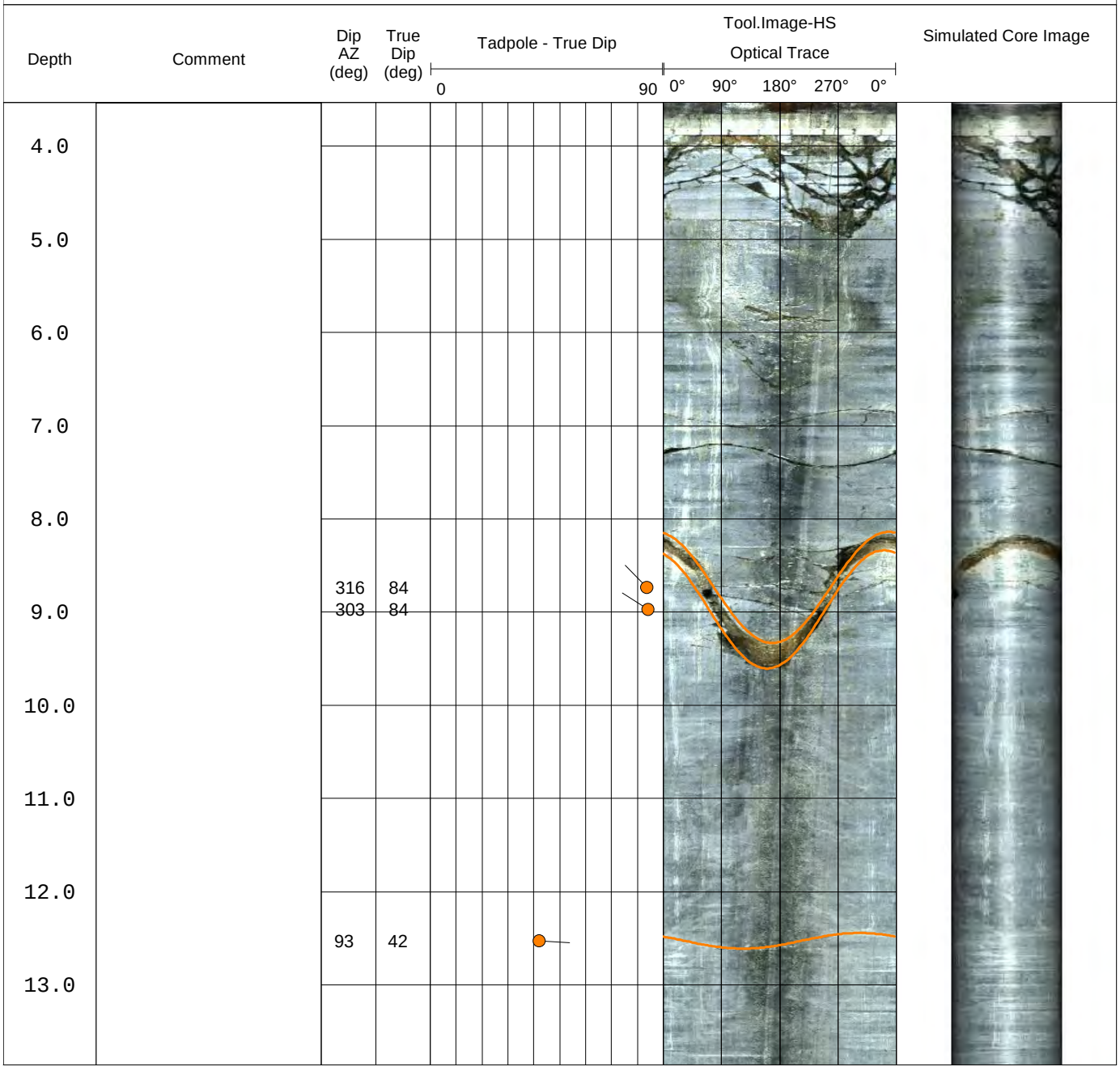
Aperture:O-Open; H-Hairline (<0.5mm)

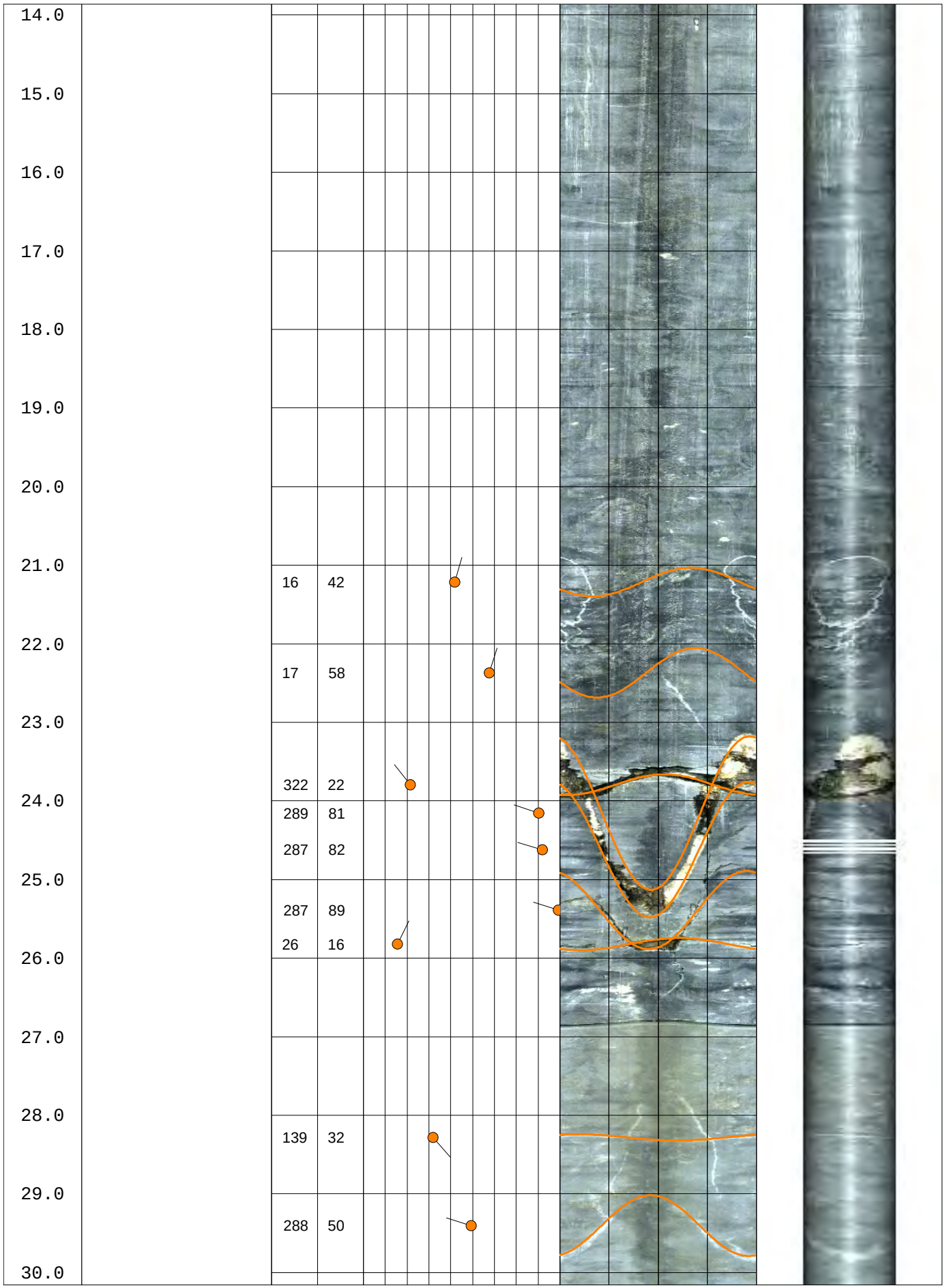
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company City and Borough of Sitka	
	Location: Sitka, AK	
	Project: Blue Lake Hydroelectric	
Date Logged:	September 12, 2009	Borehole ID: DH09-01
File Name:	DH09-01-1M.wcl	Logged By: Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from north.

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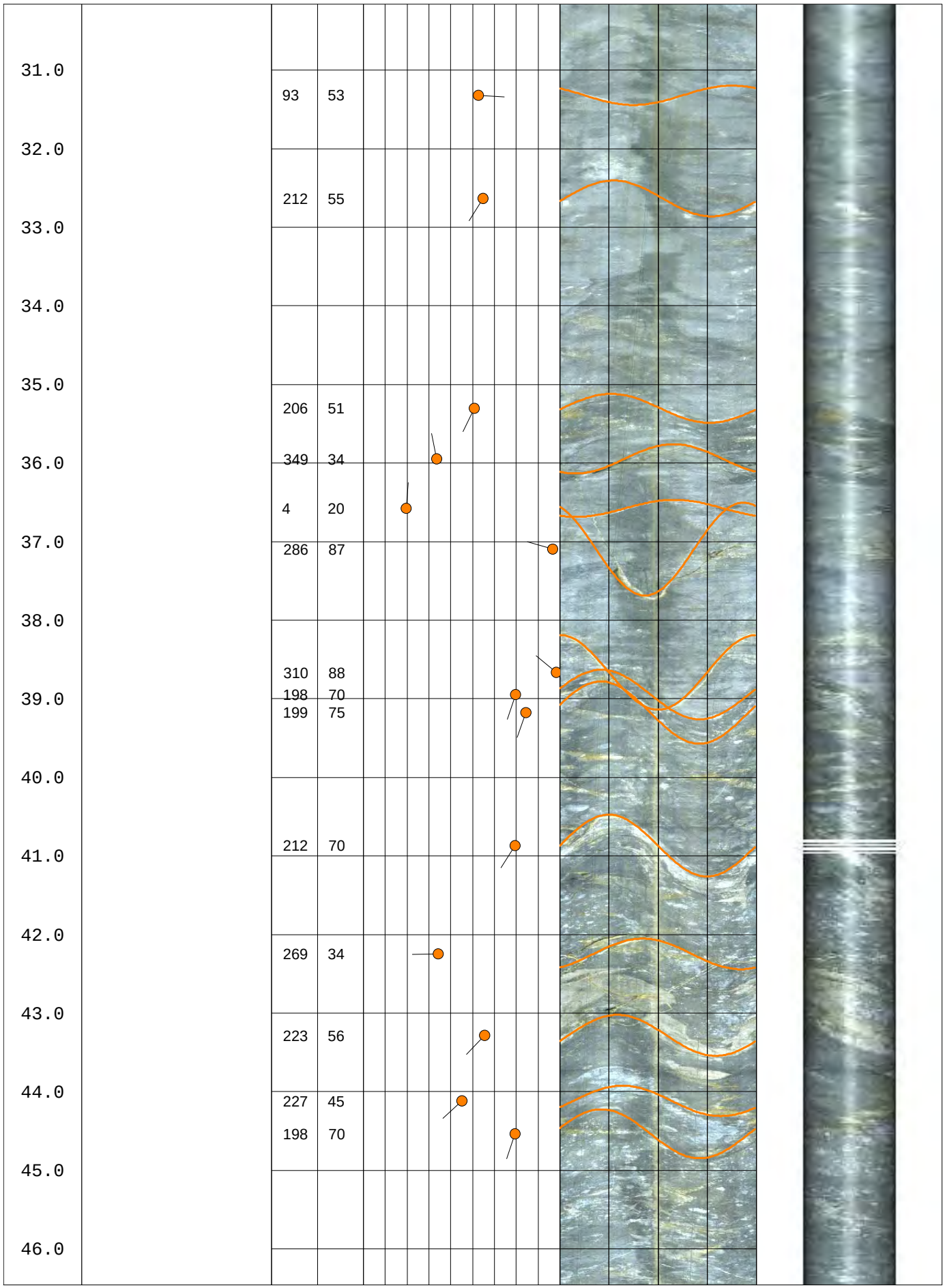
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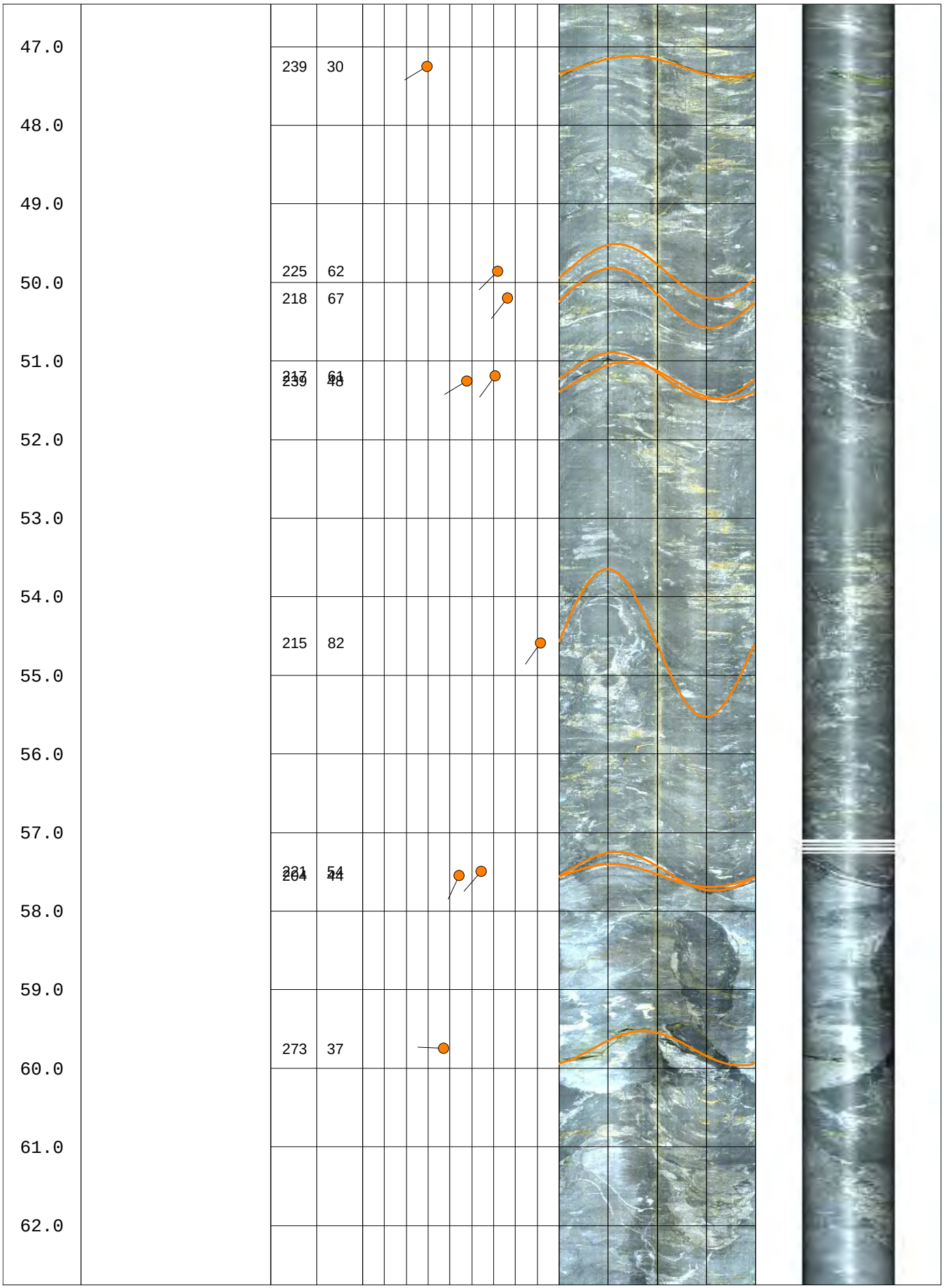
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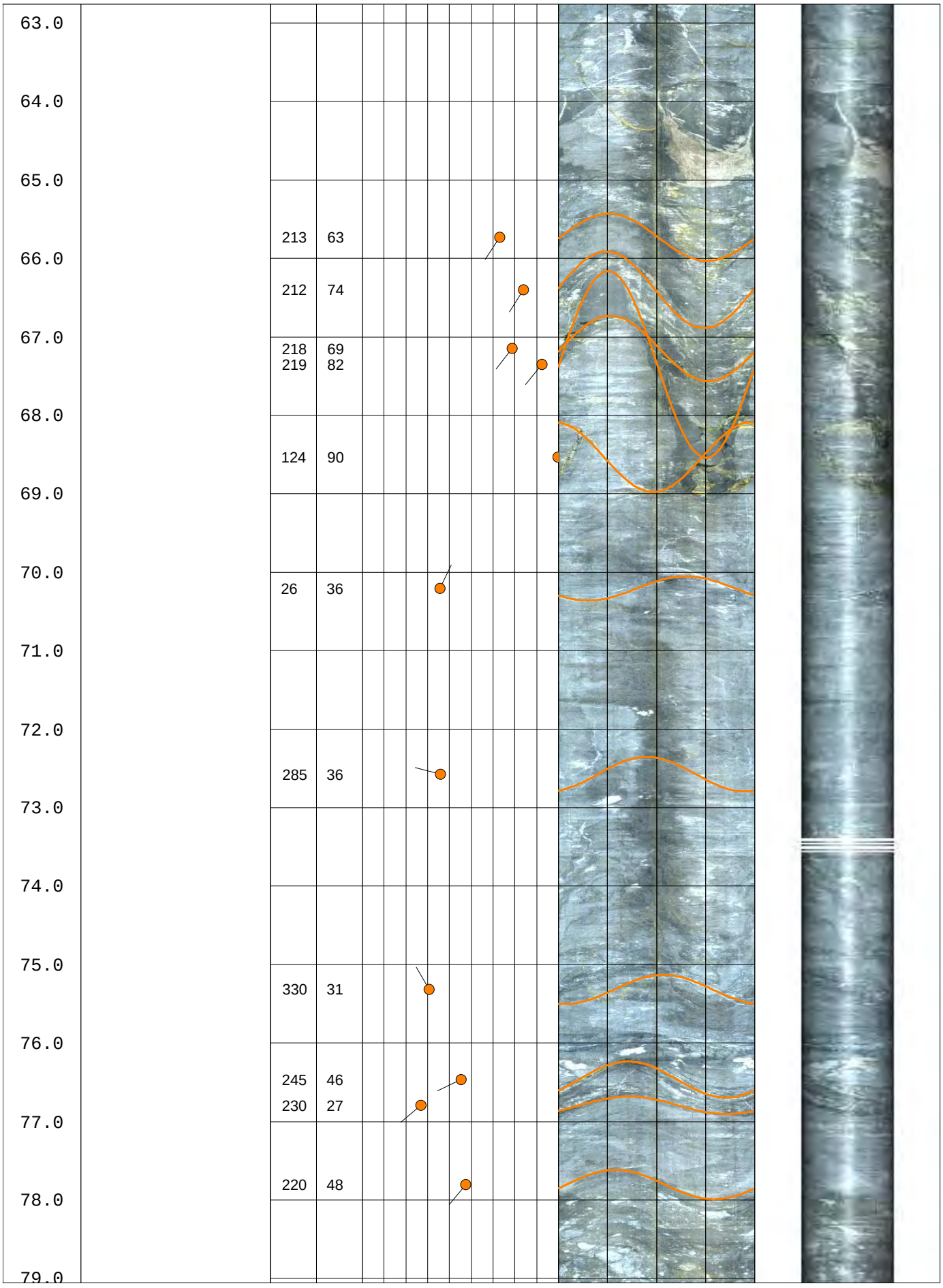
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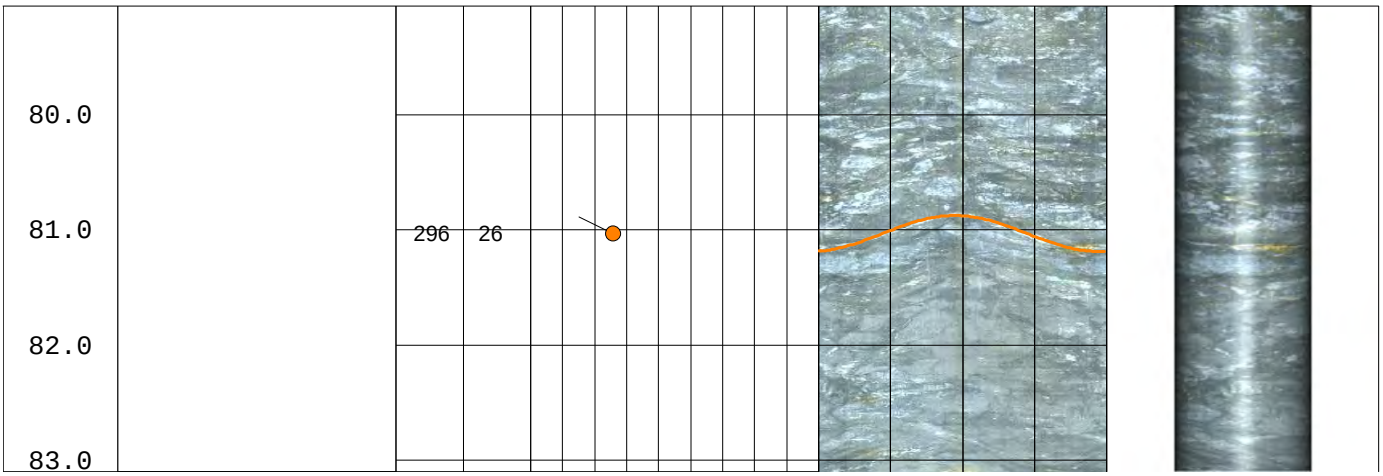
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83.0
296
26

Borehole DH09-02

Working Together SAFELY

© Hatch 2006/03 ⌘

BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-02***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 10

SITE: Left Abutment

COORDINATES: 1912969.39 N, 2380876.21 E
DIP DIRECTION: 240
DIP: 70

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 440.5
END OF HOLE: 329.1

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 2500
METHOD SOIL: HWT Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 09/14/09
FINISHED: 09/15/09
INSPECTOR: P. Friz
LOGGED BY: P. Friz
REVIEWED: S. Perkins

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN.) (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
440.5													
0.0		0.0 - 1.3 ft: Overburden Soil and woody debris - material not sampled	0	1				1.0					
		1.3 ft TOP OF BEDROCK see next sheet						2.0 3.0 4.0					

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT | NATURAL MOISTURE CONTENT | LIQUID LIMIT
W_P W_N W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-02**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 10

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	NOTES	PIEZOMETER INSTALLATION
439.3 1.3		1.3 - 13.8 ft: Metamorphosed Andesitic Siltstone - Slightly weathered dark grey, fine grained, very strong (100 - 250 MPa), light/dark turbulent flow banding @ 45 deg to core axis; some calcite veinlets; Iron staining on joint surfaces; Average discontinuity spacing of 1.0 ft; GSI = 55 - 60.		In this hole the following general discontinuities were noted: 42% of the discontinuities are rough, 36% are smooth, 20% are slightly rough, 2% are slick. 89% of discontinuities are planar, 9% are curved and 2% are irregular. 67% of discontinuities have hematite staining and 69% are slightly weathered. For data on each discontinuity see detailed discontinuity log.		2	100	38		
						3	100	48		
						4	100	96		
427.5 13.8		13.8 - 21.5 ft: Metamorphosed Andesitic Siltstone Light/dark grey, fine grained, very strong (100 - 250 MPa), less obvious flow banding; few calcite				5	100	100		

RECOVERY AND RQD (%) — 20 40 60 80

PERMEABILITY (lugeons) — 0.1 1 10 100

(cm/sec) — No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

DEPTH (ft) — 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

SAMPLING METHOD

A - Split Tube
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K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-02**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 10

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		veinlets; Iron staining on joint surfaces; GSI = 65 - 70. 19.8 ft; 5 mm wide calcite vein 60 deg to axis				6	100	100	17 18 19 20 21	20 40 60 80	0.1 1 10 100 (cm/sec) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
420.3 21.5		21.5 - 33.0 ft: Metamorphosed Fragmental Andesitic Siltstone Dark grey, fine grained, very strong (100 - 250 MPa), light/dark turbulent flow banding @ 45 deg to core axis; conglomeratic areas within flow bands with clasts 0.25-1" in size; lots of calcite veinlets; Iron staining on joint surfaces; Average discontinuity spacing of 2.3 ft; GSI = 60 - 70.				7	100	100	22 23				
						8	100	98	24 25 26 27 28				
						9	100	100	29 30 31				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

Project: **H-332360**

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-02**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 10

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
409.5 / 33.0		33.0 - 56.1 ft: Metamorphosed Bedded Andesitic Siltstone Dark grey, fine grained, very strong (100 - 250 MPa), less obvious dark flow banding @ 45 deg to core axis; few calcite veinlets; few clasts <0.5"; Iron staining on joint surfaces; Average discontinuity spacing of 1.9 ft; GSI = 60 - 70.				10	100	100	32 33 34 35 36 37 38	20 40 60 80	0.1 1 10 100 (lugeons) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3} (cm/sec)		
		38.5 - 56.1 ft: Dark grey, fine grained, very strong (100 - 250 MPa), light/dark turbulent flow banding @ 45 deg to core axis; conglomeratic areas within flow bands with clasts 0.25-1" in size; few calcite veinlets.				11	100	100	39 40 41 42 43				
						12	100	100	44 45 46				

SAMPLING METHOD

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F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-02**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 10

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
387.8 / 56.1		56.1 - 84.8 ft: Metamorphosed Bedded Andesitic Siltstone 56.1 - 62.7 ft: Light grey, fine grained, turbulent flow banding @ 45 deg to core axis; very strong (100 - 250 MPa); some calcite veinlets; Iron staining on joint surfaces. Average discontinuity spacing of 3.2 ft; GSI = 65 - 70.				13	100	100	47 48 49 50 51 52 53	20 40 60 80	0.1 1 10 100 No take 10^-6 10^-5 10^-4 10^-3		
						14	100	96	54 55 56 57 58				
						15	100	96	59 60 61				

SAMPLING METHOD

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F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-02**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 10

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		62.7 - 70.0 ft: Medium grey, fine grained, turbulent flow-banding; some clasts <0.5" in size; many calcite veins/veinlets; Iron staining on joint surfaces.							62				
									63				
									64				
									65				
		65.5 ft: 0.25" calcite vein 69 deg to axis				16	100	100	66				
									67				
									68				
									69				
		70.0 - 84.8 ft: Med. grey, fine grained, very strong (100 - 250 MPa), less turbulent light/dark flow banding @ 45 deg to core axis except in small areas; some calcite veinlets; Iron staining on joint surfaces.							70				
						17	100	100	71				
									72				
									73				
									74				
									75				
						18	100	100	76				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

PERMEABILITY (cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
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F - Wash
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SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-02**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 7 **OF:** 10

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
									77				
									78				
									79				
									80				
						19	100	100	81				
									82				
									83				
		83.4 ft: 0.25" calcite vein 60 deg to axis							84				
360.8 / 84.8		84.8 - 118.5 ft: Metamorphosed Fragmental Andesitic Siltstone Average discontinuity spacing of 2.8 ft; GSI = 75 - 80				20	100	100	85				
									86				
									87				
									88				
		84.8 - 98.5 ft: Dark grey, conglomeratic texture with fine grained turbulent flow-banded matrix and mostly small (0.25-1.00") clasts, some up to 3" in size; very few calcite veinlets in matrix but some thicker veins cut at 30 deg to axis; Iron staining on							89				
									90				
						21	100	100	91				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100; (cm/sec): No take, 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-02**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 8 **OF:** 10

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		surfaces, rock appears weaker (approx 50-100 MPa). 90.5 - 90.9 ft: Sample R4-PL = 90.83 MPa 90.9 - 91.7 ft: Sample R4-UCS = 83.0 MPa							92 93 94 95				
						22	100	100	96 97 98				
		98.5 - 101.5 ft: Dark grey, fine grained very little flow-banding, mostly uniform; very few calcite veins/veinlets. 101.5 - 106.5 ft: Dark grey; conglomeratic texture with mostly small (<0.25") clasts, some up to 0.5-1.0" in size; fine grained flow-banded matrix with some wide (<5") light coloured bands; very few calcite veinlets.				23	100	100	99 100 101 102 103				
						24	100	100	104 105 106				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

PERMEABILITY (cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
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P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

Project: **H-332360**

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-02**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 9 **OF:** 10

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		106.5 - 113.0 ft: Dark grey, fine grained very little flow-banding, mostly uniform; very few calcite veins/veinlets; 107.0 ft: 0.25" calcite vein 60 deg to axis							107 108 109 110 111 112 113				
		112.3 - 112.7 ft: Sample R5-UCS = 198.0 MPa 112.7 - 113.3 ft: Sample R5-UCS = 144.45 MPa 113.0 ft - 118.5 ft: Dark grey; conglomeratic texture with mostly small (<0.25") clasts, some up to 0.5-1.0" in size; fine grained flow-banded matrix with some wide (<5") light coloured bands; some calcite veinlets. 117.1 ft: 0.25" calcite vein 60 deg to axis				25 26	100 100	100 100	114 115 116 117 118				
329.1 118.5		**END OF BOREHOLE**											

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100; (cm/sec): No take, 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-02

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 10 **OF:** 10

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at 37.2 ft on September 15, 2009.
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-02
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Left Abutment
Azimuth (Deg)	300
Inclination (Deg)	70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
1.9					Joint	70							x	x			H		S		P	
2.3					Drill Break																	
2.5					Joint	40							x	x			H	S	S		P	
2.6					Joint	80							x	x			H		S		P	
2.6	3.3		x		Broken core zone																	
3.3					Drill Break																	
3.8					Joint	15							x	x			H		S			
3.8	5.0				Broken core zone																	
5.0					Drill Break																	
5.5					Drill Break																	
6.2	7.0		x		Broken core zone																	
7.0					Joint	20					x			x			H	S	S		P	
7.3	7.9			x	Fragmented zone																	
7.9					Drill Break																	
8.3					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 300
Inclination (Deg): 70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
8.8					Drill Break																
9.3					Joint	60					x			x			H	S	S		P	
9.8					Joint	60					x			x			H	S	S		P	
10.4					Drill Break																	
10.5					Drill Break																	
10.8					Joint	15					x			x			H		S		P	
11.3					Hammer Break																	
11.8					Joint	50	34	347			x			x			H		S		P	
12.0					Joint	20							x	x			H		S		P	
12.5					Drill Break																	
12.6					Drill Break																	
13.3					Drill Break																	
13.7					Drill Break																	
14.5					Hammer Break																	
15.9					Hammer Break																	
16.3					Hammer Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-02
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 300
Inclination (Deg): 70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
17.9					Hammer Break																
18.3					Drill Break																
19.1					Calcite Vein (no break)		32	117													H	
19.3					Fracture		21	200													P	O
20.2					Drill Break																	
20.6					Break on Bedding Plane		32	212														
21.5					Drill Break																	
22.7					Drill Break																	
23.0					Drill Break																	
23.1					Drill Break																	
23.3					Drill Break																	
24.6					Drill Break																	
25.0					Joint	30	70	14			x			x			H		S			O
25.3					Drill Break																	
26.3					Drill Break																	
26.8					Joint	50	80	358				x		x			H		S			O

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-02
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Left Abutment
Azimuth (Deg) 300
Inclination (Deg) 70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
26.9					Joint	30	32	284					x	x				S				O
27.7					Joint	35						x		x			H		S			O
28.3					Drill Break																	
29.8					Drill Break																	
30.8					Bedding Contact		66	349														
31.4					Drill Break																	
32.7					Joint	25	54	181				x			x		H		S			O
33.2					Drill Break																	
33.4					Drill Break																	
33.8					Hammer Break																	
34.2					Hammer Break																	
35.0					Hammer Break																	
36.0					Drill Break																	
36.3					Calcite Vein (no break)		25	344													H	
38.3					Joint	25					x			x			H		S		P	
38.8					Joint	20	27	313				x		x			H		S		P	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 300
Inclination (Deg): 70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
38.8					Joint	45						x		x			H		S		P	
40.7					Joint	50							x	x			H		S		P	
41.6					Joint	45	33	200					x	x			H		S		P	
43.3					Drill Break																	
44.4					Joint	25	49	234					x	x			H		S		P	
45.0					Drill Break																	
45.3					Joint	45							x	x			H		S		P	
47.6					Drill Break																	
48.3					Drill Break																	
49.6					Joint	20							x		x		H		S		P	
51.3					Drill Break																	
51.6					Joint	30	37	315					x	x			H		S			
52.3					Joint	55							x	x								
52.3					Joint	60				x				x			H		S		P	
53.8					Drill Break																	
54.0					Joint	15							x	x			H	SC	T		P	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-02
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 300
Inclination (Deg): 70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
54.7					Drill Break																
55.3					Drill Break																
56.7					Joint	70					x			x			H		S		P	
57.6					Drill Break																
58.2					Joint	45															
59.3					Drill Break																
59.5					Drill Break																
60.9					Drill Break																
61.6					Drill Break																
62.0					Drill Break																
62.5					Joint	25	31	315			x			x								
62.5					Joint	45					x			x			H		S		P	
62.5	62.7			x	Fragmented zone																
62.7					Drill Break																
63.1					Drill Break																
63.3					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 300
Inclination (Deg): 70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
64.4					Drill Break																
65.5					Calcite Vein (no break)		18	310													H	
65.9					Drill Break																
66.1					Hammer Break																
66.8					Drill Break																
67.3					Drill Break																
67.3					Joint	5	84	268			x			x			H	S	S		P	
70.0					Drill Break																
70.6					Joint	70					x			x			H					
71.6					Drill Break																
72.7					Drill Break																
73.3					Drill Break																
73.7					Joint	55	54	180			x			x			B					
75.1					Drill Break																
76.9					Drill Break																
77.3					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-02
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 300
Inclination (Deg): 70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
78.3					Drill Break																	
78.6					Drill Break																	
79.4					Hammer Break																	
81.2					Banding		22	199														
82.1					Drill Break																	
82.3					Banding		80	33														
83.0					Drill Break																	
83.3					Drill Break																	
83.3					Calcite Vein (no break)		14	309														
83.9					Drill Break																	
84.1					Banding		61	302														
84.4					Joint - 1.5 ft long	15							x			x	H	S	S		P	
84.9					Hammer Break																	
85.6					Drill Break																	
87.9					Banding		41	289														
88.3					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-02
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Left Abutment
Azimuth (Deg) 300
Inclination (Deg) 70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
88.9					Joint	15					x			x				C				
89.9					Joint	25					x			x								
92.1					Joint	15					x			x			H		S		P	
92.7					Joint	5	56	202					x	x			H		S		P	
93.1					Joint	10	56	197					x	x			H		S		P	
93.3					Drill Break																	
93.3	93.6			x	Fragmented zone - Hammer Break																	
93.8					Joint	10						x		x								
94.9					Joint	15	51	220				x		x								
96.6					Joint	25	48	207				x		x								
97.0					Joint	10	48	202				x		x								
98.0					Drill Break																	
98.3					Drill Break																	
98.6					Drill Break																	
98.7					Drill Break																	
99.1					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-02
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Left Abutment
Azimuth (Deg)	300
Inclination (Deg)	70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
100.1					Drill Break																
100.3					Drill Break																
100.7					Drill Break																
101.7					Bedding		35	215													
102.1					Bedding		39	220													
102.4					Drill Break																
102.5					Bedding		19	224													
103.0					Hammer Break																
103.5					Drill Break																
103.8					Microfracture	15							x		x						
104.5					Bedding		52	193													
105.1					Microfracture	10							x		x						
106.3					Drill Break																
106.4					Calcite Vein (no break)		26	214													
106.8					Drill Break																
106.9					Calcite Vein (no break)		20	101													

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-02
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Left Abutment
Azimuth (Deg)	300
Inclination (Deg)	70

Depth (B)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
107.3					Drill Break																	
107.6					Hammer Break																	
108.3					Drill Break																	
109.8					Drill Break																	
112.5					Drill Break																	
113.3					Drill Break																	
113.6					Drill Break																	
114.2					Drill Break																	
115.1					Bedding (no break)		57	179														
115.5					Drill Break																	
115.9					Drill Break																	
117.1					Drill Break																	
117.8					Drill Break																	
118.3					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

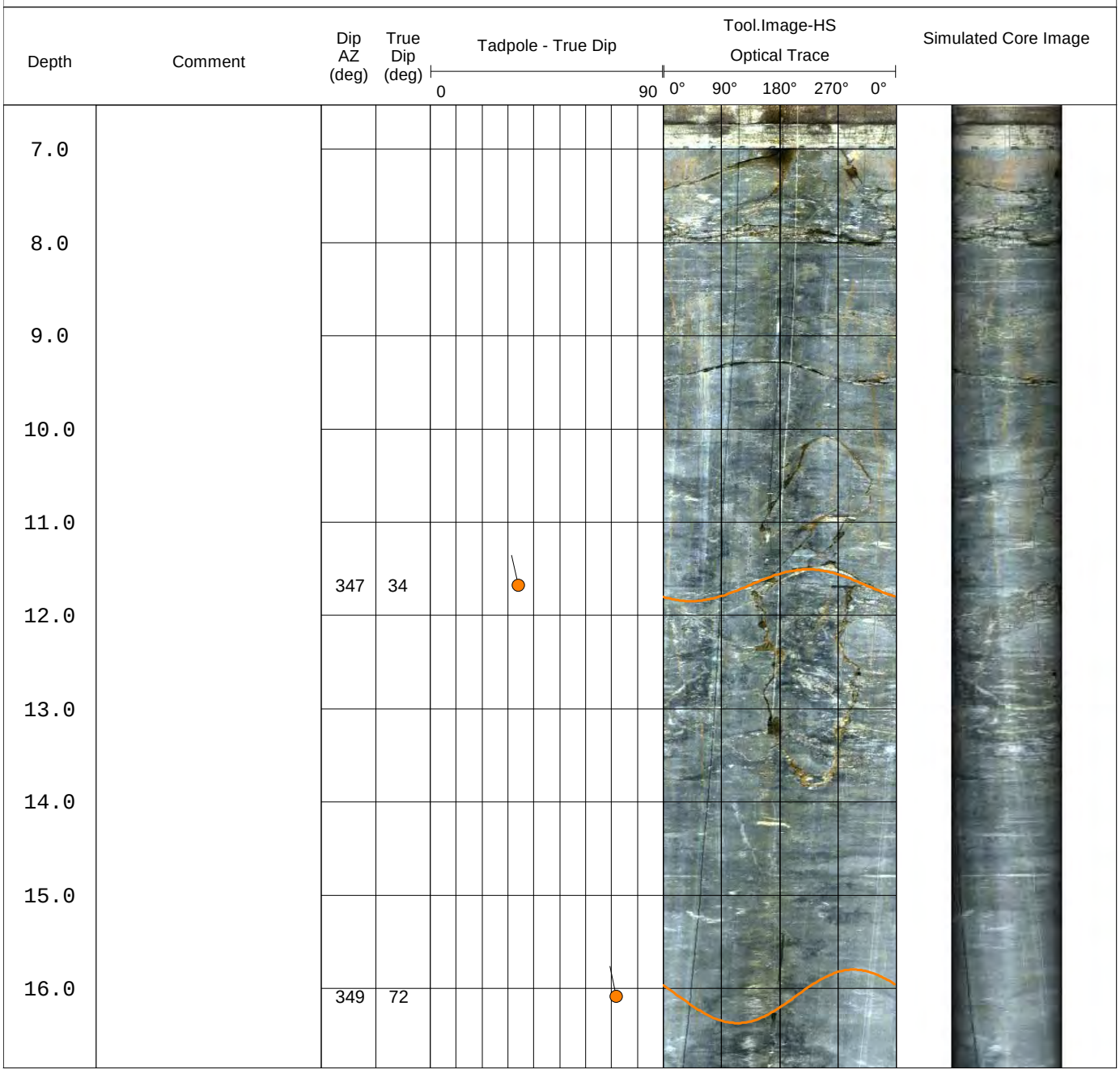
Aperture:O-Open; H-Hairline (<0.5mm)

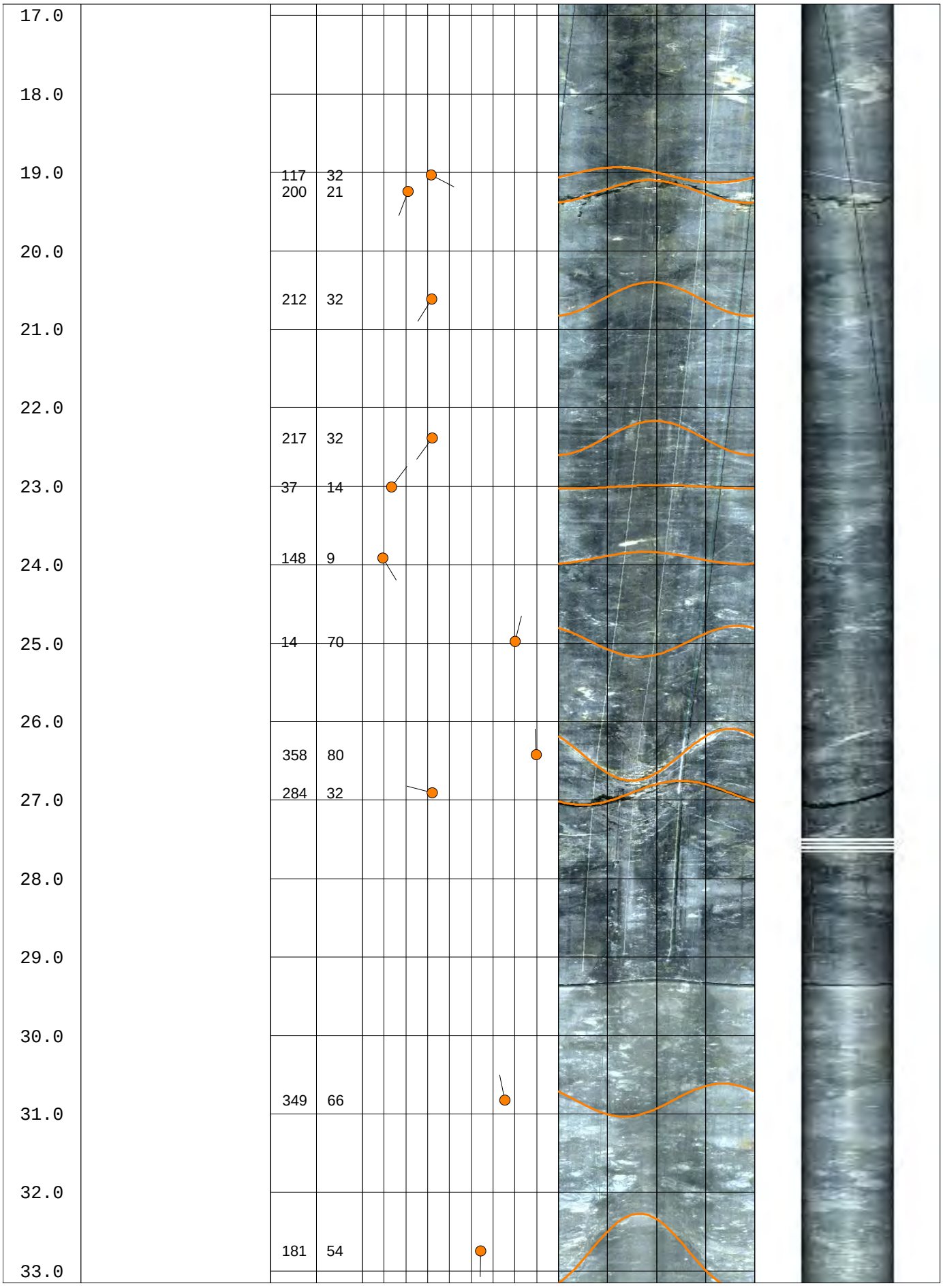
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company	City and Borough of Sitka
	Location:	Sitka, AK
	Project:	Blue Lake Hydroelectric
Date Logged:	September 23, 2009	Borehole ID: DH09-02
File Name:	DH09-02-1M.wcl	Logged By: Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from north.

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30.0
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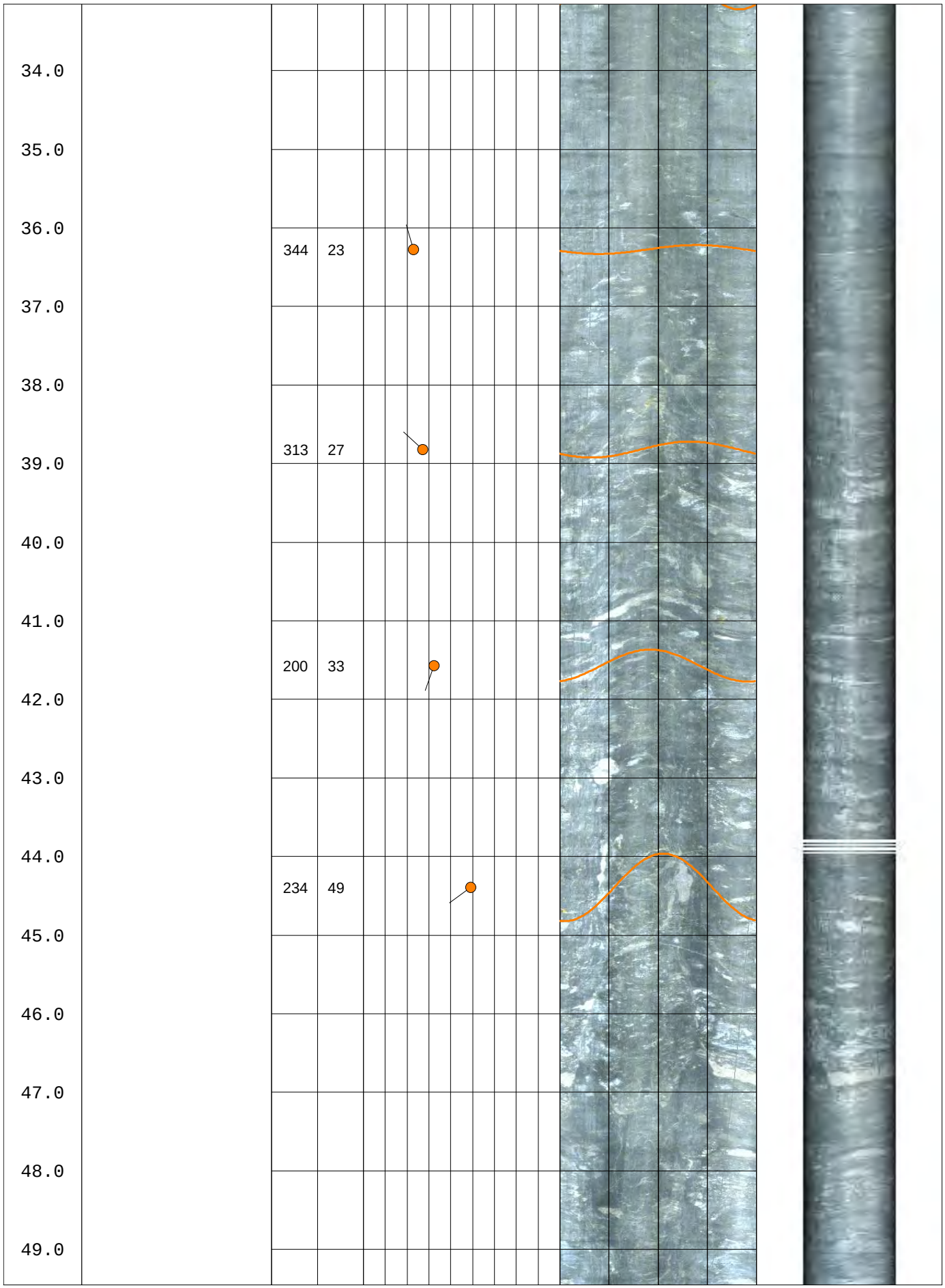
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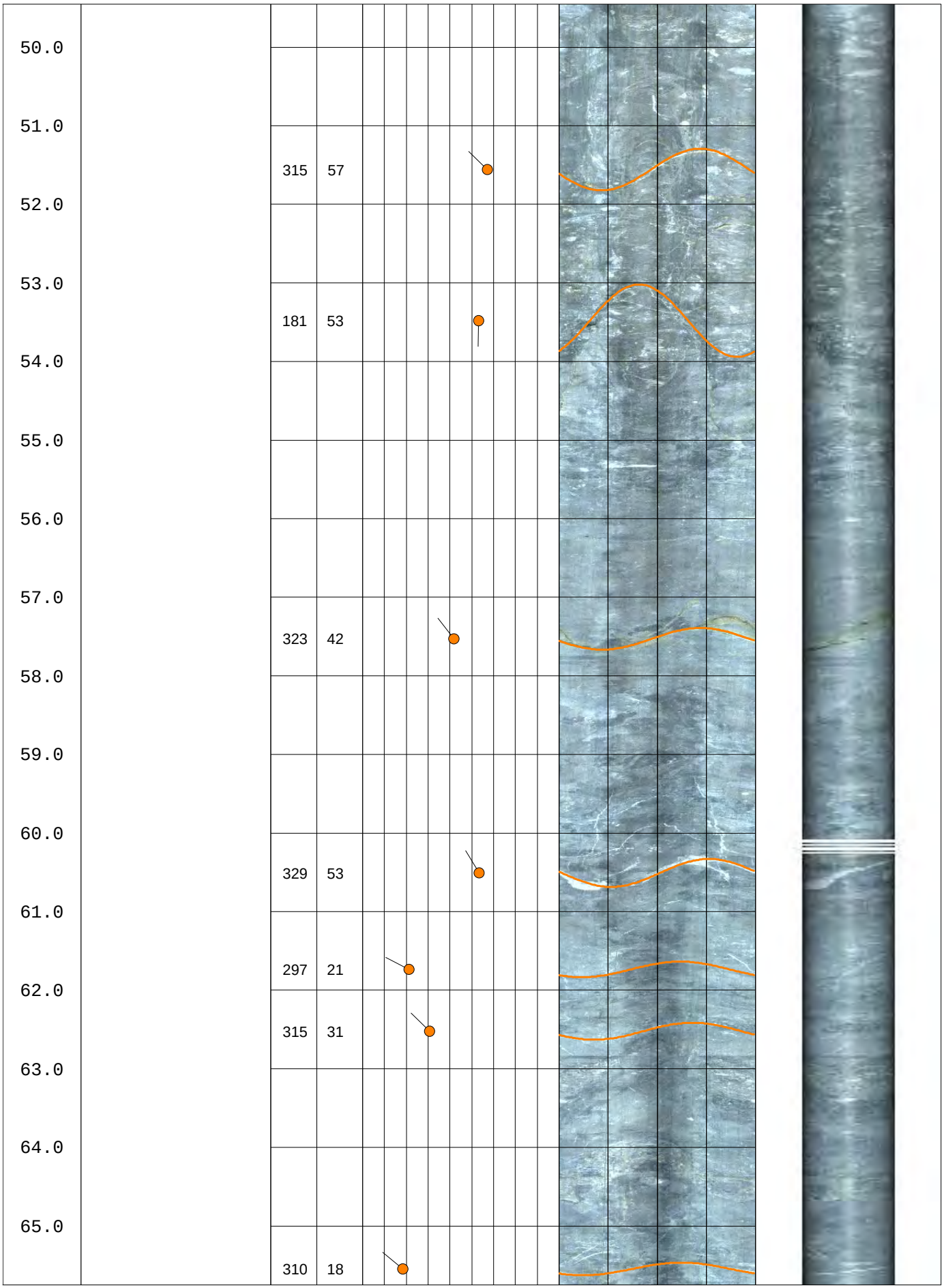
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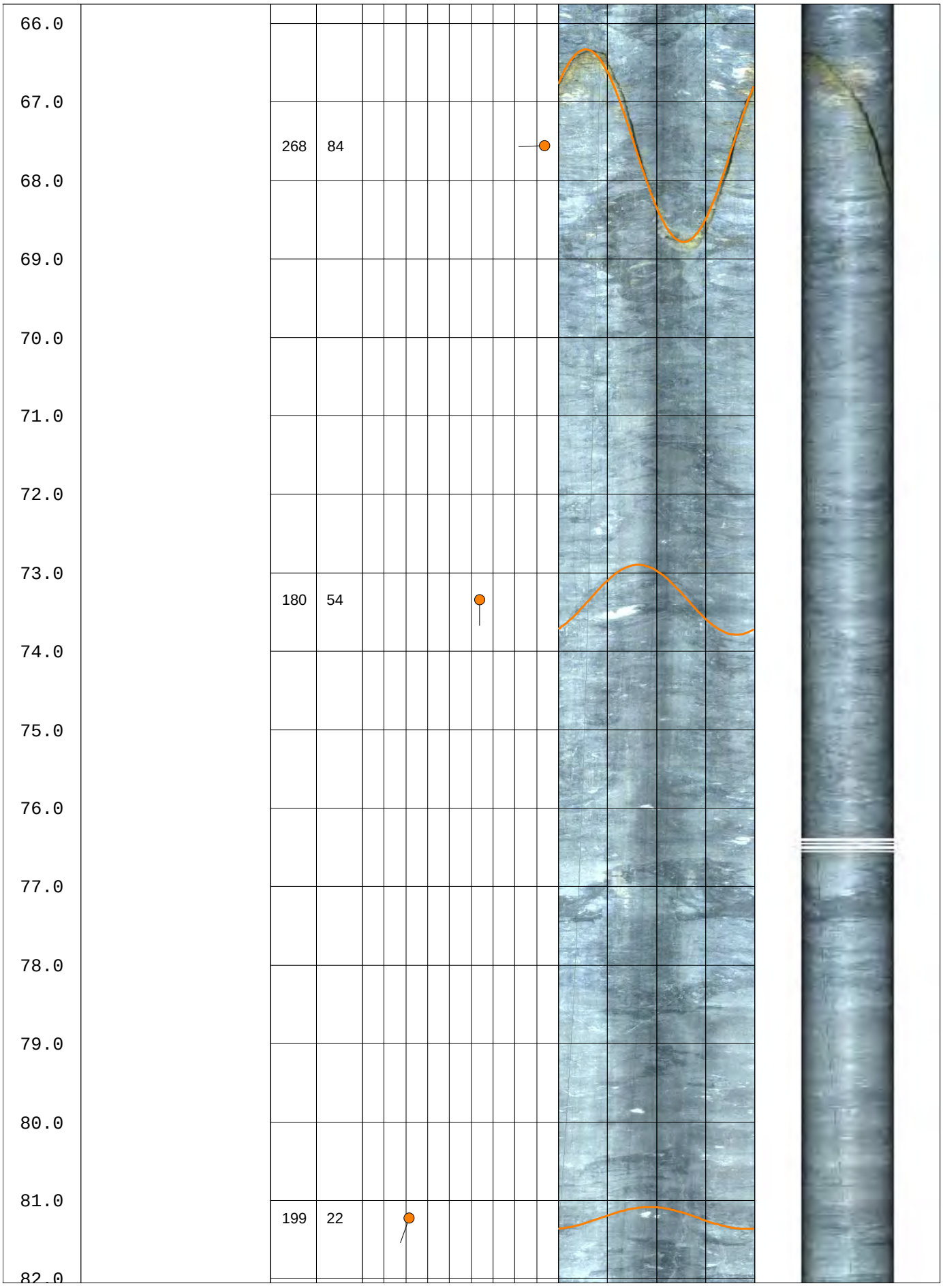
65.0
310 18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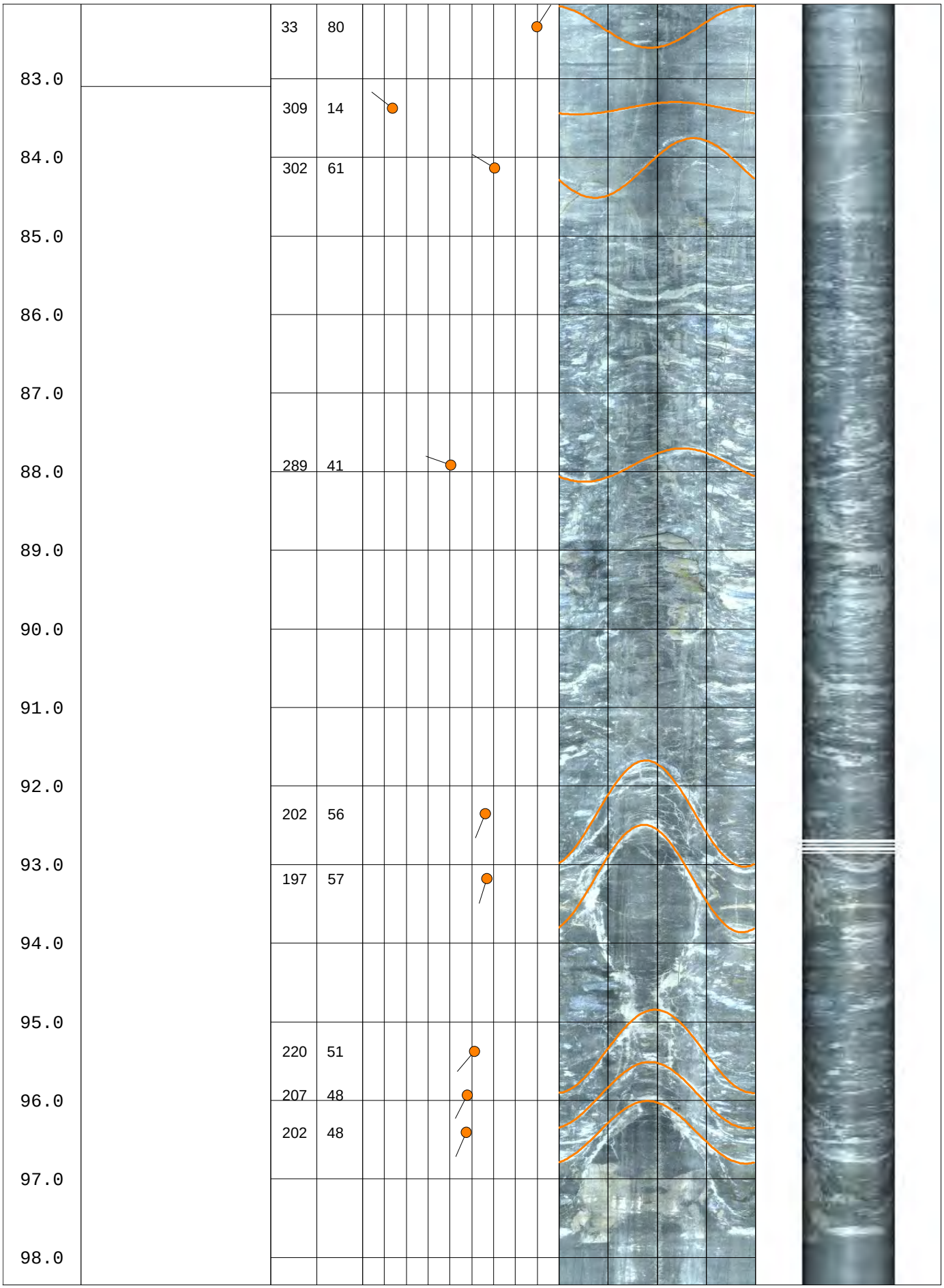
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202 56
197 57
220 51
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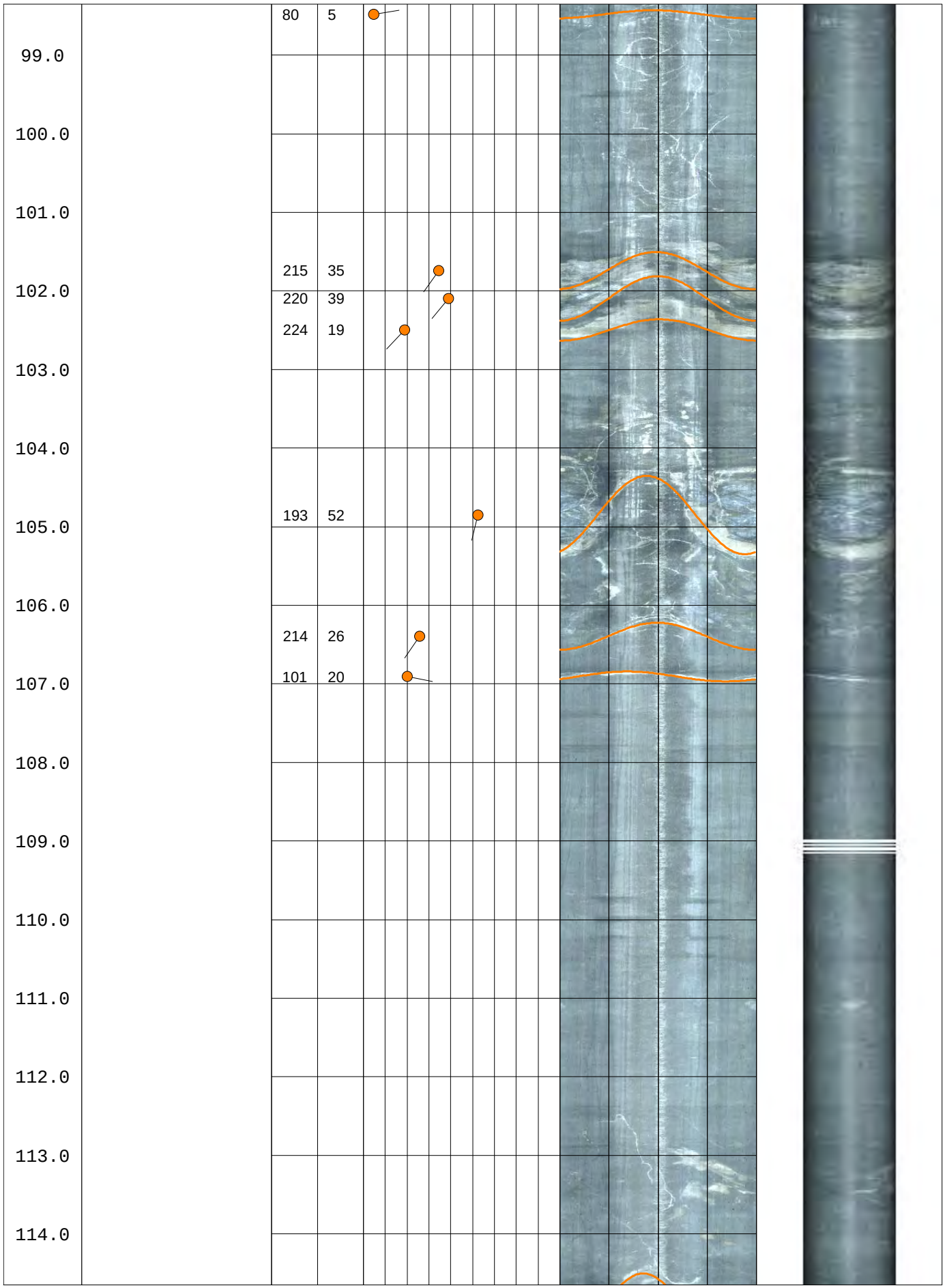
202 48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220 39
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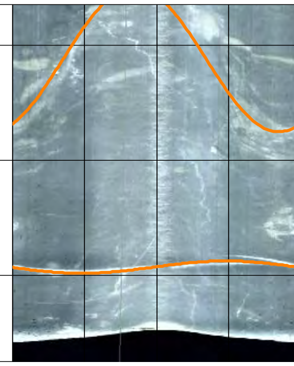
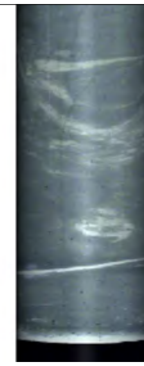
104.0
193 52
105.0
106.0
214 26
101 20
107.0
108.0
109.0
110.0
111.0
112.0
113.0
114.0

115.0		179	57
116.0			
117.0		347	27





Borehole DH09-03

Working Together SAFELY

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HATCH

BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: **DH09-03**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 5

SITE: Left Abutment

COORDINATES: 1912948.11 N, 2380841.19 E
DIP DIRECTION: 120
DIP: 30

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 385.3
END OF HOLE: 354.3

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: 1 Ton
METHOD SOIL: N/A
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 9/19/09
FINISHED: 9/21/09
INSPECTOR: M. Mammoliti
LOGGED BY: P. Friz
REVIEWED: S. Perkins

DATE: 11/20/2009

See end page for detailed groundwater measurements and notes

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
385.3 / 0.0		0.0 - 37.6 ft: Metamorphosed Bedded to Fragmental Andesitic Siltstone 0.0 - 1.5 ft: Interval not core; casing installed. Medium grey, very strong (100 - 250 Mpa), fine grained to conglomeratic texture, increasing with depth; conglomeratic clasts are up to 1 inch in diameter and angular to subrounded; flow banding increases with depth, contains occassional quartz-carbonate veins up to 0.25 in. thick, contact with carbonaceous unit below is gradational over 3 ft; Average discontinuity spacing is 2.6 ft; GSI = 65 - 70. 30 - 40 g piece of core removed for ARD Comp 7 @ 10.7 ft, 15.9 ft, 17.0 ft, 19.8 ft (disseminated pyrite). 10.8 - 11.2 ft: Sample R12-PL= 138.25 MPa 11.2 - 12.0 ft: Sample R12-UCS = 134.0 MPa		The following general discontinuity characteristics were noted for this hole: 79% of the discontinuities are smooth, 13% are rough. 96% of the discontinuities are planar, 4% are irregular. 60% of discontinuities have hematite staining and 84% are slightly weathered. For data on discontinuity see detailed discontinuity log.	0 1.5 6.5 7 12	1 2 3 4 5	0 100 100 100 100	0 100 60 100 94	1 2 3 4 5 6 7 8 9 10 11 12 13 14	20 40 60 80	No take; 0.1 1 10 100; 10^{-6} 10^{-5} 10^{-4} 10^{-3}		

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost
RQD, Recovery
Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-03**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 5

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		17.0 ft: Lost circulation during drilling.			17	6	100	100	16 17 18 19 20 21 22	20 40 60 80	0.1 1 10 100 (cm/sec) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
					22	7	100	100	23 24 25 26 27				
					27	8	100	100	28 29 30 31 32 33 34				
					32								

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-03**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 5

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
366.5 / 37.6		37.6 - 62.0 ft: Metamorphosed Carbonaceous Andesitic Siltstone/Mudstone Black, displays some flow banding, contains disseminated pyrite in hairline quartz-carbonate fractures, and veins up to 0.25" thick. Rock is strong (50 - 100 MPa), pyrite is preferential along fracture planes. Average discontinuity spacing of 2.4 ft; GSI = 60 - 65. 30 - 40 g pieces of core removed for ARD Comp 8 @ depths 39.0 ft, 43.7 ft, 48.4 ft, 51.9 ft and 60.9 ft.			37	9	100	100	35 36 37	20 40 60 80	0.1 1 10 100 No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
					42	10	100	100	38 39 40 41 42				
					47	11	100	100	43 44 45 46 47				
					52	12	100	98	48 49 50 51 52				
				51.6 - 53.4 ft: FRAGMENTED CORE ZONE					53				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-03**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 5

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		55.4 - 56.2 ft: Sample R13-UCS 56.2 - 56.4 ft: Sample R13-PL = 40.76 MPa			57	13	100	72	54 55 56 57 58 59 60 61 62	20 40 60 80	0.1 1 10 100 (lugeons) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3} (cm/sec)		
354.3 62		**END OF BOREHOLE**				14	100	100					

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-03

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 5

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level assumed to be at reservoir elevation (Elev. 336.7 ft).
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-03
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Left Abutment
Azimuth (Deg)	120
Inclination (Deg)	30

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
1.5					Drill break																
2.0					Drill break																
2.6					Drill break																
2.8					Drill break																
5.6					Drill break																
6.5					Drill break																
6.8					Break along Calcite Vein	45					x			x			H		S	T		
7.0					Drill break																
7.6					Drill break																
8.1					Joint		33	276												P	H
9.1					Break along Calcite Vein	65	26	298				x		x			H	C	S		P	
9.8					Joint	10						x		x			H		S			
10.1					Drill break																
10.7					Drill break																
10.8					Drill break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-03
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 120
Inclination (Deg): 30

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
11.2					Drill break																
12.0					Drill break																
12.5					Drill break																
12.6					Joint	60	35	275			x			x					S			
12.9					Joint		81	279			x			x					S			
13.1					Joint		26	313			x			x								
13.6					Bedding		15	46														
14.0					Vein (no break)		14	354													H	
14.2					Vein (no break)		21	358													H	
14.4					Vein (no break)		15	358													H	
15.1					Microfracture (no break)		73	285														
15.8					Vein (no break)		60	277													H	
16.0					Joint	70	80	278			x			x			H	C	S			O
16.5					Joint	45	89	337			x			x			H		S			
17.0					Drill break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-03
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 120
Inclination (Deg): 30

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
17.4					Drill break																	
17.5					Vein (no break)		86	100													H	
19.1					Drill break																	
19.5					Vein (no break)		61	309														
19.5					Vein (no break)		50	317														
19.7					Drill break																	
20.0					Drill break																	
21.2					Drill break																	
21.6					Drill break																	
22.0					Drill break																	
24.4					Joint	50	89	99			x			x			H	S	S			O
24.7					Drill break																	
25.8					Drill break																	
27.0					Drill break																	
27.8					Vein (no break)		78	281														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Left Abutment
Azimuth (Deg) 120
Inclination (Deg) 30

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
28.2					Drill break																
30.4					Vein (no break)		56	289													
30.5					Vein (no break)		60	330													
31.2					Joint	75	76	298			x			x			H		S			H
31.4					Vein (no break)		79	305													
31.6					Vein (no break)		77	309													
32.0					Drill break																
32.5					Vein (no break)		15	352													
33.5					Joint	75					x			x			H		S			H
35.1					Drill break																
35.7					Drill break																
36.2					Joint	20	72	314			x			x			H		S			H
36.5					Fracture - 2mm wide	45	66	333			x			x			H	C/S	S		H	O
37.0					Drill break																
37.6					Drill break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-03
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 120
Inclination (Deg): 30

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
38.8					Drill break																	
38.9					Drill break																	
39.0					Microfracture		51	234														
39.2					Drill break																	
39.9					Drill break																	
41.6					Drill break																	
42.0					Drill break																	
42.4					Joint		35	334		x				x								H
43.4					Longitudinal Fracture	5	48	158					x	x				C				H
43.7					Drill break																	
44.4					Vein (no break)		46	261														
44.5					Vein (no break)		27	255														
45.5					Drill break																	
45.8					Break on Calcite Vein	65	42	278			x			x				C	S			H
46.1					Drill break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 120
Inclination (Deg): 30

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
46.5					Drill break																
47.0					Drill break																
47.6					Break on pyrite-filled fracture	30					x			x			H	S	S			H
48.5					Drill break																
48.7					Drill break																
49.1					Joint		42	192			x			x				C	S			H
49.3					Calcite Vein	75	29	314					x			x		C	S			
49.7					Drill break																
50.5					Joint	75					x			x			H		S			H
50.7					Joint	75					x			x			H		S			H
51.6	53.4			x	Fragmented zone; 1 visible joint		48	213					x	x			H		S			H
53.0					Vein (no break)		74	338														
53.4					Vein (no break)		47	212														
53.9					Drill break																	
54.2					Vein (no break)		74	359														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-03
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Left Abutment
Azimuth (Deg): 120
Inclination (Deg): 30

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
54.8					Joint	50					x			x			H		S			
55.6					Drill break																	
56.3					Drill break																	
56.5					Drill break																	
57.0					Drill break																	
57.7					Drill break																	
58.1					Drill break																	
58.1					Vein (no break)		53	204			x			x				C				
59.2					Drill break																	
60.2	61.1				Longitudinal Fracture	5					x			x				C	S			
60.3					Drill break																	
60.6					Drill break																	
62.0					Drill break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

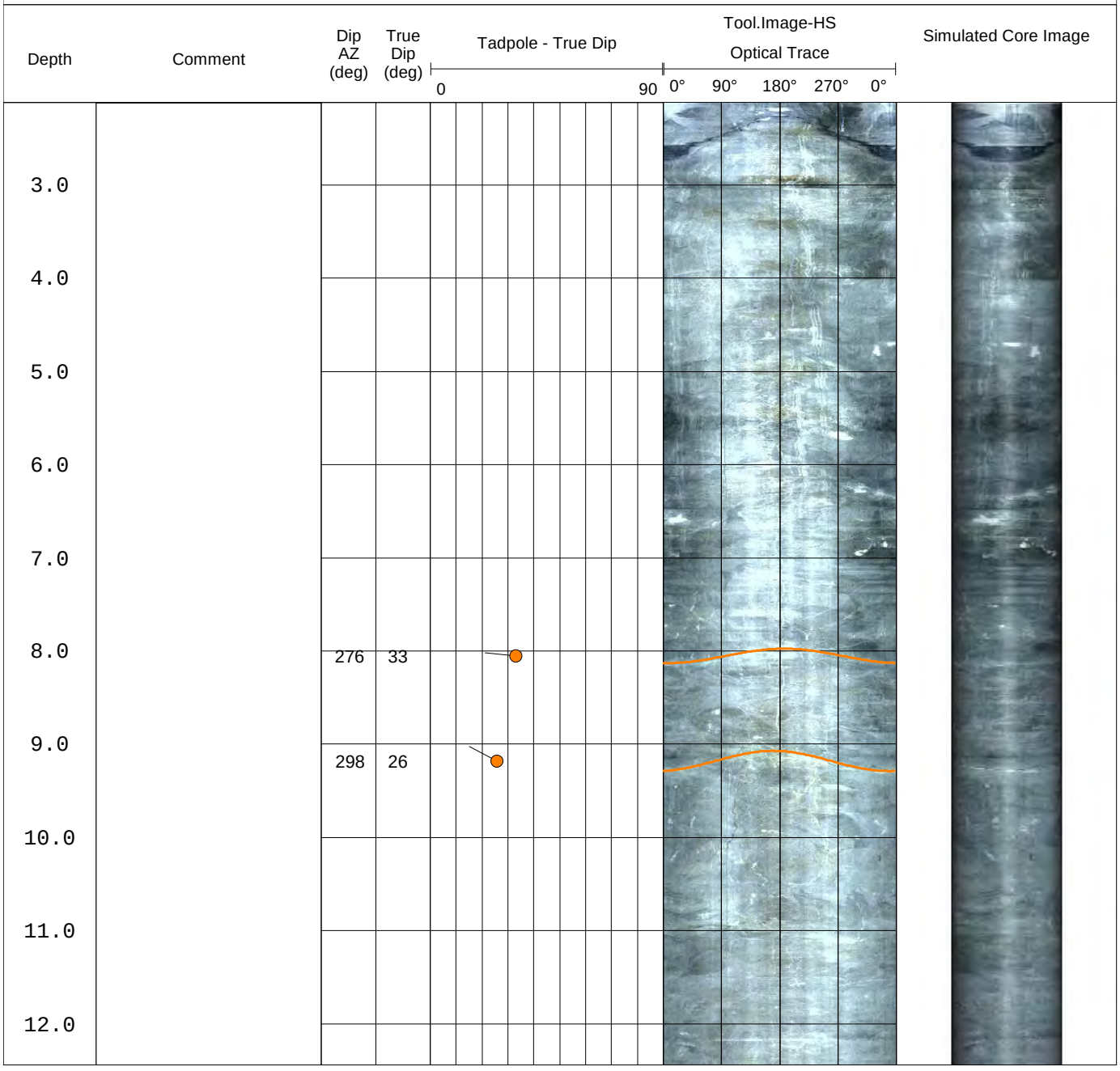
Aperture:O-Open; H-Hairline (<0.5mm)

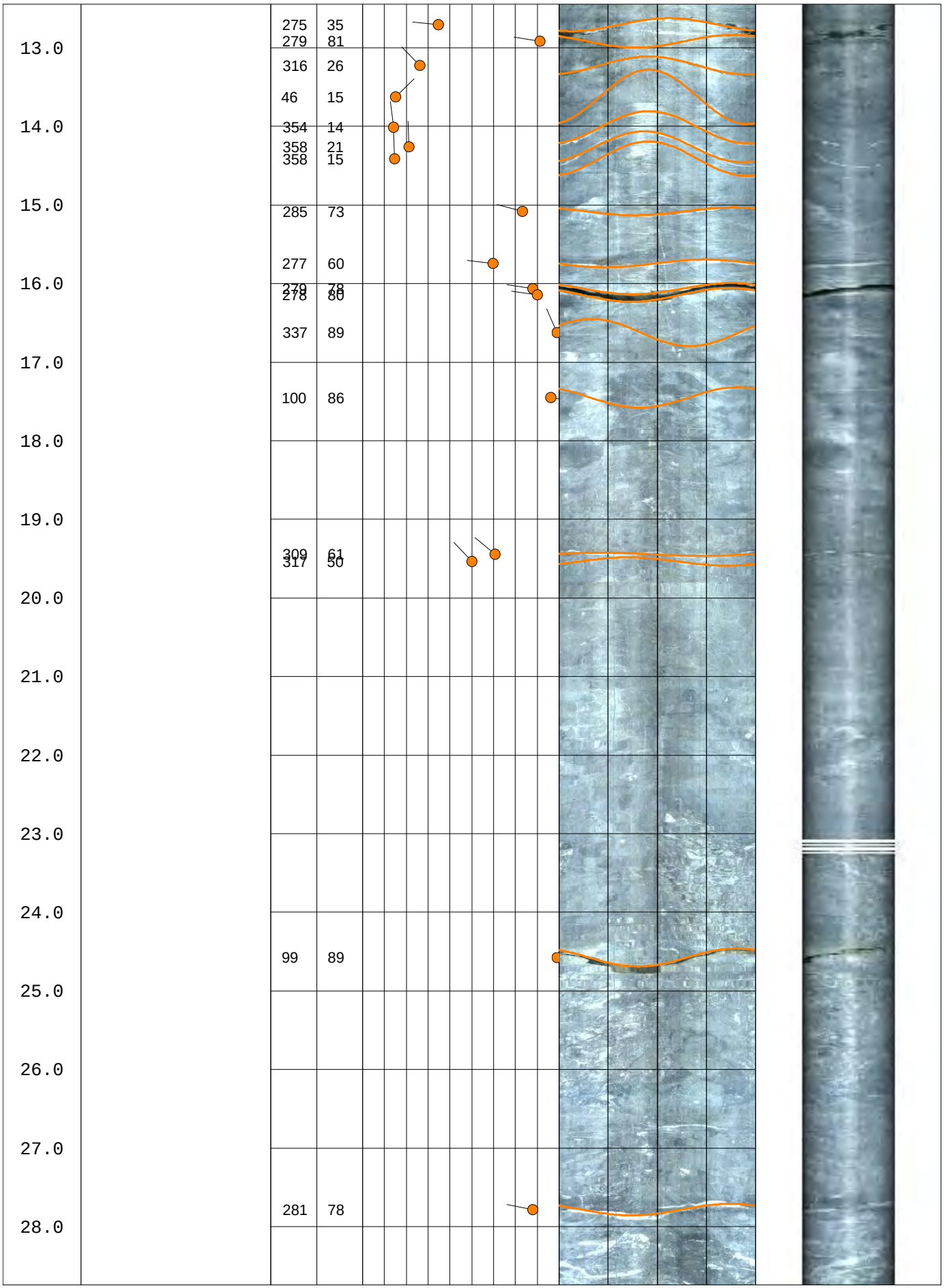
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company City and Borough of Sitka	
	Location: Sitka, AK	
	Project: Blue Lake Hydroelectric	
Date Logged:	September 22, 2009	Borehole ID: DH09-03
File Name:	DH09-03-1M.wcl	Logged By: Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from north.

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15.0
16.0
17.0
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19.0
20.0
21.0
22.0
23.0
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26.0
27.0
28.0
275 35
279 81
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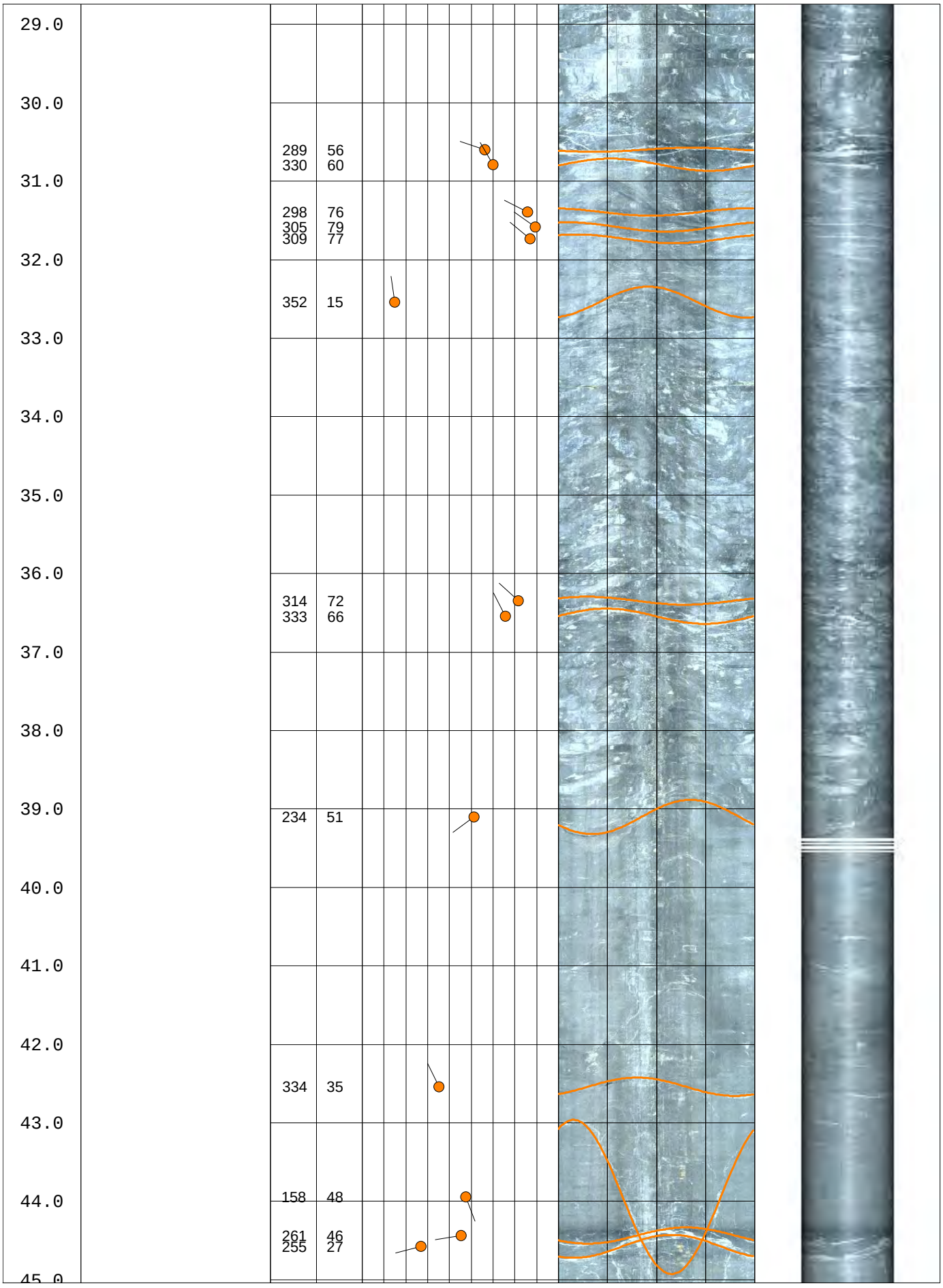
317 50
99 89
281 78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38.0
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41.0
42.0
43.0
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298 76
305 79
309 77
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314 72
333 66
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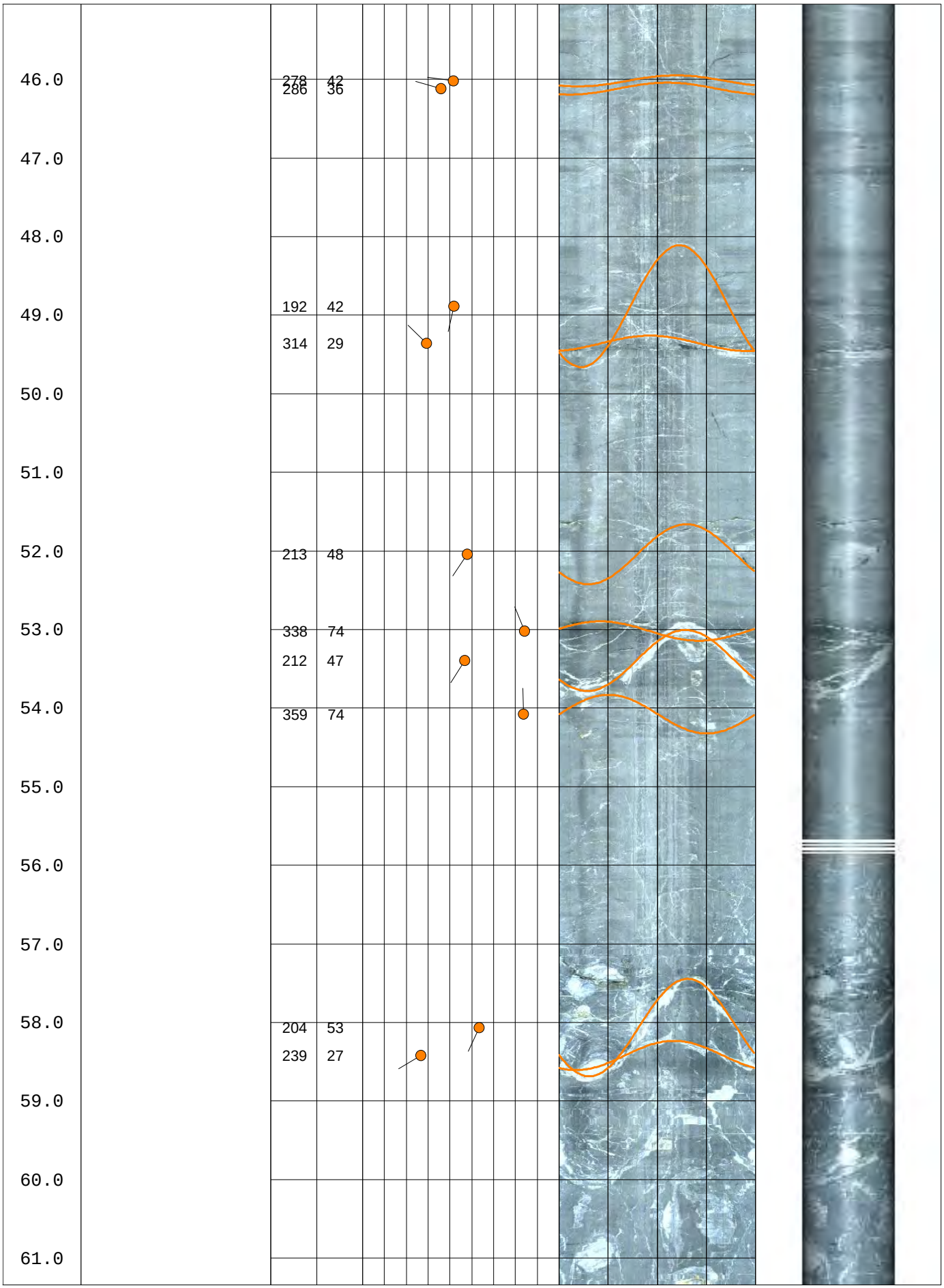
334 35
158 48
261 46
255 27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47.0
48.0
49.0
50.0
51.0
52.0
53.0
54.0
55.0
56.0
57.0
58.0
59.0
60.0
61.0
278 42
286 36
192 42
314 29
213 48
338 74
212 47
359 74
204 53
239 27

62.0														

Borehole DH09-04

Working Together SAFELY

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BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: **DH09-04**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 8

SITE: Left Abutment

COORDINATES: 1912969.98 N, 2380831.29 E
DIP DIRECTION: 150
DIP: 60

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 345.6
END OF HOLE: 262.6

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 2500
METHOD SOIL: N/A
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 09/04/09
FINISHED: 09/06/09
INSPECTOR: P. Nolan
LOGGED BY: P. Friz
REVIEWED: S. Perkins

DATE: 11/20/2009

See end page for detailed groundwater measurements and notes

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
345.6													
0.0		CONCRETE Up to 1.5" aggregate is subrounded to rounded. Contact with bedrock is bonded. 0.3 - 0.9 ft: Sample C1-UCS = 42.7 MPa 3.4 - 4.1 ft: Sample C2-UCS = 34.6 MPa			0	1	100	100	1	20 40 60 80	No take 0.1 1 10 100 (cm/sec) 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
					5	2	100	100	5				
		7.2 - 7.8 ft: Sample C3-UCS = 55.3 MP			5.8	3	100	100	6 7 8				
337.1					10.8								
9.8		9.8 - 17.8 ft: Metamorphosed Carbonaceous Andesitic Siltstone/Mudstone Fine grained, weakly bedded, iron staining on		10.8 - 13.6 ft: FRAGMENTED CORE ZONE		4	100	0	11				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost
Permeability units: RQD, Recovery, Lugeons, cm/sec

Project: H-332360

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-04**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		joint surfaces. 12.8 - 15.8 ft: Magnetism due to rebar in rock and concrete interfering with core orientation system. 15.8 - 17.8 ft: Vuggy quartz veins 16.4 - 17.1 ft: Sample R1 17.1 - 17.7 ft: Sample R1-PL = 134.80 MPa Average discontinuity spacing of 0.9 ft; GSI = 55 - 60		The following general discontinuity measurements were noted for this hole: 52% of discontinuities are smooth, 35% are rough and 13% are slightly rough. 68% of discontinuities are planar, 19% are irregular and 13% are curved. 58% of discontinuities have hematite staining and 65% are slightly weathered. For data on each discontinuity see detailed discontinuity log.	12.8				13	20 40 60 80	0.1 1 10 100 (lugeons); No take; 10^{-6} 10^{-5} 10^{-4} 10^{-3} (cm/sec)		
					15.8	5	100	43	14				
330.2 / 17.8									15				
		17.8 - 39.8 ft: Metamorphosed Andesitic Siltstone Weakly bedded, grey colour, fine grained. Contains numerous quartz-carbonate veins. Discontinuities very widely spaced (26 ft). Bedding contact oriented at 43/207; GSI = 70 - 75. 19.1 - 19.9 ft: Sample R2-PL = 96.11 MPa 19.9 - 20.1 ft: Sample R2-UCS = 144.0 MPa				6	100	88	16				
									17				
									18				
									19				
					20.8				20				
						7	100	100	21				
									22				
									23				
									24				
					25.8				25				
									26				
									27				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-04**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
311.1 / 39.8		39.8 - 56.8 ft: Metamorphosed Bedded to Fragmental Andesitic Siltstone Grey black colour; very strong (100 - 250 Mpa); quartz clasts up to 0.5" in diameter.			30.8	8	100	100	28 29 30				
					35.8	9	100	100	31 32 33 34 35				
					40.8	10	100	100	36 37 38 39 40 41 42				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

PERMEABILITY (cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-04**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		Microfractures parallel and cut across bedding. Carbonate-filled fractures 1 - 2 mm wide. 43.7 ft: Pyrite on joint surfaces. Average discontinuities spacing of 2.8 ft; GSI = 70 - 75.			45.8	11	100	100	43 44 45	20 40 60 80	0.1 1 10 100 (lugeons) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3} (cm/sec)		
					50.8	12	100	100	46 47 48 49 50				
					55.8	13	100	88	51 52 53 54 55				
296.4 56.8		56.8 - 70.8 ft: Metamorphosed Andesitic Siltstone							56 57				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-04**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		Sharp contact sub-parallel to core axis. Interlayered with occasional thin layers with conglomerate texture up to 0.5 ft wide with clasts up to 0.5 " wide. Very strong (100 - 250 MPa). Average discontinuity spacing of 2.3 ft; GSI = 65 - 70.			60.8	14	100	92	58 59 60	20 40 60 80	0.1 1 10 100 No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
					65.8	15	100	98	61 62 63 64 65				
					70.8	16	100	90	66 67 68 69 70				
284.3 70.8		70.8 - 95.8 ft: Metamorphosed Bedded to Fragmental Andesitic Siltstone Grey, fine-grained, displays weak to moderately strong							71 72 73				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-04**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		bedding. Clasts within the conglomerate display deformation (stretching) parallel to bedding. Average discontinuity spacing of 2.8 ft; GSI = 65 - 70. 70.8 - 75.8 ft: Rock appears weaker (50 - 100 Mpa); altered appearance. Black colour, slightly weathered. 75.8 ft: Vuggy carbonate vein with iron staining.			75.8	17	100	92	74 75 76 77 78 79 80	20 40 60 80	0.1 1 10 100 (lugeons) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3} (cm/sec)		
					80.8	18	100	80					
					85.8	19	100	100	81 82 83 84 85 86 87 88				
							100						

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-04**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 7 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						20		84	89				
					90.8				90				
									91				
									92				
						21	100	100	93				
									94				
									95				
262.6 / 95.8		**END OF BOREHOLE**											

Recovery and RQD (%): 20 40 60 80

Permeability (lugeons): 0.1 1 10 100

Permeability (cm/sec): No take, 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

RQD, Recovery

Permeability units: Lugeons, cm/sec

Project: **H-332360**

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-04

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 8 **OF:** 8

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level assumed to be at reservoir level on September 6, 2009 (Elev. 331.6 ft).
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-04
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Expansion Project
Site	Left Abutment - Top of Concrete Dam
Azimuth	160
Inclination	60

Depth (ft)		drill induced	zone		Description	Discontinuity surface and shape																
			broken	fragmented		Angle with core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	Aperture
from	to																					
9.8					Concrete - bedrock contact								x			x						
10.0					Drill Break																	
10.2					Drill Break																	
10.8					Drill Break																	
10.8	12.8			x	Fragmented zone																	
12.8					Joint	10					x			x			H		S			
13.2					Longitudinal Joint	5						x		x			H		S			
13.8					Joint	20							x		x		H		S			
13.9					Drill Break																	
14.4					Drill Break																	
15.0					Drill Break																	
15.6					Drill Break																	
15.8					Drill Break																	
15.8					Joint		33	33			x			x			H		S			H
16.0					Joint		90	38					x	x			H		S		P	H
16.0					Joint	10							x			x	H		S			H
16.9					Joint	70							x	x			H		S		P	H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Weathering:
S-slightly; M-moderately; H-highly

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Expansion Project
Site	Left Abutment - Top of Concrete Dam
Azimuth	160
Inclination	60

Depth (ft)		drill induced	zone		Description	Discontinuity surface and shape															
			broken	fragmented		Angle with core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	Aperture
from	to																				
17.5					Joint		77	275					x	x							
18.0					Drill Break																
18.0					Joint	30						x		x			L	C,Q	S		P	H
19.3					Drill Break																
20.3					Drill Break																
20.8					Drill Break																
21.1					Drill Break																
22.5					Hammer Break																
22.8					Hammer Break																
24.0					Drill Break																
25.8					Drill Break																
27.3					Hammer Break																
29.5					Drill Break																
29.8					Drill Break																
30.8					Drill Break																
32.0					Drill Break																
32.5					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Expansion Project
Site: Left Abutment - Top of Concrete Dam
Azimuth: 160
Inclination: 60

Depth (ft)		drill induced	zone		Description	Discontinuity surface and shape																
			broken	fragmented		Angle with core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	Aperture
from	to																					
32.8					Drill Break																	
33.5					Joint		75	330			x			x			H		S			
33.8					Drill Break																	
34.9					Drill Break																	
35.8					Drill Break																	
40.8					Drill Break																	
41.5					Drill Break																	
42.4					Drill Break																	
43.1					Drill Break																	
43.7					Joint		53	207					x			x		C	S			
44.2					Joint		46	208			x				x				S			
44.5					Drill Break																	
44.9					Drill Break																	
45.1					Drill Break																	
45.5					Drill Break																	
45.8					Drill Break																	
46.2					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Weathering:
S-slightly; M-moderately; H-highly

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Expansion Project
Site: Left Abutment - Top of Concrete Dam
Azimuth: 160
Inclination: 60

Depth (ft)		drill induced	zone		Description	Discontinuity surface and shape																
			broken	fragmented		Angle with core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	Aperture
from	to																					
46.6					Drill Break																	
47.3					Drill Break																	
47.8					Drill Break																	
49.4					Drill Break																	
50.0					Drill Break																	
50.4					Drill Break																	
50.8					Drill Break																	
52.3					Drill Break																	
52.6					Drill Break																	
52.9					Joint	45					x			x			H		S			H
53.0					Break on Quartz Vein	35					x			x			H	C	S			H
53.3					Drill Break																	
53.9					Joint	50					x			x			H	C	S			H
55.1					Joint		46	204					x			x						
55.8					Drill Break																	
58.8					Joint		78	190			x			x				C			P	H
59.8					Joint		49	281					x			x						H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-04
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Expansion Project
Site	Left Abutment - Top of Concrete Dam
Azimuth	160
Inclination	60

Depth (ft)		drill induced	zone		Description	Discontinuity surface and shape																
			broken	fragmented		Angle with core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	Aperture
from	to																					
61.6					Joint		27	42			x			x			H		S			H
63.1					Joint		61	2			x			x								H
65.0					Drill Break																	
65.8					Drill Break																	
67.2					Drill Break																	
68.6					Drill Break																	
69.2					Drill Break																	
69.3					Joint		81	297			x			x			H	C	S		P	O
69.4					Drill Break																	
69.6					Drill Break																	
70.8					Drill Break																	
71.3					Hammer Break																	
72.0					Drill Break																	
73.0					Joint		67	188			x					x		S			P	O
74.0					Hammer Break																	
74.3					Drill Break																	
75.5					Joint		73	192			x			x								O

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Weathering:

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

S-slightly; M-moderately; H-highly

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Expansion Project
Site: Left Abutment - Top of Concrete Dam
Azimuth: 160
Inclination: 60

Depth (ft)		drill induced	zone		Description	Discontinuity surface and shape																
			broken	fragmented		Angle with core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	Aperture
from	to																					
75.8					Drill Break																	
77.6					Drill Break																	
78.5					Bedding (no break)		47	240														
79.9					Bedding (no break)		43	229														
80.8					Drill Break																	
81.4					Joint		54	224				x			x		H					O
81.8					Drill Break																	
82.4					Drill Break																	
82.8					Drill Break																	
83.5	84.9				Longitudinal Joint	5					x				x							O
84.2					Drill Break																	
85.2					Drill Break																	
85.9					Drill Break																	
85.9					Joint		51	271				x		x			H		S			O
86.3					Bedding (no break)		41	248														
86.5					Bedding (no break)		45	262														
86.7					Bedding (no break)		63	251														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-04
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Expansion Project
Site Left Abutment - Top of Concrete Dam
Azimuth 160
Inclination 60

Depth (ft)		drill induced	zone		Description	Discontinuity surface and shape																
			broken	fragmented		Angle with core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	Aperture
from	to																					
87.1					Joint	20							x	x			H		S	H	P	H
88.5					Bedding		41	247														
90.5					Joint		55	280			x			x			H		S			H
91.2					Drill Break																	
91.4					Bedding (no break)		52	288														
91.8					Joint		25	231			x			x								
92.9					Drill Break																	
93.4					Joint		56	293					x	x			H		S			H
93.9					Drill Break																	
94.5					Bedding (no break)		60	252														
95.8					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

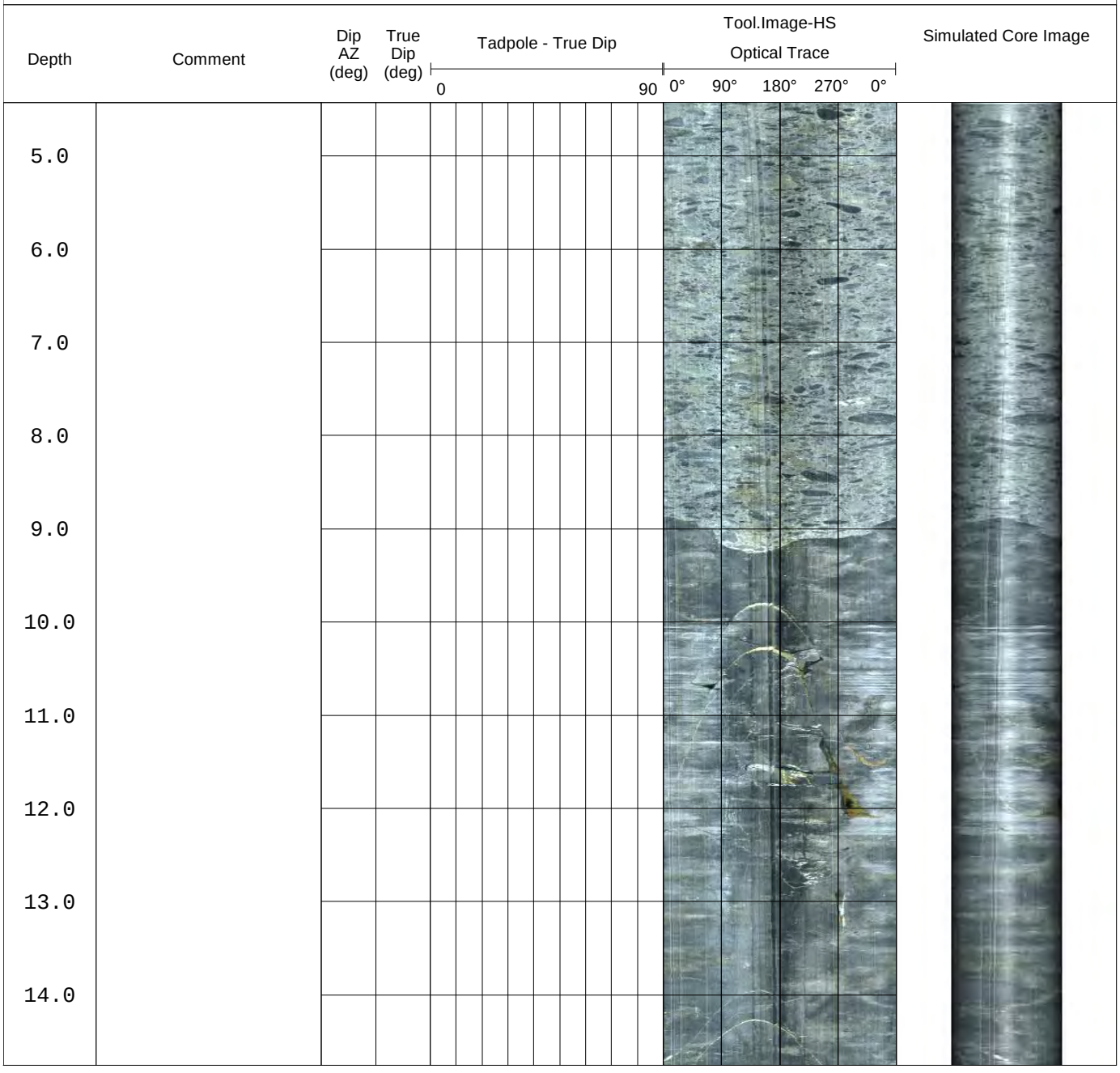
Aperture:O-Open; H-Hairline (<0.5mm)

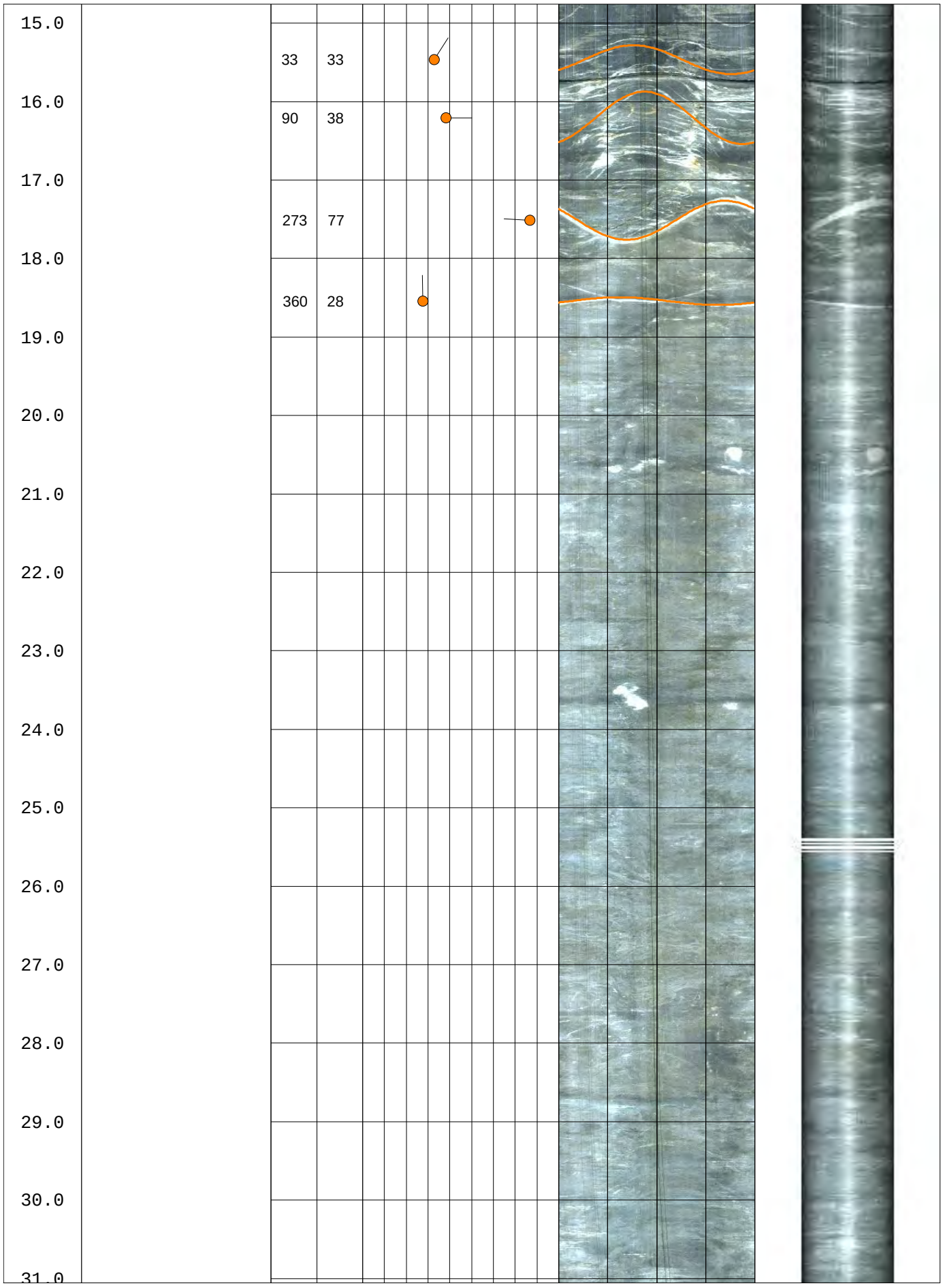
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company City and Borough of Sitka	
	Location: Sitka, AK	
	Project: Blue Lake Hydroelectric	
Date Logged:	September 6, 2009	Borehole ID: DH09-04
File Name:	DH09-04-1M.wcl	Logged By: F G Kruger

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from north.

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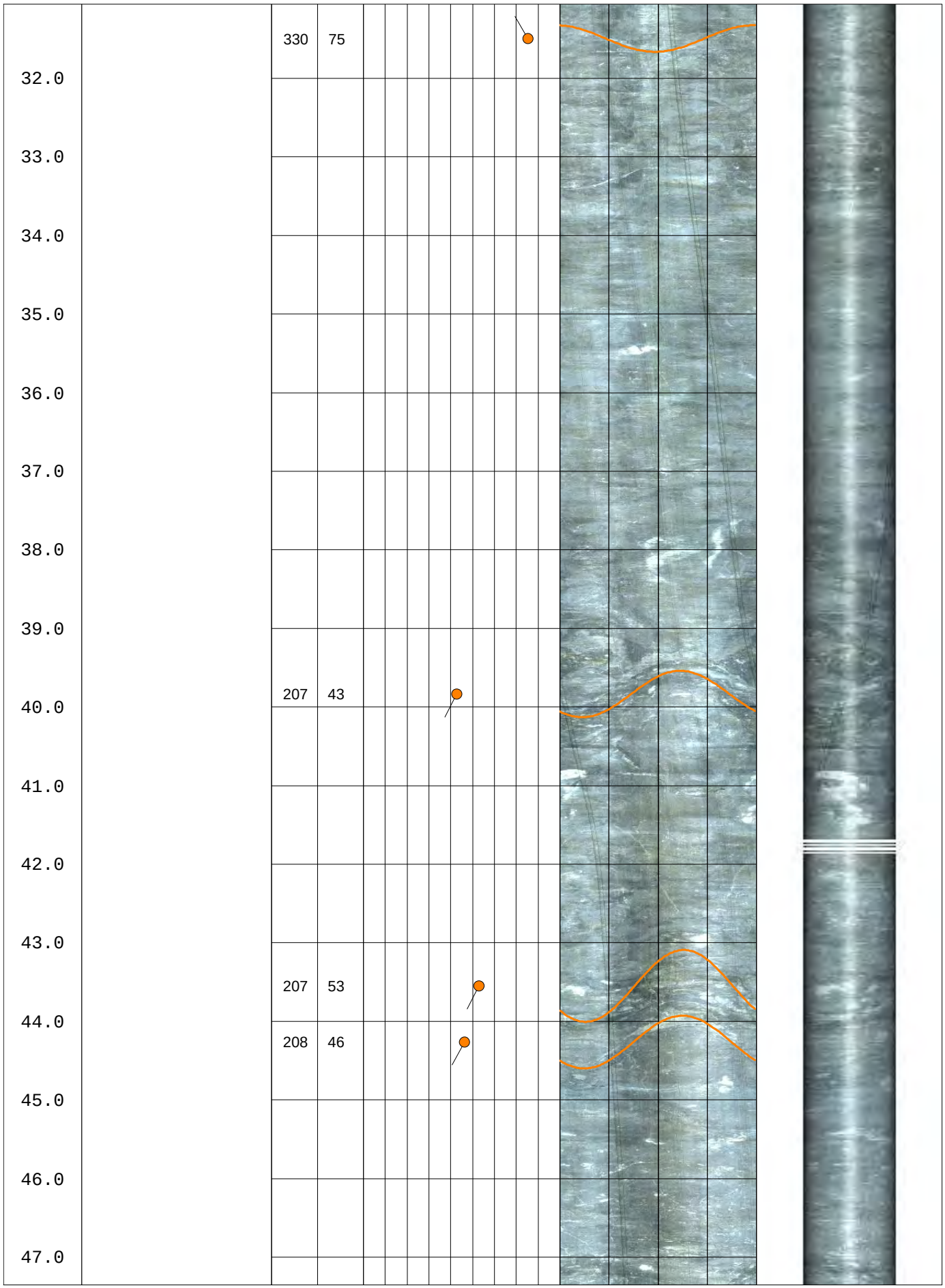
33
90
38
273
77
360
28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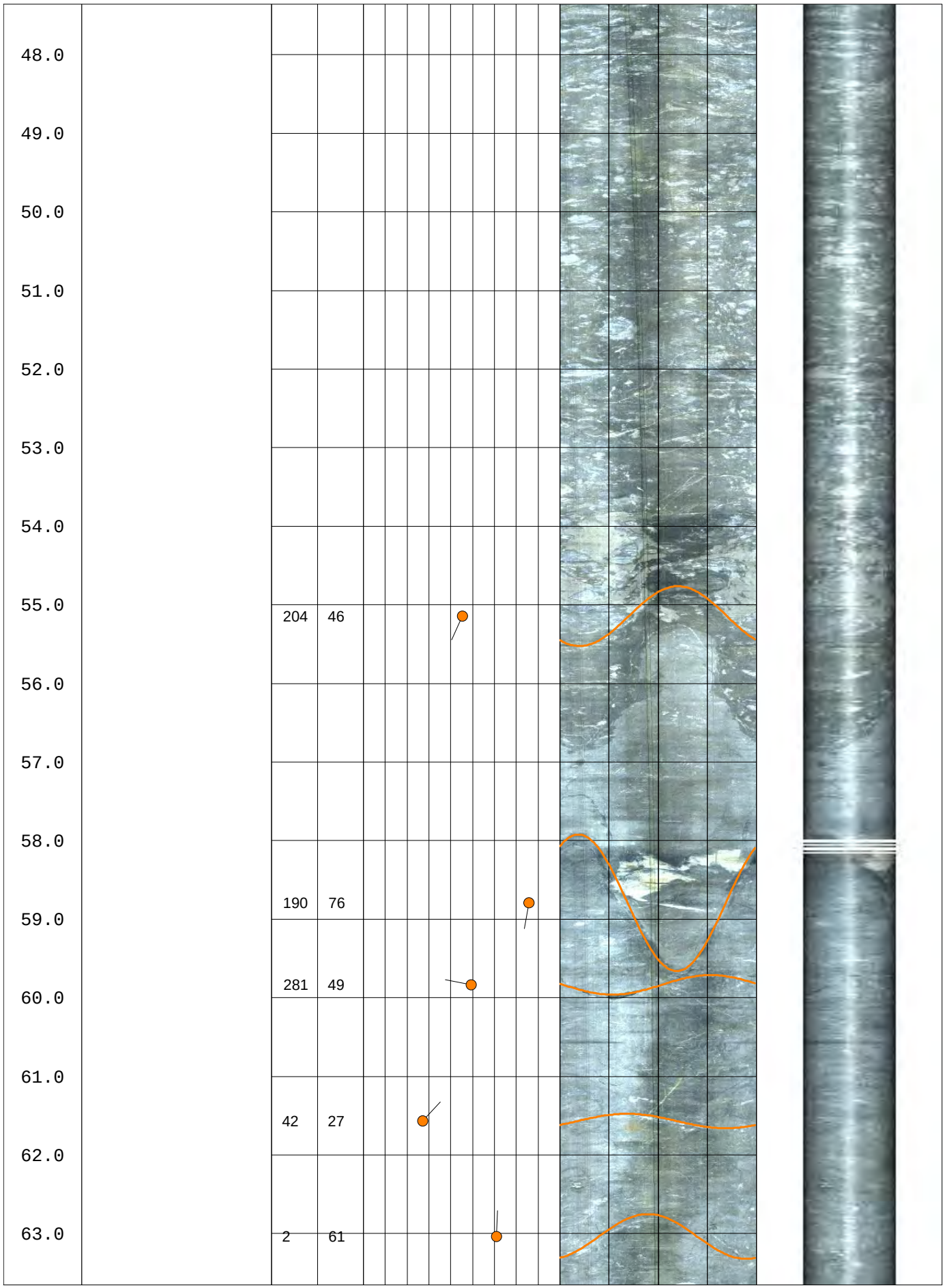
208
46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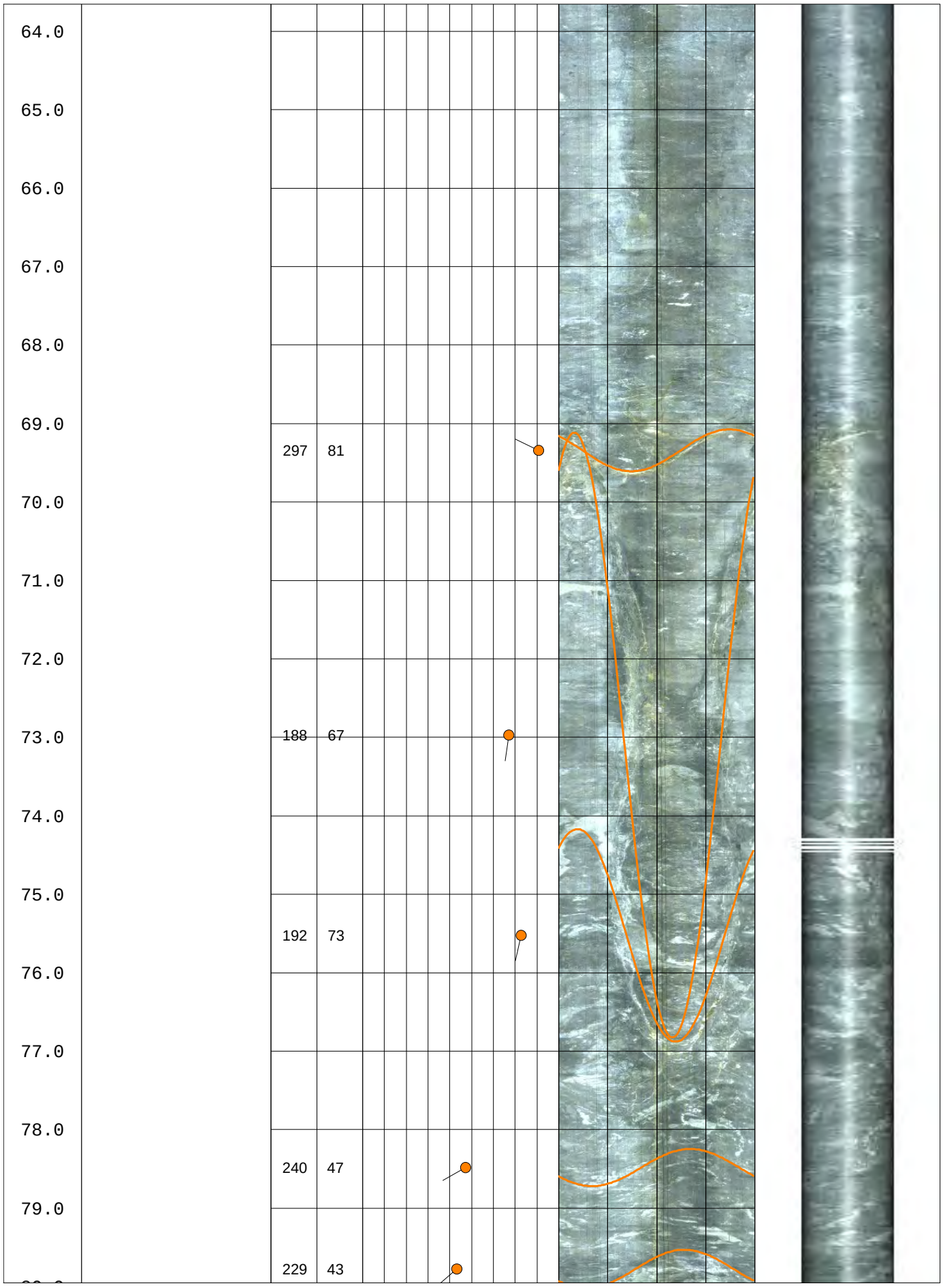
2 61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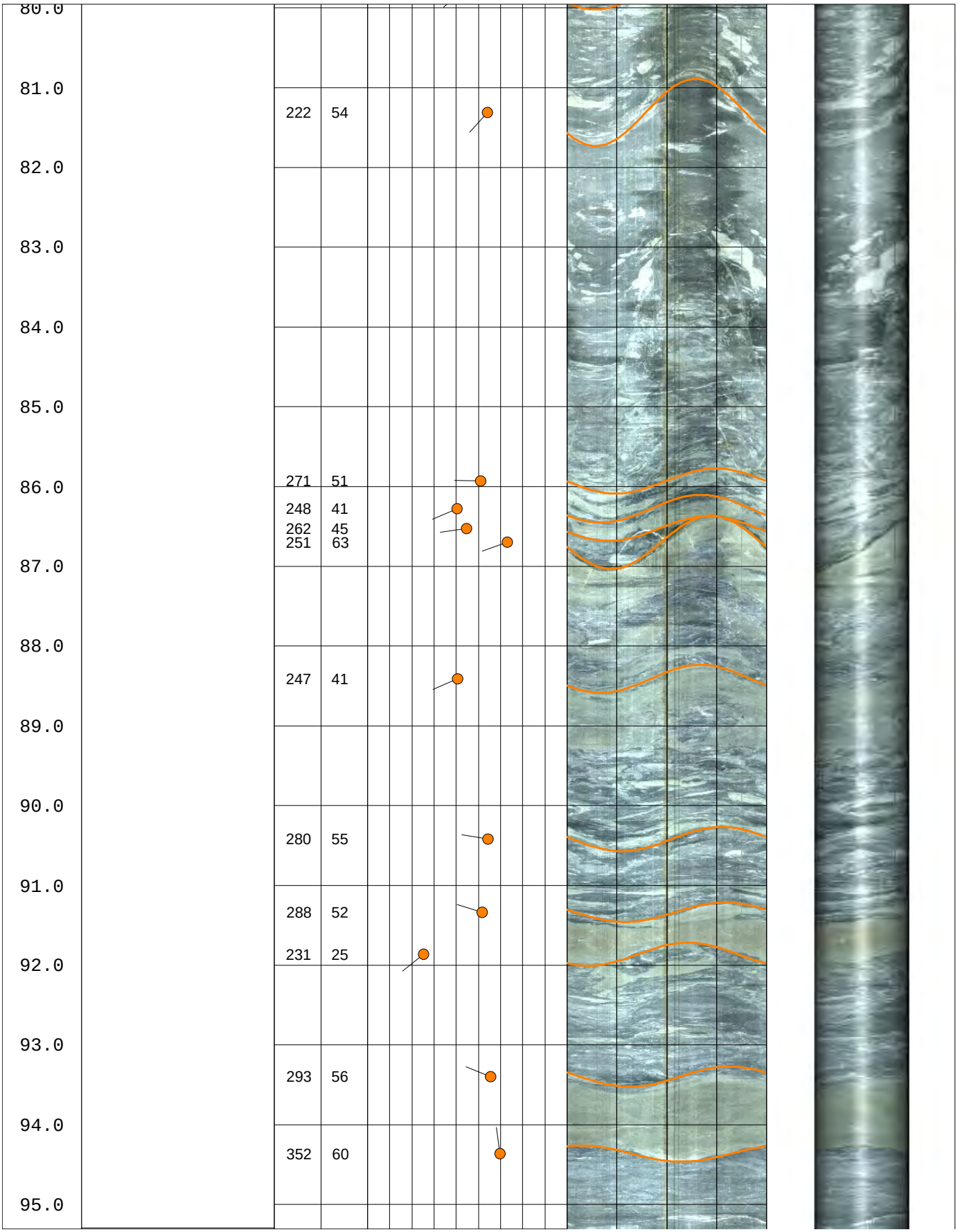
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93.0
94.0
95.0
222 54
271 51
248 41
262 45
251 63
247 41
280 55
288 52
231 25
293 56
352 60

Borehole DH09-05

Working Together SAFELY

© Hatch 2006/03 ⌘

BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-05***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 3

SITE: Right Abutment area, on access road

COORDINATES: 1912866.20 N, 2380387.0 E
DIP DIRECTION: N/A
DIP: 90

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 442.1
END OF HOLE: 411.3

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 4500
METHOD SOIL: HWT Casing Advancer
ROCK: Diamond Drill HQ Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 9/25/09
FINISHED: 9/26/09
INSPECTOR: P. Nolan
LOGGED BY: M. Mammoliti
REVIEWED: P.Friz

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE REC'Y (in)	SAMPLE REC'Y (%)	SAMPLE BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN. (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
442.1													
0.0		0.0 -10.0 ft: Overburden											
		0.0 - 3.0 ft: Roadfill gravel & sand	1	AS-1			14 46 12 7	1.0					
			3					2.0					
		3.0 - 5.0 ft: Clay & gravel, woody debris	3	AS-2			5 5 2 8	3.0					
			5					4.0					
		5.0 - 7.0 ft: Gravel & boulders SPT/Split spoon sample advances 1" after 50 blows.	5	AS-3			50	5.0					
			7					6.0					
								7.0					
								8.0					
								9.0					
								10.0					
		10 ft TOP OF BEDROCK see next sheet											

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT (W_P) NATURAL MOISTURE CONTENT (W_N) LIQUID LIMIT (W_L)

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-05**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 3

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
432.1 10		10.0 - 30.8 ft: Metamorphosed Bedded to Fragmental Andesitic Siltstone Dark grey, fine grained, very strong (100 - 250 MPa), light and dark flow banding @ 45 deg to core axis; calcite veins/veinlets are more frequent from 10.8-17.0', less frequent from 17.0-30.8'; occasional small clasts (<0.5") within banding; Iron staining on joint surfaces. Discontinuities are widely spaced (>6.0 ft); GSI = 65 - 70. 16.9 ft: 20 mm wide quartz vein @ 40 deg to core axis		The following general discontinuity characteristics were noted in this hole: 67% of discontinuities are rough, 33% are smooth 100% of discontinuities display hematite staining and 67% are slightly weathered See detailed discontinuity log for data on each discontinuity.		1	75	75	11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	20 40 60 80	0.1 1 10 100 No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						2	100	100					
						3	100	100					
						4	100	100					
						5	100	100					
411.3 30.8				**END OF BOREHOLE**									

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-05

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 3

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level could not be measured accurately due to low rock permeability.
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-05
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment area
Azimuth (Deg): N/A
Inclination (Deg): 90

Depth (m)		Drill Induced	zone		# of discontinuities	Description	Discontinuity surface and shape															
from	to		broken	fragmented			Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
10.2						Drill Break																
10.8						Drill Break																
11.5						Drill Break																
11.8						Drill Break																
12.4					1	Calcite Vein	25							x	x				C	s			
12.8						Drill Break																
13.1						Drill Break																
13.4					1	Joint	45							x	x			H	C	s	x		
14.1						Drill Break																
15.3						Hammer Break																
15.8						Drill Break																
16.9						Drill Break																
16.8					1	Quartz Vein	40						x		x				C			
20.2						Drill Break																
20.8						Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-05
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment area
Azimuth (Deg)	N/A
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		# of discontinuities	Description	Discontinuity surface and shape																
from	to		broken	fragmented			Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
21.2						Drill Break																	
22.0						Drill Break																	
24.1						Drill Break																	
24.6						Hammer Break																	
25.0						Hammer Break																	
25.8						Drill Break																	
28.7						Drill Break																	
29.5						Drill Break																	
30.2						Drill Break																	
30.4						Drill Break																	
30.6						Drill Break																	
30.7						Drill Break																	
30.8						Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Borehole DH09-06

Working Together SAFELY

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BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-06***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 6

SITE: Right Abutment area, on access road

COORDINATES: 1913105.2 N, 2380348.6 E
DIP DIRECTION: N/A
DIP: 90

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 450.9
END OF HOLE: 379.5

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 2500
METHOD SOIL: HWT Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 9/28/09
FINISHED: 9/30/09
INSPECTOR: M. Mammoliti
LOGGED BY: M. Mammoliti
REVIEWED: P.Friz

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE REC'Y (in)	SAMPLE REC'Y (%)	SAMPLE BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION / SHEAR STRENGTH (psi) / HYDRAULIC CONDUCTIVITY (ft/s) / WATER CONTENT & ATTERBERG LIMITS	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%)	PIEZOMETER INSTALLATION
450.9											GR SA SI CL	
0.0		0.0 - 3.1 ft: Overburden - Roadfill gravel, sand 0.0 - 2.0 ft: SPT/Split spoon sample 2.0 - 3.1 ft: SPT/Split spoon hit refusal after advancing 1.1 ft.	0 2	AS-1			17 40 40 16	1.0				
447.8			2 3.1	AS-2			34 28 50	2.0 3.0				
3.1		3.1 - 41.4 ft: Overburden - Silty sand to sandy silty clay, silty sand with gravel 5.2 - 7.2 ft: Silty sand, SPT/Split spoon sample DH09-06-03 submitted for gradational analyses.	5.2 7.2	AS-3			9 16 18 24	4.0 5.0 6.0 7.0 8.0			9 43 36 12	

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W_N — LIQUID LIMIT W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-06***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 6

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE REC'Y (in)	SAMPLE REC'Y (%)	SAMPLE BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN. (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
		10.2 ft: Falling head test - hydraulic conductivity of 5.92×10^{-4} ft/s. 10.2 - 15.2 ft: Silty sand 10.2 - 12.2 ft: SPT sample DH09-06-04 submitted for laboratory analyses.	10.2	AS-4			20 23 28 37	10.0 11.0 12.0	● at 11.0			6 44 36 14	
		15.2 - 25.2 ft: Sand silty clay 15.2 - 16.6 ft: SPT hit refusal (50 blows) after advancing 1.4 ft.	15.2 16.6	AS-5			20 41 50	13.0 14.0 15.0 16.0	● at 16.0				
			20.2				37	17.0 18.0 19.0 20.0					

SAMPLING METHOD

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SHIPPING CONTAINER

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Z - Discarded

PLASTIC LIMIT (W_P) NATURAL MOISTURE CONTENT (W_N) LIQUID LIMIT (W_L)

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-06***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 6

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE REC'Y (in)	SAMPLE REC'Y (%)	SAMPLE BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION / SHEAR STRENGTH (psi)	HYDRAULIC CONDUCTIVITY (ft/s) / WATER CONTENT & ATTERBERG LIMITS	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL	PIEZOMETER INSTALLATION
		20.2 - 21.6 ft: SPT hit refusal (50 blows) after advancing 1.4 ft. SPT sample DH09-06-06 submitted for laboratory testing.		AS-6			49 50	21.0	● at 21.0			8	27	56	9	
		25.2 - 36.5 ft: Silty sand with gravel 25.2 - 25.5 ft: SPT/Split spoon hit refusal (50 blows) after advancing 0.3 ft. SPT sample DH09-07-06 submitted for laboratory testing. 27.2 - 31.5 ft: Silty sand with gravel contains cobbles and boulders	25.2 25.5	AS-7			50	25.0	● at 25.0			23	32	36	9	
		31.5 - 31.8 ft: SPT/Split spoon hit refusal (50 blows) after advancing 0.3 ft.	31.5 31.8	AS-8			50	31.0	● at 31.0							

SAMPLING METHOD

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Z - Discarded

PLASTIC LIMIT — NATURAL MOISTURE CONTENT — LIQUID LIMIT

W_P W_N W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-06***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 6

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE REC'Y (in)	SAMPLE REC'Y (%)	SAMPLE BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION / SHEAR STRENGTH (psi)	HYDRAULIC CONDUCTIVITY (ft/s) / WATER CONTENT & ATTERBERG LIMITS	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
		36.5 - 41.4 ft: Silty sand, contains cobbles and boulders. 36.5 - 37.4 ft: SPT hit refusal (50 blows) after advancing 0.9 ft. SPT Sample DH09-06-09 submitted for laboratory testing.	36.5 37.4	AS-9			10 50	32.0 33.0 34.0 35.0 36.0 37.0 38.0 39.0 40.0 41.0	● SPT N-VALUES; ≀ DYNAMIC CONE PENETRATION (20 40 60 80); SHEAR STRENGTH (psi): □ UNCONFINED, ■ QUICK TRIAXIAL, ✖ FIELD VANE, ✚ LAB VANE, ✪ POCKET PEN. (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) 10^{-6} 10^{-5} 10^{-4}; WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))		3 65 19 13	
		41.4 ft TOP OF BEDROCK see next sheet						42.0 43.0					

SAMPLING METHOD

A - Split Tube
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PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W_N — LIQUID LIMIT W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-06***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 6

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
409.5 41.4		41.4 - 71.4 ft: Metamorphosed Andesitic Siltstone Dark grey, fine grained, very strong (100 - 250 MPa), light/dark prominent flow banding @ 45 deg to core axis; occasional calcite veins/veinlets; occasional small clasts (<0.5") within and oriented to banding; Iron staining and pyrite on joint surfaces; discontinuities are widely spaced; GSI = 65 - 70.		See detailed discontinuity log for data on each discontinuity.		1	100	100	42 43 44 45 46	20 40 60 80	0.1 1 10 100 (lugeons) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3} (cm/sec)		
						2	100	100	47 48 49 50 51				
						3	100	100	52 53 54 55 56				
						4	100	100	57 58 59 60 61				
						5	100	100	62 63 64 65 66				
						6	100	100	67 68 69 70 71				
379.5 71.4				**END OF BOREHOLE**									

SAMPLING METHOD

A - Split Tube
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C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

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U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-06

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 6

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level could not be measured accurately due to low rock permeability.
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-06
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment, on access road
Azimuth (Deg)	N/A
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
41.4					Top of bedrock																
42.2					Drill Break																
42.6					Drill Break																
43.3					Drill Break																
43.7					Joint (pyrite)							x		x			H	C	S		P	H
45.1					Drill Break																
45.8					Drill Break																
46.4					Drill Break																
47.1					Drill Break																
49.0					Drill Break																
49.7					Hammer Break																
50.5					Hammer Break																
51.4					Drill Break																
52.1					Hammer Break																
54.7					Hammer Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-06
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment, on access road
Azimuth (Deg)	N/A
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
55.1					Hammer Break																	
55.4					Hammer Break																	
55.7					Hammer Break																	
56.2					Hammer Break																	
59.3					Drill Break																	
61.4					Drill Break																	
62.2					Drill Break																	
64.6					Drill Break																	
65.5					Drill Break																	
66.4					Drill Break																	
68.9					Drill Break																	
69.7					Drill Break																	
70.2					Drill Break																	
71.4					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Borehole DH09-07

Working Together SAFELY

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BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-07***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 6

SITE: Right Abutment

COORDINATES: 1912941.2 N, 2380563.7 E
DIP DIRECTION: 050
DIP: 60

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 468.1
END OF HOLE: 321.9

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 4500
METHOD SOIL: HWT Casing Advancer,
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 09/21/09
FINISHED: 09/25/09
INSPECTOR: M. Bandruzuman
LOGGED BY: P. Friz
REVIEWED: S. Perkins

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN.) (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
468.1													
0.0		0.0 - 4.0 ft: Overburden - not sampled Roadfill, woody debris, soil						1.0 2.0 3.0					
								4.0	**4 ft TOP OF BEDROCK see next sheet**				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W_N — LIQUID LIMIT W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-07**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 6

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
464.64		4.0 - 168.8 ft: Metamorphosed Bedded - Fragmental Andesitic Siltstone Medium -dark gey and black; texture fine grained to clastic; clastic sections contains clasts up to 4 in. in size (mean size approximately 1 inch); clasts display some stretching parallel to bedding and flow banding, flow banding oriented at 45 to 70 deg to core axis; intersected by quartz carbonate veinlets up to 0.5 in. thick, overall rock is very strong (100 - 250 MPa); Average discontinuity spacing of 1.8 ft; GSI = 60 - 70. 53.7 - 58.7 ft: Pervasive carbonate microfractures.		For detailed data on each discontinuity, see the discontinuity log. 5.1 - 5.3 ft: FRAGMENTED CORE ZONE 12.7 - 13.1 ft: FRAGMENTED CORE ZONE 21.8 - 22.8 ft: FRAGMENTED CORE ZONE 27.6 - 28.2 ft: FRAGMENTED CORE ZONE (drill induced) 28.7 - 29.3 ft: Longitudinal joint The following general discontinuity data were noted for this hole: 58% of the discontinuities are smooth, 29% are slightly rough, 11% are rough and 2% are slick. 82% of the discontinuities are planar. 98% of the discontinuities have hematite staining, 94% are slightly weathered and 4% are moderately weathered.		3	100	85	5 6 7 8				
						4	100	90	9 10 11 12 13				
						5	100	100	14 15 16 17 18				
						6	100	76	19 20 21 22 23				
						7	100	82	24 25 26 27 28				
						8	100	100	29 30 31 32 33				
						9	100	98	34 35 36 37 38				
						10	100	100	39 40 41 42 43				
						11	100	94	44 45 46 47 48				
						12	100	96	49 50 51 52 53				

SAMPLING METHOD

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Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-07**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 6

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						13	100	98	55–58				
						14	100	100	59–63				
						15	100	100	62–63				
						16	100	100	64–68				
						17	100	100	69–73				
						18	100	100	74–78				
						19	100	98	79–83				
				85.9 - 86.1 ft: FRAGMENTED CORE ZONE		20	100	60	84–88				
		91.4 - 93.7 ft: 2 in. wide quartz vein on top of andesite dyke.		87 - 88.8 ft: FRAGMENTED CORE ZONE 92.4 - 93.1 ft: Longitudinal joint		21	100	98	89–93				
						22	100	100	94–98				
						23	100	100	99–103				

PERMEABILITY (lugeons): 0.1 1 10 100 — (cm/sec): No take, 10^{-6} 10^{-5} 10^{-4} 10^{-3}

RECOVERY AND RQD (%): 20 40 60 80

SAMPLING METHOD

A - Split Tube
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SHIPPING CONTAINER

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U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-07**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 6

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						24	100	100	105–108				
						25	100	100	109–113				
						26	100	100	114–118				
						27	100	100	119–123				
						28	100	100	124–128				
						29	100	100	129–133				
						30	100	100	134–138				
				140.0 - 141.0 ft: Longitudinal joint 141.3 - 142.0 ft: Longitudinal joint		31	100	74	139–143				
						32	100	100	144–148				
						33	100	100	149–153				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-07**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 6

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						34	100	100	155–158				
						35	100	100	159–163				
				165.5 - 166.5 ft: Longitudinal joint		36	100	80	164–168				
321.9 / 168.8		**END OF BOREHOLE**											

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost — RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-07

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 6

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at 20 ft below borehole collar on September 24, 2009. However, it should be noted that this value may not reflect actual ground water level due to the low permeability of the rock.
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-07
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment
Azimuth (Deg)	050
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
4.0					Top of bedrock																
4.2					Joint	35					x			x			H		S			
4.8					Drill Break																	
5.1	5.3			x	Fragmented zone																	
5.3					Joint	60							x	x			H		S			
5.4					Joint	55						x		x			H		S			
5.7					Joint	45						x		x			H		S			
6.0					Drill Break																	
6.3					Drill Break																	
7.0					Joint	50					x			x			H		S			
7.3					Drill Break																	
7.8					Drill Break																	
8.0					Drill Break																	
8.7					Drill Break																	
8.8					Joint	70					x					x	H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-07
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
9.4					Drill Break																
10.2					Drill Break																
11.3					Bedding (no break)		60	228													
11.7					Bedding (no break)		64	211													
11.8					Joint	15	86	103			x			x			H		S			
12.2					Bedding (Drill Break)		67	225													
12.5					Bedding (no break)		63	217													
12.7					Bedding (Drill Break)		72	217													
12.7	13.1			x	Fragmented zone																
13.1					Joint	60	44	199			x			x			H	C	S	x		O
13.7					Bedding (Drill Break)		58	212													
14.6					Bedding (no break)		67	200													
14.8					Drill Break																
15.2					Bedding (no break)		58	229													
15.5					Joint	25						x		x			H		S	x		

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
15.6					Bedding (no break)		75	211														
15.9					Drill Break																	
16.1					Bedding (no break)		73	215														
16.9					Joint	50					x			x			H		S	x		
17.0					Drill Break																	
17.4					Drill Break																	
18.0					Drill Break																	
18.2					Bedding (no break)		64	208														
18.6					Bedding (Drill Break)		64	210														
18.7					Bedding (Drill Break)		80	220														
19.3					Bedding (no break)		53	204														
19.5					Bedding (no break)		49	197														
20.0					Joint	50					x			x			H		S	x		H
20.1					Joint	70					x			x			H		S	x		H
20.7					Vein (no break)		88	211														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-07
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
21.5					Vein (no break)		79	219														
21.8					Calcite Vein		85	203														
21.8	22.8			x	Fragmented zone																	
22.2					Joint	40					x			x			H	C	S			
22.6					Drill Break																	
22.8					Bedding (Drill Break)		72	209														
23.0					Drill Break																	
23.1					Bedding (no break)		63	213														
23.5					Bedding (no break)		55	216														
23.6					Break on Calcite Vein	50					x			x			H	C	S		P	
23.7					Drill Break																	
23.9					Bedding (no break)		62	209														
23.9					Joint	30					x			x			H	C	S			
24.2					Bedding (Drill Break)		70	203														
24.4					Bedding (no break)		68	218														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
24.5					Drill Break																
24.8					Joint	45					x			x			H		S			
25.2					Bedding (no break)		75	201														
25.6					Drill Break																	
25.8					Joint	30					x			x			H		S			
25.9					Joint	45					x			x			H		S			
26.4					Bedding (no break)		73	223														
26.9					Joint	45	83	213			x			x			H		S			
27.3					Joint	45	84	206			x			x			H		S			
27.6					Hammer Break																	
27.6	28.2				Fragmented zone (drill induced)																	
28.1					Hammer Break																	
28.7					Drill Break																	
28.7					Joint	10	51	008					x		x		H	C	M	x		O
29.3					Joint	45	88	121			x			x			H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
29.9					Joint	85					x					x	H		S			
30.3					Bedding (no break)		56	221														
30.5					Joint	40					x			x			H		S			
30.8					Drill Break																	
31.0					Drill Break																	
31.2					Joint	80					x			x			H		S			
31.8					Joint	60					x			x			H		S			
32.0					Hammer Break (vein)																	
32.2					Hammer Break																	
32.4					Bedding (Hammer Break)		85	203														
33.3					Bedding (Drill Break)		79	227														
33.7					Drill Break																	
33.9					Drill Break																	
34.0					Bedding (no break)		80	205														
34.3					Joint	70					x			x			H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-07
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
34.4					Joint	80					x			x			H		S			
34.9					Bedding (no break)		71	205														
35.2					Joint	35	72	209			x			x			H		S			
36.8					Drill Break																	
37.5					Bedding (no break)		51	187														
38.4					Bedding (no break)		65	221														
38.6					Bedding (no break)		75	204														
38.7					Drill Break																	
39.8					Bedding (no break)		75	214														
40.6					Bedding (no break)		90	030														
40.8					Drill Break																	
41.7					Bedding (Hammer Break)		69	192														
42.0					Bedding (Hammer Break)		67	196														
42.9					Bedding (no break)		64	217														
43.7					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-07
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
43.8					Joint	65	58	229			x			x			H		S			
45.2					Bedding (no break)		53	232														
45.9					Joint	50	73	262														
46.0					Joint	50							x	x			H		S			
46.3					Joint	35					x			x			H		S			
46.5					Calcite Vein		78	231														
48.4					Drill Break																	
48.7					Drill Break																	
51.1					Joint	45	79	201			x			x			H		S			
52.1					Joint	30	81	177			x			x			H		S			
52.2					Joint	30					x			x			H		S			
52.5					Joint	30					x					x	H		S			
53.5					Bedding (no break)		54	212														
53.7					Drill Break																	
53.9					Joint	35						x		x			H		S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-07
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
54.7					Calcite Vein		55	247													
54.8					Calcite Vein		42	283													
54.9					Joint	70						x		x			H	CS	S			O
55.0					Joint	70					x					x	H	CS	M			O
55.2					Drill Break																	
55.3					Drill Break																	
55.9					Bedding (Drill Break)		60	219													
56.9					Joint		73	226				x		x			H		S			
57.2					Bedding (Drill Break)		35	178													
57.6					Drill Break																	
57.9					Drill Break																	
58.7					Bedding (Drill Break)		63	201													
59.5					Joint	60						x				x	H		S			
60.1					Bedding (Drill Break)		64	243													
60.5					Hammer Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
61.0					Hammer Break																	
61.8					Joint	10						x		x			H		S			
62.1					Vein (no break)		56	222														
62.4					Joint	75					x			x			H		S			
63.0					Bedding (no break)		31	292														
63.6					Drill Break																	
64.6					Drill Break																	
65.1					Hammer Break																	
65.4					Bedding (Drill Break)		62	215														
65.8					Bedding (no break)		52	193														
66.0					Drill Break																	
66.6					Drill Break																	
67.2					Vein (no break)		47	224														
68.7					Bedding (Drill Break)		50	258														
69.0					Bedding (no break)		62	255														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
69.3					Bedding (Drill Break)		58	245														
69.6					Bedding (no break)		55	209														
70.5					Hammer Break																	
70.7					Hammer Break																	
72.1					Drill Break																	
72.7					Drill Break																	
73.4					Drill Break																	
73.5					Drill Break																	
73.7					Drill Break																	
74.1					Bedding (no break)		70	210														
74.5					Drill Break																	
75.0					Drill Break																	
75.3					Calcite Vein		73	218														
75.6					Vein (no break)		70	213														
76.6					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
77.4					Bedding (Drill Break)		73	219														
77.6					Bedding (Drill Break)		57	202														
78.0					Joint	25	84	111					x	x			H		S			H
78.8					Calcite Vein		61	212														
79.1					Calcite Vein	65					x			x			H	C	S		P	O
79.4					Bedding (no break)		62	179														
80.0					Drill Break																	
80.3					Drill Break																	
81.0					Vein (no break)		44	211														
82.4					Bedding (no break)		57	206														
82.5					Joint	30						x			x		H	C	S			O
83.1					Joint	40	34	030				x		x								
83.1					Bedding (no break)		61	203														
83.2					Joint	40						x		x								
83.8					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-07
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
84.9					Calcite Vein		76	209														
85.3					Drill Break																	
85.9					Drill Break																	
85.9	86.1			x	Fragmented zone																	
86.2					Joint	30	37	041				x		x			H		S			O
87.0					Drill Break																	
87.0	88.8			x	Fragmented zone																	
87.0	88.2				Joint	10						x				x	H		S			O
87.7					Bedding (no break)		68	222														
88.8					Drill Break																	
89.6					Drill Break																	
89.7					Drill Break																	
90.1					Drill Break																	
90.4					Joint	20					x			x			H		S			H
90.8					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
90.9					Drill Break																
91.1					Bedding (Drill Break)		70	190													
91.5					Drill Break																
91.6					Calcite Vein	40	45	141				x		x			H	C	S			
92.2					Drill Break																
92.5					Joint	60					x					x	H	C	S			
92.4	93.1				Joint	10					x					x	H	C	S			
92.8					Vein (no break)		81	086													
93.1					Drill Break																
93.3					Drill Break																
93.7					Joint	45	48	183			x			x			H	C	S			
93.8					Drill Break																
94.3					Bedding (Drill Break)		54	197													
94.4					Drill Break																
94.6					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-07
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
94.9					Joint	50				x				x			H		M	x		O
95.2					Drill Break																	
95.5					Joint	40				x				x			H		M	x		O
95.7					Vein (no break)		50	181														
95.9					Drill Break																	
96.8					Drill Break																	
97.0					Bedding (no break)		74	249														
97.7					Drill Break																	
98.1					Bedding (Drill Break)		80	190														
98.5					Drill Break																	
98.8					Drill Break																	
99.3					Calcite Vein		47	239														
99.6					Drill Break																	
99.9					Drill Break																	
100.4					Bedding (no break)		57	204														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
101.5					Joint	45					x			x			H	C	S			
101.7					Bedding (no break)		61	215														
102.1					Bedding (no break)		76	203														
103.0					Drill Break																	
103.8					Drill Break																	
104.0					Bedding (no break)		68	209														
104.2					Hammer Break																	
104.4					Bedding (no break)		72	194														
106.9					Drill Break																	
107.2					Joint	20							x	x			H		S			
107.5					Calcite Vein		86	105														
107.7					Drill Break																	
108.3					Drill Break																	
108.8					Drill Break																	
108.8					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
109.0					Hammer Break																	
109.2					Hammer Break																	
109.5					Drill Break																	
110.0					Bedding (no break)		53	201														
110.3					Bedding (no break)		64	221														
110.9					Drill Break																	
112.1					Drill Break																	
112.7					Bedding (Drill Break)		69	220														
113.2					Joint	40	84	209			x			x			H	C	S			O
113.5					Drill Break																	
113.8					Bedding (Drill Break)		41	208														
114.0					Drill Break																	
114.3					Drill Break																	
114.8					Drill Break																	
115.3					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
115.7					Joint	45	33	319			x			x			H	C	S	x		
116.0					Drill Break																	
117.3					Joint	30						x		x			H	C	S			
117.7					Drill Break																	
117.9					Vein (no break)		85	113														
118.8					Drill Break																	
119.6					Bedding (no break)		74	214														
119.9					Bedding (no break)		69	213														
120.8					Bedding (no break)		74	189														
121.0					Drill Break																	
121.3					Vein (no break)		89	212														
123.8					Drill Break																	
124.1					Bedding (no break)		62	221														
124.5					Bedding (no break)		57	222														
124.8					Bedding (no break)		60	204														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
125.3					Calcite Vein	30					x			x			H	C	S			
127.8					Joint	30					x			x			H	C	S			
128.1					Vein (no break)		85	008														
128.4					Drill Break																	
128.8					Drill Break																	
129.3					Joint	30						x			x		H	C	S			
129.6					Joint	70						x			x		H	C	S			
130.0					Joint	70	65	241			x			x			H	C	S			
130.5					Bedding (no break)		53	198														
130.9					Joint	75					x			x			H	C	S			
131.4					Joint	40					x			x			H	C	S			
131.6					Vein (no break)		75	198														
132.2					Bedding (no break)		71	205														
132.6					Bedding (no break)		74	197														
133.8					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-07
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment
Azimuth (Deg)	050
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
135.1					Joint	60					x			x			H	C	S			
136.1					Joint	35					x			x			H	C	S			
136.4					Drill Break																	
137.1					Bedding (no break)		77	201														
137.4					Joint	40	63	188			x			x			H	C	S			
137.7					Joint	40	59	215			x			x			H	C	S			
138.3					Drill Break																	
138.8					Drill Break																	
139.2					Joint	35					x			x			H	C	S			
140.0	141.0				Joint	10							x	x			H	C	S			O
141.3					Joint	45						x		x			H	C	S			
141.3	142.0				Joint	15						x		x			H	C	S			
141.7					Bedding (no break)		75	213														
142.1					Bedding (no break)		71	205														
142.5					Joint	30						x		x			H	C	S			O

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
142.8					Joint	40						x		x			H	C	S			
143.1					Joint	40	57	303			x			x			H	C	S			
143.2					Bedding (no break)		62	199														
143.8					Drill Break																	
146.1					Calcite Vein		19	001														
147.7					Bedding (no break)		62	198														
148.6					Bedding (Drill Break)		66	207														
148.8					Drill Break																	
149.1					Joint	45						x		x			H	C	S			
149.3					Bedding (no break)		73	218														
149.8					Bedding (no break)		67	221														
150.1					Calcite Vein	45	71	194				x		x			H	C	S			
151.8					Bedding (no break)		86	230														
152.7					Drill Break																	
153.2					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 050
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
153.6					Bedding (no break)		69	197													
153.8					Drill Break																
155.3					Joint	20							x	x			H	C	S		
155.5					Vein (no break)		88	105													
157.0					Bedding (no break)		60	214													
157.3					Joint	30						x		x			H	C	S		
157.5					Vein (no break)		69	293													
157.7					Drill Break																
158.0					Joint	40	58	201				x		x			H	C	S		
158.5					Vein (no break)		77	268													
158.8					Drill Break																
160.6					Bedding (no break)		46	220													
160.8					Bedding (no break)		56	237													
162.0					Joint	45					x			x			H	C	S		
162.2					Vein (no break)		34	293													

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 050
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
163.3					Vein	45					x			x			H	C	S			
163.8					Drill Break																	
164.6					Joint	45	68	261					x	x			H	C	S			O
164.9					Joint	60						x		x			H	C	S			O
165.5					Joint	55							x	x			H	C	S			
165.5	166.5				Joint	20							x	x			H	C	S			H
166.2					Vein (no break)		86	111														
166.5					Joint	70					x			x			H		S			
167.9					Joint	85					x			x			H		S			
168.1					Vein (no break)		66	299														
168.4					Calcite Vein	35	90	008			x			x			H	C	S			H
168.8					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

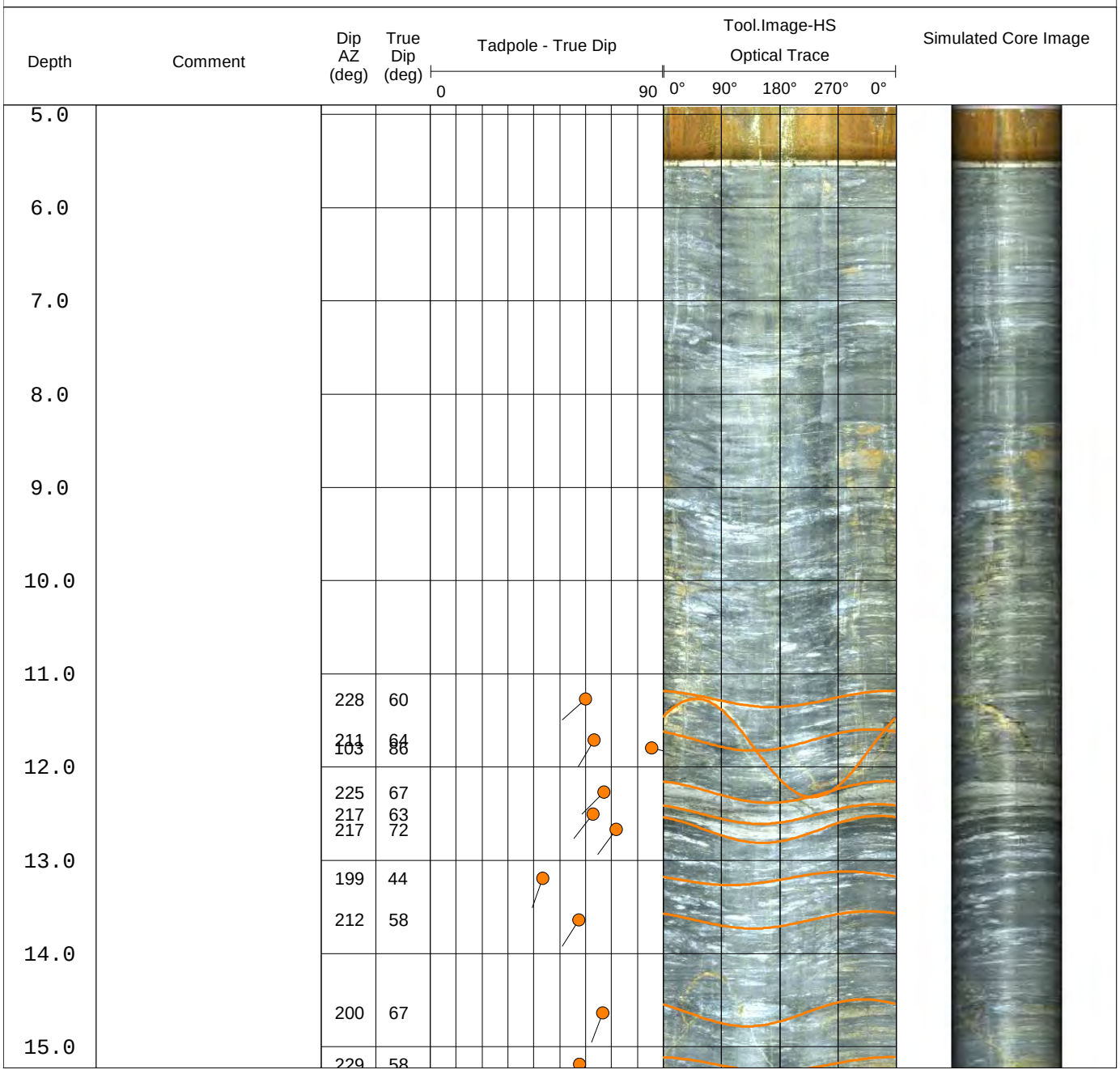
Aperture:O-Open; H-Hairline (<0.5mm)

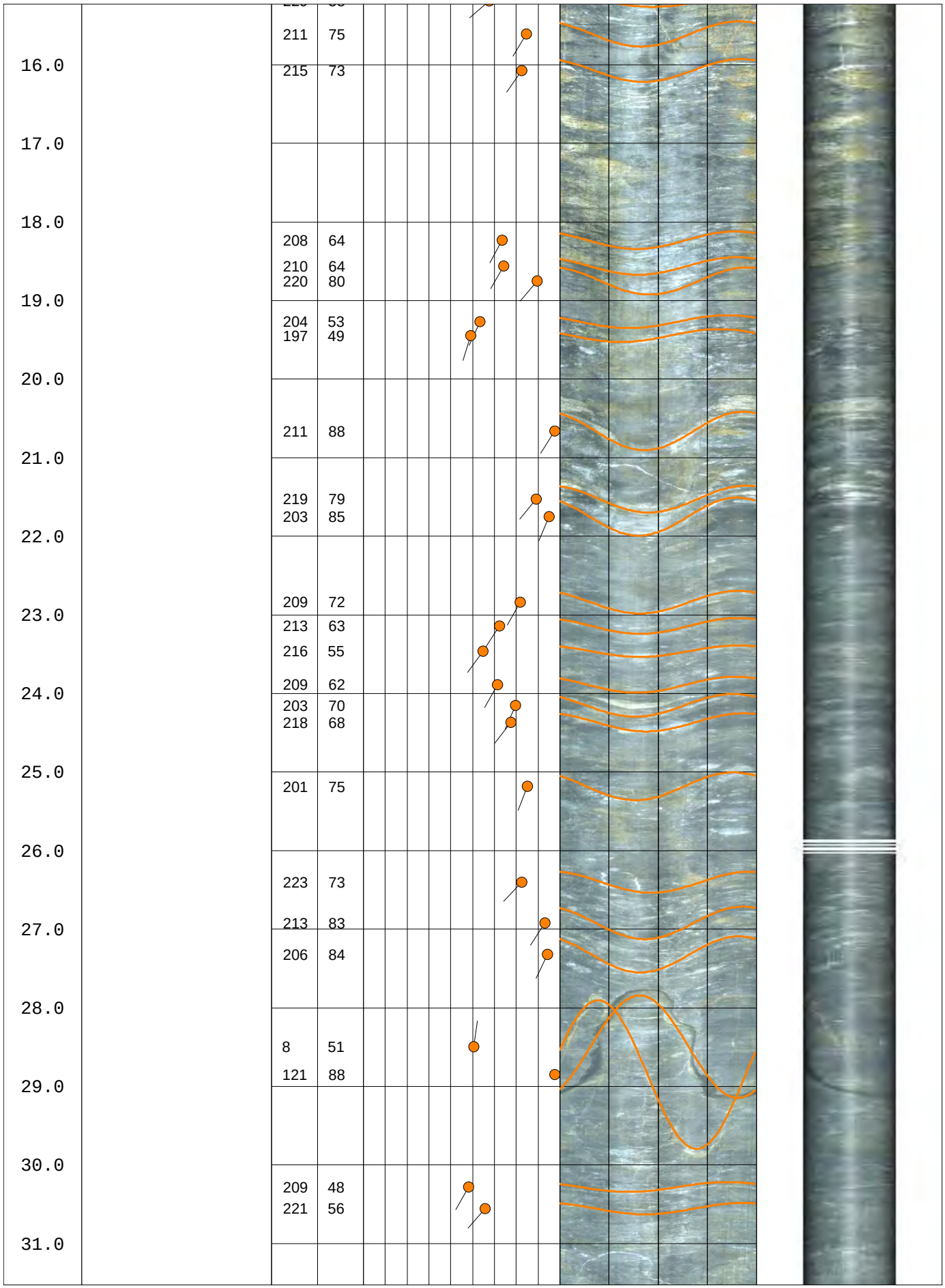
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company City and Borough of Sitka	
	Location: Sitka, AK	
	Project: Blue Lake Hydroelectric	
Date Logged:	October 2, 2009	Borehole ID: DH09-07
File Name:	DH09-07-1M.wcl	Logged By: Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from high side.

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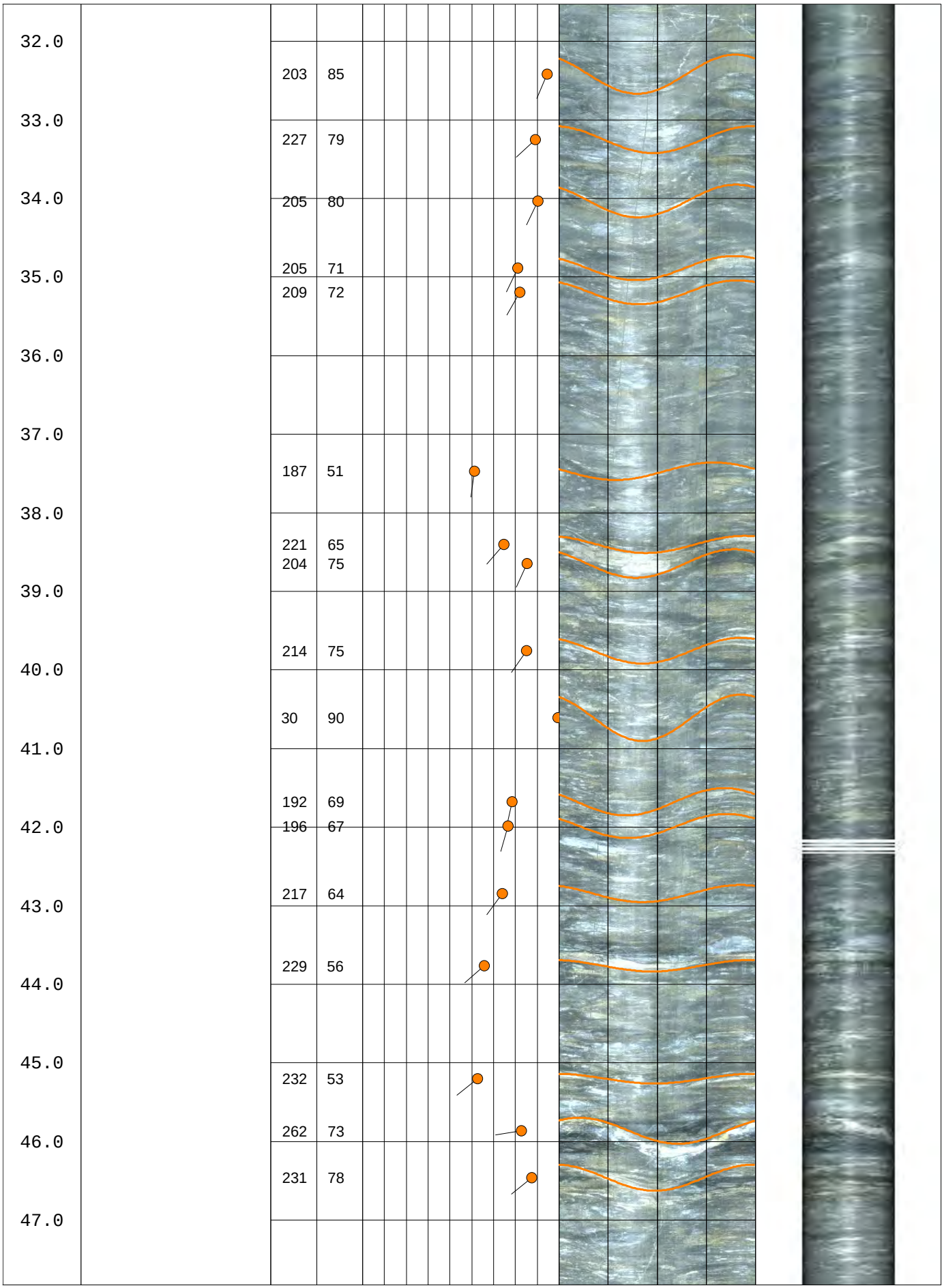
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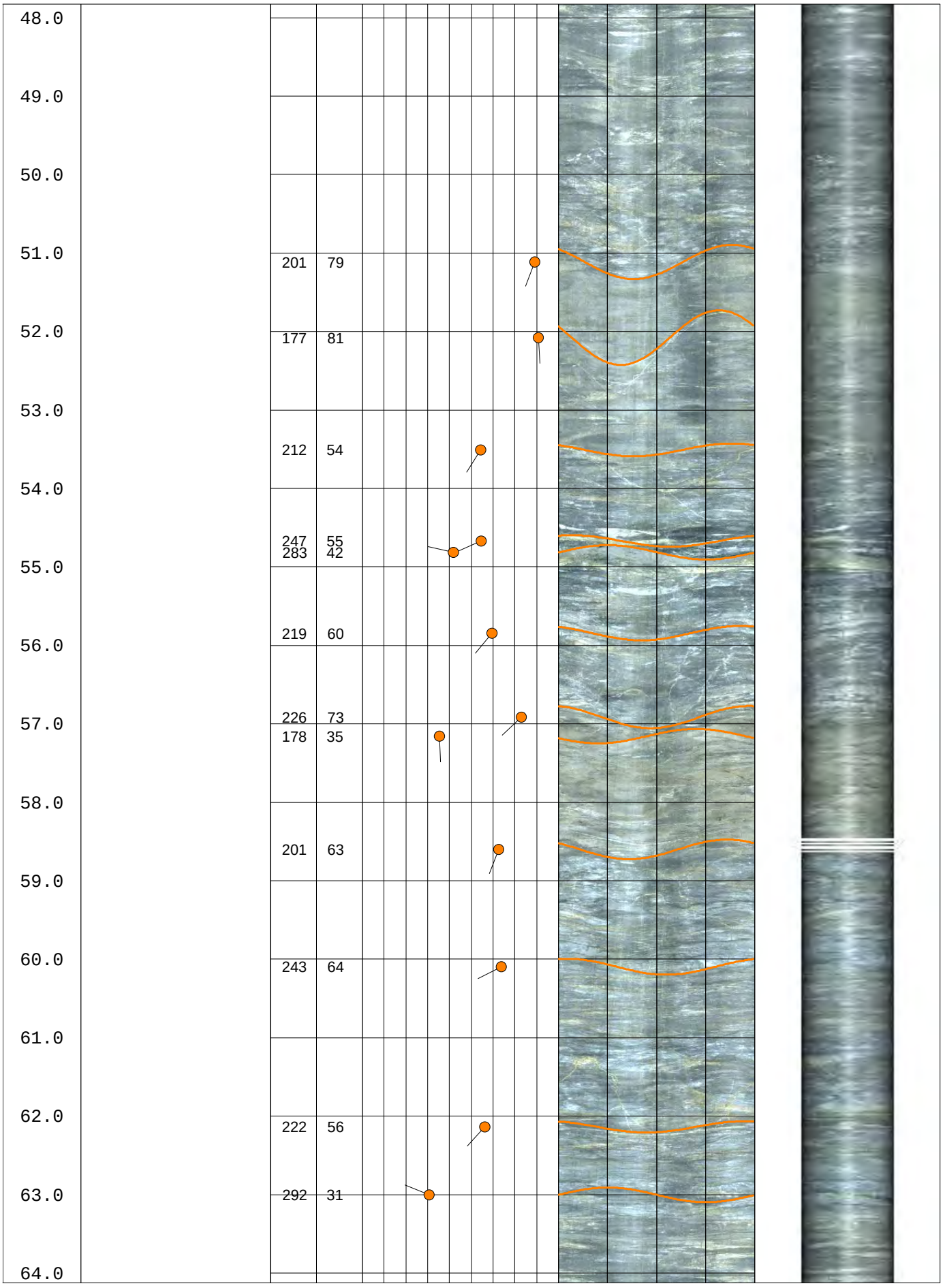
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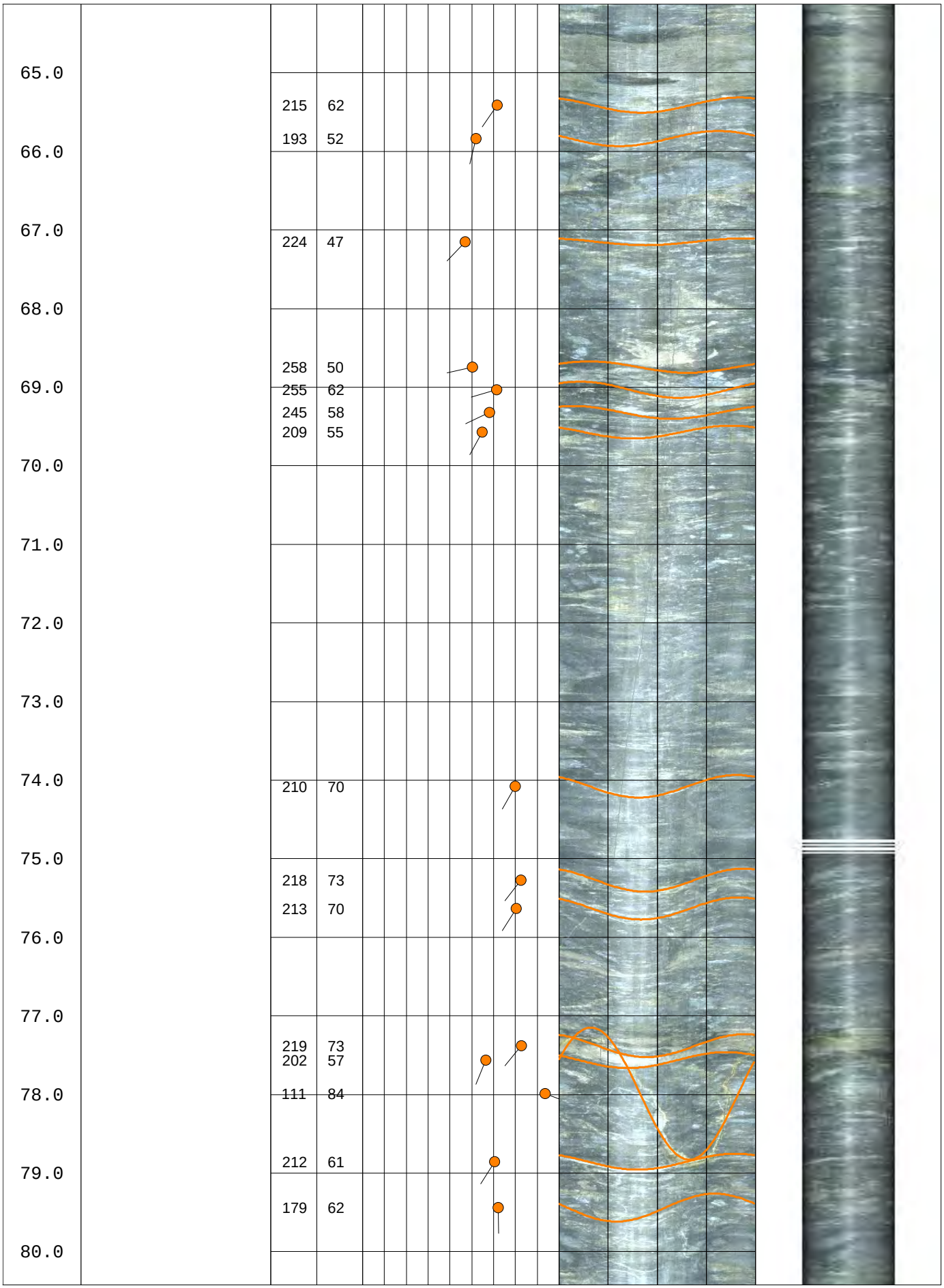
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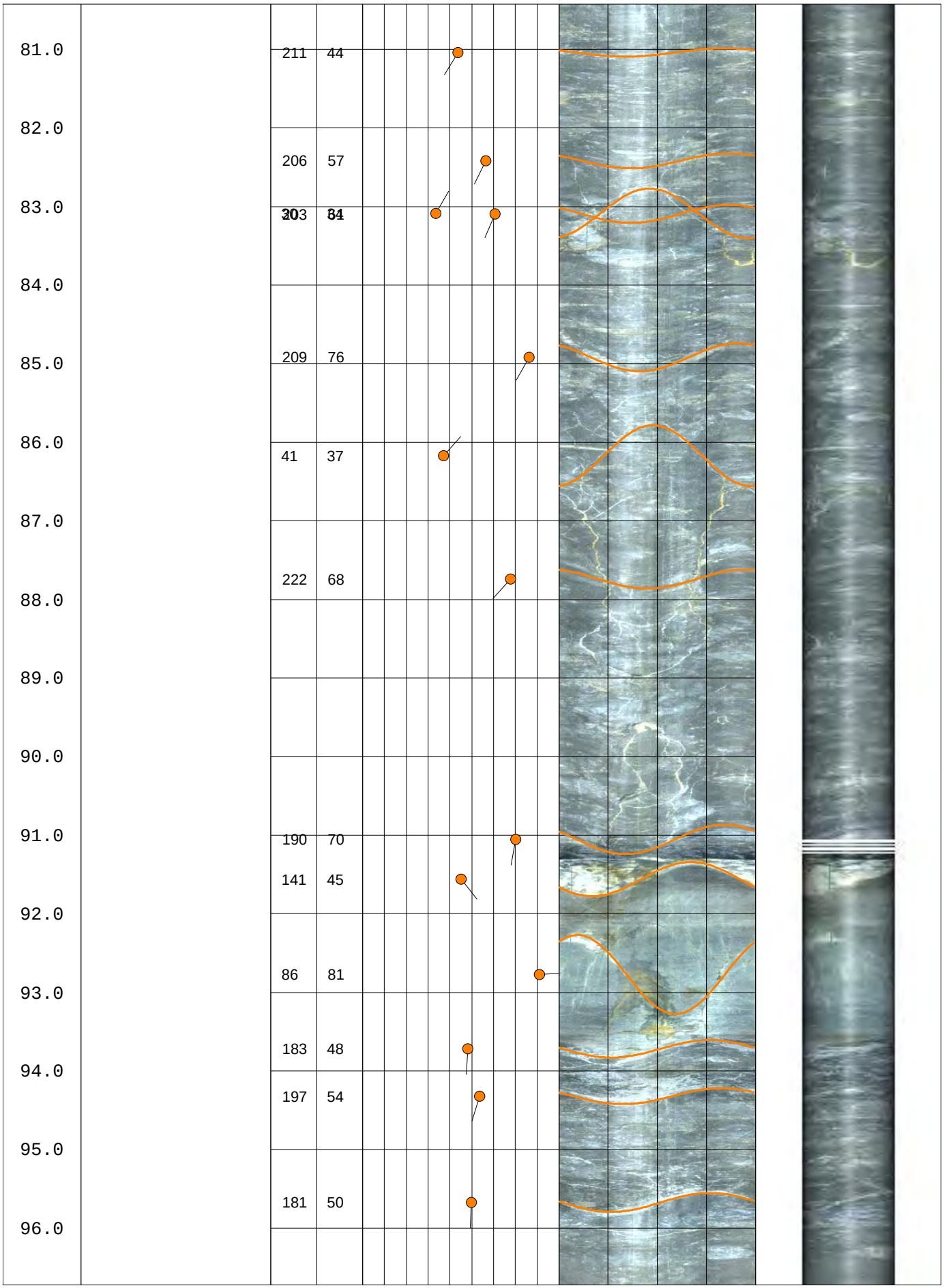
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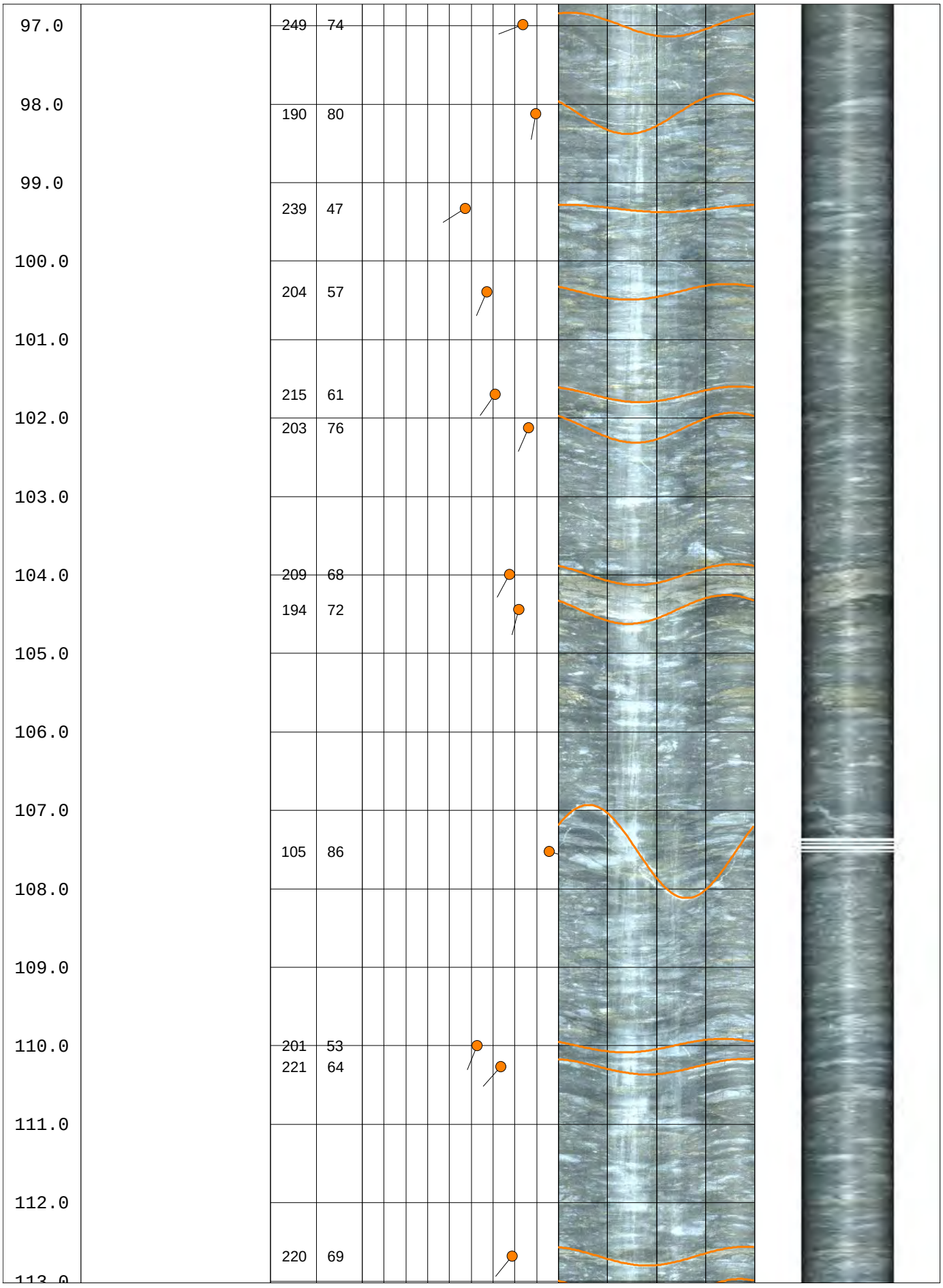
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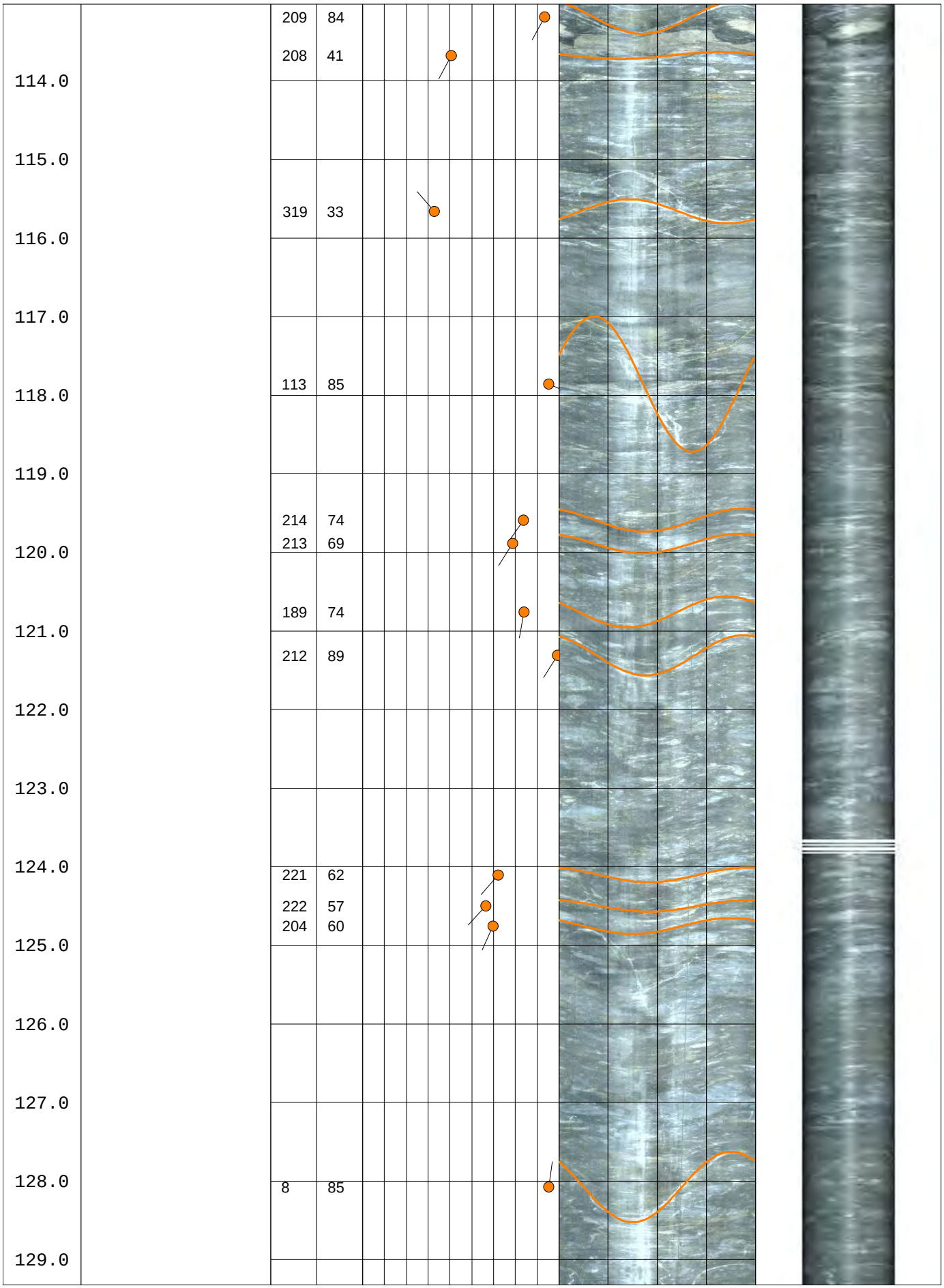
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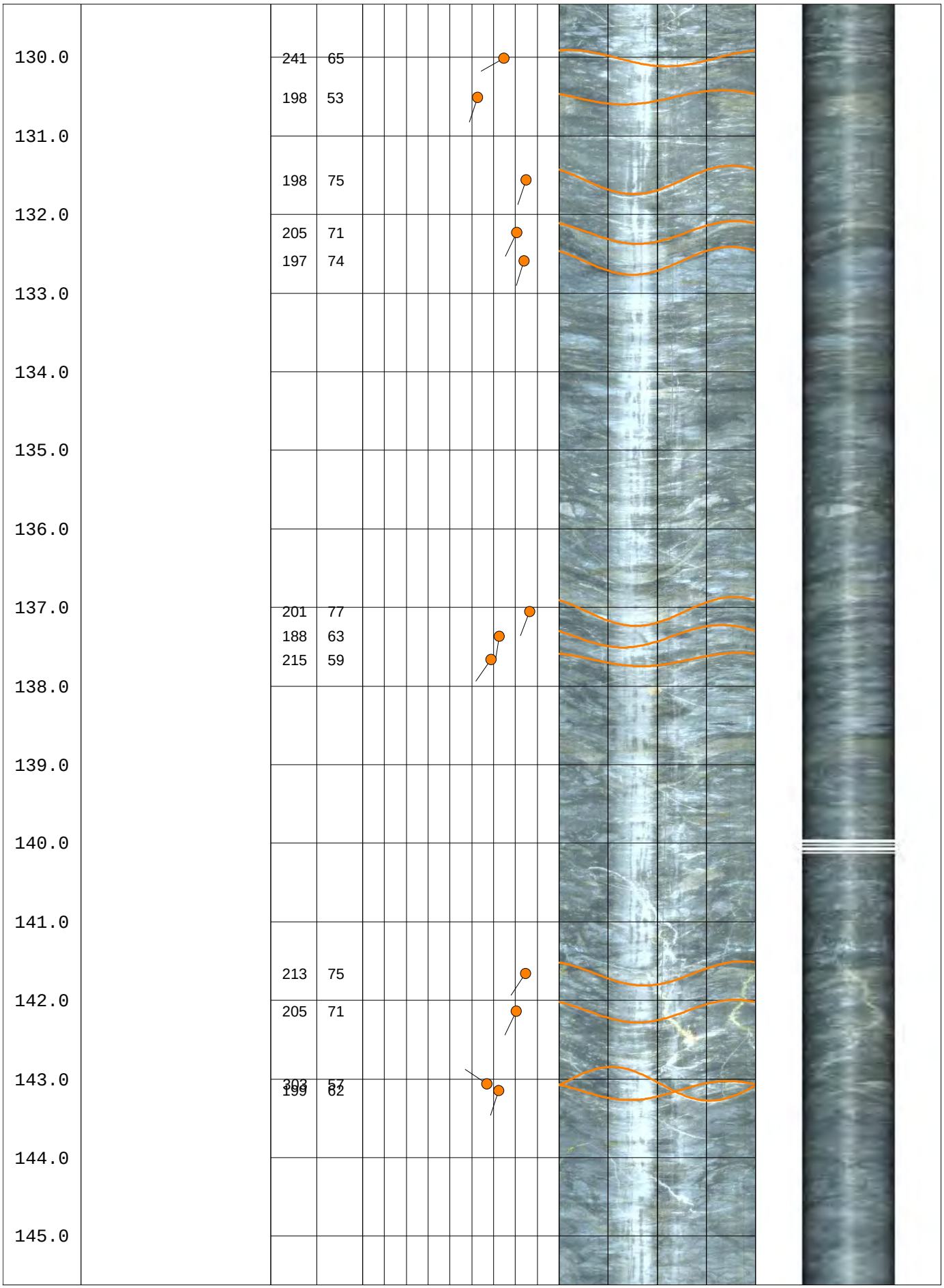
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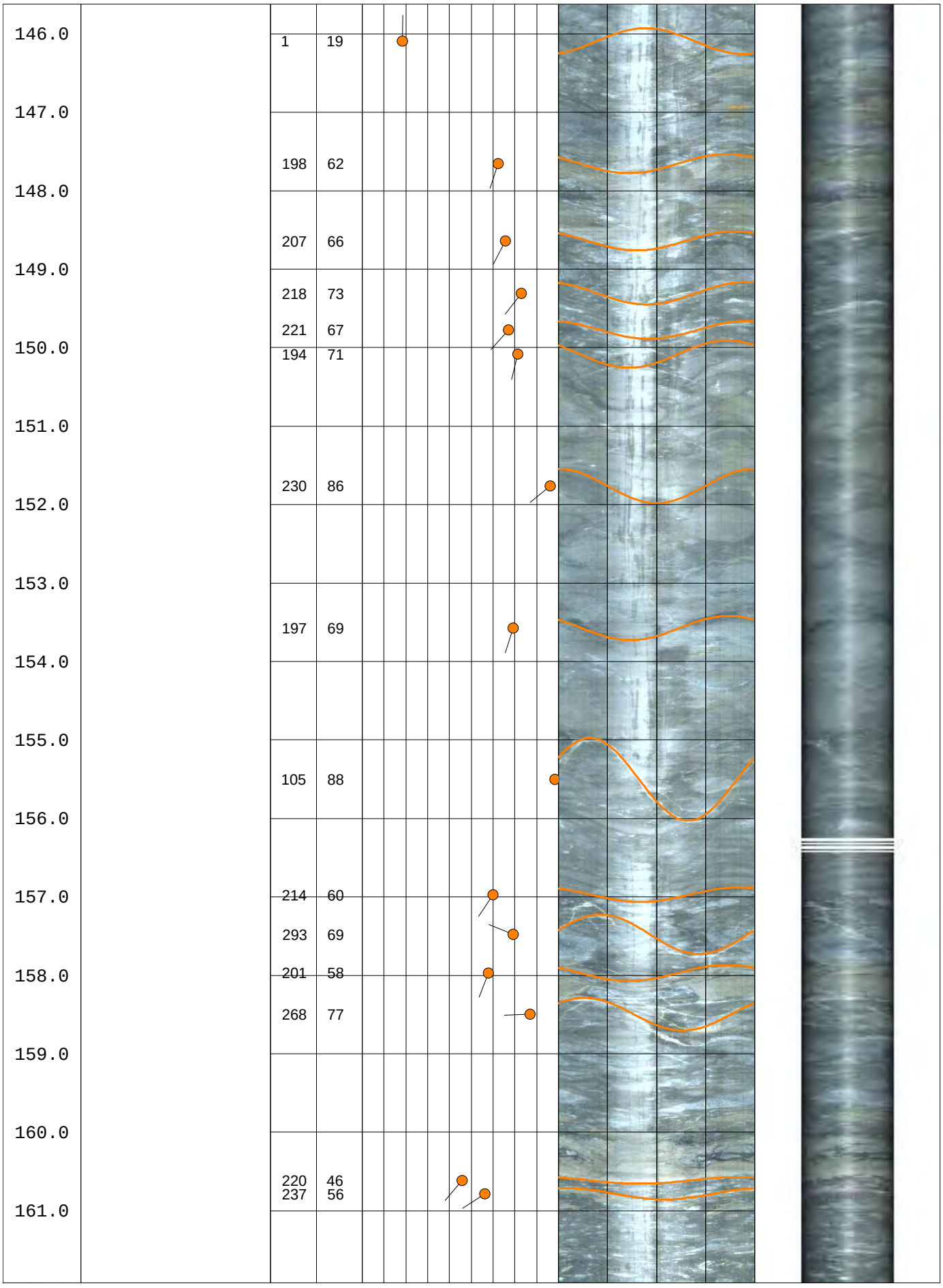
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161.0
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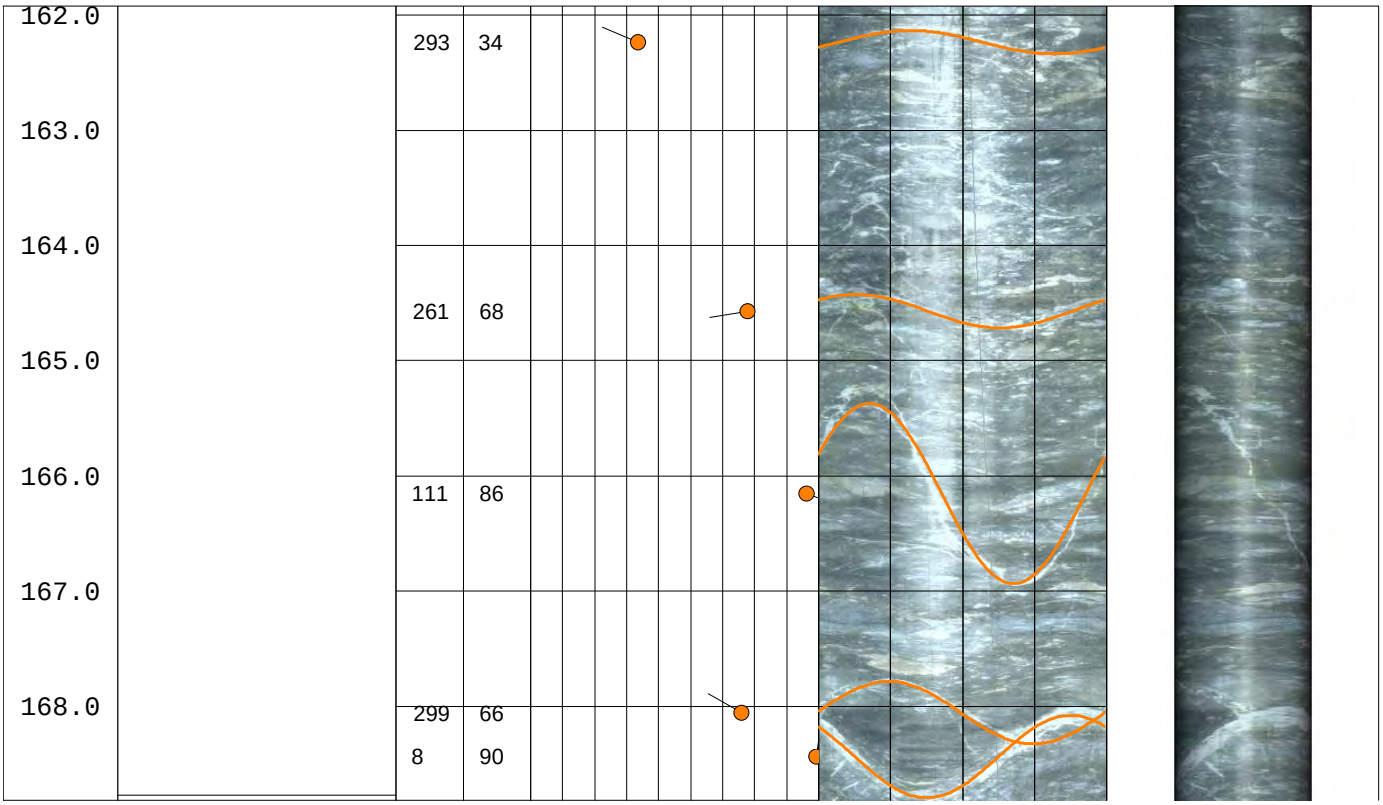
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168.0
293
34
261
68
111
86
299
66
8
90

Borehole DH09-08

Working Together SAFELY

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BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-08***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 5

SITE: Base of Dam, Upstream of Plunge Pool

COORDINATES: 1912949.55 N, 2380724.88 E
DIP DIRECTION: N/A
DIP: 90
ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 155.2
END OF HOLE: 74.2

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 4500
METHOD SOIL: HWT Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT
CORE: HQ3

STARTED: 09/03/09
FINISHED: 09/05/09
INSPECTOR: P. Friz
LOGGED BY: P. Friz
REVIEWED: S. Perkins
DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN.) (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
155.2 0.0		0.0 - 21.2 ft: Alluvium/Colluvium 0.0 - 12.0 ft: Boulder						1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT (W_P) NATURAL MOISTURE CONTENT (W_N) LIQUID LIMIT (W_L)

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-08***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 5

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE REC'Y (in)	SAMPLE REC'Y (%)	SAMPLE BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN. (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
		12.2 - 16.3 ft Boulder 12.2 - 12.3 ft: SPT hit refusal (50 blows) after advancing 0.1 ft.	12.2 12.3	AS-1			50	13.0 14.0 15.0					
		16.3 ft - 18.3 ft: Cobbles recovered in core barrel 18.3 ft - 18.5 ft: No recovery 18.5 - 18.9 ft: Granitic and volcanic rock fragments 18.9 - 21.0 ft: No recovery 20.5 ft: Bottom of vibrating wire piezometer 21.0 - 21.2 ft: Mud recovered 21.0 - 21.2 ft: SPT hit refusal (50 blows)						16.0 17.0 18.0 19.0 20.0					
			21	AS-2			50	21.0					
		21.2 ft TOP OF BEDROCK see next sheet						22.0 23.0 24.0 25.0 26.0 27.0					

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

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Y - Core Box
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PLASTIC LIMIT (W_P) NATURAL MOISTURE CONTENT (W_N) LIQUID LIMIT (W_L)

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-08**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 5

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
134.0 21.2		21.0 - 81.0 ft: Metamorphosed Bedded to Fragmental Andesitic Siltstone Contains quartz veins up to 1/2 " wide, numerous carbonate-filled hairline fractures; conglomerate layers contain quartz clasts up to 1" in diameter. Very strong (estimated UCS of 100 - 250 MPa). 21.2 - 31.0 ft: Slightly weathered, can be broken along hairline fractures Pervasive carbonate hairline fractures from 21.0 - 26.0 ft; Average discontinuity spacing of 2.0 ft; Overall GSI = 60 - 65		For detailed information on each discontinuity, please see the discontinuity log. 21.2 ft - 22.2 ft: FRAGMENTED CORE ZONE 29.5 - 30.0 ft: FRAGMENTED CORE ZONE 30.3 - 30.6 ft: BROKEN CORE ZONE The following general discontinuity characteristics were noted for this hole: 81% of discontinuity surfaces are smooth, 16% are rough and 3% are slightly rough. 94% of discontinuity surfaces are planar, 3% are curved and 3% are irregular. 13% of discontinuity surfaces are hematite stained and 58% are slightly weathered.		11	94	62	22 23 24 25 26	20 40 60 80 0.1 1 10 100 No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						12	100	30	27 28 29 30				
						13	100	62	31 32 33 34 35				
						14	100	100	36 37 38 39 40				
						15	100	100	41				
						16	100	96	42 43 44 45 46				
						17	100	100	47 48 49 50 51				
									52				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-08**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 5

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						18	100	100	53–56				
						19	100	100	56–61				
				62.2 - 62.4 ft: FRAGMENTED CORE ZONE		20	100	96	61–66				
						21	100	100	66				
						22	100	100	66–71				
						23	100	100	71–76				
						24	96	96	76–81				
74.2 / 81		**END OF BOREHOLE**											

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

Project: **H-332360**

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-08

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 5

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at 9.8 ft below the hole collar (Elev. 144.7 ft) on September 5, 2009.
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-08
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Plunge Pool
Azimuth (Deg)	n/a
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
21.2	22.2			x	Fragmented zone																	
22.2					Joint	30					x			x			H	C/S	S		P	O
22.5					Joint	30					x			x				C/S	S		P	O
22.8					Joint	30					x			x			B	C/S	S			
23.0					Joint	60					x			x			H		S			
23.4					Joint	30					x			x			H		S			
23.8					Drill Break																	
23.9					Drill Break																	
24.1					Drill Break																	
24.4					Drill Break																	
24.5					Drill Break																	
24.7					Drill Break																	
24.7	24.9		x		Broken zone																	
24.9					Drill Break																	
25.3					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-08
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Plunge Pool
Azimuth (Deg): n/a
Inclination (Deg): 90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
25.7					Drill Break																	
26.0					Drill Break																	
26.5					Drill Break																	
27.1					Joint	45							x	x				C			P	O
27.4					Drill Break																	
27.5					Joint	25							x	x				C			P	O
28.3					Drill Break																	
28.6					Joint	40					x			x			B		S			O
28.9					Joint	60						x		x				C/S				O
29.1					Joint	15					x			x								O
29.5	30.0			x	Fragmented zone																	
30.0					Drill Break																	
30.3	30.6		x		Broken zone																	
31.0					Drill Break																	
32.7					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

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Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Plunge Pool
Azimuth (Deg): n/a
Inclination (Deg): 90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
33.3					Drill Break																
33.5					Joint	25					x			x				C				O
34.1					Drill Break																
34.1	36.0		x		Broken zone																
36.3					Drill Break																
37.3					Joint	70					x			x					S			
37.9					Joint	35					x			x					S			O
39.2					Drill Break																
39.4					Calcite Vein	40							x			x					P	
39.6					Drill Break																
40.6					Drill Break																
41.0					Drill Break																
41.2					Drill Break																
41.4					Drill Break																
41.8					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-08
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Plunge Pool
Azimuth (Deg) n/a
Inclination (Deg) 90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
41.9					Drill Break																
42.4					Joint	30					x			x					S			
42.4					Joint	70					x			x			H		S			
42.6					Joint	30					x			x				S	S			
43.4					Joint	70					x			x					S			
43.8					Drill Break																	
46.0					Drill Break																	
46.4					Joint	30					x			x								
48.3					Joint	65					x			x					S			
49.7					Drill Break																	
50.5					Joint	65					x			x					S			
51.0					Drill Break																	
51.4					Drill Break																	
52.4					Joint	45					x				x							
52.9					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Plunge Pool
Azimuth (Deg) n/a
Inclination (Deg) 90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
53.1					Drill Break																
53.2					Drill Break																
53.2					Joint	20					x			x							
54.5					Drill Break																
55.8					Drill Break																
56.0					Drill Break																
56.4					Drill Break																
57.3					Drill Break																
57.6					Hammer Break																
58.3					Hammer Break																
59.9					Drill Break																
60.2					Drill Break																
60.9					Drill Break																
61.0					Drill Break																
61.8					Joint	60					x			x					S			O

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Plunge Pool
Azimuth (Deg) n/a
Inclination (Deg) 90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
62.2					Drill Break																
62.2	62.4			x	Fragmented zone																
62.6					Drill Break																
63.3					Joint	10					x			x					S			
64.4					Joint	65					x			x					S			
64.9					Joint	60					x			x					S			
65.0					Drill Break																
66.4					Drill Break																
67.4					Joint	60					x			x							
70.3					Joint	20					x			x							
72.3					Joint	15							x	x							P	
76.0					Drill Break																
77.1					Drill Break																
77.7					Drill Break																
77.8					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-08
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Plunge Pool
Azimuth (Deg)	n/a
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
78.6					Drill Break																	
79.3					Drill Break																	
79.8					Quartz Vein	40							x	x				C			P	
80.3					Drill Break																	
80.7					Drill Break																	
80.8					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
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Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Borehole DH09-09

Working Together SAFELY

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BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-09***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 9

SITE: Intake Tunnel

COORDINATES: 1912811.78 N, 2379784.5 E
DIP DIRECTION: 095
DIP: 60

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 392.1
END OF HOLE: 175.6

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 4500
METHOD SOIL: Diamond Drill Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 10/01/09
FINISHED: 10/04/09
INSPECTOR: P. Nolan
LOGGED BY: M. Mammoliti
REVIEWED: P.Friz

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
392.1 / 0.0		0.0 - 3.7 ft: Overburden - not sampled Soil, small stones, organics						1.0 2.0 3.0					
								4.0	**3.7 ft TOP OF BEDROCK see next sheet**				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W_N — LIQUID LIMIT W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-09***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
388.9 3.7		3.7 - 93.9 ft: Metamorphosed Andesitic Siltstone Light/dark greenish grey, fine grained, massive, very strong (100 - 250 MPa), less prominent flow banding @ 45 deg to core axis with occasional small (0.25 - 0.50") rounded clasts; some calcite veinlets throughout and larger veins as noted, generally 20-45 deg to core axis. 3.7 - 20.8 ft: Highly fractured rock, moderately weathered. Average discontinuity spacing of 2.2 ft. ~50 g samples obtained for ARD COMP 6 @ depths of 12.3 ft, 26.7 ft, 39.4 ft, 52.9 ft, 72.8 ft and 83.6 ft. 3.70 - 15.0 ft: RMR = 41 - 56; GSI = 50 - 60 15.0 - 55.0 ft: RMR = 64 - 80; GSI = 55 - 60		For detailed data on each discontinuity, see the discontinuity log. 3.7 - 5.4 ft: FRAGMENTED ZONE 5.9 - 6.2 ft: FRAGMENTED ZONE 7.1 - 8.3 ft: FRAGMENTED ZONE 9.9 -10.8 ft: FRAGMENTED ZONE 12.1 - 12.8 ft: FRAGMENTED ZONE 20.1 - 23.6 ft: FRAGMENTED ZONE The following general discontinuity characteristic were noted for this hole: 58% of discontinuity surface are smooth, 32% are slightly rough and 10% are rough. 95% of discontinuity surface are planar and 5% are irregular. 58% of discontintuity surface have hematite staining, 67% are slightly weathered and 33% are moderately weathered. 26.6 - 28.6 ft: FRAGMENTED ZONE 37.8 - 38.2 ft: FRAGMENTED ZONE		1	92	0	4 5			
						2	98	36	6 7 8 9 10				
						3	94	40	11 12 13 14 15				
						4	100	98	16 17 18 19 20				
						5	98	28	21 22 23 24 25				
						6	100	60	26 27 28 29 30				
						7	100	88	31 32 33 34 35				
						8	100	88	36 37 38 39				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100; No take

PERMEABILITY (cm/sec): 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-09***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
				39.1 - 40.1 ft: FRAGMENTED ZONE					40				
									41				
									42				
				41.9 - 42.5 ft: FRAGMENTED ZONE		9	100	68	43				
									44				
									45				
									46				
						10	100	100	47				
									48				
									49				
									50				
									51				
						11	100	94	52				
									53				
									54				
		55.0 - 93.9 ft: RMR >80; GSI = 70 - 75							55				
									56				
		57.0 ft: 4 mm quartz vein 60 deg to core axis.				12	100	100	57				
									58				
									59				
									60				
									61				
						13	100	100	62				
									63				
									64				
									65				
									66				
						14	100	100	67				
									68				
									69				
									70				
									71				
									72				
		75.2 ft: 5 mm calcite vein 30 deg to core axis (COBL 83/121).				15	100	100	73				
									74				
									75				

SAMPLING METHOD

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K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-09***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%) 20 40 60 80	PERMEABILITY (lugeons) 0.1 1 10 100 / (cm/sec) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}	NOTES	PIEZOMETER INSTALLATION
310.8 / 93.9		93.9 - 109.1 ft: Metamorphosed Bedded to Fragmental Andesitic Siltstone 95.5 - 96.2 ft: Andesitic Dyke @ 45 deg to core axis Alteration due to intrusive dyke: dark grey, fine grained, strong (100 MPa), strong to turbulent flow banding @ 45 deg to core axis contains equant/elongate, sub-rounded to rounded clasts 0.25-1.0" are oriented with flow bands, larger clasts appear stretched. Discontinuities are widely spaced (>5 ft); RMR = 74 to 83; GSI = 70 - 75.		96.6 ft: FRAGMENTED ZONE		16	100	100	76 77 78 79 80				
						17	100	100	80 81 82 83 84 85				
						18	100	100	85 86 87 88 89 90				
						19	100	100	90 91 92 93 94 95				
						20	100	78	95 96 97 98 99 100				
						21	100	100	100 101 102 103 104 105				
						22	100	100	105 106 107 108 109 110				
297.6 / 109.1									110 111				

SAMPLING METHOD

A - Split Tube
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C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

Project: **H-332360**

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-09***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%) 20 40 60 80	PERMEABILITY (lugeons) 0.1 1 10 100 / (cm/sec) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}	NOTES	PIEZOMETER INSTALLATION
		~50 g sample obtained for ARD COMP 6 @ depth of 94.0 ft .				23	100	100	112				
		101.8 ft: 15mm quartz vein 60 deg to core axis.							113				
									114				
									115				
		109.1 - 180.7 ft: Metamorphosed Andesitic Siltstone				24	100	100	116				
									117				
		Discontinuities are widely spaced (>10 ft); RMR >80; GSI = 70 - 75.							118				
									119				
									120				
		~50 g samples obtained for ARD COMP 6 @ depths of 121.1 ft, 134.2 ft, 145.4 ft, 151.9 ft, 169.4 ft and 176.6 ft.				25	100	100	121				
									122				
									123				
									124				
		118.0 - 118.6 ft: Sample R9-PL = 122 MPa							125				
									126				
		118.6 - 119.3 ft: Sample R9-UCS = 77.5 MPa				26	100	100	127				
									128				
									129				
		121.5 ft: 25 mm calcite vein 30 deg to core axis							130				
									131				
		125.4 ft - 5 mm calcite vein 45 deg to core axis				27	100	100	132				
									133				
									134				
									135				
									136				
						28	100	100	137				
									138				
									139				
									140				
		141.9 ft - 15 mm quartz vein 25 deg to core axis							141				
									142				
						29	100	100	143				
									144				
									145				
									146				
									147				
						30	100	100					

SAMPLING METHOD

A - Split Tube
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D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-09***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
									148				
									149				
									150				
						31	100	100	151				
									152				
									153				
									154				
									155				
						32	100	100	156				
									157				
									158				
									159				
									160				
						33	100	100	161				
									162				
									163				
									164				
									165				
		168.2 ft - 5 mm calcite vein 50 deg to core axis				34	100	100	166				
		168.7 ft - 10 mm calcite vein 30 deg to core axis							167				
									168				
									169				
									170				
						35	100	100	171				
									172				
									173				
									174				
									175				
		176.6 ft: ARD COMP 6 sample taken, ~50 g				36	100	100	176				
		178.6 ft - 15 mm quartz vein 70 deg to core axis							177				
									178				
									179				
									180				
235.6 / 180.7									181				
									182				
						37	100	100	183				
		180.7 - 250 ft:											

SAMPLING METHOD

A - Split Tube
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D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-09***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 7 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		Metamorphosed Bedded to Fragmental Andesitic Siltstone Dark grey, fine grained, very strong (100 - 250 MPa), turbulent flow banding @ 45 deg to core axis contains equant/elongate, sub-rounded to rounded clasts 0.25-1.0" and some 1-3" angular lithic fragments are oriented with flow bands, larger clasts appear stretched; some calcite veinlets throughout; Iron staining on joint surfaces; Average discontinuity spacing of 6.0 ft; RMR = 70 to over 80; GSI = 70 - 80. ~50 g pieces core collected for sample ARD COMP 6 @ depths of 193.1 ft, 208.7 ft, 216.3 ft, 227.7 ft. and 249.6 ft. 208.0 ft: 4 mm quartz vein 15 deg to core axis.				38	100	100	184 185 186 187 188 189	20 40 60 80	0.1 1 10 100 No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
					39	100	100	190 191 192 193 194				
					40	100	100	195 196 197 198 199				
					41	100	100	200 201 202 203 204				
					42	100	100	205 206 207 208 209				
					43	100	100	210 211 212 213 214				
					44	100	100	215 216 217 218 219				

SAMPLING METHOD

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G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

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O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** ***DH09-09***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 8 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						45	100	100	220–225	20 40 60 80	0.1 1 10 100 / No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						46	100	94	225–230				
						47	100	100	230–235				
						48	100	100	235–240				
						49	100	100	240–245				
						50	100	100	245–250				
175.6 / 250.0		**END OF BOREHOLE**											

SAMPLING METHOD

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F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

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Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-09

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 9 **OF:** 9

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level was measured at 4.59 ft below the hole collar, however due to the low permeability of the rock encountered in this borehole, this level should not be considered accurate.
7 RMR (Rock Mass Rating) estimation based on visual assessments of exposed outcrops, drill core and laboratory test results on rock and core samples in the vicinity of the intake tunnel, north portal of the lower tunnel and surge chamber as outlined in Bieniawski (1989).
8 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
9 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-09
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Tunnel
Azimuth (Deg)	105
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
3.7	5.4			x	Fragmented Zone																
5.9	6.2			x	Fragmented Zone																
6.5					Joint	45					x			x			H		S			
7.1	8.3			x	Fragmented Zone																
8.6					Joint	85							x	x			H		S			O
8.8					Joint	60							x	x			H		S			O
9.6					Joint	40							x	x			H		M			O
9.9					Joint	40							x	x			H		M			O
9.9	10.8			x	Fragmented Zone																
10.8					Joint	45					x			x			H		M			O
11.1					Joint	40					x			x			H		M			O
11.4					Joint	45					x			x			H		M			O
11.6					Joint	30					x			x			H		S			
12.1	12.8			x	Fragmented Zone																
12.8					Joint	30					x			x			H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-09
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
13.4					Joint	80					x			x			H		S			
13.7					Joint	55					x			x			H		S			O
14.0					Drill Break																	
16.2					Drill Break																	
16.7					Drill Break																	
17.8					Joint	10					x					x	H		S			
18.1					Joint	75					x			x			H		S			
18.2					Joint	65					x			x			H		S			O
19.1					Drill Break																	
19.8					Joint	45					x					x	H		S			
20.1	23.6			x	Fragmented Zone																	
26.6	28.6			x	Fragmented Zone																	
27.6	28.6				Longitudinal Joint	5					x			x			H	C/S	M			O
29.0					Joint	20					x			x			H	Cl	M	x		O
29.5					Joint	20					x			x			H	Cl	M	x		H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-09
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
29.7					Drill Break																	
29.9					Joint	30						x		x			H		S			
30.5					Joint	30						x		x			H		S			
30.8					Joint	30						x		x			H		M			H
31.3					Drill Break																	
31.9					Joint	85						x		x			H		M			O
32.2					Joint	45						x		x			H		S			
33.3					Joint	60						x				x	H		S			
33.6					Drill Break																	
34.0					Drill Break																	
35.0					Drill Break																	
35.3					Drill Break																	
35.5					Drill Break																	
36.4					Drill Break																	
36.6					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
36.8					Drill Break																
37.2					Joint	35						x		x			H		S			
37.6					Drill Break																
37.8	38.2			x	Fragmented Zone																
38.2					Joint	45					x			x			H		S			
38.3					Joint	45					x			x			H		S			
38.4					Joint	45					x			x			H		S			
38.6					Drill Break																
39.1	40.1			x	Fragmented Zone																
40.4					Drill Break																
41.0					Drill Break																
41.9					Drill Break																
41.9	42.5			x	Fragmented Zone																
43.4					Vein (no break)	30															
43.6					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-09
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
44.1					Drill Break																
44.3					Joint	30						x		x			H		S			
44.5					Calcite Vein	30						x		x			H	C	M		P	
45.9					Drill Break																	
47.3					Drill Break																	
48.6					Drill Break																	
48.7					Drill Break																	
50.6					Drill Break																	
51.0					Drill Break																	
52.7					Joint	80					x			x				Cl	M	x		O
53.0					Joint	35					x			x				Cl	M	x		H
53.7					Drill Break																	
56.0					Drill Break																	
57.0					Vein (no break)	60																
58.6					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Tunnel
Azimuth (Deg) 105
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
58.8					Drill Break																	
59.5					Drill Break																	
60.1					Drill Break																	
61.7					Drill Break																	
62.4					Drill Break																	
63.1					Drill Break																	
63.8					Drill Break																	
65.1					Drill Break																	
67.7					Drill Break																	
68.6					Drill Break																	
68.8					Drill Break																	
69.1					Vein (no break)		34	005														
70.0					Drill Break																	
71.6					Bedding (no break)		10	025														
72.3					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
73.5					Bedding (no break)		77	336														
73.8					Drill Break																	
75.2					Vein (no break)		83	121														
75.7					Drill Break																	
76.8					Bedding (no break)		76	236														
77.2					Drill Break																	
77.7					Drill Break																	
77.8					Drill Break																	
78.1					Drill Break																	
78.8					Drill Break																	
80.4					Drill Break																	
81.2					Hammer Break																	
81.3					Hammer Break																	
81.5					Hammer Break																	
81.9					Hammer Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
83.2					Drill Break																	
83.7					Drill Break																	
84.7					Hammer Break																	
85.9					Drill Break																	
87.8					Drill Break																	
88.4					Hammer Break																	
88.9					Bedding (Drill Break)		61	221														
89.6					Bedding (no break)		70	222														
90.5					Drill Break																	
91.1					Bedding (no break)		36	252														
91.5					Hammer Break																	
91.8					Bedding (no break)		35	210														
92.8					Drill Break																	
93.5					Drill Break																	
93.7					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
93.9					Drill Break																	
94.1					Drill Break																	
94.5					Bedding (no break)		80	200														
94.7					Hammer Break																	
95.0					Hammer Break																	
95.2					Drill Break																	
95.5					Top of Dyke (Drill Break)																	
95.7					Bedding (no break)		55	216														
96.2					Bottom of Dyke (Drill Break)																	
96.3					Bedding (no break)		52	235														
96.6					Drill Break																	
96.6	97.7			x	Fragmented Zone																	
96.8	97.7				Joint	20					x			x					S			H
97.0					Vein (no break)		19	355														
97.1					Vein (no break)		88	212														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
97.2					Drill Break																	
97.5					Vein (no break)		89	032														
97.7					Drill Break																	
98.0					Drill Break																	
98.4					Drill Break																	
98.9					Drill Break																	
99.2					Drill Break																	
99.8					Drill Break																	
100.2					Vein (no break)		89	024														
101.8					Vein (no break)		25	342														
101.8					Quartz Vein	60	90	032				x		x				C	S		P	
104.1					Drill Break																	
104.5					Bedding (no break)		79	222														
105.0					Hammer Break																	
105.6					Bedding (no break)		73	147														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
105.8					Drill Break																	
107.3					Drill Break																	
107.5					Bedding (no break)		76	214														
108.5					Drill Break																	
109.3					Drill Break																	
109.8					Bedding (no break)		70	213														
111.0					Drill Break																	
111.4					Drill Break																	
111.8					Drill Break																	
111.9					Bedding (no break)		49	200														
112.1					Vein (no break)		41	102														
112.3					Hammer Break																	
112.6					Hammer Break																	
113.3					Drill Break																	
114.0					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Tunnel
Azimuth (Deg) 105
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
114.3					Drill Break																	
114.6					Drill Break																	
115.5					Hammer Break																	
115.8					Calcite Vein (Drill Break)	30					x			x								
116.2					Vein (no break)		58	018														
117.3					Drill Break																	
117.9					Calcite Vein (Drill Break)	35					x			x								
118.2					Vein (no break)		46	020														
118.4					Drill Break																	
119.3					Drill Break																	
120.6					Bedding (no break)		56	197														
121.1					Drill Break																	
121.5					Vein (no break)	30	89	140														
122.4					Hammer Break																	
123.0					Hammer Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
123.9					Drill Break																	
124.3					Drill Break																	
124.7					Drill Break																	
125.4					Vein (no break)	45	33	008														
125.6					Hammer Break																	
126.6					Hammer Break																	
126.8					Drill Break																	
128.2					Bedding (no break)		76	244														
128.9					Bedding (Drill Break)		66	248														
129.4					Drill Break																	
129.6					Vein (no break)		89	344														
130.3					Hammer Break																	
130.9					Drill Break																	
132.4					Drill Break																	
133.9					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
134.1					Calcite Vein (Drill Break)	50	62	238			x			x								
134.4					Drill Break																	
134.6					Drill Break																	
134.8					Drill Break																	
135.1					Bedding (no break)		59	239														
136.1					Drill Break																	
137.3					Calcite Vein (Hammer Break)	45	65	350			x			x								
137.9					Drill Break																	
138.5					Bedding (no break)		42	228														
139.1					Drill Break																	
139.3					Drill Break																	
139.4					Vein (no break)		20	342														
139.8					Drill Break																	
140.0					Bedding (no break)		51	255														
140.7					Calcite Vein (Drill Break)	40					x			x								

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
141.0					Bedding (no break)		55	248														
141.9					Vein (no break)	25	87	148														
142.9					Bedding (Drill Break)																	
143.5					Vein (no break)		86	059														
143.9					Bedding (no break)		77	246														
144.5					Drill Break																	
144.8					Bedding (no break)		55	230														
145.7					Bedding (Drill Break)																	
146.9					Bedding (Drill Break)																	
147.9					Bedding (Hammerl Break)																	
148.2					Bedding (Hammerl Break)																	
148.5					Bedding (Drill Break)																	
149.5					Bedding (Drill Break)		59	216														
150.2					Bedding (Drill Break)		64	225														
151.1					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
151.6					Hammer Break																	
151.8					Hammer Break																	
152.3					Hammer Break																	
153.5					Drill Break																	
154.5					Drill Break																	
155.1					Drill Break																	
155.4					Hammer Break																	
155.6					Bedding (no break)		63	255														
156.3					Hammer Break																	
157.1					Bedding (Drill Break)		51	282														
158.4					Bedding (Drill Break)		36	253														
158.6					Bedding (Hammer Break)		56	204														
158.8					Hammer Break																	
159.4					Drill Break																	
160.4					Vein (no break)		63	023														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
161.2					Calcite Vein (Drill Break)		87	032														
161.7					Drill Break																	
161.8					Hammer Break																	
162.3					Calcite Vein (Hammer Break)	40	70	333			x			x								
162.5					Calcite Vein (Hammer Break)	30	73	329			x			x								
162.9					Vein (no break)		86	290														
164.2					Drill Break																	
164.5					Drill Break																	
165.0					Hammer Break																	
165.7					Hammer Break																	
166.0					Calcite Vein (Hammer Break)	45					x			x								
166.3					Calcite Vein (Hammer Break)	75					x			x								
167.3					Bedding (Drill Break)		60	243														
168.2					Vein (no break)	50	28	023														
168.7					Vein (no break)	30	87	327														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
169.5					Drill Break																	
169.6					Drill Break																	
170.2					Drill Break																	
172.3					Hammer Break																	
173.1					Hammer Break																	
174.3					Bedding (Hammer Break)		81	237														
174.6					Hammer Break																	
174.7					Drill Break																	
175.3					Bedding (no break)		78	240														
175.9					Drill Break																	
176.8					Bedding (Drill Break)		57	238														
177.4					Bedding (no break)		69	229														
178.6					Vein (no break)	70	18	334														
179.2					Drill Break																	
179.5					Bedding (Hammer Break)		39	230														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
179.8					Drill Break																	
180.0					Bedding (no break)		39	229														
180.3					Bedding (Drill Break)		52	232														
180.6					Drill Break																	
180.8					Drill Break																	
181.2					Bedding (no break)		80	229														
181.7					Bedding (no break)		67	233														
181.9					Drill Break																	
182.2					Drill Break																	
182.4					Bedding (no break)		59	234														
182.7					Bedding (Drill Break)		66	237														
183.0					Drill Break																	
183.3					Bedding (Drill Break)		60	209														
183.7					Bedding (no break)		53	228														
184.1					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
184.4					Drill Break																	
184.8					Drill Break																	
185.7					Bedding (Drill Break)		80	215														
186.2					Bedding (no break)		70	219														
186.5					Quartz Vein	45	62	206					x	x			H		s			
187.2					Calcite Vein (Drill Break)		84	141														
187.6					Drill Break																	
188.5					Bedding (no break)		45	118														
188.8					Hammer Break																	
189.1					Hammer Break																	
189.3					Drill Break																	
189.8					Drill Break																	
191.4					Bedding (no break)		42	233														
191.5					Quartz Vein	45							x	x								
192.8					Bedding (Drill Break)		74	210														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Tunnel
Azimuth (Deg) 105
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
193.5					Bedding (no break)		70	204														
193.7					Bedding (Drill Break)		61	223														
194.0					Drill Break																	
194.8					Drill Break																	
195.5					Bedding (no break)		67	228														
196.4					Drill Break																	
196.7					Bedding (no break)		51	233														
197.5					Hammer Break																	
198.4					Hammer Break																	
199.8					Drill Break																	
200.1					Bedding (no break)		66	229														
200.3					Bedding (no break)		70	223														
201.3					Bedding (no break)		79	222														
201.7					Drill Break																	
202.1					Bedding (no break)		46	144														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
203.1					Hammer Break																	
203.4					Joint	25					x			x								
204.5					Bedding (no break)		75	219														
204.9					Drill Break																	
206.7					Drill Break																	
207.8					Hammer Break																	
208.0					Vein (no break)	15	78	133														
208.8					Drill Break																	
209.0					Hammer Break																	
209.7					Bedding (no break)		66	210														
210.0					Drill Break																	
212.2					Hammer Break																	
212.9					Bedding (no break)		53	218														
214.0					Drill Break																	
215.0					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
216.1					Joint	20	86	341				x		x								
216.3					Drill Break																	
217.1					Hammer Break																	
218.6					Bedding (Drill Break)		67	209														
220.0					Drill Break																	
220.7					Drill Break																	
221.8					Hammer Break																	
223.3					Hammer Break																	
224.1					Drill Break																	
225.0					Drill Break																	
225.9					Bedding (no break)		70	213														
226.7					Hammer Break																	
227.2					Calcite Vein		64	215														
227.6					Joint	30	55	212				x		x								
227.7					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
228.1					Drill Break																
229.5					Joint	30	60	221				x		x					S			
229.8					Joint	30						x		x					S			
230.0					Drill Break																	
230.6					Hammer Break																	
230.6	233.9				Longitudinal Joint	5					x			x								
231.3					Hammer Break																	
233.9					Joint	30						x		x								
235.0					Drill Break																	
236.1					Hammer Break																	
236.6					Bedding (no break)		72	222														
237.0					Vein	40					x			x				C				
237.9					Vein (no break)		12	344														
238.8					Joint	40						x		x				C	S			
239.2					Bedding (no break)		49	224														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Tunnel
Azimuth (Deg): 105
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
240.0					Drill Break																	
240.9					Hammer Break																	
241.0					Bedding (no break)		39	232														
241.6					Bedding (no break)		41	210														
242.4					Bedding (no break)		56	219														
242.6					Drill Break		67	228														
243.0					Bedding (no break)		54	210														
243.5					Bedding (no break)		63	203														
243.9					Bedding (no break)		70	215														
244.5					Bedding (no break)		64	224														
245.0					Drill Break																	
246.1					Bedding (no break)		60	211														
246.3					Drill Break																	
246.8					Bedding (no break)		80	205														
247.0					Joint	30						x		x			H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-09
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Tunnel
Azimuth (Deg) 105
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
247.7					Drill Break																	
248.0					Drill Break																	
248.4					Drill Break		76	203														
248.7					Drill Break																	
248.8					Joint	30						x		x								
250.0					End of BH																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

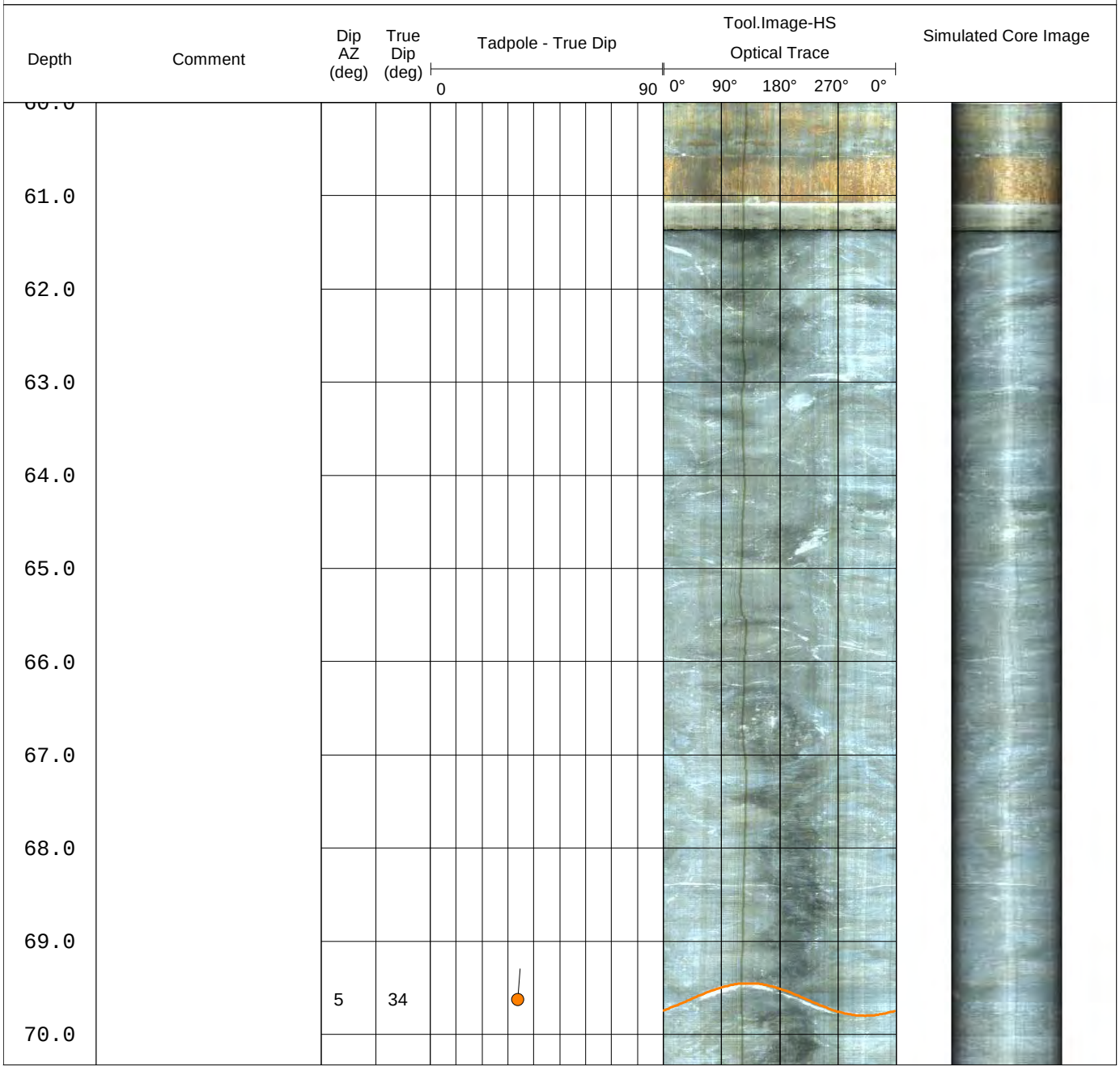
Aperture:O-Open; H-Hairline (<0.5mm)

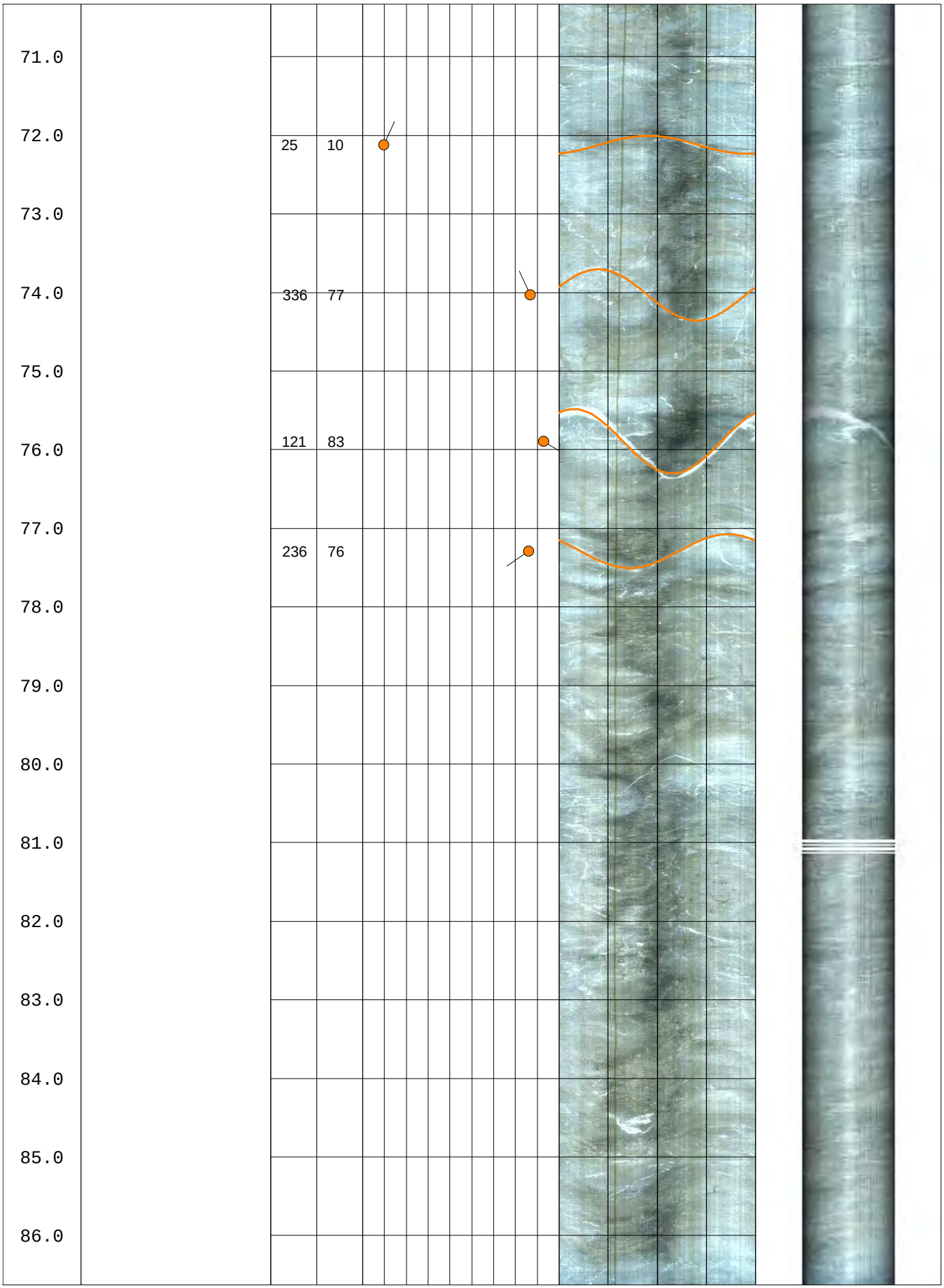
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company City and Borough of Sitka	
	Location: Sitka, AK	
	Project: Blue Lake Hydroelectric	
Date Logged:	Occtober 5, 2009	Borehole ID: DH09-09
File Name:	DH09-09-1M.wcl	Logged By: Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from high side.

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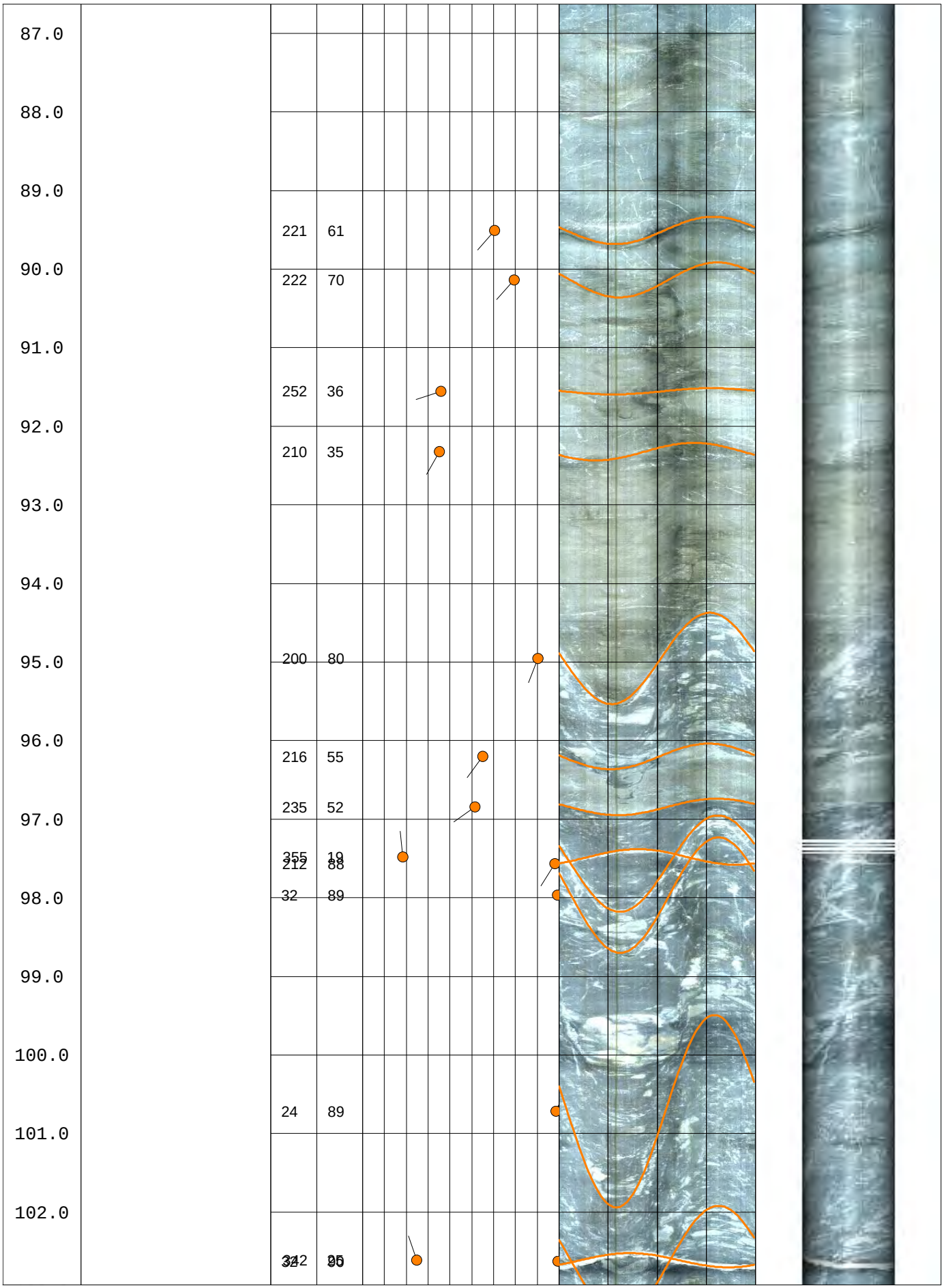
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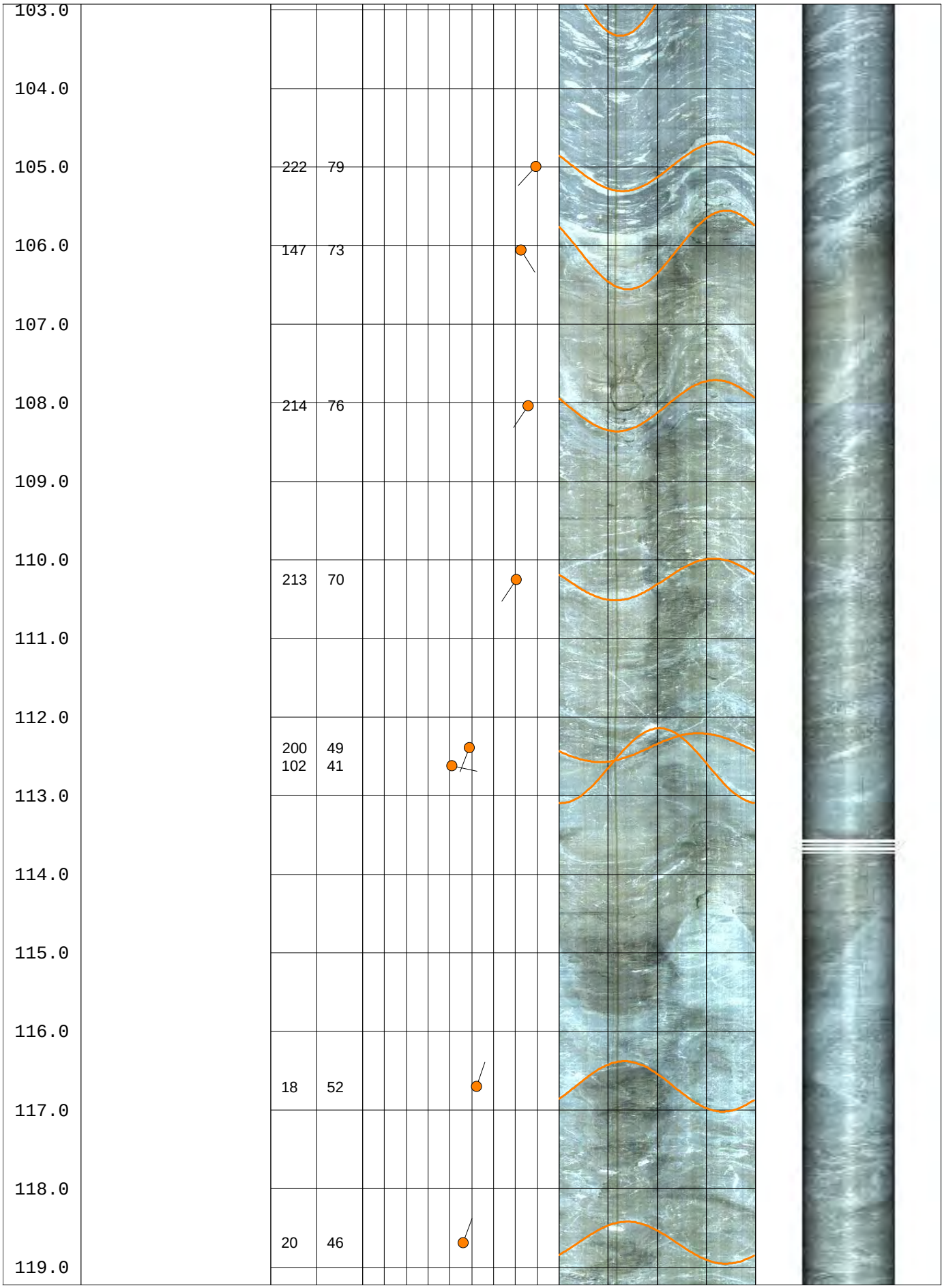
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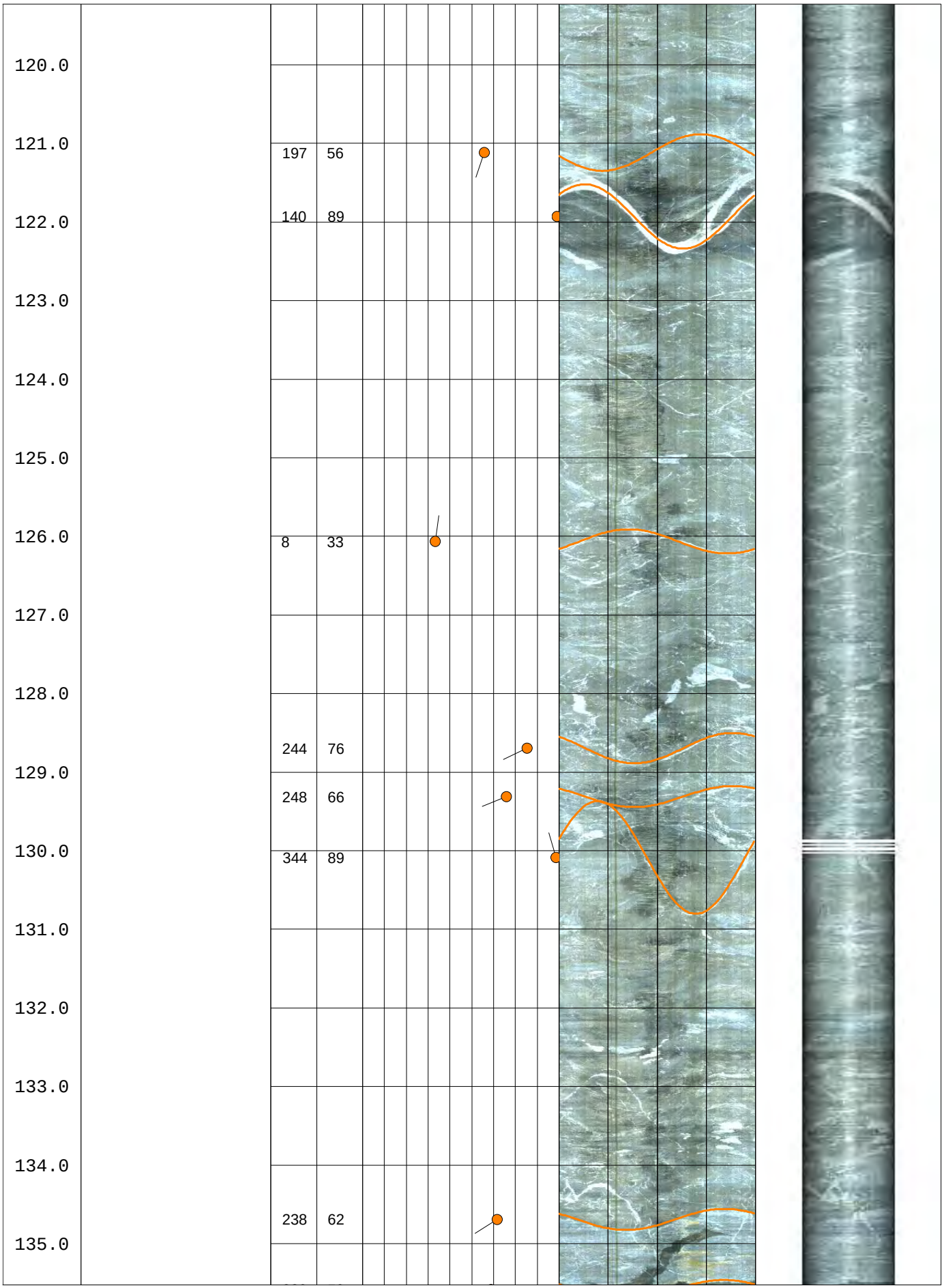
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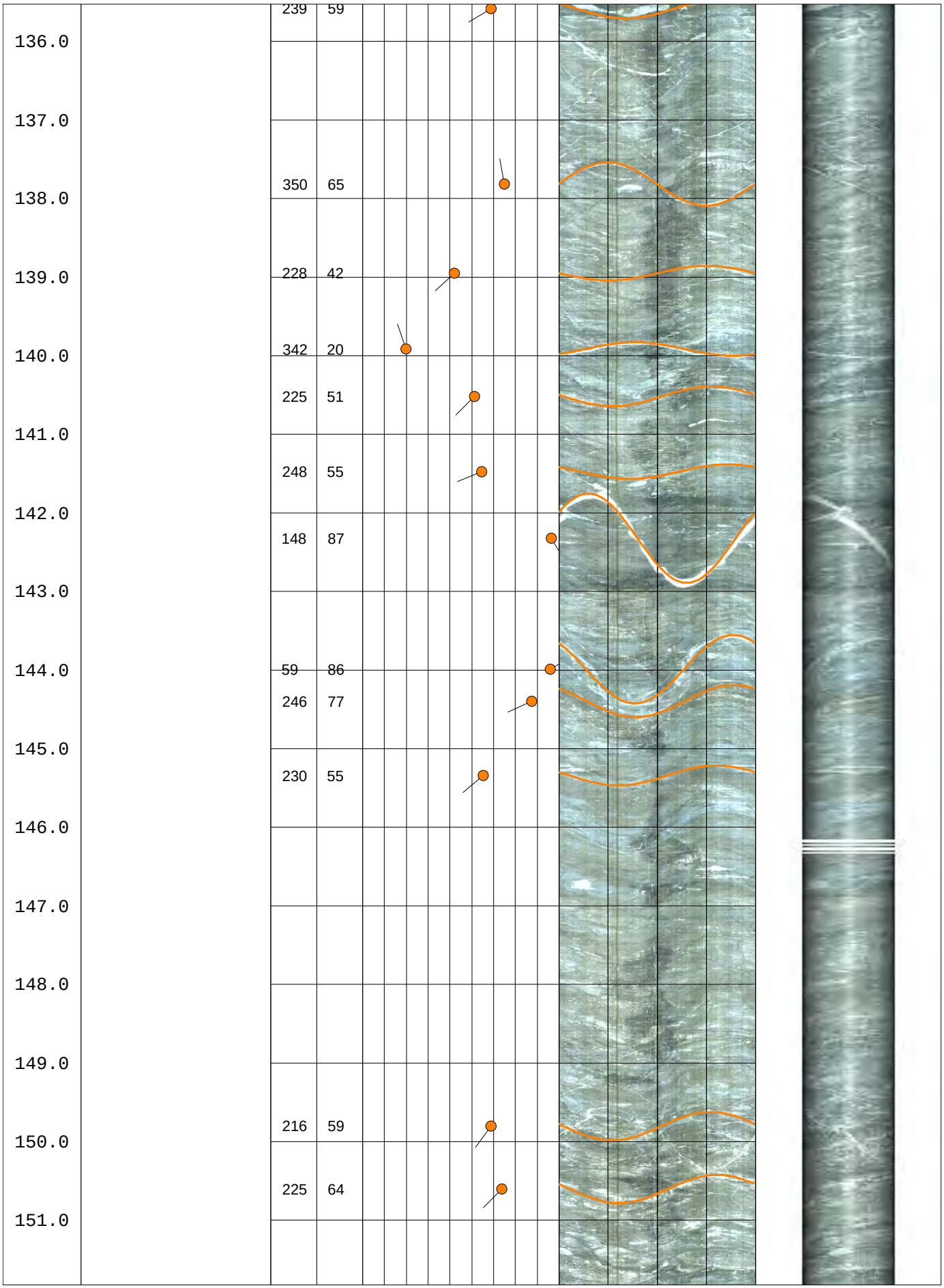
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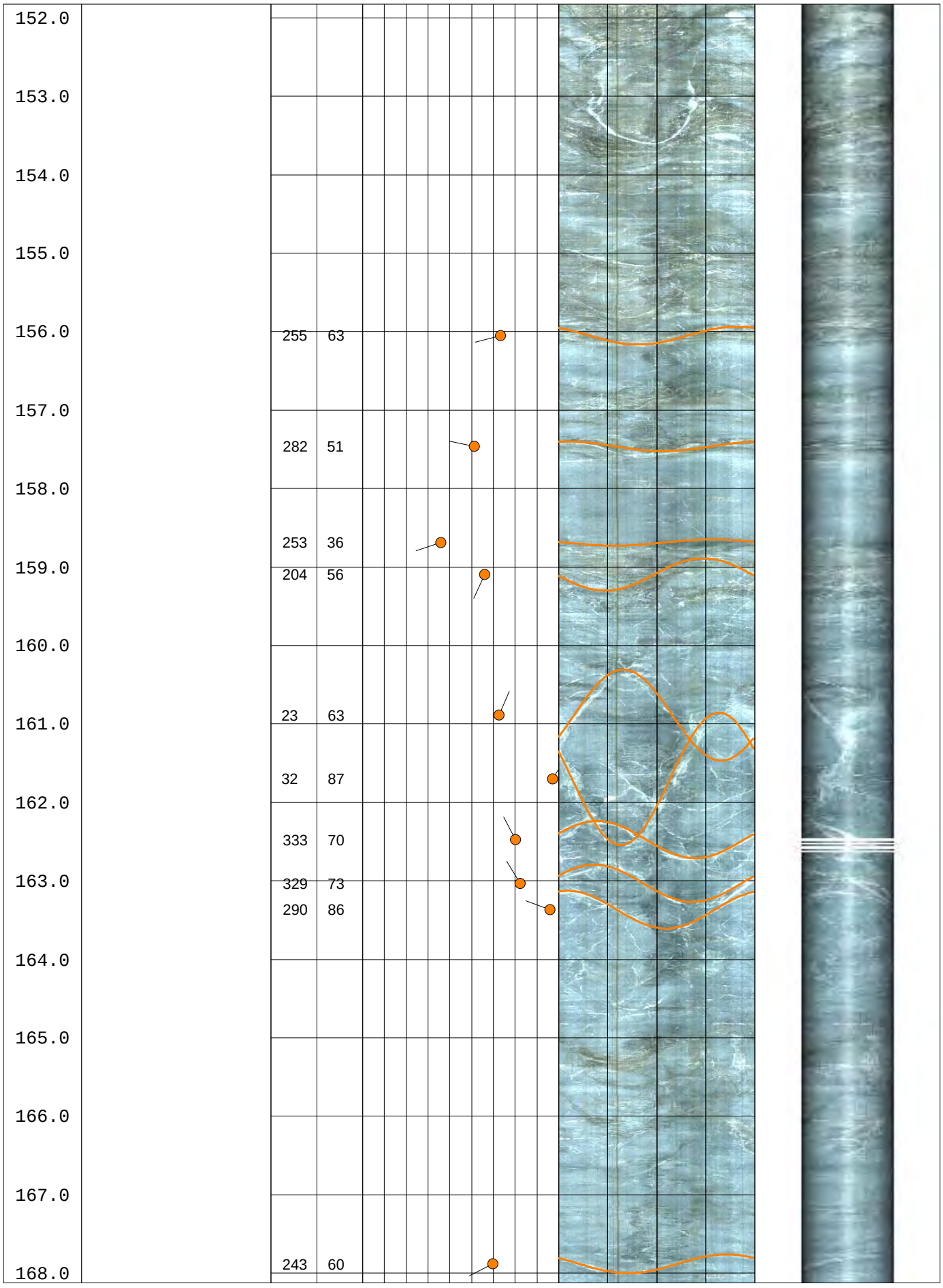
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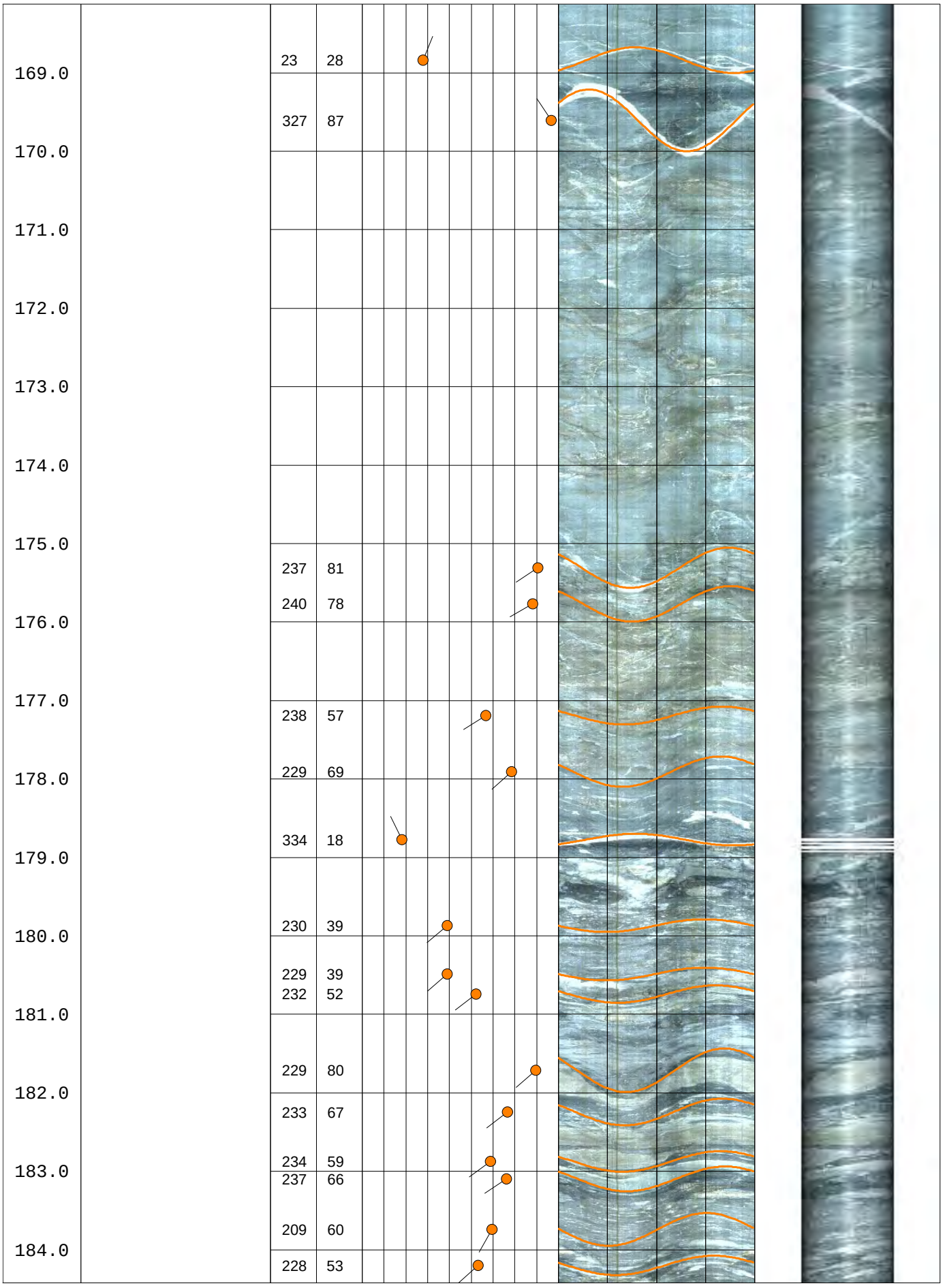
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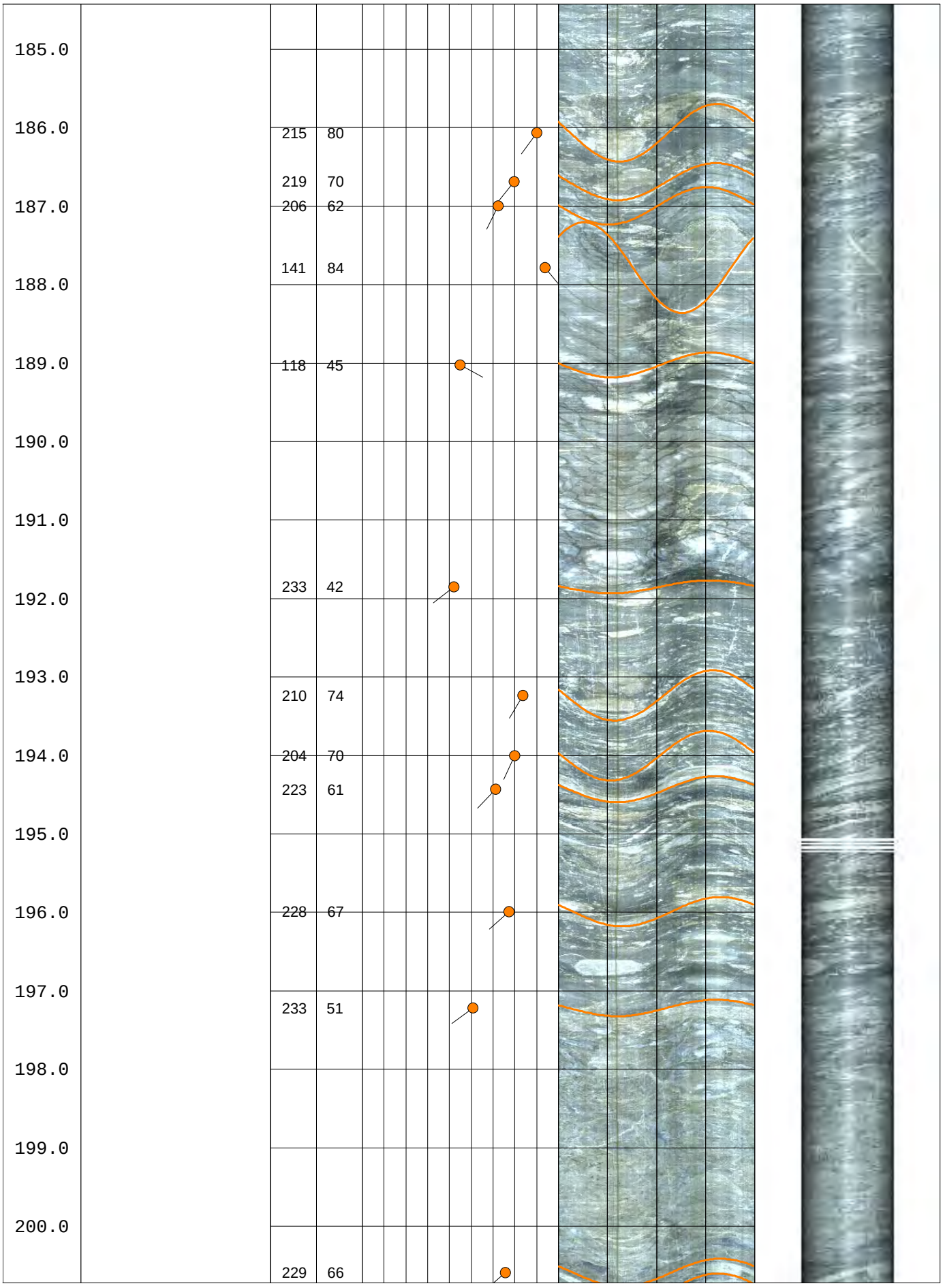
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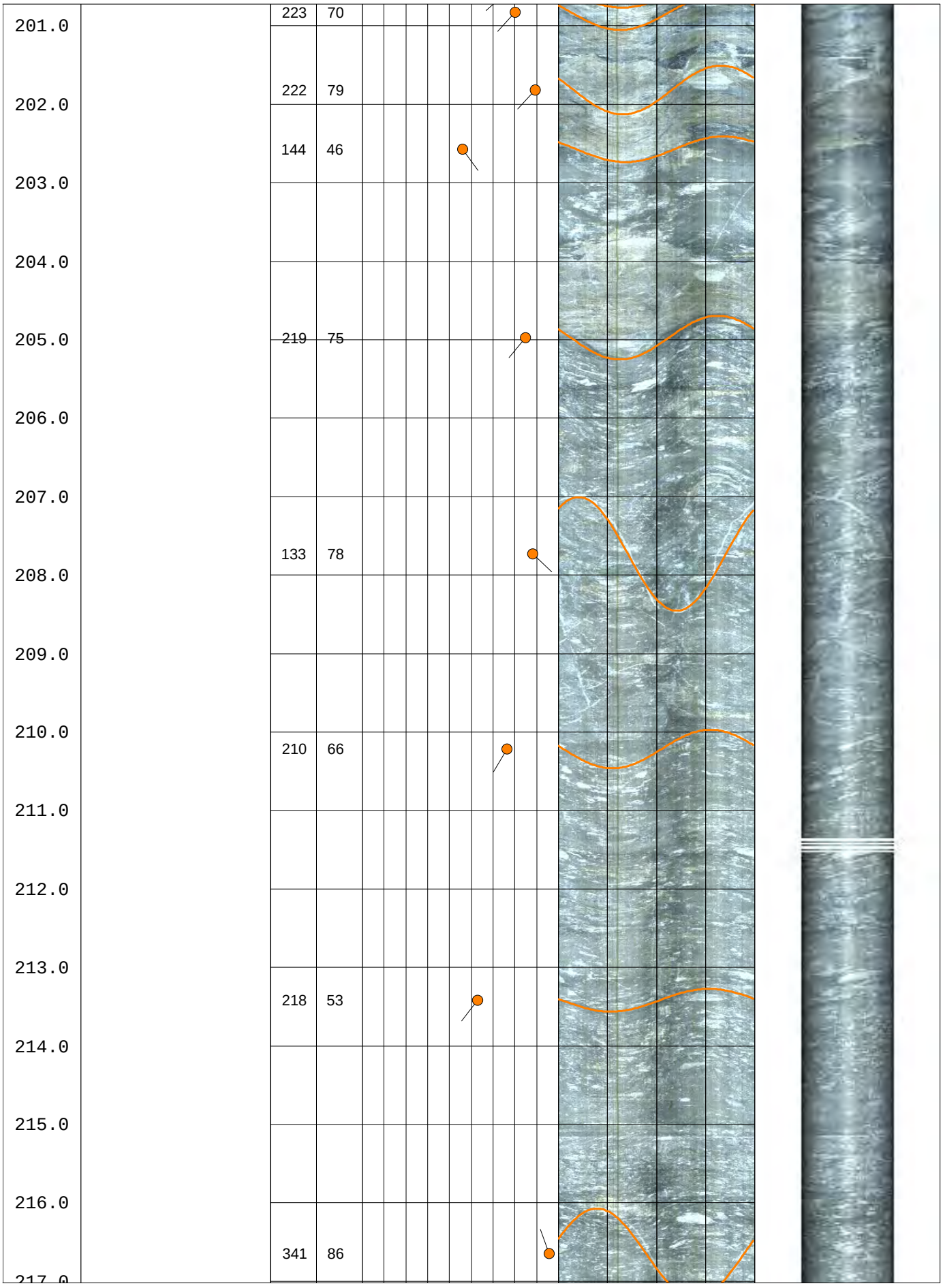
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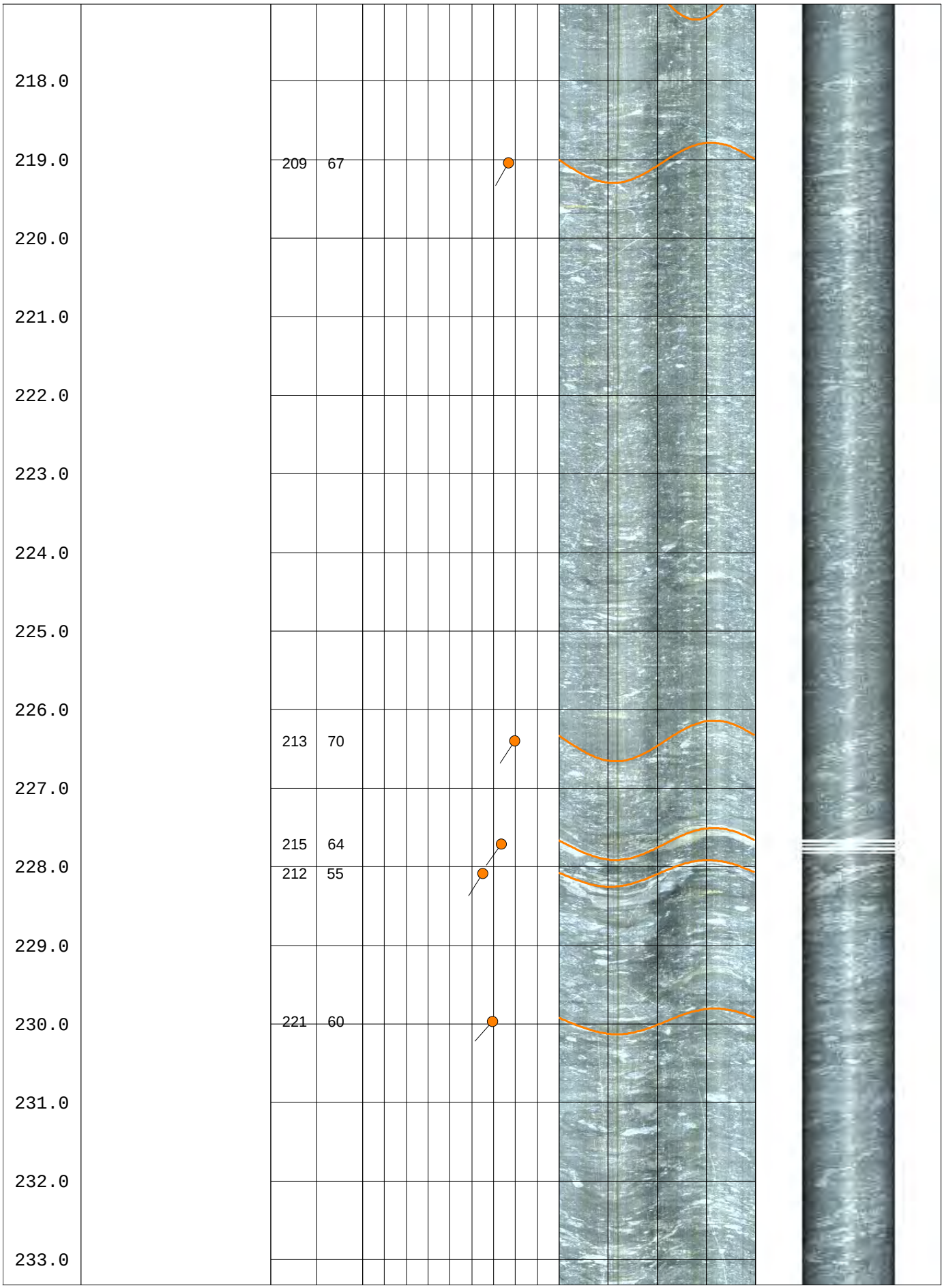
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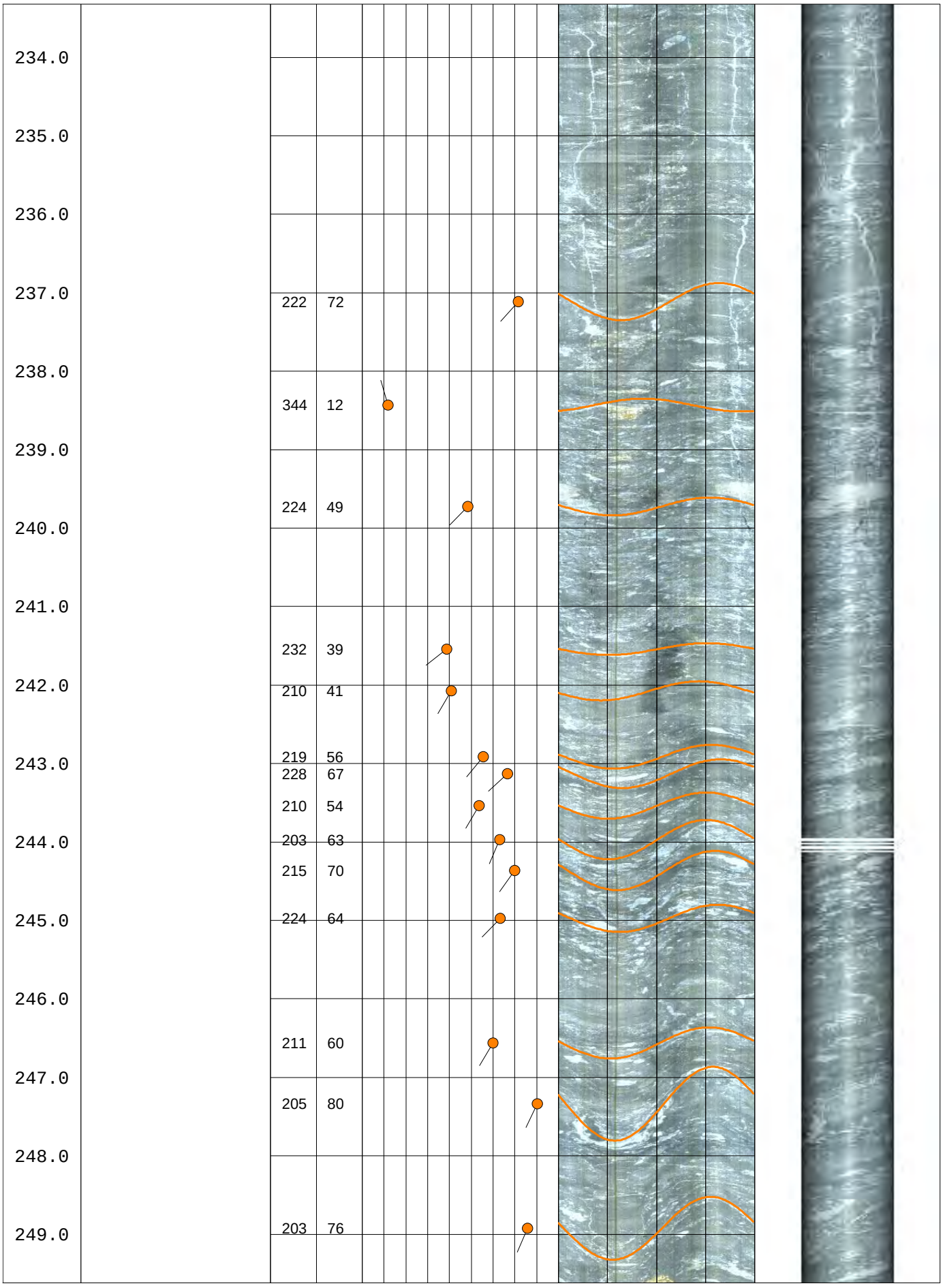
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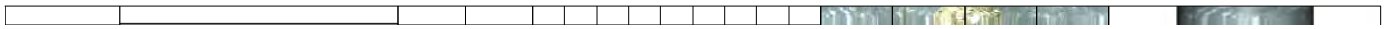
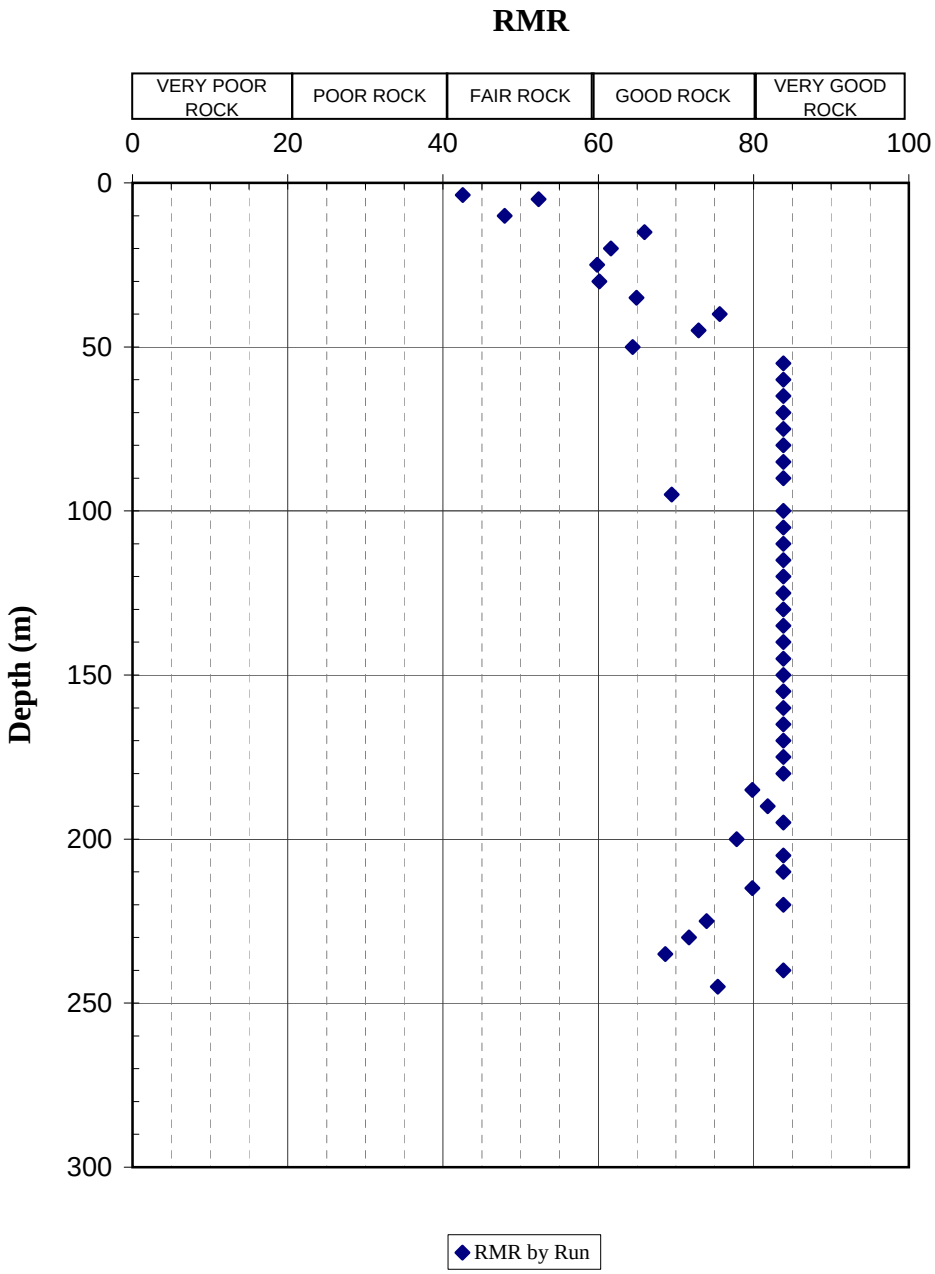


RMR vs Depth and Elevation DH09-09



Borehole DH09-10

Working Together SAFELY

© Hatch 2006/03 ⌘

BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-10***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 9

SITE: Intersection of gate shaft and existing tunnel

COORDINATES: 1913151.8 N, 2380543.8 E
DIP DIRECTION: 060
DIP: 60

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 421.5
END OF HOLE: 238.2

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 4500
METHOD SOIL: Diamond Drill Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 9/26/09
FINISHED: 9/29/09
INSPECTOR: M. Mammoliti
LOGGED BY: P. Nolan
REVIEWED: P. Friz

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) □ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN. (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) 10^{-6} 10^{-5} 10^{-4} / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
421.5													
0.0		0.0 - 0.5 ft: Overburden - Not sampled during drilling Roadfill											
		.5 ft TOP OF BEDROCK see next sheet						1.0					
								2.0					
								3.0					

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT | NATURAL MOISTURE CONTENT | LIQUID LIMIT
W_P W_N W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-10**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 9

ELEV. / DEPTH (ft)	DESCRIPTION	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
421.1 0.5	0.5 - 10.0 ft: Metamorphosed Andesitic Siltstone Fine grained, contains calcite veinlets, joint surfaces are hematite stained, very strong (100-250 MPa). 0.5 - 3.3 ft: No core recovery - casing installed 8.5 ft: ~30 g removed for sample ARD COMP 3. Average discontinuity spacing of 1.3 ft; RMR = 63 - 67; GSI = 60 - 65.	The following general discontinuity characteristic were noted for this hole: 6% of the discontinuities are slick, 85% are smooth, 9% are slightly rough. 92% of the discontinuities are planar, 30% are curved, 5% are irregular. 83% of the discontinuities have hematite staining, 86% are slightly weathered, and 2% are moderately weathered.		1	0	0	1 2 3	20 40 60 80	0.1 1 10 100 No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
412.8 10.0	10.0 - 23.0 ft: Metamorphosed Fragmental Andesitic Siltstone Clasts comprised primarily of quartz up to 1 in. dia. Average discontinuity spacing of 1.4 ft; RMR = 58 - 76; GSI = 60 - 65.	8.2 - 8.8 ft: FRAGMENTED ZONE		2	100	94	4 5 6				
				3	100	88	7 8 9 10 11				
				4	100	100	12 13 14 15 16				
				5	100	100	17 18 19 20 21				
401.6 23	23.0 - 32.0 ft: Fine grained metamorphosed andesitic siltstone, occasional clasts up to 1.5 in. dia. very strong (100-250 MPa). 28.1 ft: ~30 g removed for sample ARD Comp 3. Average discontinuity spacing of 1.8 ft; RMR = 69 - 76; GSI = 60 - 65.			6	100	100	22 23 24 25 26				
				7	100	100	27 28 29 30				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-10**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 9

ELEV. / DEPTH (ft)	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
393.8 / 32	32.0 - 49.5 ft: Metamorphosed Fragmental Andesitic Siltstone Clastic texture, carbonate veinlets, slightly weathered very strong (100-250 MPa), clasts up to 3 in. dia. very strong (100-250 MPa); Average discontinuity spacing of 1.1 ft; RMR = 62 - 66; GSI = 60 - 65.		36.0 - 36.3 ft: FRAGMENTED ZONE		8	100	90	32				
								33				
								34				
								35				
								36				
					9	100	100	37				
								38				
								39				
								40				
								41				
					10	100	98	42				
								43				
								44				
								45				
								46				
	47.6 ft: ~30 g removed for sample ARD Comp 3.											
378.6 / 49.5	49.5 - 60.0 ft: Fine grained metamorphosed andesitic siltstone Occasional clasts up to 1 in. dia. very strong (100-250 MPa); Average discontinuity spacing of 1.0 ft; RMR = 62 - 68; GSI = 60 - 65.		53.8 - 53.9 ft: FRAGMENTED ZONE		11	100	100	47				
								48				
								49				
								50				
								51				
					12	100	100	52				
								53				
								54				
								55				
								56				
					13	100	100	57				
								58				
								59				
369.5 / 60	60.0 - 211.7 ft: Fine-grained							60				
								61				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-10**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		metamorphosed andesitic siltstone Contains 6 in. wide coarse clastic bands; Average discontinuity spacing of 2.8 ft; RMR = 57 - 86; GSI = 70 - 80. ~30 g removed for ARD COMP 3 @ depths of 70.4 ft, 88.5 ft, 105.0 ft, 117.1 ft, 136.4 ft, 153.1 ft, 175.7 ft, 196.5 ft and 199.7 ft .		65.2 - 66.2 ft: FRAGMENTED ZONE		14	100	80	62 63 64 65 66				
						15	100	100	67 68 69 70 71				
						16	100	100	72 73 74 75 76				
						17	100	100	77 78 79 80 81				
						18	100	100	82 83 84 85 86				
						19	100	100	87 88 89 90 91				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-10**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						20	100	100	93–96				
						21	100	100	97–101				
						22	100	100	102–106				
						23	100	98	107–111				
						24	100	100	112–116				
						25	100	100	117–121				
									122				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-10**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						26	100	100	123–126				
						27	100	100	127–131				
						28	100	72	132–136				
				135.4 - 136.7 ft: FRAGMENTED ZONE		29	100	84	137–141				
				141.1 - 141.7 ft: FRAGMENTED ZONE		30	100	94	142–146				
				144.9 - 145.2 ft: FRAGMENTED ZONE		31	100	100	147–152				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take, 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-10**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 7 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
				153.8 - 154.2 ft: FRAGMENTED ZONE		32	100	90	154				
									155				
									156				
						33	100	90	157				
									158				
									159				
									160				
									161				
						34	100	96	162				
									163				
									164				
									165				
									166				
						35	100	90	167				
									168				
									169				
									170				
									171				
						36	100	94	172				
									173				
									174				
									175				
									176				
				176.4 - 176.7 ft: FRAGMENTED ZONE		37	100	98	177				
									178				
									179				
									180				
									181				
									182				
									183				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

PERMEABILITY (cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-10**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 8 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						38	100	100	184–186				
						39	100	100	187–191				
						40	100	90	192–196				
						41	100	100	197–201				
						42	100	100	202–206				
						43	100	100	207–211				
238.2 / 211.7		**END OF BOREHOLE**											

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-10

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 9 **OF:** 9

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at a depth of 26.8 ft on September 29, 2009.
7 RMR (Rock Mass Rating) estimation based on visual assessments of exposed outcrops, drill core and laboratory test results on rock and core samples in the vicinity of the intake tunnel, north portal of the lower tunnel and surge chamber as outlined in Bieniawski (1989).
8 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
9 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-10
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intersection of gate shaft and existing tunnel
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
3.3					Start of Core																
3.5					Joint	25						x		x			H		s			
5.4					Drill Break																
6.7					Drill Break																
8.2					Joint	35					x			x			H	C	m			O
8.2	8.8			x	Fragmented Zone																
8.5					Bedding (no break)		81	251													
8.8					Joint	30						x		x			H		s			
9.2					Vein (no break)		84	065													
9.7					Calcite Vein	45					x			x				C			P	
9.9					Bedding (no break)		20	115													
10.1					Drill Break																
11.1					Drill Break																
11.3					Joint	30	77	037				x				x		C	s			
11.4					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
11.6					Drill Break																
11.7					Drill Break																
11.9					Drill Break																
12.3					Bedding (no break)		67	229													
12.7					Joint	45					x			x				C	s		P	H
13.1					Joint	35					x			x				C	s		P	H
13.6					Hammer Break																
14.4					Drill Break																
14.6					Joint	30						x		x			H	C	s			
15.1					Joint	35				x				x			H	C	s			
15.3					Bedding (no break)		58	213													
15.8					Bedding (no break)		89	211													
16.4					Drill Break																
16.7					Drill Break																
17.1					Joint	45				x				x			H	C	s		P	H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intersection of gate shaft and existing tunnel
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
17.4					Bedding (no break)		74	219														
17.4					Joint	20					x			x			H	C	s			
17.7					Bedding (no break)		65	221														
17.7					Joint	50				x				x			H	C	s			
18.0					Joint	50				x				x			H	C	s			
18.2					Bedding (no break)		71	193														
18.3					Hammer Break																	
18.5					Drill Break																	
19.6					Bedding (no break)		17	089														
21.7					Drill Break																	
22.0					Bedding (no break)		76	026														
22.7					Bedding (no break)		66	214														
23.2					Drill Break																	
23.5					Bedding (no break)		54	120														
24.4					Joint	50					x			x			H	C	s			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
26.7					Drill Break																
27.2					Drill Break																
28.0					Hammer Break																
28.3					Drill Break																
28.8					Drill Break																
29.0					Joint	15					x			x			H		s			
29.2					Drill Break																
29.4					Bedding (no break)		84	271													
29.5					Drill Break																
30.3					Drill Break																
30.9					Joint	45					x			x			H	C	s			
31.7					Joint	40	78	210			x			x			H	C	s			
31.9					Joint	40	83	207			x			x			H	C	s			
32.4					Joint	65					x			x			H	C	s			
33.1					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
34.4					Joint	45	7	082			x			x			H	C	s			
34.7					Drill Break (Contact)																	
35.0					Bedding (no break)		73	199														
35.3					Joint	25					x			x			H	C	s			
35.6					Vein (no break)		83	305														
35.8					Drill Break																	
36.0	36.3			x	Fragmented Zone																	
36.3					Joint	60					x				x		H	C	s			
36.7					Drill Break																	
37.0					Drill Break																	
37.1					Drill Break																	
37.3					Joint	55					x			x			H					
37.7					Joint	40	69	221			x			x								
38.3					Joint	40	47	186			x			x			H					
39.2					Bedding (no break)		78	203														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
39.9					Joint	70	32	286			x				x		H	C	s			
40.5					Joint	45	75	211			x			x			H	C	s			
40.9					Drill Break																	
41.7					Drill Break																	
42.8					Joint	45					x			x			H	C	s			
43.0					Bedding (Hammer Break)		54	190														
44.0					Drill Break																	
44.3					Joint	25	73	321			x			x			H	C	s			
45.2					Joint	25					x			x			H	C	s			
45.3					Drill Break																	
45.6					Joint	40					x			x			H	C	s			
46.7					Joint	30					x			x			H	C	s			
46.8					Drill Break																	
47.4					Joint	30					x			x			H		s			
47.6					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
48.2					Drill Break																
48.3					Bedding (no break)		20	213													
49.5					Joint	60	51	201			x			x			H		s			
49.8					Joint	45	41	309			x			x			H		s			O
51.7					Joint	10					x					x	H		s			
52.0					Drill Break																
52.6					Hammer Break																
52.9					Hammer Break																
53.3					Joint	35					x			x			H	C	s			
53.8	53.9			x	Fragmented Zone																
54.0					Joint	80	56	239			x			x			H		s			
54.4					Quartz Vein (Drill Break)	70	44	220			x			x				C				
55.0					Drill Break																
55.2					Drill Break																
55.4					Hammer Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Intersection of gate shaft and existing tunnel
Azimuth (Deg): 65
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
55.9					Joint	55						x		x			H	C	s			O
56.2					Bedding (Drill Break)		62	231														
56.3					Joint	75					x			x			H	C	s			
56.5					Drill Break																	
56.7					Drill Break																	
57.1					Hammer Break																	
57.5					Joint (Hammer Break)	30					x			x			H	C				
58.7					Drill Break																	
60.0					Joint	70					x			x			H		s			
60.1					Drill Break																	
60.2					Bedding (no break)		44	229														
60.3					Drill Break																	
60.5					Bedding (no break)		48	226														
61.1					Vein (no break)		87	032														
61.6					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
61.7					Drill Break																
62.3					Joint	30					x					x	H	C	s			
62.7					Joint	45					x			x			H		s			
63.1					Joint	75					x			x			H	C	s			
64.1					Drill Break																	
64.4					Bedding (no break)		63	219														
64.5					Drill Break																	
64.7					Joint	30				x				x					s			
64.9					Bedding (no break)		57	156														
65.1					Drill Break																	
65.2	66.2			x	Fragmented Zone																	
65.3					Joint	25						x		x			H	C	s			
66.2					Drill Break																	
66.7					Drill Break																	
66.9					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
67.0					Bedding (Drill Break)		80	034														
67.5					Joint	45					x			x			H	C	s			
67.7					Drill Break																	
67.8					Drill Break																	
67.9					Bedding (no break)		78	207														
68.0					Bedding (Drill Break)		89	014														
69.3					Drill Break																	
69.4					Joint	55					x					x	H	C	s			
69.6					Vein (no break)		29	317														
70.3					Bedding (no break)		70	209														
70.5					Drill Break																	
70.6					Joint	70				x				x			H	C	s			
71.3					Joint	50				x				x			H	C	s			
71.7					Hammer Break																	
72.1					Joint	65	33	187			x			x			H	C	s			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intersection of gate shaft and existing tunnel
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
72.4					Joint	35					x			x			H	C	s			
72.4					Calcite Vein	30					x			x			H	C	s		P	
72.6					Bedding (no break)		43	349														
73.2					Drill Break																	
73.6					Joint	45					x			x			H	C	s			
73.8					Bedding (no break)		62	199														
75.0					Bedding (no break)		63	218														
76.7					Calcite Vein	60					x			x			H	C	s		P	
78.2					Bedding (no break)		74	217														
78.7					Drill Break																	
79.8					Drill Break																	
81.1					Drill Break																	
81.7					Drill Break																	
84.2					Joint	60					x			x			H	C	s			
84.9					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-10
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
85.3					Vein (no break)		56	303														
86.7					Drill Break																	
87.0					Bedding (no break)		55	209														
87.4					Bedding (no break)		28	276														
89.4					Calcite Vein	25	86	119				x		x			H	C	s		P	
91.7					Calcite Vein	75					x			x			H	C	s		P	
92.0					Vein (no break)	75	31	289														
94.8					Vein (no break)		81	124														
95.5					Calcite Vein	45					x			x			H	C	s		P	
96.7					Drill Break																	
97.6					Calcite Vein	40					x			x				C				
98.1					Vein (no break)		10	007														
100.6					Bedding (no break)		49	203														
101.7					Calcite Vein (Drill Break)		29	299														
104.1					Vein (no break)		36	005														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intersection of gate shaft and existing tunnel
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
104.9					Drill Break																
106.7					Drill Break																
110.9					Joint	45					x			x			H	C	s			
111.0					Vein (no break)		29	321														
111.1					Drill Break																
111.5					Joint	45	35	001			x			x				C	s	x		O
111.7					Drill Break																
112.2					Drill Break																
113.7					Drill Break																
113.9					Bedding (no break)		67	203													
114.5					Bedding (Drill Break)		51	220													
115.6					Bedding (no break)		67	212													
116.3					Drill Break																
116.7					Drill Break																
117.0					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Intersection of gate shaft and existing tunnel
Azimuth (Deg): 65
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
117.2					Drill Break																	
117.8					Bedding (Drill Break)		56	198														
119.9					Bedding (Drill Break)		58	198														
121.7					Drill Break																	
123.7					Calcite Vein	45	39	324			x			x				C				
124.7					Drill Break																	
125.9					Bedding (no break)		67	189														
126.7					Drill Break																	
127.3					Vein (no break)		23	011														
127.8					Bedding (no break)		15	154														
128.7					Bedding (no break)		59	191														
129.7					Drill Break																	
131.4					Bedding (no break)		66	181														
131.7					Drill Break																	
132.4					Calcite Vein (Drill Break)		10	359														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
133.2					Joint	40	79	222			x			x			H		s			
133.3					Drill Break																	
133.5					Joint	40	80	221			x			x			H	C	s	x		
133.6					Joint	55					x			x			H	C	s	x		
134.1					Joint	45	89	037			x			x			H	C	s			
134.4					Calcite Vein	35					x			x			H	C	s			
134.8					Joint	35					x			x			H		s	x		
135.1					Bedding (Drill Break)		88	218														
135.4	136.7			x	Fragmented Zone																	
135.5					Joint	35					x			x			H	C	m	x		O
135.7					Bedding (no break)		80	223														
136.6					Bedding (no break)		57	212														
136.7					Drill Break																	
136.8					Bedding (no break)		80	219														
137.5					Joint	35						x			x		H	C	s			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
138.0					Joint	40					x			x			H	C	s			
138.3					Bedding (Drill Break)		77	212														
138.5					Drill Break																	
138.7					Bedding (no break)		60	232														
139.1					Bedding (no break)		47	222														
139.3					Drill Break																	
139.6					Vein (no break)		56	280														
140.0					Drill Break																	
140.2					Joint	45					x			x			H	C	s	x		O
140.4					Bedding (no break)		69	225														
141.1					Joint	50	79	232			x			x			H	C	s	x		O
141.1	141.7			x	Fragmented Zone																	
141.3					Joint		72	227														
141.5					Calcite Vein		40	326														
141.7					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
142.1					Drill Break																
142.2					Drill Break																
142.3					Joint	30					x			x			H	C	s			
143.0					Drill Break																
143.1					Joint	45					x			x			H	C	s			
143.3					Bedding (no break)		75	222													
144.5					Bedding (no break)		80	219													
144.6					Drill Break																
144.9	145.2			x	Fragmented Zone																
145.2					Joint	45	71	204			x			x			H	C	s			
145.5					Drill Break																
146.2					Joint	60					x			x			H	C	s			
146.2					Joint	15					x			x			H	C	s			
146.4					Vein (no break)		56	270													
146.7					Bedding (Drill Break)		82	223													

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
147.0					Hammer Break																	
147.6					Calcite Vein (Hammer Break)		49	267														
148.0					Joint	35						x		x			H	C	s			
149.1					Bedding (no break)		82	058														
149.4					Drill Break																	
150.2					Drill Break																	
150.3					Drill Break																	
150.5					Bedding (no break)		49	212														
151.2					Drill Break																	
151.3					Bedding (no break)		64	210														
151.4					Drill Break																	
151.7					Drill Break																	
152.1					Calcite Vein (Drill Break)		26	221														
152.6					Drill Break																	
152.8					Bedding (no break)		50	278														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Intersection of gate shaft and existing tunnel
Azimuth (Deg): 65
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
153.0					Drill Break																	
153.1					Joint	40						x		x			H	C	s			
153.3					Bedding (no break)		68	204														
153.8					Joint	45					x					x	H	C	s			
153.8	154.2			x	Fragmented Zone																	
154.1					Joint	20					x				x		H	C	s			
154.1					Bedding (no break)		77	215														
154.6					Calcite Vein	50	51	312			x			x			H	C	s		P	
154.7					Joint	15					x			x			H	C	s			
154.8					Drill Break																	
154.9					Bedding (no break)		84	227														
155.4					Bedding (no break)		58	239														
155.5					Joint	55					x			x			H	C	s			
156.2					Joint	55					x			x			H	C	s			
156.2					Vein (no break)		42	191														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
156.4					Bedding (Drill Break)		33	218														
156.7					Drill Break																	
157.1					Joint	60	31	276			x					x	H	C	s			
157.3					Joint	25	86	319			x			x			H	C	s			
158.1					Bedding (no break)		36	264														
159.3					Joint	30	82	300			x			x			H	C	s	x		
159.9					Drill Break																	
161.3					Joint	60					x			x				C	s	x		
161.7					Drill Break																	
162.0					Drill Break																	
162.6					Drill Break																	
162.9					Drill Break																	
164.3					Vein (no break)		17	359														
165.6					Calcite Vein	55					x			x				C	s		P	
166.0					Joint	55	56	211			x			x			H	C	s			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
166.1					Drill Break																
166.2					Joint	60					x			x				C	s	x		
166.7					Drill Break																
166.8					Bedding (Drill Break)		74	205													
167.2					Bedding (no break)		67	209													
167.4					Drill Break																
167.7					Bedding (no break)		76	213													
167.7					Joint	35					x			x				C	s	x		
167.8					Joint	45					x			x				C	s	x		
167.9					Joint	55					x			x				C	s	x		
168.1					Bedding (no break)		64	224													
168.2					Joint	45					x			x				C	s	x		
168.3					Joint	50	70	219			x			x				C	s	x		
168.5					Calcite Vein	40					x			x			H	C	s	x		O
168.8					Bedding (no break)		58	215													

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Intersection of gate shaft and existing tunnel
Azimuth (Deg): 65
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
168.8					Joint	20						x		x			H	C	s	x		O
169.4					Drill Break																	
169.6					Joint	55	63	208			x			x			H	C	s	x		
169.9					Bedding (no break)		58	216														
171.7					Drill Break																	
172.8					Bedding (no break)		39	218														
173.9					Bedding (no break)		61	193														
175.0					Bedding (no break)		76	215														
175.0					Joint	40					x			x			H	C	s			
175.5					Drill Break																	
175.8					Drill Break																	
176.4					Joint	70					x			x				C	s	x		
176.4	176.7			x	Fragmented Zone																	
176.7					Joint	45	37	322			x			x			H	C	s	x		
177.4					Bedding (no break)		70	171														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
177.8					Drill Break																
178.0					Vein (no break)		70	297													
178.4					Vein (no break)		14	055													
178.5					Joint	45					x			x			H	C	s			
178.6					Calcite Vein	30					x			x			H	C	s			
179.2					Joint	55					x			x			H	C	s			
179.9					Drill Break																
180.1					Drill Break																
180.2					Vein (no break)		81	306													
180.8					Drill Break																
181.1					Drill Break																
181.4					Joint	45					x			x				C	s	x		
181.5					Drill Break																
181.7					Drill Break																
182.2					Bedding (Drill Break)		10	162													

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
183.0					Bedding (Drill Break)		29	177														
183.9					Bedding (no break)		22	202														
185.3					Vein (no break)		32	281														
186.1					Vein (no break)		47	282														
186.2					Joint	25					x			x			H	C	s			
186.5					Vein (no break)		47	292														
186.7					Joint	60	24	282			x			x			H	C	s			
187.2					Vein (no break)		63	288														
187.9					Drill Break																	
188.8					Vein (no break)		59	298														
189.1					Vein (no break)		84	292														
189.2					Joint	30					x			x			H	C	s			
190.8					Bedding (no break)		78	194														
191.7					Drill Break																	
192.5					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Intersection of gate shaft and existing tunnel
Azimuth (Deg) 65
Inclination (Deg) 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
193.8					Bedding (no break)		67	231														
194.0					Vein (no break)		57	325														
195.7					Joint	60	52	198			x			x			H	C				
195.9					Joint	30					x			x			H	C				
196.4					Calcite Vein	45	32	300			x			x			H	C	s			
196.6					Joint	10					x			x			H					
196.7					Joint	60					x			x			H	C	s			
197.0					Calcite Vein		85	288														
197.0					Bedding (Drill Break)		59	178														
199.3					Vein (no break)		26	293														
199.6					Drill Break																	
199.8					Vein (no break)		83	294														
201.3					Drill Break																	
201.7					Calcite Vein (Drill Break)		69	308														
202.8					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-10
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intersection of gate shaft and existing tunnel
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
203.0					Calcite Vein (Drill Break)		77	294														
206.1					Vein (no break)		55	343														
206.6					Vein (no break)		60	307														
206.7					Drill Break																	
208.3					Vein (no break)		28	353														
209.1					Vein (no break)		52	321														
210.3					Vein (no break)		28	277														
210.6					Vein (no break)		28	284														
210.7					Drill Break																	
210.8					Vein (no break)		82	109														
211.7					End of Hole																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

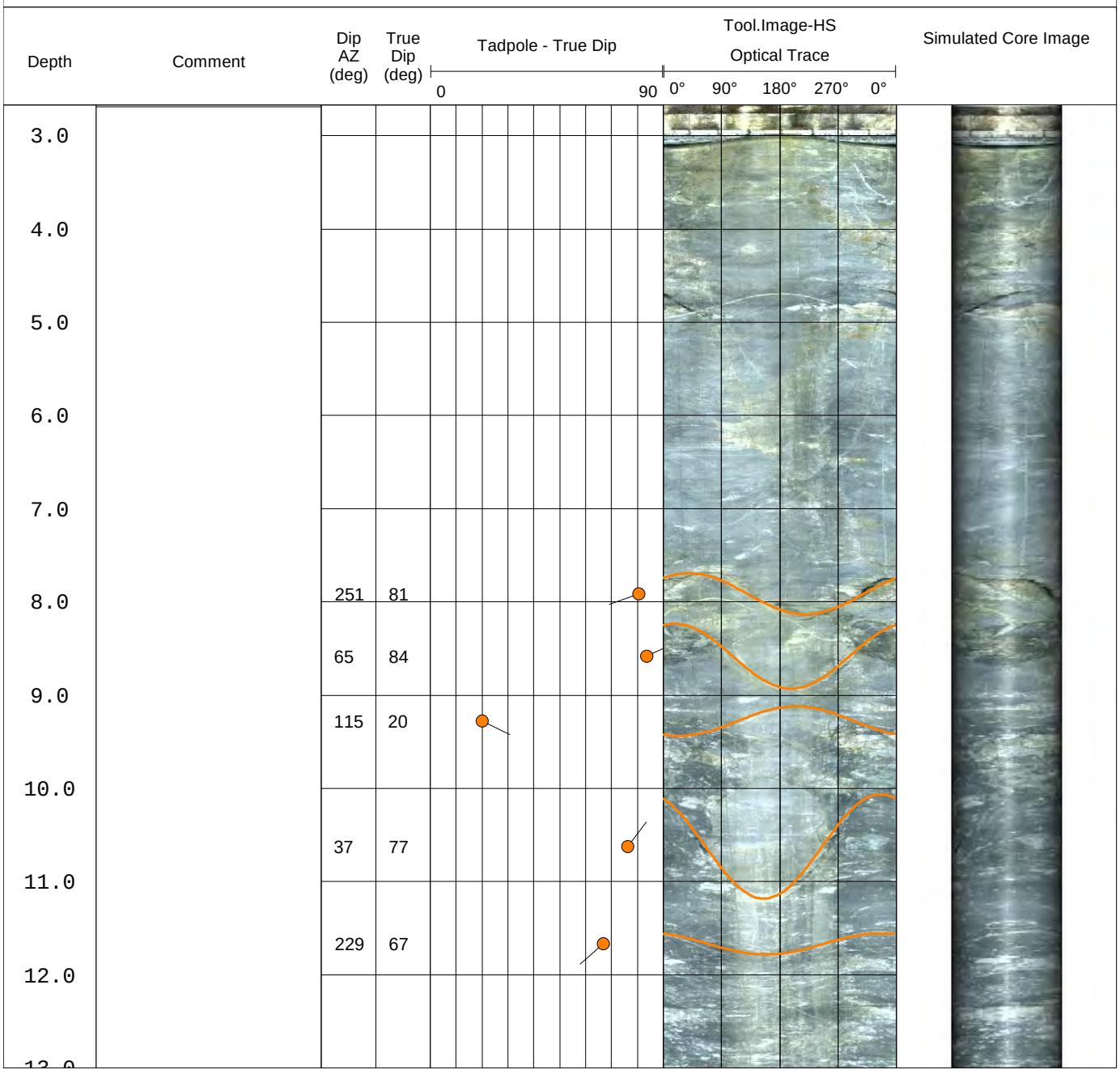
Aperture:O-Open; H-Hairline (<0.5mm)

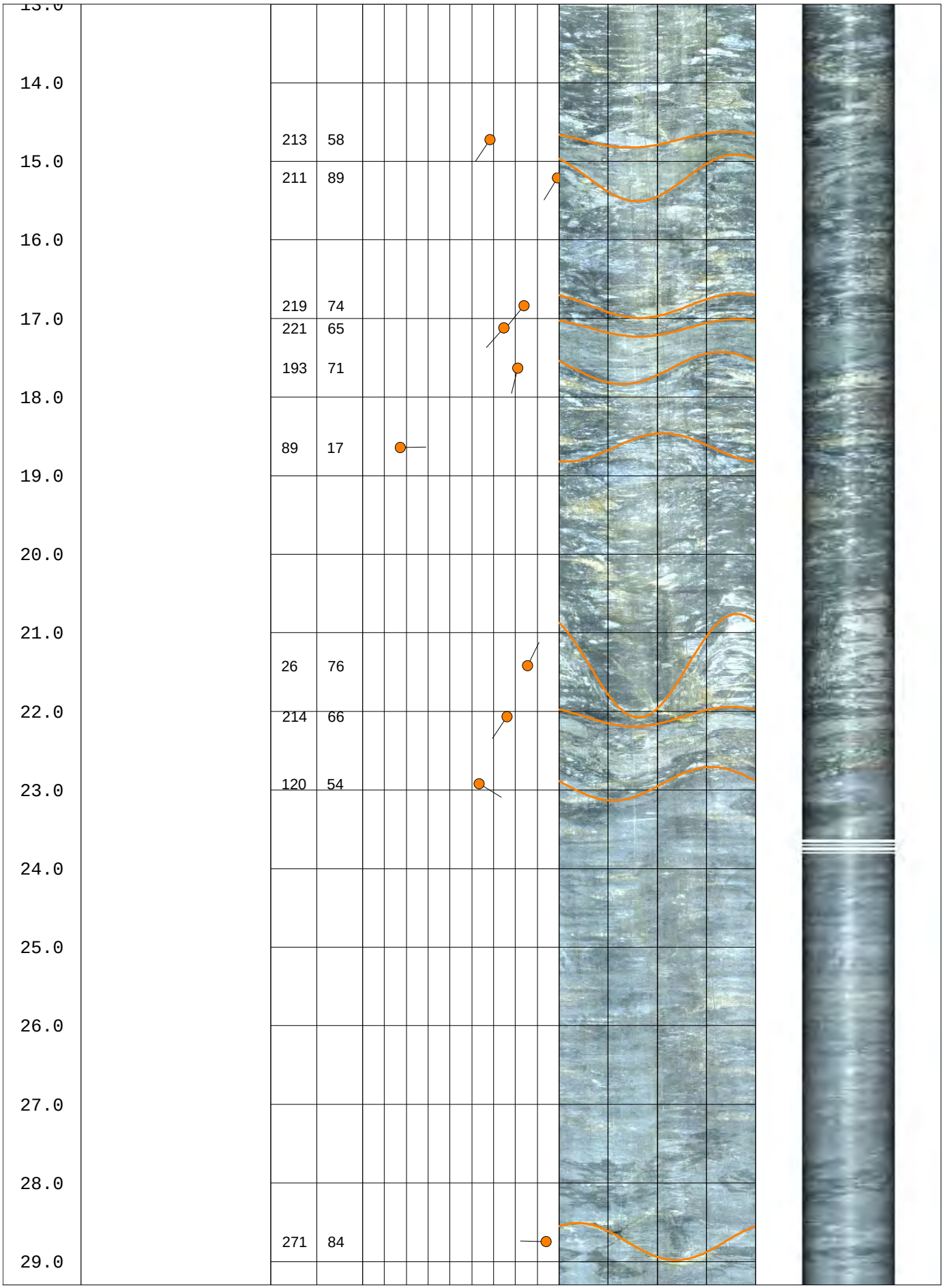
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company City and Borough of Sitka	
	Location: Sitka, AK	
	Project: Blue Lake Hydroelectric	
Date Logged:	October 2, 2009	Borehole ID: DH09-10
File Name:	DH09-10-1M.wcl	Logged By: Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from high side.

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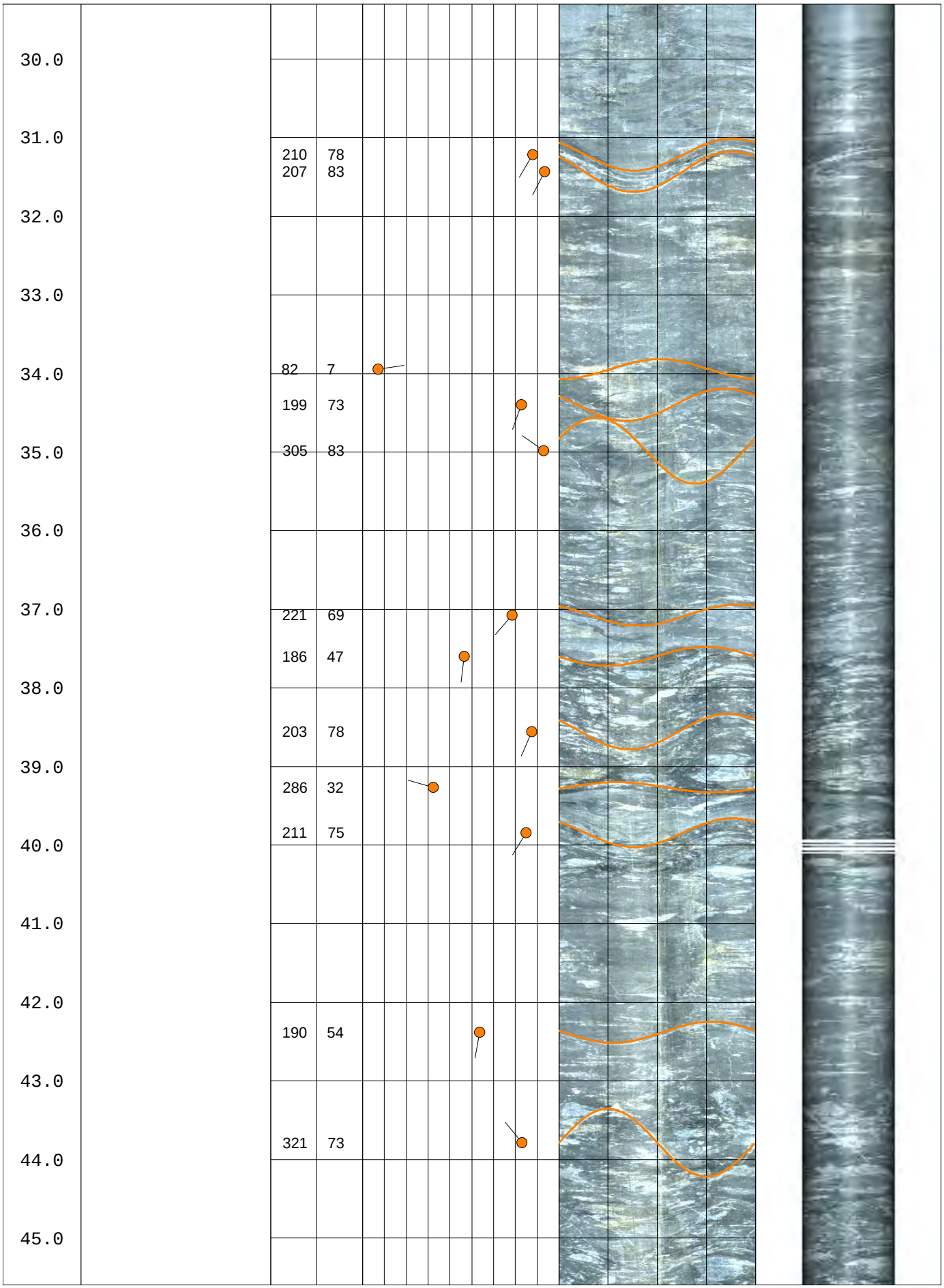
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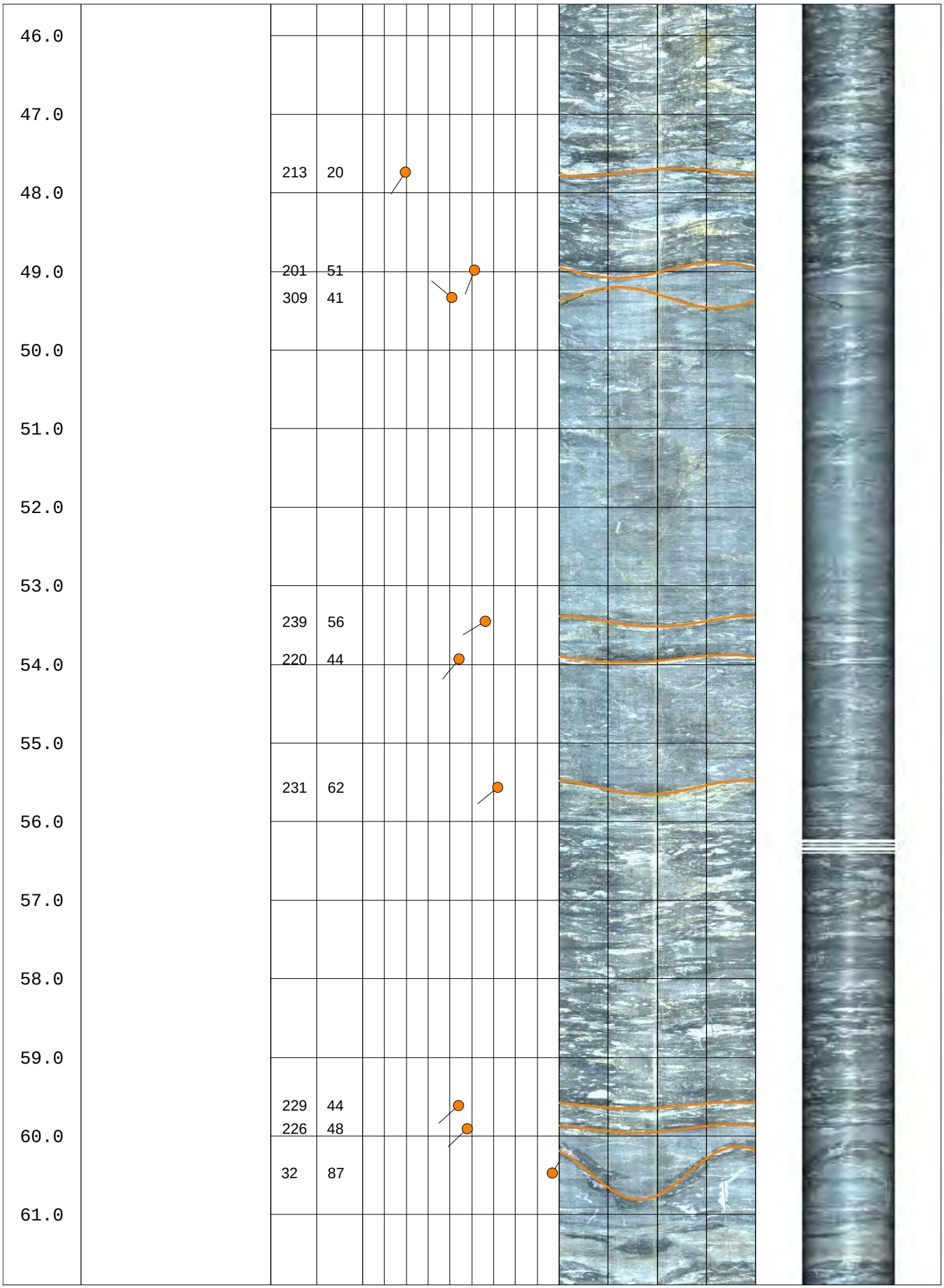
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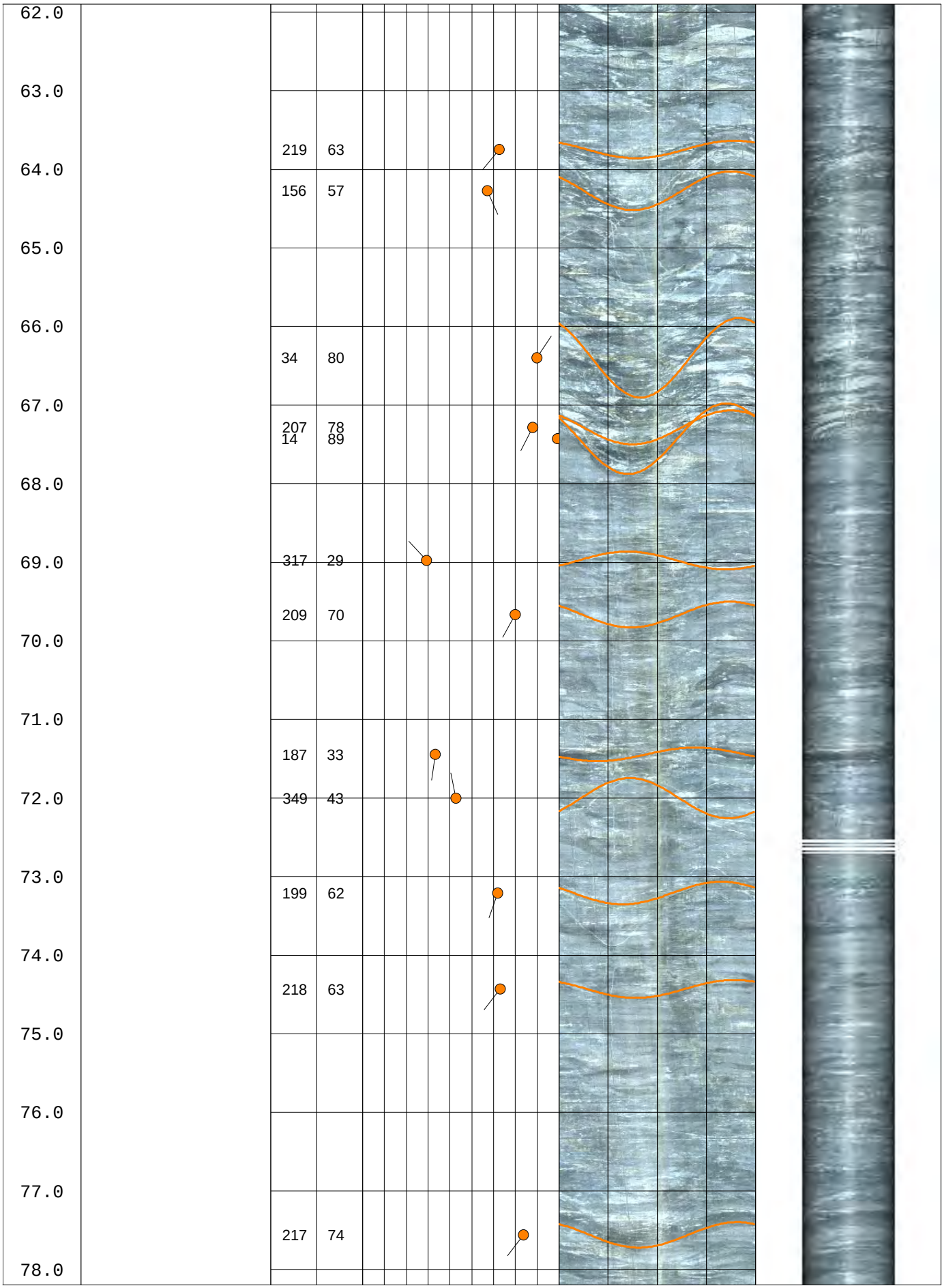
32 87
61.0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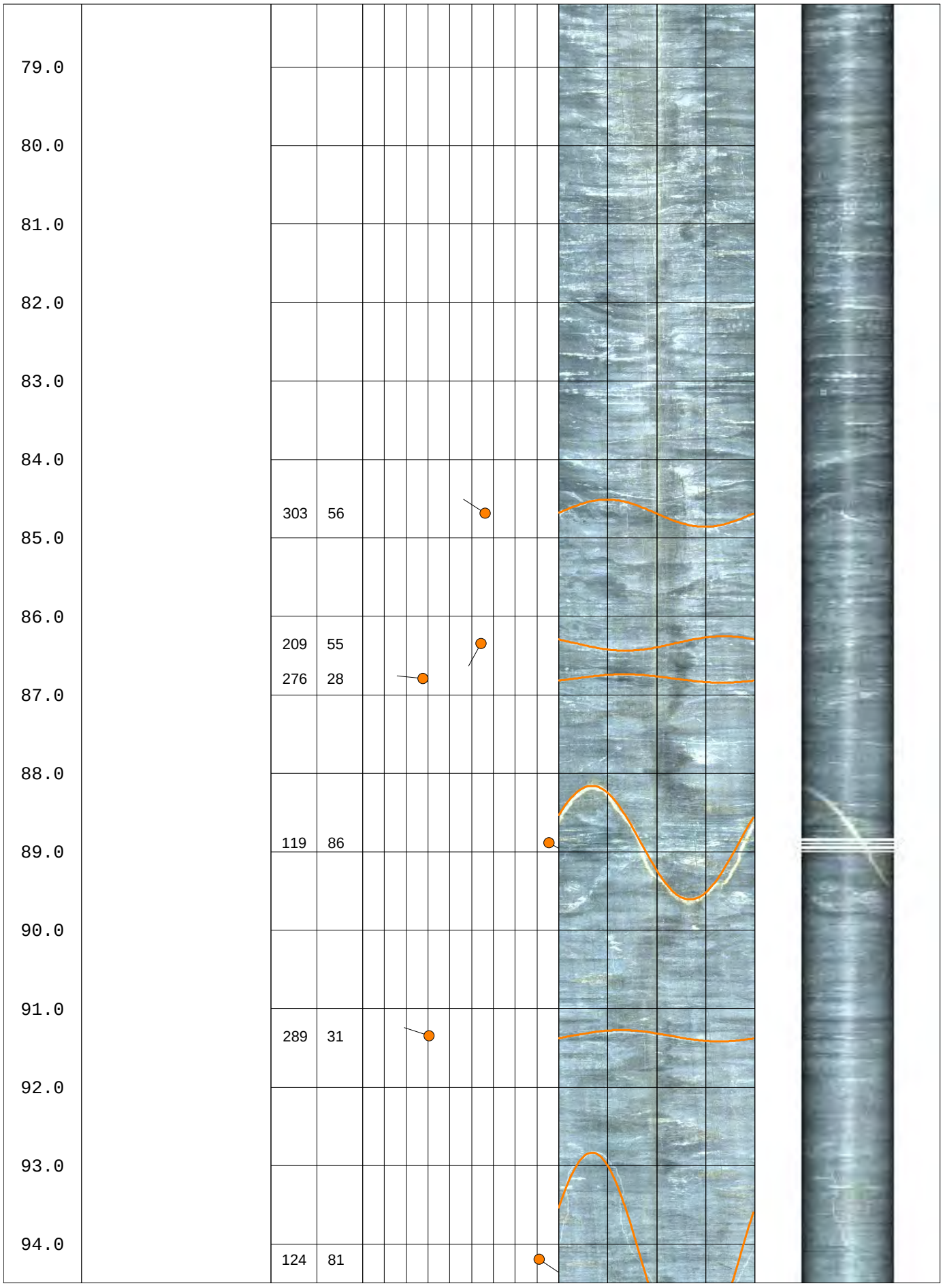
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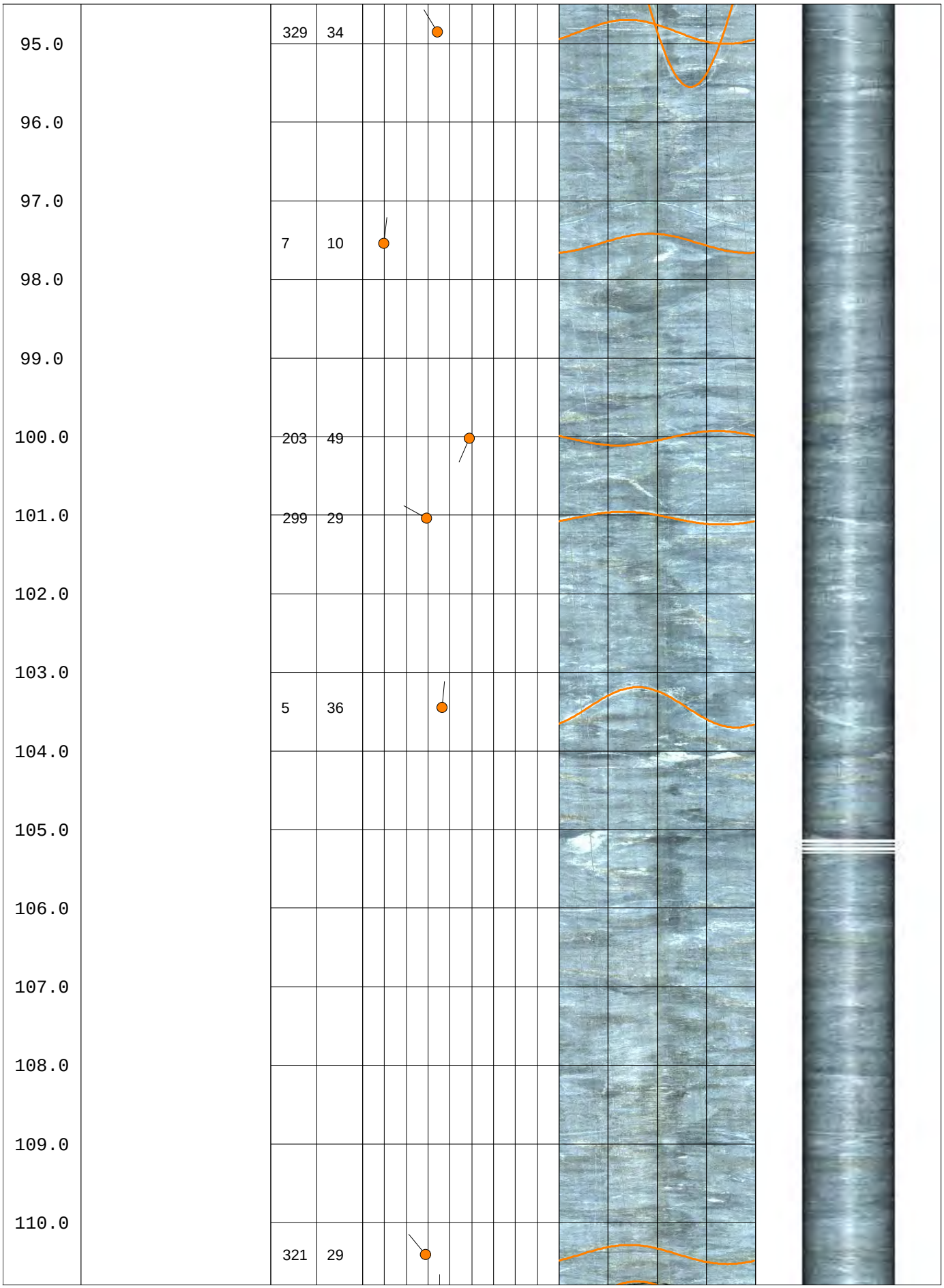
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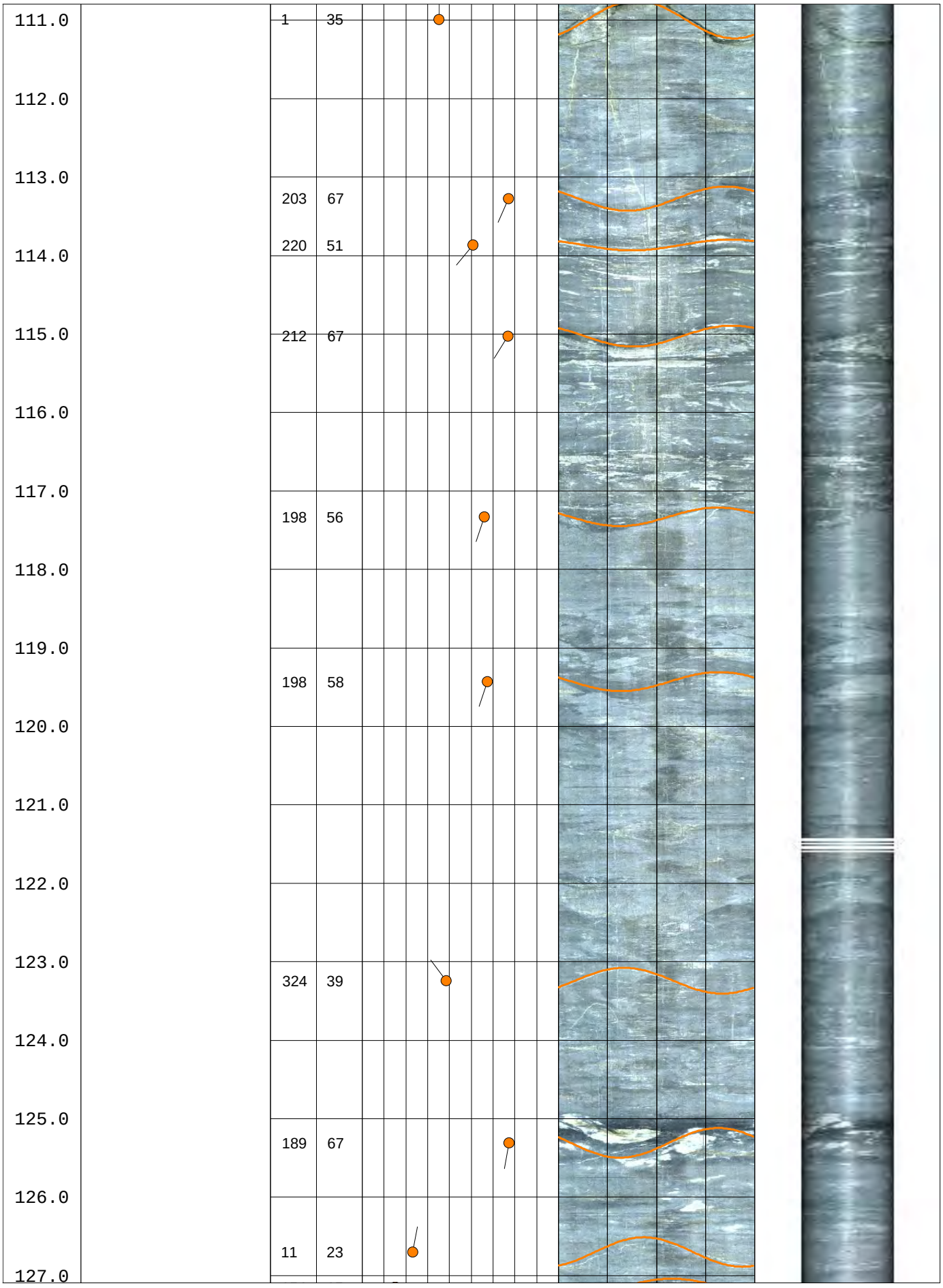
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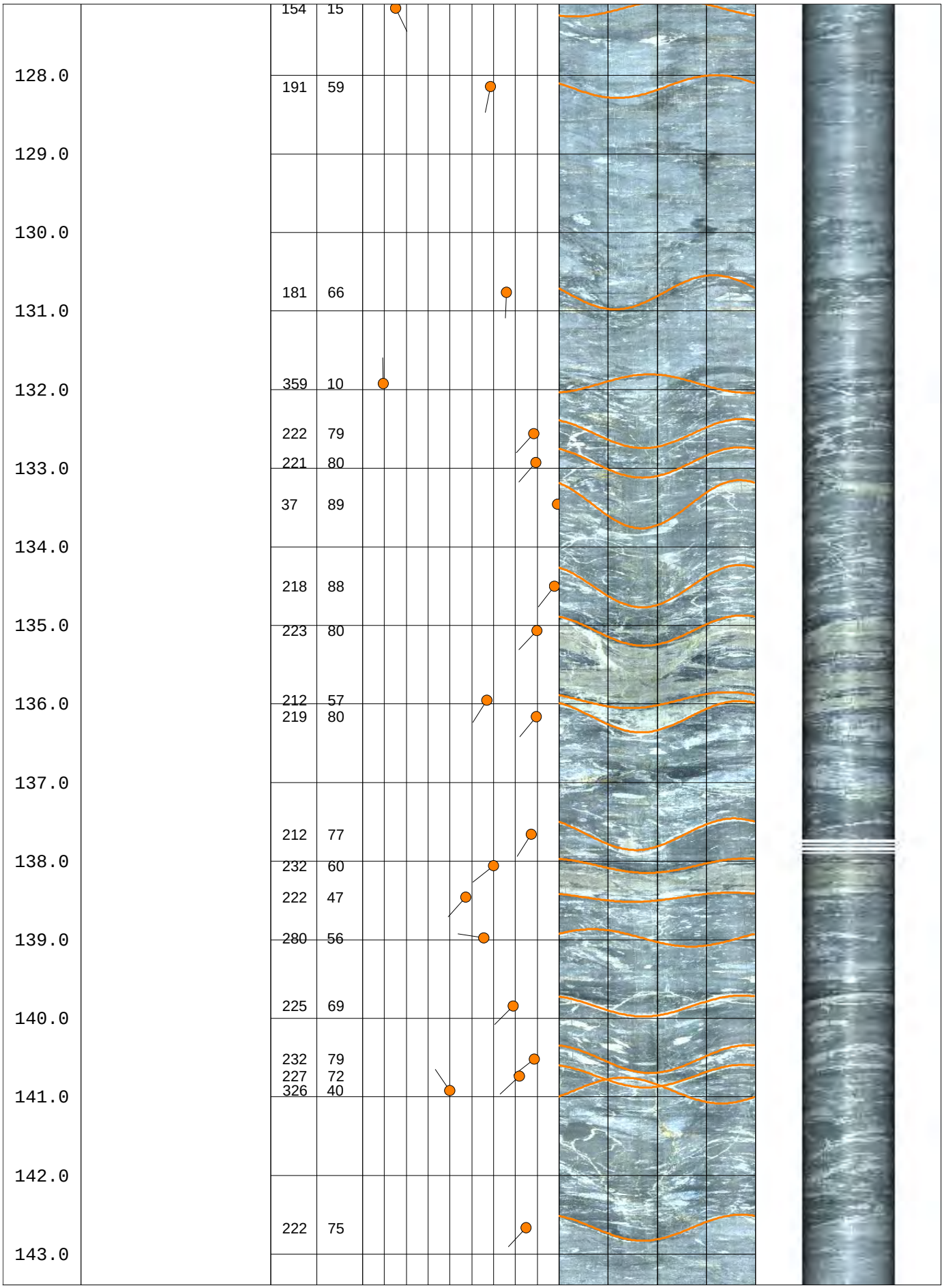
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359 10
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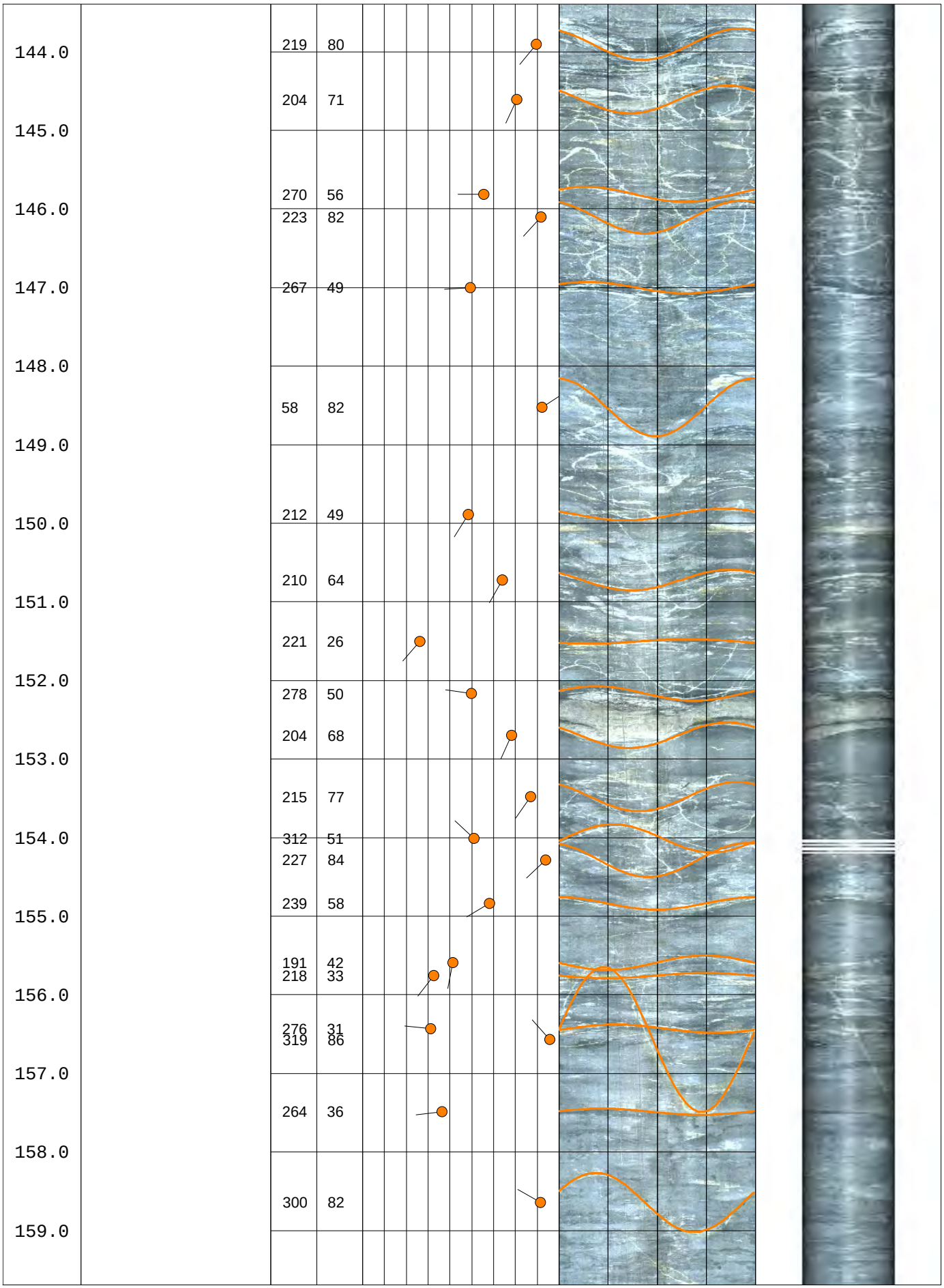
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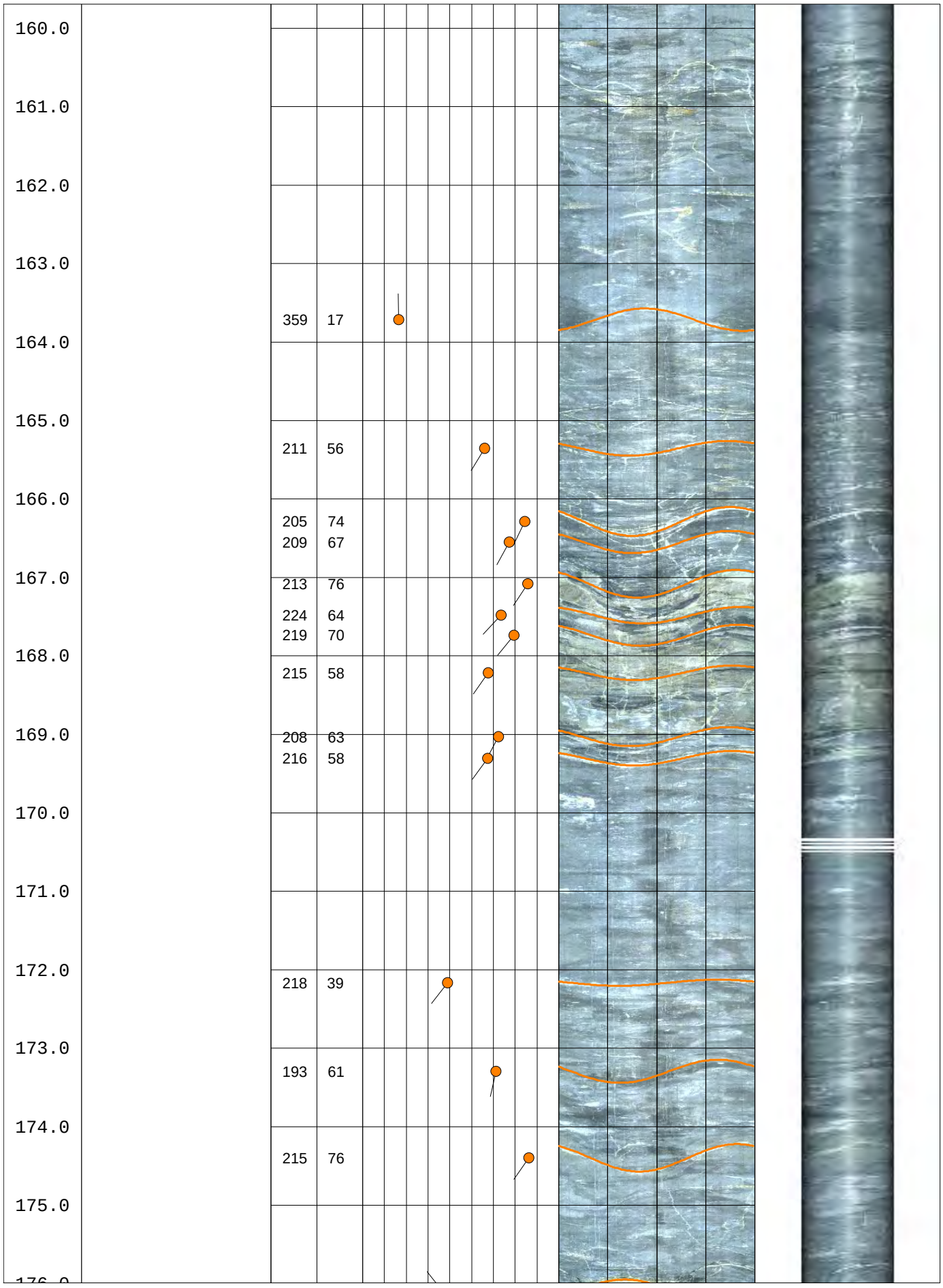
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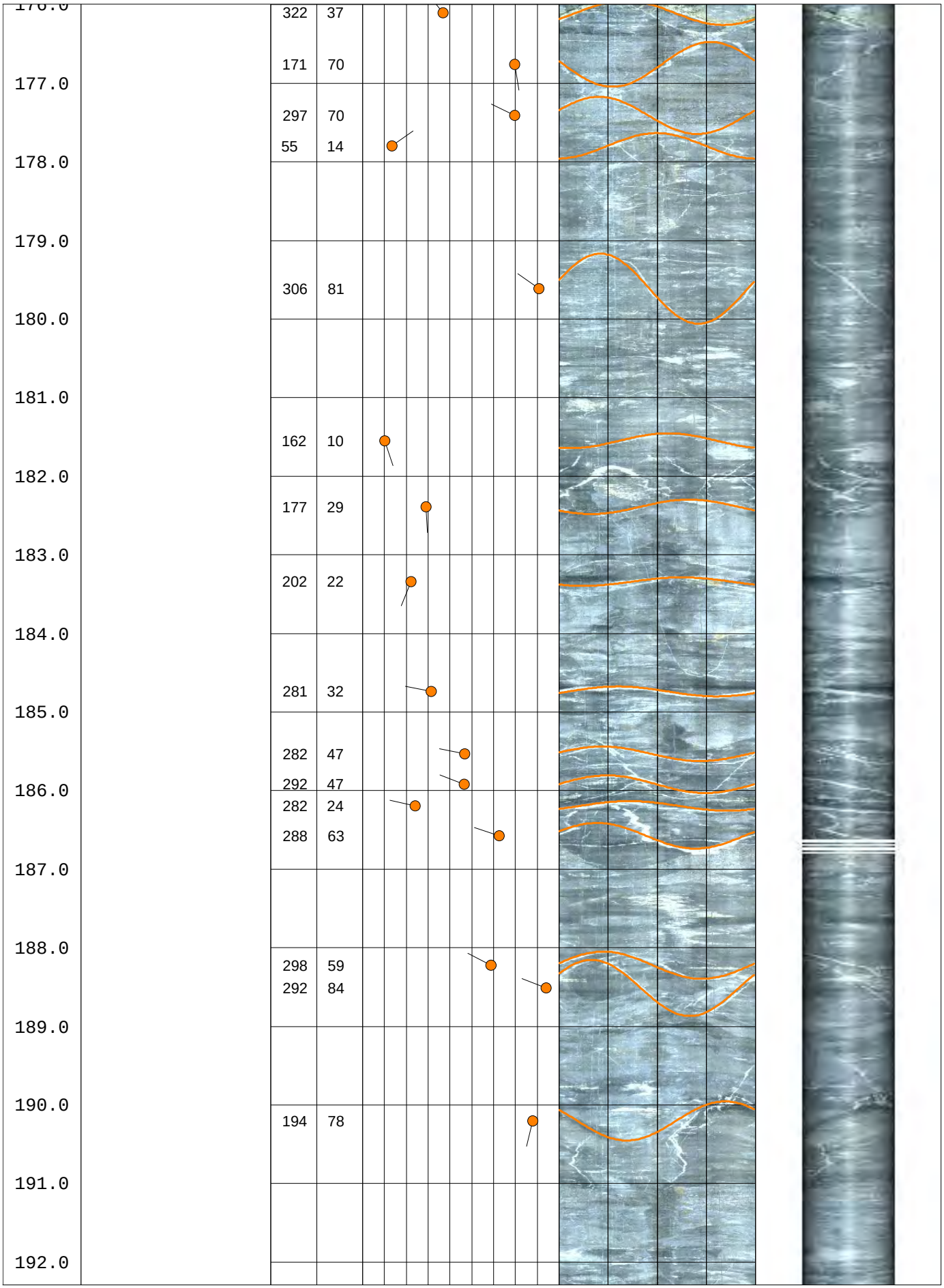
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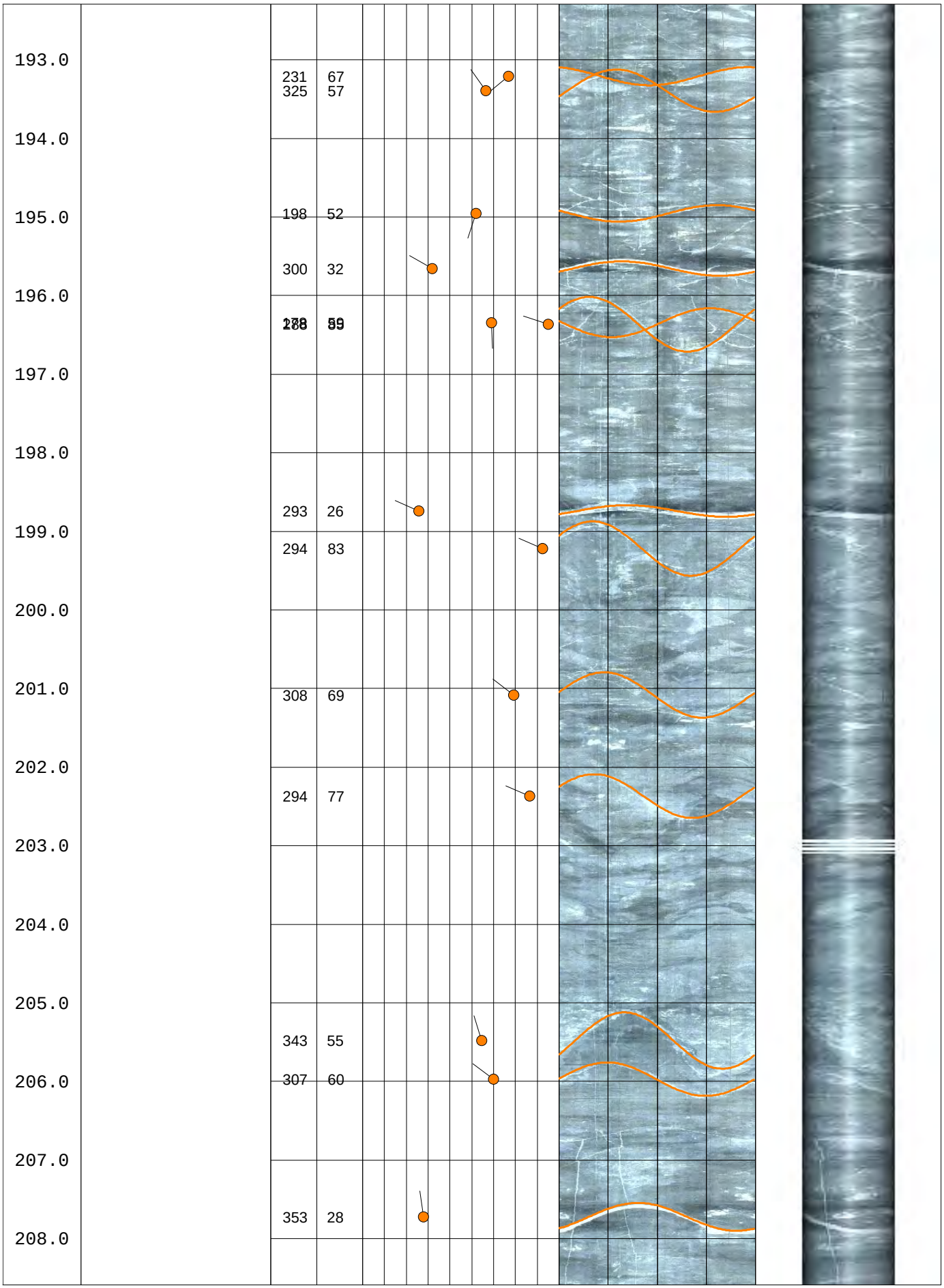
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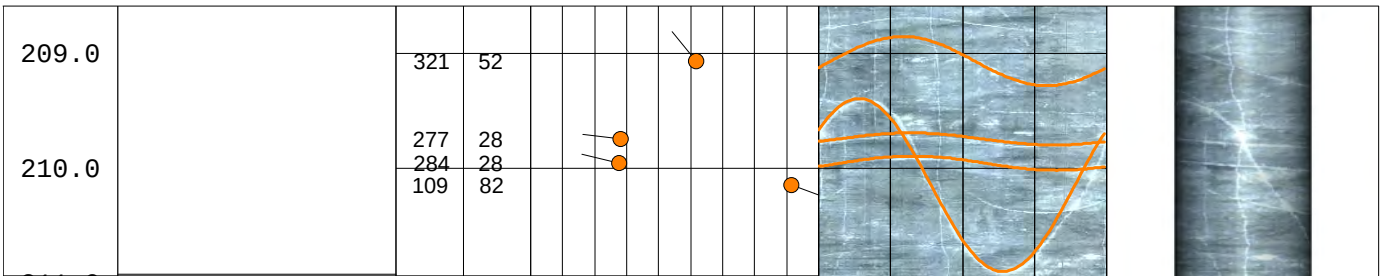
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277 28
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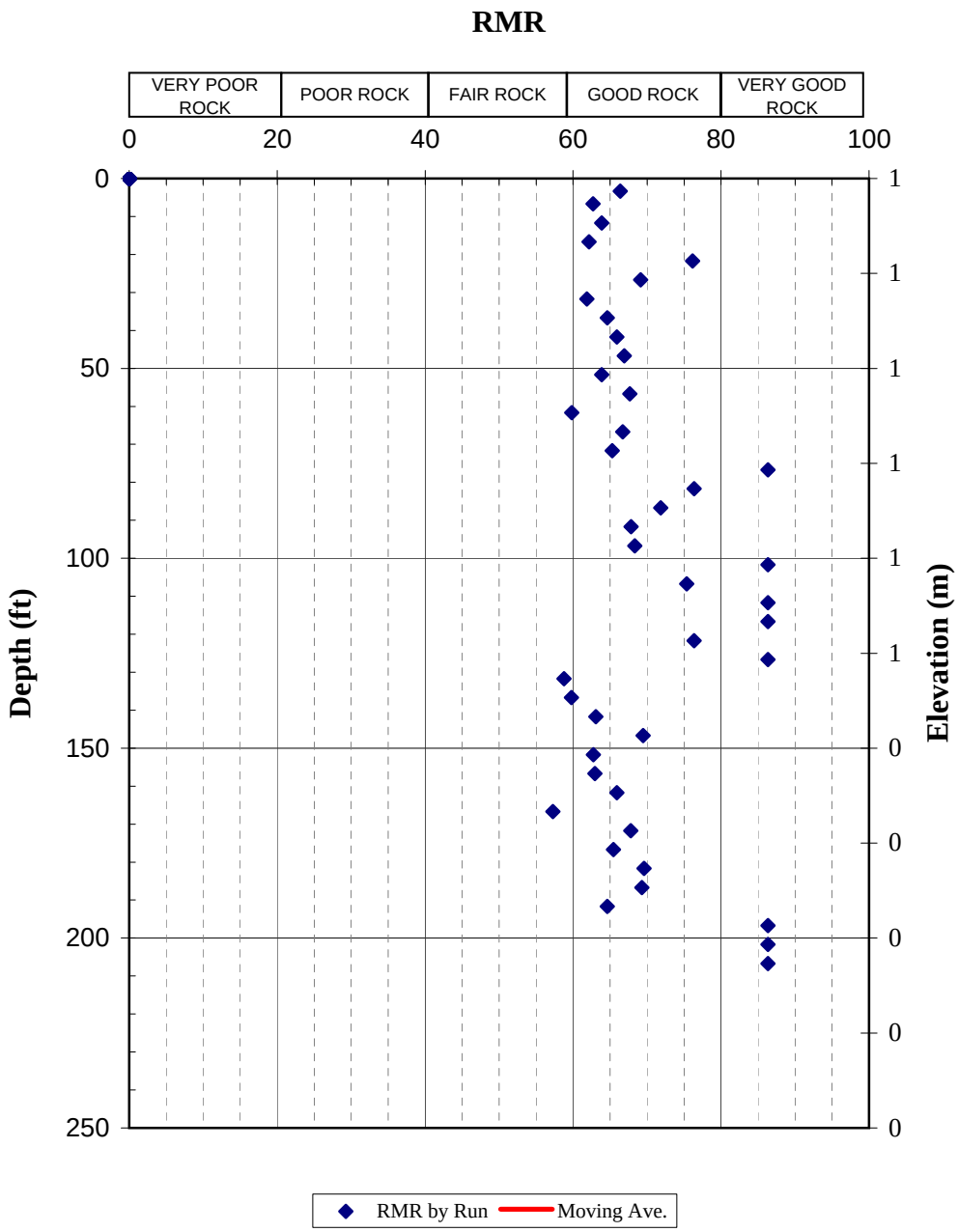
109 82

RMR vs Depth and Elevation DH09-10



Borehole DH09-11

Working Together SAFELY

© Hatch 2006/03 ⌘

BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: **DH09-11**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 9

SITE: Right Abutment

COORDINATES: 1913027.3 N, 2380558.1 E
DIP DIRECTION: 120
DIP: 70

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 484.6
END OF HOLE: 324.1

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 2500
METHOD SOIL: Diamond Drill Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 9/23/09
FINISHED: 9/25/09
INSPECTOR: M. Mammoliti
LOGGED BY: M. Mammoliti
REVIEWED: P. Friz

DATE: 11/20/2009

See end page for detailed groundwater measurements and notes

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
484.6										20 40 60 80	No take; 0.1 1 10 100; 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
0.0		0.0 - 65.8 ft: Metamorphosed/Fragmental Andesitic Siltstone Light/dark grey, very strong (100-250 MPa), strong to turbulent flow banding @ 45 deg to core axis contains equant/elongate, sub-rounded to rounded clasts (0.25-1.0 in. dia.) and angular lithic fragments (1.0-3.0 in. dia.) are oriented with flow bands, larger clasts appear stretched; some calcite veinlets throughout; Iron staining on joint surfaces; Average discontinuity spacing of 2.3 ft; GSI = 65 - 70.		The following general discontinuity characteristic were noted for this hole: 64% of the discontinuities are smooth, 14% are slightly rough, 16% are rough, 5% are slick. 81% of the discontinuities are planar, 74% are curved and 12% are irregular. 84% of the discontinuities have hematite staining, 80% are slightly weathered, and 20% are moderately weathered.	0				0				
					5	1	96	96	1				
					5.8	2	100	100	2				
									3				
						3	100	92	4				
					10.8				5				
									6				
									7				
									8				
									9				
									10				
									11				
						4	100	100	12				
									13				
									14				
					15.8				15				
									16				
									17				
						5	100	100	18				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost
RQD
Recovery
Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-11**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
					20.8				20				
						6	100	100	21				
					25.8				26				
						7	100	100	27				
					30.8				31				
						8	100	96	32				
					35.8				36				
						9	100	96	37				
					40.8				41				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

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SHIPPING CONTAINER

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P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-11**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						10	100	100	44				
					45.8				45				
						11	100	100	46				
					50.8				47				
						12	100	100	48				
					55.8				49				
						13	100	100	50				
					60.8				51				
						14	100	100	52				
					65.8				53				
									54				
									55				
									56				
									57				
									58				
									59				
									60				
									61				
									62				
									63				
									64				
									65				
422.8 / 65.8				66.8 ft. FRAGMENTED ZONE					66				
									67				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

PERMEABILITY (cm/sec): No take, 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}

SAMPLING METHOD

A - Split Tube
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K - Slotted

SHIPPING CONTAINER

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Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-11**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
416.5 / 72.5		65.8 - 72.5 ft: Metamorphosed carbonaceous andesitic siltstone: grey black, fine grained, very strong (100-250 MPa), fewer noticible bands and clasts; Average discontinuity spacing of 2.2 ft; GSI = 65 - 70.		70.4 ft. FRAGMENTED ZONE	70.8	15	100	86	68				
									69				
									70				
									71				
									72				
412.6 / 76.6		72.5 - 76.6 ft: Andesitic Dyke @ 45 deg to core axis Average discontinuity spacing of 1.0 ft; GSI = 55 - 60.			75.8	16	100	100	73				
									74				
									75				
									76				
407.6 / 81.9		76.6 - 81.9 ft: Metamorphosed carbonaceous andesitic siltstone: grey black, fine grained, very strong (100-250 MPa), fewer noticible bands and clasts. Average discontinuity spacing of 3.5 ft; GSI = 65 - 70			80.8	17	100	96	77				
									78				
									79				
									80				
									81				
		81.9 - 170.8 ft: Metamorphosed/Fragmental Andesitic Siltstone Average discontinuity spacing of 3.5 ft; GSI = 65 - 70.			85.8	18	100	100	82				
									83				
									84				
									85				
									86				
					90.8	19	100	100	87				
									88				
									89				
									90				
									91				

SAMPLING METHOD

A - Split Tube
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C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

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P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-11**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
					95.8	20	100	100	92–95	20 40 60 80	0.1 1 10 100 / No take 10^-6 10^-5 10^-4 10^-3		
		96.9 - 97.2 ft: Sample R10-PL =124.24 MPa 97.4 - 98.6 ft: Sample R10-UCS = 127.4 MPa			100.8	21	100	100	96–100				
					105.8	22	100	100	101–105				
					110.8	23	100	100	106–110				
						24	100	100	111–115				

SAMPLING METHOD

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SHIPPING CONTAINER

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P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-11**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
					115.8				116				
									117				
						25	98	98	118				
									119				
					120.3				120				
					120.8	26	100	100					
						27	100	100	121				
					122.4				122				
						28	100	100	123				
									124				
					125.8				125				
						29	100	100	126				
									127				
									128				
									129				
					130.8				130				
						30	100	100	131				
									132				
									133				
									134				
					135.8				135				
						31	98	98	136				
									137				
									138				
									139				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

PERMEABILITY (cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-11**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 7 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
					140.8				141				
						32	100	94	142				
									143				
									144				
									145				
					145.8				146				
						33	100	98	147				
									148				
									149				
									150				
					150.8				151				
						34	100	96	152				
									153				
									154				
									155				
					155.8				156				
						35	100	100	157				
									158				
									159				
									160				
					160.8				161				
						36	100	100	162				
									163				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100; (cm/sec): No take, 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-11**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 8 **OF:** 9

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		165.8 - 166.5 ft: Sample R11-UCS = 103.0 MPa 166.5 - 166.8 ft: Sample R11-PL = 229.65 MPa			165.8	37	100	100	165 166 167 168 169 170	20 40 60 80	0.1 1 10 100 (cm/sec) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
324.1 170.8		**END OF BOREHOLE**											

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-11

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 9 **OF:** 9

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at 30.68 ft on September 27, 2009.
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-11
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment
Azimuth (Deg)	120
Inclination (Deg)	70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
0.4					Joint	45							x			x	H		M			O
0.6					Joint	45							x			x	H		M			O
1.1					Drill Break																	
1.3					Drill Break																	
2.6					Drill Break																	
3.2					Drill Break																	
3.8					Speck on fracture		89	285														
4.5					Joint	30						x			x		H		M			O
5.0					Drill Break																	
5.8					Drill Break																	
7.1					Joint	40					x			x			H		S			
8.5					Joint	45	71	329				x		x			H		S			
8.8					Joint	40					x			x			H		S			
9.2					Vein (no break)		70	334														
9.5					Joint	40	73	328			x			x			H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-11
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 120
Inclination (Deg): 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
9.6					Joint	30							x			x	H		S			H
10.8					Drill Break																	
11.2					Fracture	80							x			x	H		S			H
11.9					Joint	10	84	129				x		x			H		S			
12.7					Drill Break																	
13.2					Bedding (no break)		40	233														
13.6					Joint	50						x			x		H		S			
14.7					Joint	45						x				x	H		S			
15.4					Drill Break																	
15.8					Drill Break																	
17.7					Joint	20	73	205				x		x			H		S			
18.5					Drill Break																	
19.4					Hammer Break																	
20.3					Bedding (no break)		59	207														
20.8					Joint	45					x			x			H		S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 120
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
21.3					Joint	45					x				x		H		S			
23.1					Drill Break																	
24.2					Hammer Break																	
24.8					Drill Break																	
25.8					Drill Break																	
26.1					Drill Break																	
26.3					Vein (no break)		68	316														
26.7					Joint	30						x		x			H		M			O
27.3					Joint	15					x			x			H		S			
28.5					Drill Break																	
29.2					Hammer Break																	
29.9					Drill Break																	
30.7					Drill Break																	
30.8					Drill Break																	
30.9					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 120
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
31.0					Joint	45	70	326					x			x	H	C	S			H
33.8					Hammer Break																	
34.4					Joint	60						x		x			H		S			H
35.8					Drill Break																	
38.6					Drill Break																	
38.8					Hammer Break																	
39.3					Calcite Vein (Hammer Break)		54	209														
39.6					Vein (no break)		49	204														
40.2					Joint	45					x			x			H		S			
40.4					Joint	80					x			x			H		S			
40.8					Drill Break																	
41.5					Joint	80	16	021			x			x			H		S			
41.6					Bedding (no break)		41	216														
42.6					Bedding (no break)		44	234														
43.1					Bedding (no break)		47	227														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-11
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment
Azimuth (Deg)	120
Inclination (Deg)	70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
43.3					Drill Break																	
44.6					Bedding (no break)		60	196														
45.8					Drill Break																	
47.6					Hammer Break																	
48.2					Vein (no break)		33	328														
48.3					Hammer Break																	
49.1					Drill Break																	
50.5					Bedding (no break)		36	228														
50.8					Drill Break																	
51.1					Bedding (no break)		41	206														
51.5					Bedding (no break)		50	222														
52.0					Drill Break																	
53.2					Drill Break																	
54.0					Drill Break																	
54.2					Bedding (no break)		56	220														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 120
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
55.2					Drill Break																
55.8					Drill Break																
58.1					Hammer Break																
59.8					Drill Break																
60.3					Drill Break																
60.8					Joint	80	26	245			x			x			H		M			O
60.8					Joint	80	30	230			x			x			H		M			O
62.4					Drill Break																
62.9					Joint	50					x			x			H		S			H
63.3					Joint	40	79	311					x	x			H		M			O
63.9					Joint	45							x	x			H		M			O
64.0					Bedding (no break)		46	234														
64.7					Drill Break																
65.8					Drill Break																
66.4					Joint	50					x				x		H		S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-11
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment
Azimuth (Deg)	120
Inclination (Deg)	70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
66.8					Drill Break																	
66.8	67.1			x	Fragmented Zone																	
67.8					Drill Break																	
68.6					Drill Break																	
69.0					Drill Break																	
70.3					Bedding (no break)		54	213														
70.4	70.8			x	Fragmented Zone																	
71.0					Bedding (no break)		49	207														
71.1					Drill Break																	
72.3					Drill Break																	
72.7					Top of Dyke (no break)		50	226														
73.5					Bedding (Drill Break)		76	272														
74.1					Bedding (Drill Break)		85	103														
75.8					Drill Break																	
76.3					Joint	45				x				x					M	x		O

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-11
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment
Azimuth (Deg)	120
Inclination (Deg)	70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
76.4					Joint	45				x				x					M	x		O
76.5					Joint	45				x				x					M	x		O
76.6					Bottom of Dyke (no break)		57	221														
76.9					Drill Break																	
77.4					Bedding (no break)		66	221														
77.6					Drill Break																	
79.8					Drill Break																	
80.3					Joint	15							x			x	H		S			
80.6					Vein (no break)		83	316														
80.8					Drill Break																	
81.4					Hammer Break																	
82.2					Drill Break																	
82.5					Vein (no break)		84	322														
83.1					Drill Break																	
83.8					Vein (no break)		85	306														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

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Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 120
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
83.9					Joint	25					x			x			H		S			
84.8					Joint	25					x			x			H		S			
85.8					Drill Break																	
87.1					Vein	30					x			x				C				
88.1					Joint	35					x			x			H		S			
89.8					Bedding (no break)		48	231														
90.0					Bedding (no break)		49	214														
90.8					Drill Break																	
91.3					Drill Break																	
91.9					Bedding (no break)		48	230														
94.1					Bedding (Drill Break)		52	223														
94.4					Bedding (no break)		55	227														
95.1					Drill Break																	
95.8					Drill Break																	
96.1					Joint	40					x			x			H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

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Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 120
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
96.6					Bedding (no break)		38	219													
96.7					Drill Break																
97.2					Drill Break																
98.4					Joint	75					x			x			H		S			
99.6					Drill Break																
99.9					Bedding (no break)		49	215													
100.4					Joint	75	57	244			x			x			H		S			
100.7					Bedding (no break)		56	219													
100.8					Drill Break																
101.1					Joint	45					x			x			H		S			
102.1					Joint	15					x			x			H		S			H
102.8					Joint	20	90	140			x			x			H		S			H
103.8					Drill Break																
104.3					Bedding (no break)		53	212													
104.6					Joint	45					x			x			H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
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Aperture:O-Open; H-Hairline (<0.5mm)

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Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 120
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
105.8					Joint	75	58	218			x			x			H		S			
107.9					Bedding (no break)		59	200														
108.6					Drill Break																	
108.8					Bedding (no break)		51	212														
110.1					Drill Break																	
110.8					Bedding (Drill Break)		63	214														
114.0					Bedding (Drill Break)		46	19														
114.7					Drill Break																	
115.8					Drill Break																	
118.2					Drill Break																	
118.5					Drill Break																	
120.3					Drill Break																	
120.8					Drill Break																	
121.3					Drill Break																	
122.4					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-11
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment
Azimuth (Deg)	120
Inclination (Deg)	70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
123.6					Hammer Break																	
125.5					Hammer Break																	
125.8					Drill Break																	
126.4					Drill Break																	
129.2					Drill Break																	
129.4					Bedding (no break)		50	232														
130.1					Hammer Break																	
130.8					Drill Break																	
133.9					Joint	40					x			x			H		S			
135.2					Hammer Break																	
135.8					Drill Break																	
136.8					Drill Break																	
138.6					Drill Break																	
139.7					Drill Break																	
140.2					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-11
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Right Abutment
Azimuth (Deg) 120
Inclination (Deg) 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
140.3					Drill Break																	
140.6					Bedding (no break)		36	248														
140.8					Drill Break																	
141.2					Bedding (no break)		70	216														
142.1					Drill Break																	
142.7					Drill Break																	
142.9					Bedding (no break)		73	220														
143.2					Drill Break																	
143.7					Bedding (no break)		74	220														
144.0					Joint	70					x			x				C	S			H
144.2					Joint	70	25	266			x			x				C	S			H
145.2					Joint	15					x			x			H	C	S			H
145.3					Joint	15					x			x			H	C	S			H
145.8					Joint	35					x			x			H	C	S			H
146.1					Joint	35	82	299			x			x			H	C	S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Right Abutment
Azimuth (Deg): 120
Inclination (Deg): 70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
146.4					Joint	30					x			x			H	C	S			H
146.5					Drill Break																	
147.1					Bedding (no break)		43	207														
149.3					Drill Break																	
149.9					Bedding (no break)		61	227														
150.0					Hammer Break																	
150.8					Drill Break																	
152.7					Drill Break																	
154.8					Drill Break																	
155.2					Joint	35					x			x			H		S			
155.4					Joint	35					x			x			H		S			
155.8					Drill Break																	
158.1					Drill Break																	
158.3					Drill Break																	
158.6					Bedding (no break)		37	199														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-11
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Right Abutment
Azimuth (Deg)	120
Inclination (Deg)	70

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
159.1					Drill Break																	
159.6					Joint	30					x			x				C	S			H
160.2					Joint	30					x			x				C	S			
160.8					Drill Break																	
164.7					Drill Break																	
165.8					Drill Break																	
167.8					Bedding (no break)		21	35														
168.6					Joint	30							x	x				C	S			H
169.1					Drill Break																	
170.0					Bedding (no break)		47	244														
170.8					End of hole																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

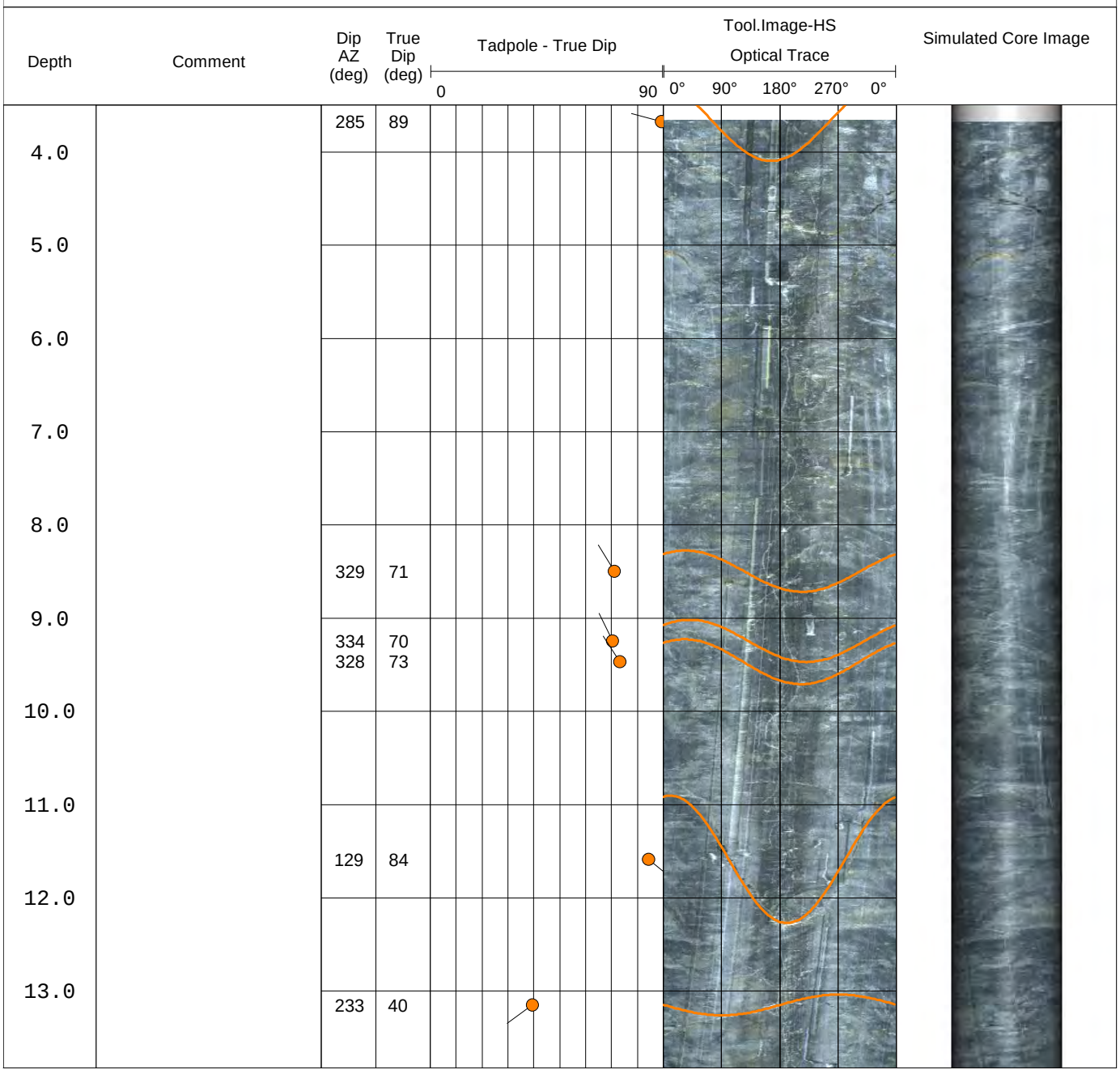
Aperture:O-Open; H-Hairline (<0.5mm)

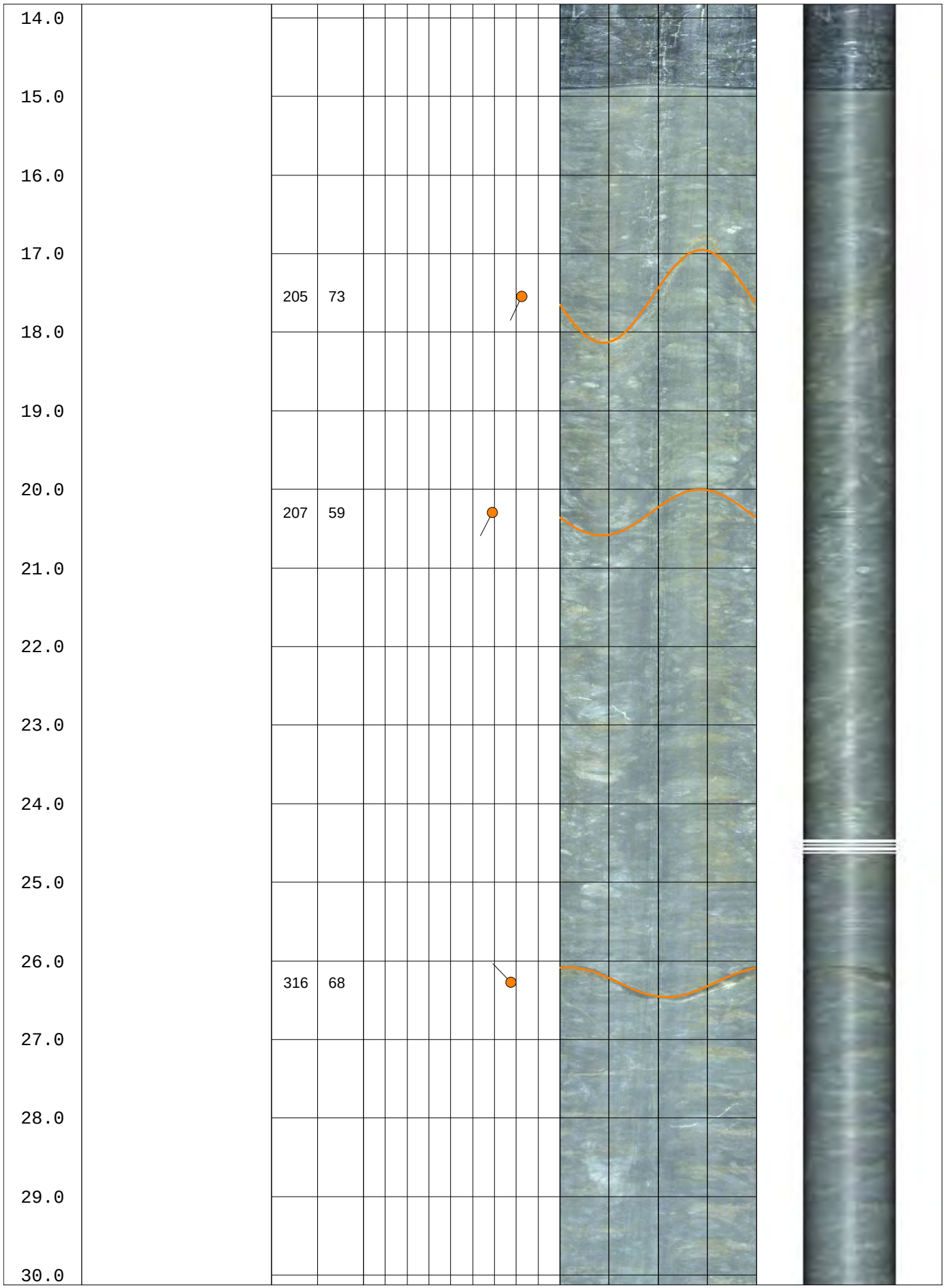
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company City and Borough of Sitka	
	Location: Sitka, AK	
	Project: Blue Lake Hydroelectric	
Date Logged:	September 28, 2009	Borehole ID: DH09-11
File Name:	DH09-11-2.wcl	Logged By: Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from high side.

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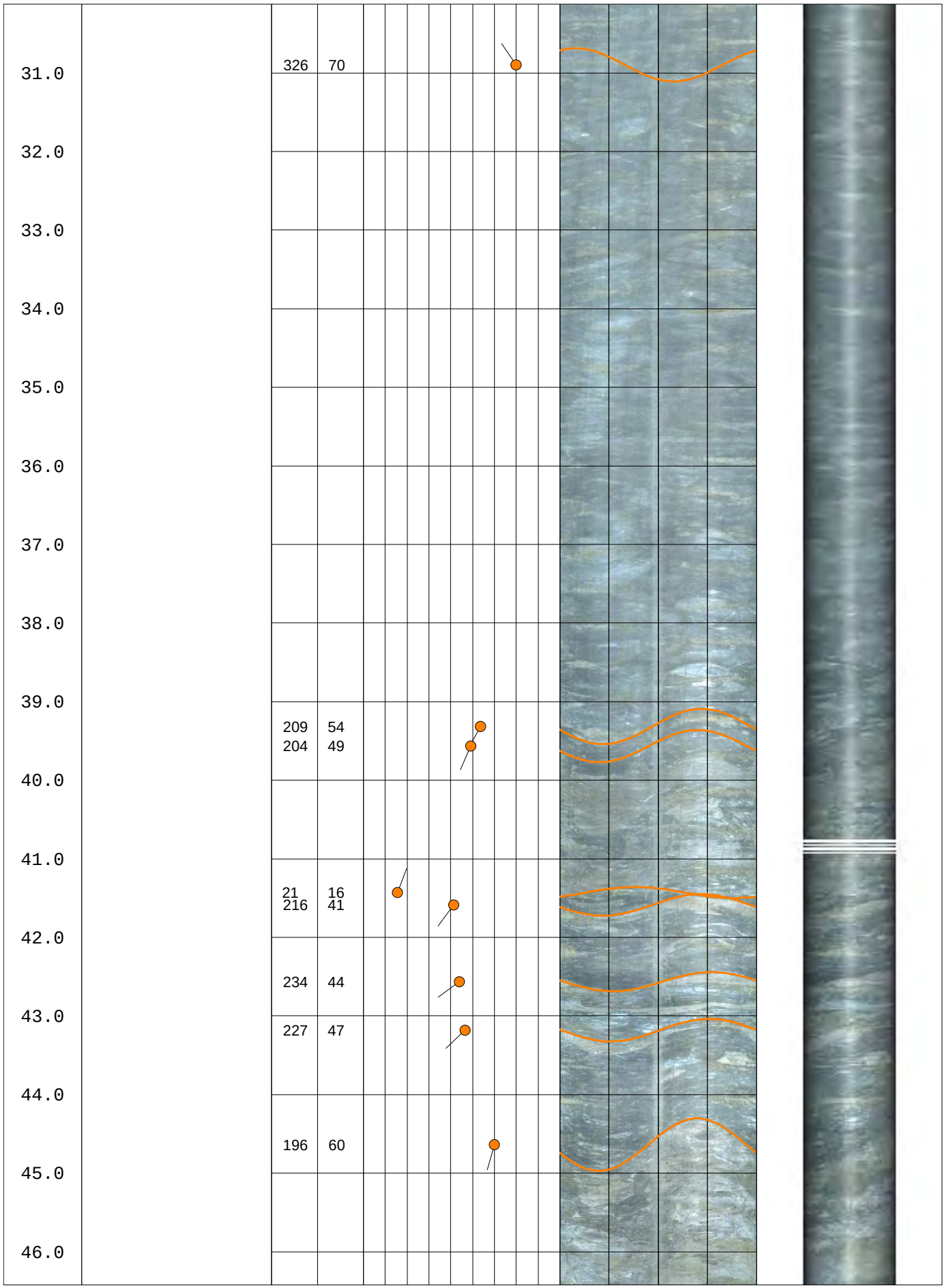
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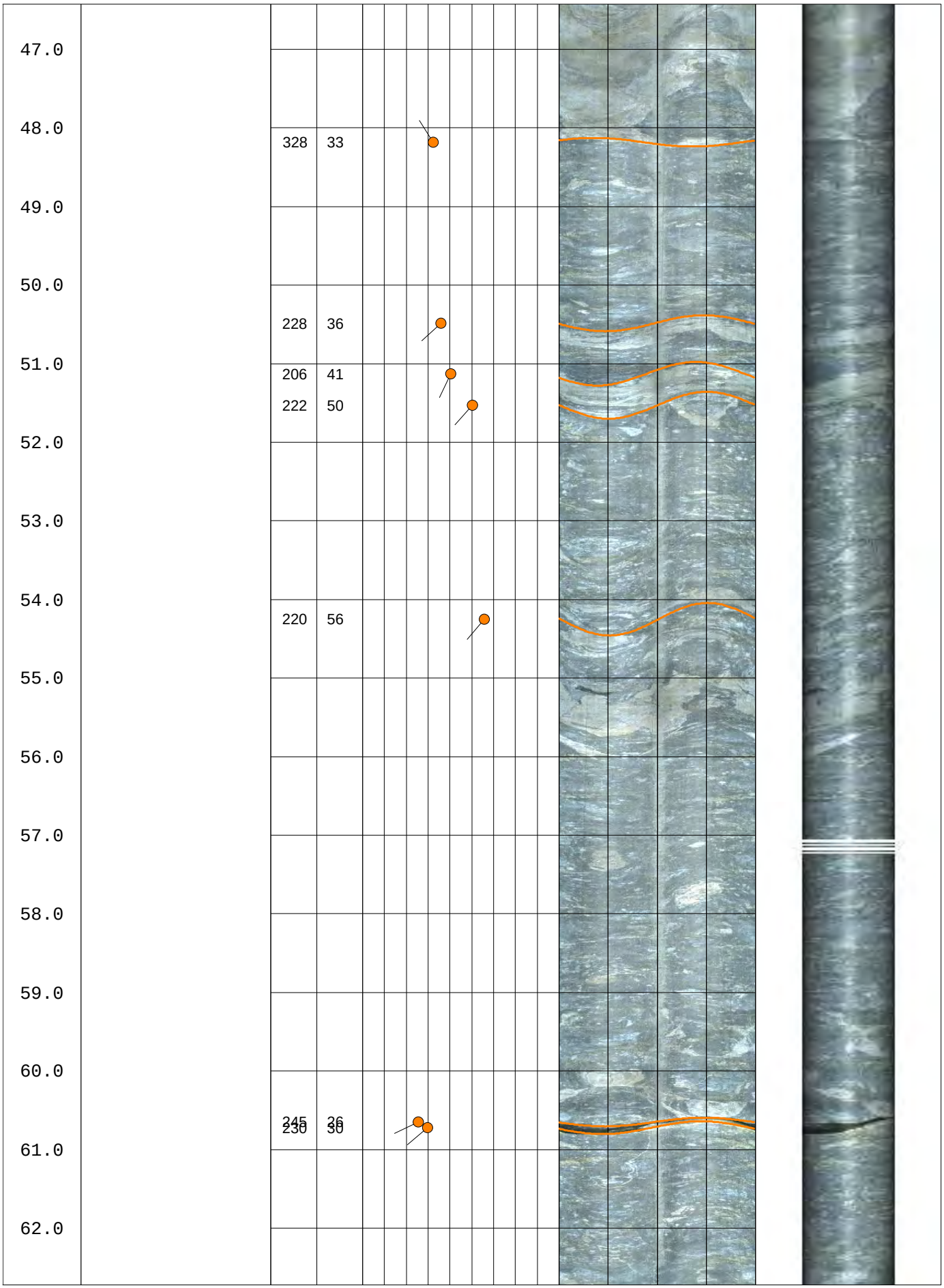
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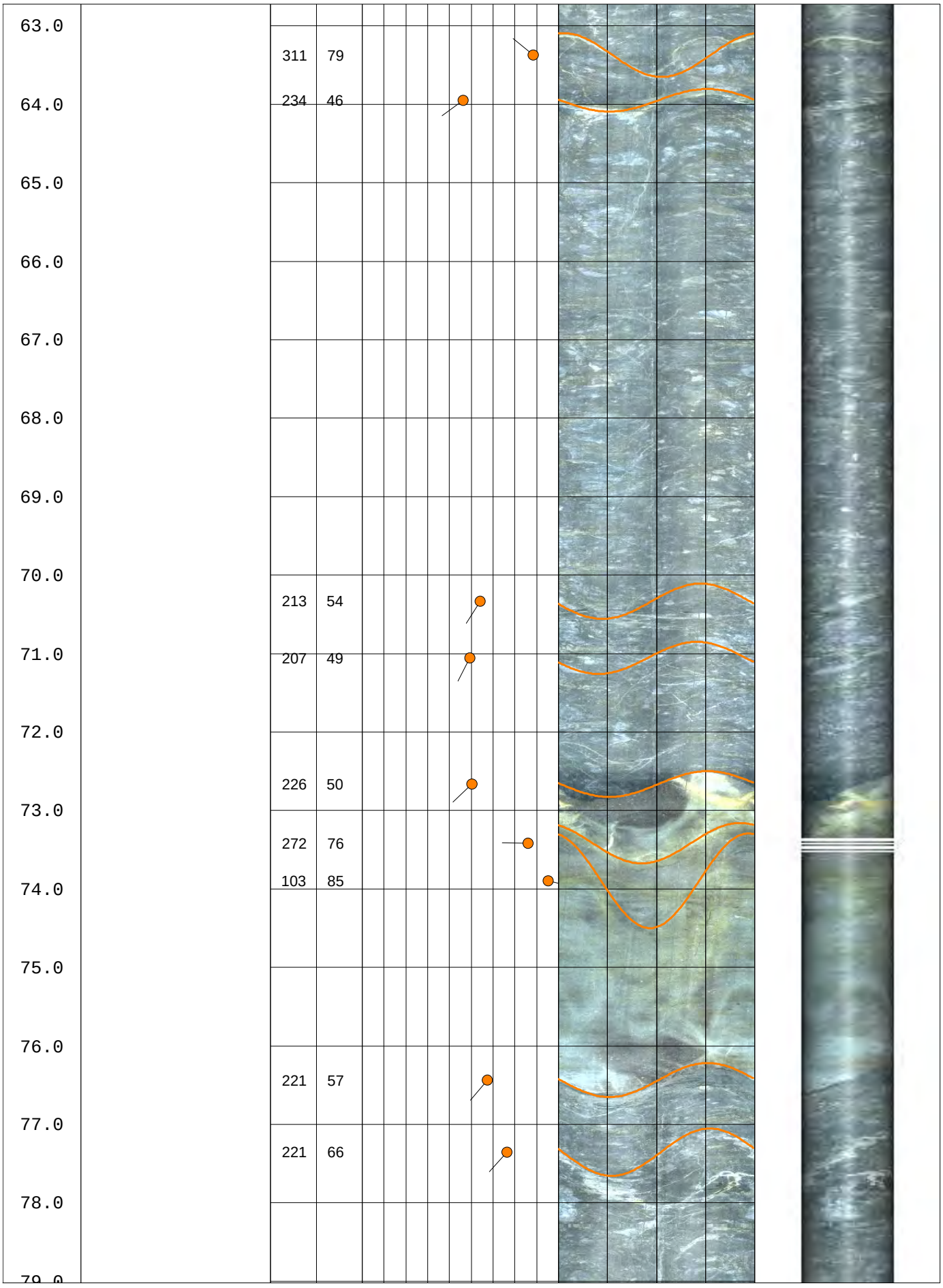
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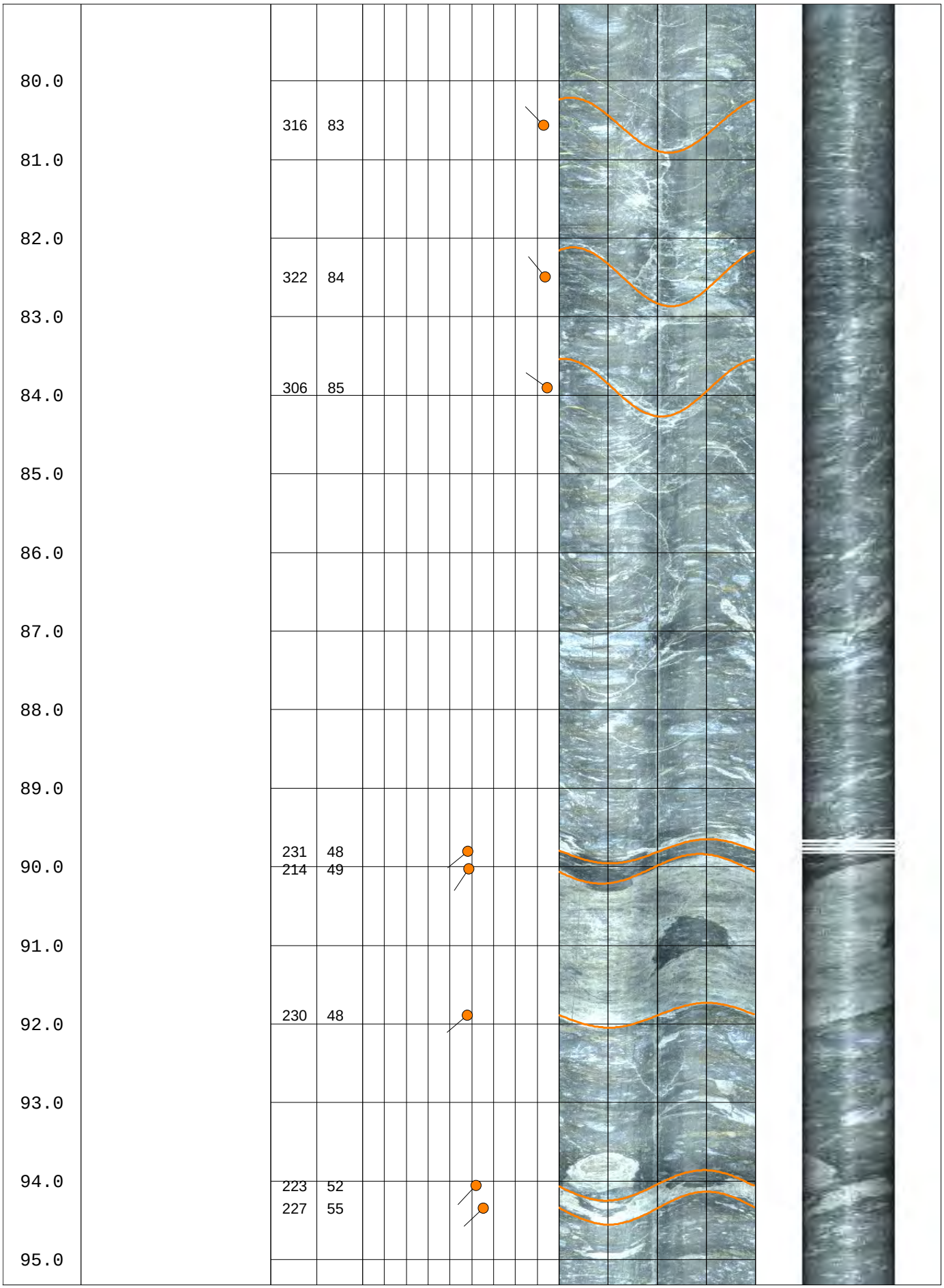
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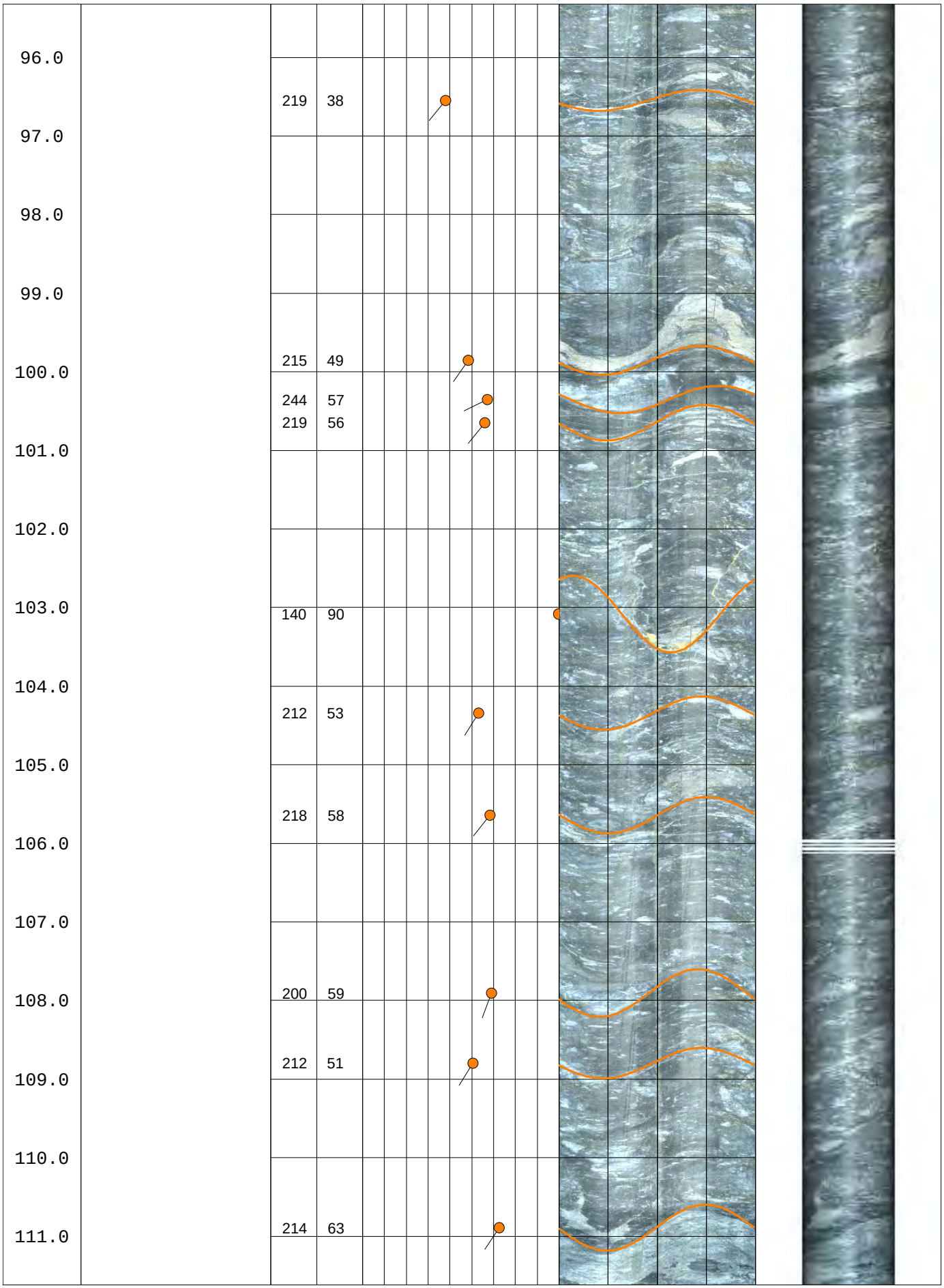
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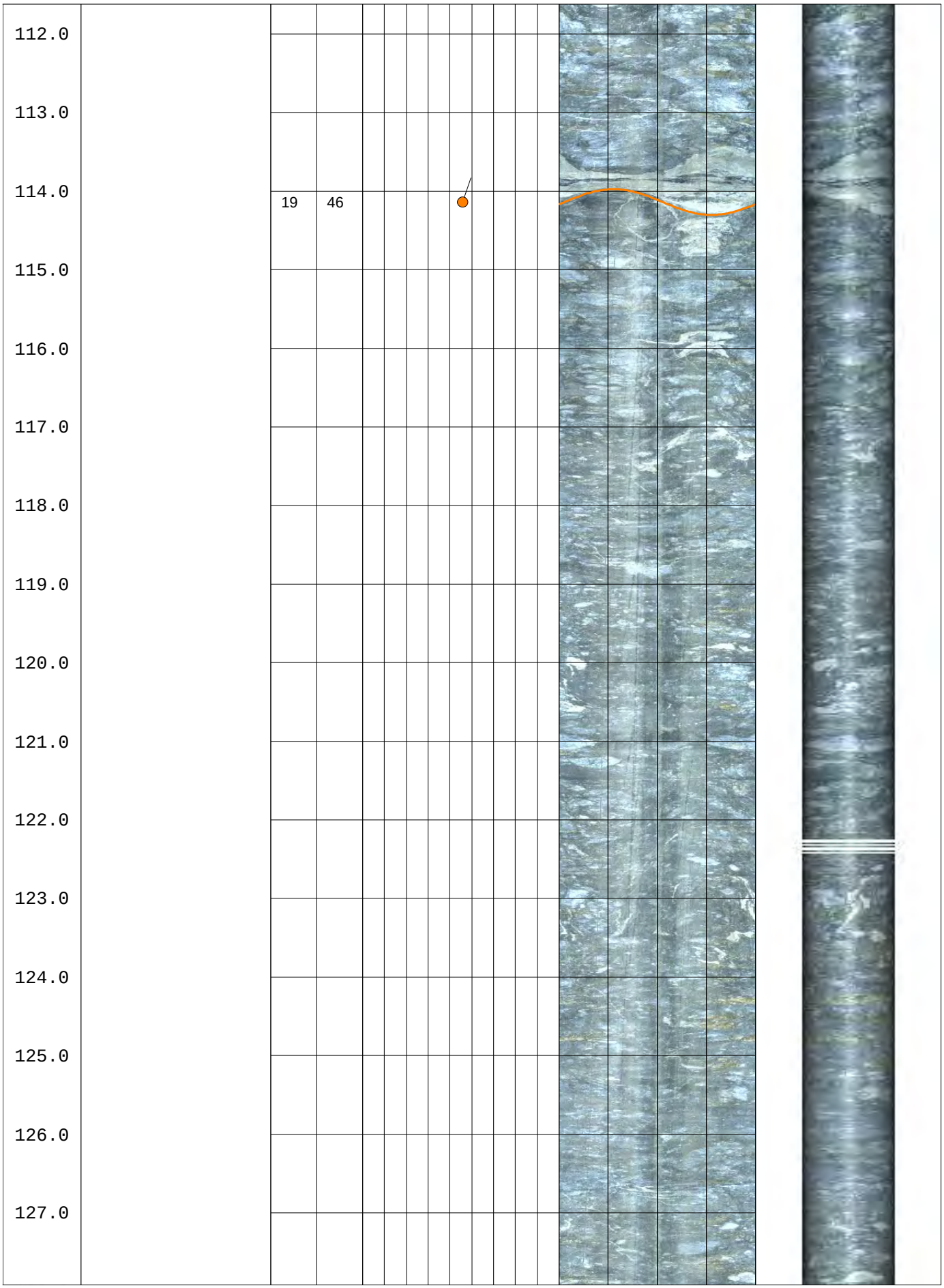
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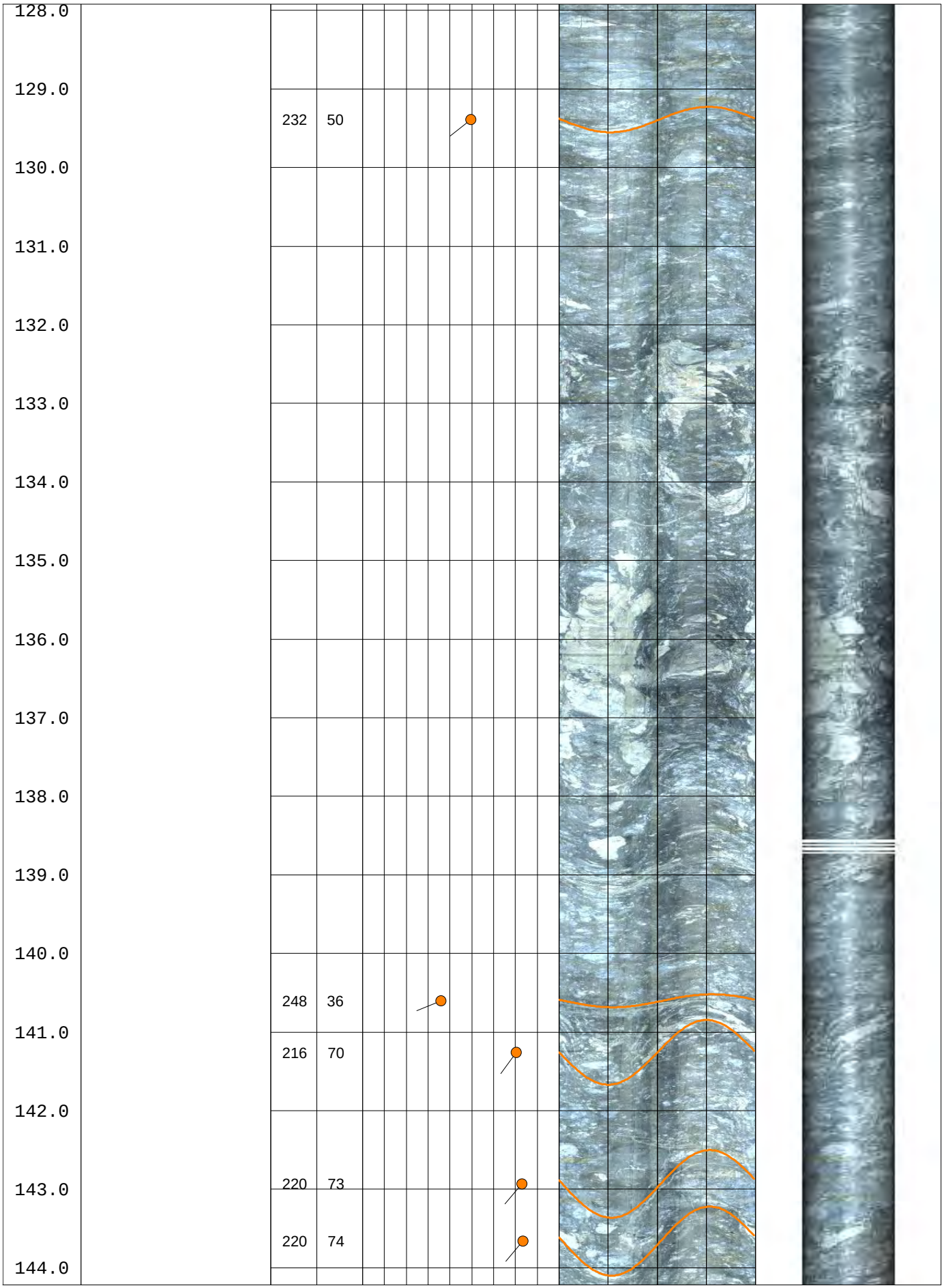
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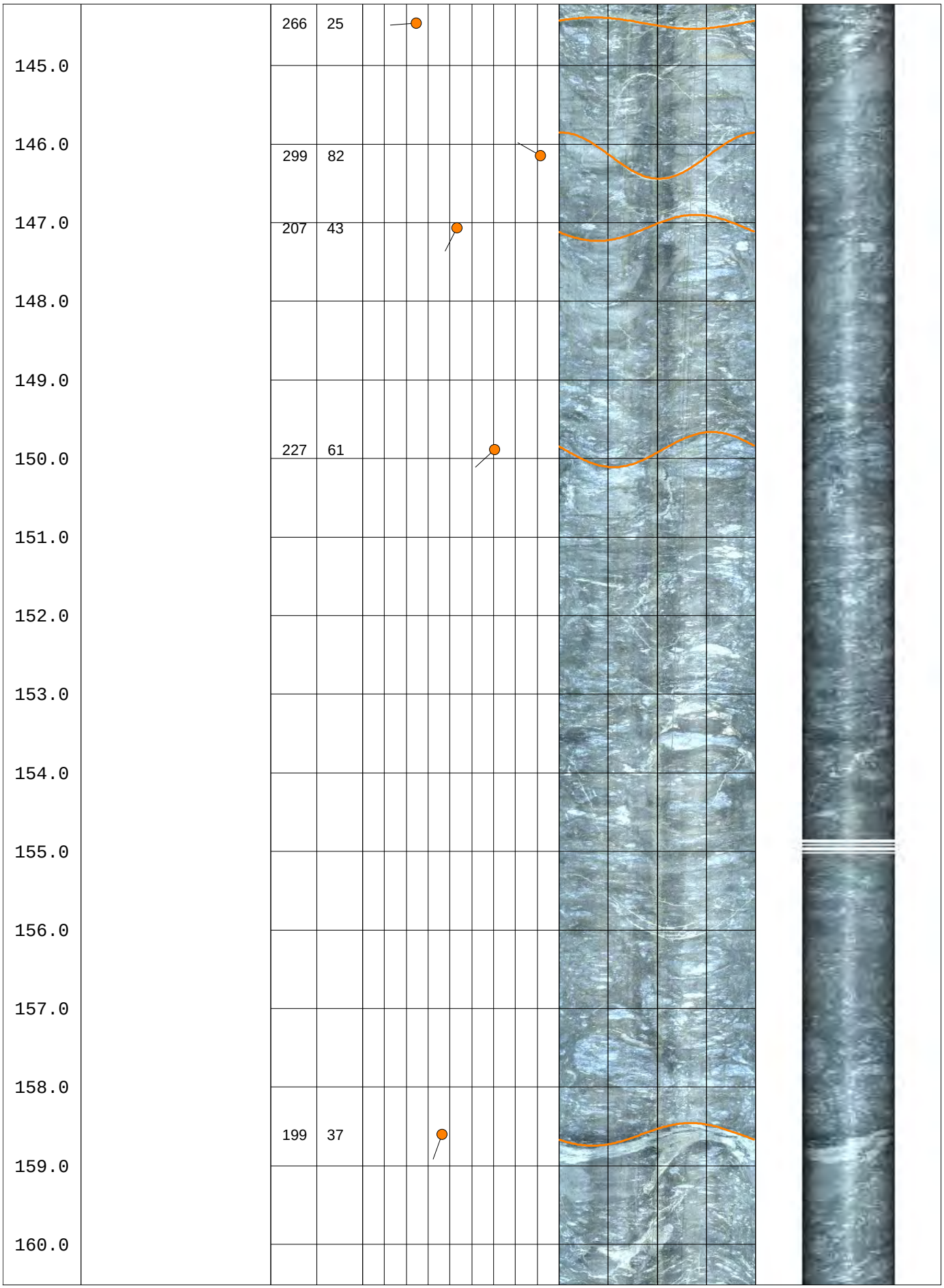
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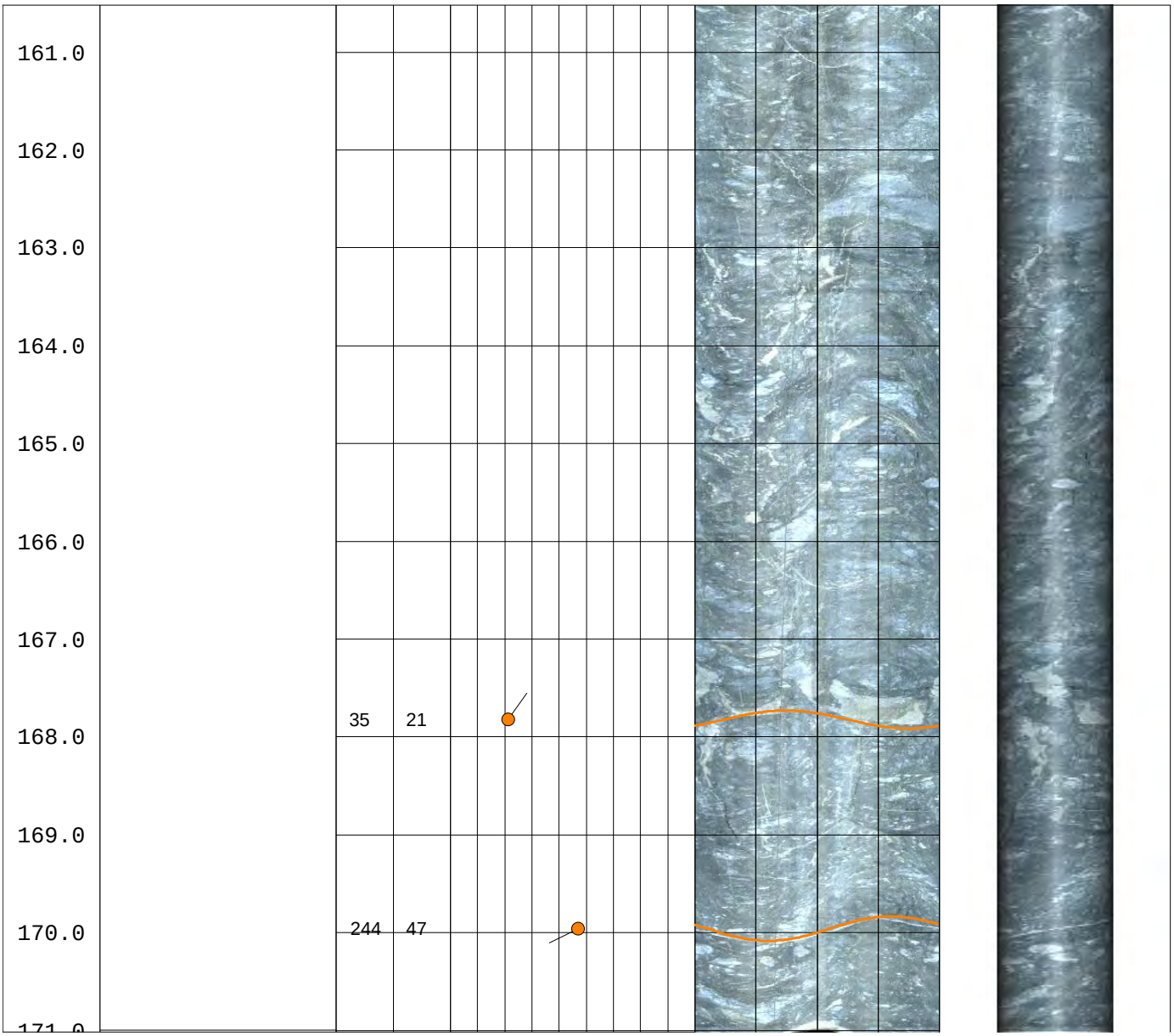
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35
21
244
47

Borehole DH09-12

Working Together SAFELY

© Hatch 2006/03 ⌘

BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-12***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 8

SITE: Intake Tower

COORDINATES: 1913192.6 N, 2380627.0 E
DIP DIRECTION: 060
DIP: 60

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 413.1
END OF HOLE: 308.6

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 4500
METHOD SOIL: Diamond Drill Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 9/30/09
FINISHED: 9/30/09
INSPECTOR: P. Nolan
LOGGED BY: M. Mammoliti
REVIEWED: P. Friz

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN.) (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
413.1													
0.0		0.0 - 5.9 ft: Overburden 0.0 - 1.7 ft: Soil and woody debris 1.7 - 5.9 ft: Large boulder						1.0 2.0 3.0 4.0 5.0					
		5.9 ft TOP OF BEDROCK see next sheet						6.0 7.0 8.0 9.0					

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT (W_P) NATURAL MOISTURE CONTENT (W_N) LIQUID LIMIT (W_L)

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-12**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
408.0 5.9		5.9 - 31.0 ft: Metamorphosed Carbonaceous Andesitic Siltstone Grey-black, fine grained, strong (50 - 100 MPa), turbulent light/dark flow banding; some calcite veinlets throughout and wider veins; Iron staining on joint surfaces; Average discontinuity spacing of 1.0 ft: RMR = 45 - 63; GSI = 60 - 65. Removed samples @ depths of 23.4 ft and 25.9 ft for ARD COMP 5.		5.9 - 12.9 ft: FRAGMENTED ZONE The following general discontinuity characteristic were noted for this hole: 74% of the discontinuities are smooth,5% are slightly rough and 21% are rough. 92% of the discontinuities are planar, 8% are irregular. 95% of the discontinuities have hematite staining, 99% are slightly weathered, and 1% are moderately weathered. 16 - 16.5 ft: FRAGMENTED ZONE 19.4 - 20.3 ft: FRAGMENTED ZONE 20.7 - 21.1 ft: FRAGMENTED ZONE 21.8 - 22.1 ft: FRAGMENTED ZONE 22.6 - 22.9 ft: FRAGMENTED ZONE 24.5 - 24.8 ft: FRAGMENTED ZONE		2	30	0	6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25	RECOVERY AND RQD (%) 20 40 60 80 PERMEABILITY (lugeons) 0.1 1 10 100 (cm/sec) No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						3	64	64					
						4	100	68					
						5	100	72					

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-12**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 8

ELEV. / DEPTH (ft)	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)
			27.2 - 27.5 ft: FRAGMENTED ZONE		6	100	92
386.3 / 31.0	31.0 - 44.3 ft: Metamorphosed/Fragmental Andesitic Siltstone Light/dark grey, fine grained, very strong (100 - 200 MPa), strong flow banding; some calcite veinlets throughout and wider veins; Iron staining on joint surfaces; Average discontinuity spacing of 1.0 ft; RMR = 66 - 69; GSI = 60 - 65.		31.4 -31.6 ft: FRAGMENTED ZONE 31.9 - 32.2 ft: FRAGMENTED ZONE 34.7 - 35.0 ft: FRAGMENTED ZONE		7	100	84
			38.7 - 39.2 ft: FRAGMENTED ZONE		8	100	90
					9	100	100
374.7 / 44.3	44.3 - 76.4 ft: Metamorphosed Carbonaceous Andesitic Siltstone						

RECOVERY AND RQD (%) — 20 40 60 80

PERMEABILITY (lugeons) — 0.1 1 10 100

(cm/sec) — No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

NOTES

PIEZOMETER INSTALLATION

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

Project: **H-332360**

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-12**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		Strong (50 - 100 MPa); iron staining on joints surfaces; Average discontinuity spacing of 1.1 ft; RMR = 66 - 70; GSI = 60 - 65. ~30 g removed @ depths 52.3 ft, 60.7 ft and 76.2 ft for sample ARD COMP 5.				10	100	98	46 47 48 49 50	20 40 60 80	0.1 1 10 100 (cm/sec); No take; 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						11	100	94	51 52 53 54 55				
						12	100	94	56 57 58 59 60				
		64.2 ft: 4mm wide Calcite Vein @ 45 deg to core axis				13	100	100	61 62 63 64 65				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-12**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
346.9 / 76.4		76.4 - 85.1 ft: Metamorphosed/Fragmental Andesitic Siltstone Very strong (100 - 250 MPa); Average discontinuity spacing of 0.9 ft; RMR = 69 - 74; GSI = 60 - 65.				14	100	100	66				
									67				
									68				
									69				
									70				
						15	100	100	71				
									72				
									73				
									74				
									75				
						16	100	98	76				
									77				
									78				
									79				
									80				
						17	100	100	81				
									82				
									83				
									84				
339.4 / 85.1									85				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

PERMEABILITY (cm/sec): No take, 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-12**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		85.1 - 106.3 ft: Metamorphosed Carbonaceous Andesitic Siltstone Strong (50 - 100 MPa); Average discontinuity spacing of 0.9 ft; RMR = 63 - 64; GSI = 60 - 65 86.8 ft: 12mm wide Calcite Vein @ 45 deg to core axis ~30 g removed @ depths of 89.7 ft and 104.3 ft for sample ARD COMP 5. 93.7 ft: 5mm wide Calcite Vein @ 45 deg to core axis 98.4 ft: 10mm wide Calcite Vein @ 45 deg to core axis 103.3 ft: 5mm wide Calcite Vein @ 45 deg to core axis		89.6 - 90.7 ft: FRAGMENTED ZONE		18	100	78	86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105	20 40 60 80	No take 0.1 1 10 100 (cm/sec) 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						19	100	96					
						20	100	98					
						21	100	100					

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-12**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 7 **OF:** 8

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
321.0									106	20 40 60 80	0.1 1 10 100 / No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
106.3		106.3 - 120.7 ft: Metamorphosed Fragmental Andesitic Siltstone Very strong (100 - 250 MPa); Average discontinuity spacing of 2.9 ft; RMR = 65 - 82; GSI = 65 - 70 109.4 ft: 4mm wide Calcite Vein @ 45 deg to core axis 110.1 ft: 5mm wide Calcite Vein @ 45 deg to core axis				22	100	98	107 108 109 110				
						23	100	100	111 112 113 114 115				
		117.9 ft: 8mm wide Calcite Vein @ 45 deg to core axis				24	100	94	116 117 118 119				
308.6				120.5 - 120.7 ft: FRAGMENTED ZONE					120				
120.7				**END OF BOREHOLE**									

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

Project: H-332360

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-12

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 8 **OF:** 8

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at 40 ft below the hole collar on October 1, 2009.
7 RMR (Rock Mass Rating) estimation based on visual assessments of exposed outcrops, drill core and laboratory test results on rock and core samples in the vicinity of the intake tunnel, north portal of the lower tunnel and surge chamber as outlined in Bieniawski (1989).
8 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
9 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-12
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
5.9	12.9			x	Fragmented zone																
14.3					Joint	60					x			x			H		s			
14.5					Joint	45					x			x			H		s			
15.4					Joint	35					x			x			H		s			
15.7					Drill Break																	
16.0	16.5			x	Fragmented zone																
17.2					Joint	45					x			x			H		s			
17.4					Joint	45					x			x			H		s			
17.8					Joint	60					x			x			H		s			H
18.1					Joint	30					x			x			H		s			
18.6					Hammer Break																	
19.0					Joint	70	36	031			x			x			H		s			
19.4	20.3			x	Fragmented zone																
19.8					Joint		27	015														
20.7					Bedding		86	220														
20.7	21.1			x	Fragmented zone																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
21.6					Bedding (no break)		59	215													
21.8	22.1			x	Fragmented zone																
22.1					Bedding		68	214													
22.6	22.9			x	Fragmented zone																
23.2					Joint	45						x		x			H		s			H
23.5					Joint	80					x					x	H		s			O
23.6					Joint	80					x					x	H		s			O
24.0					Joint	80					x					x	H		s			O
24.2					Drill Break																
24.3					Drill Break																
24.5	24.8			x	Fragmented zone																
25.3					Joint	70					x			x			H		s			O
25.7					Drill Break																
25.9					Drill Break																
26.0					Joint	45					x			x			H		s			O
26.3					Joint	80							x	x			H		s			O

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
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Drilling Report (Discontinuities)

Borehole: DH09-12
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
26.4					Joint	70							x	x			H		s			H
26.7					Joint	45							x	x			H		s			H
27.2					Joint		85	080														
27.2	27.5			x	Fragmented zone																	
28.3					Joint	45							x	x			H		s			H
28.5					Drill Break																	
29.2					Drill Break																	
29.3					Joint	40					x			x			H		s			O
29.7					Drill Break																	
30.7					Drill Break																	
31.0					Joint	15	33	022			x			x			H		S			O
31.4	31.6			x	Fragmented zone																	
31.9	32.2			x	Fragmented zone																	
32.2					Joint	45					x			x			H		S			H
32.5					Joint	80	67	224			x			x			H		S			H
33.1					Joint	45					x			x			H		S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
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Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
33.4					Drill Break																
33.9					Bedding		73	219													
34.1					Joint	45							x	x			H		S		H
34.4					Bedding		69	252													
34.7	35.0			x	Fragmented zone																
35.1					Drill Break																
35.2					Drill Break																
35.7					Calcite Vein (Drill Break)		14	333													
35.9					Drill Break																
36.3					Drill Break																
37.6					Drill Break																
38.2					Joint	30					x			x				C	S			H
38.7	39.2			x	Fragmented zone																
39.6					Drill Break																
39.7					Joint	40							x			x	H		S		
40.7					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

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Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
40.8					Drill Break																
41.3					Drill Break																
41.7					Drill Break																
42.3					Joint	35					x			x			H		S			H
42.7					Drill Break																
43.0					Bedding (Hammer Break)		69	198													
43.3					Hammer Break																
43.6					Drill Break																
43.9					Drill Break																
44.0					Drill Break																
44.3					Joint	40					x			x			H		S			H
44.9					Joint	45						x		x			H		S			
45.2					Joint	50					x			x			H		S			H
45.7					Drill Break																
46.6					Drill Break																
47.7					Joint	60	77	219			x			x			H		S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-12
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
48.0					Joint	50					x			x			H		S			H
48.1					Joint	60					x			x			H		S			H
49.1					Bedding (no break)		83	236														
49.4					Joint	40					x			x			H		S			H
50.0					Bedding (Drill Break)		81	236														
50.4					Drill Break																	
50.7					Drill Break																	
51.7					Joint	80							x	x			H		S			
51.9					Joint	80							x	x			H		S			
52.3					Joint	40	79	214			x			x			H		S			H
52.4					Joint	40					x			x			H		S			H
52.9					Joint	35	70	209			x			x			H		S			H
53.0					Drill Break																	
53.5					Bedding (no break)		68	196														
53.9					Drill Break																	
54.8					Joint	35					x			x			H		S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
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Drilling Report (Discontinuities)

Borehole: DH09-12
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
55.7					Drill Break																
56.3					Drill Break																
57.0					Drill Break																
57.4					Bedding (Drill Break)		19	123													
57.8					Joint	30					x			x			H	C	S			H
58.0					Joint	45							x	x			H		S			
58.7					Joint	40							x	x			H	C	S			
59.8					Joint	30					x			x			H		S			H
60.2					Bedding (no break)		43	211													
60.7					Drill Break																
61.6					Drill Break																
61.7					Joint	45							x			x	H		S			
62.8					Joint	30	88	101			x			x			H		S			H
63.3					Vein (no break)		38	304													
63.6					Drill Break																
64.0					Bedding (no break)		51	313													

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Intake Tower
Azimuth (Deg): 65
Inclination (Deg): 60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
64.5					Joint	35	77	290			x			x			H		S			H
65.7					Drill Break																	
65.9					Bedding (no break)		61	195														
66.1					Joint	60					x			x			H		S			H
66.5					Joint	25	88	114			x			x			H		S			H
67.9					Drill Break																	
68.1					Bedding (no break)		60	188														
68.8					Joint	55						x		x			H		S			
70.7					Drill Break																	
71.8					Joint	30	88	275			x			x			H		S			H
72.2					Hammer Break																	
72.5					Drill Break																	
72.6					Joint	40	82	217			x			x			H		S			H
73.5					Drill Break																	
73.8					Joint	45	21	003					x			x	H		S			
74.1					Bedding (no break)		76	210														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

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S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

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Drilling Report (Discontinuities)

Borehole: DH09-12
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
74.8					Drill Break																
75.4					Joint	60					x			x			H		S			H
75.7					Drill Break																
76.1					Bedding (Drill Break)		61	214													
76.2					Joint	55					x			x			H		S			H
76.4					Joint	60					x			x			H		S			H
76.7					Joint	45					x			x			H		S			H
77.2					Joint	45							x			x	H		S			
77.2	78.6				Joint	10							x	x			H		S			
79.1					Joint	75					x			x			H		S			
79.5					Joint	45							x	x			H		S			
80.1					Joint	55					x			x			H		S			
80.7					Joint	60	46	177			x			x			H		S			
81.7					Drill Break																
82.1					Joint	35	80	188			x			x			H		S			
82.7					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

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Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
83.4					Calcite Vein (Drill Break)		18	188														
83.6					Drill Break																	
83.9					Drill Break																	
84.7					Drill Break																	
85.2					Joint	20					x			x			H		S			
85.7					Drill Break																	
86.0					Drill Break																	
86.4					Joint	55	23	029			x			x			H		S			
86.8					Vein (no break)	40	59	313														
87.5					Drill Break																	
88.5					Joint	45	50	311			x			x			H		S			
89.2					Joint	75					x			x			H		S			
89.6	90.7			x	Fragmented zone																	
92.4					Joint	40					x			x			H		S			
93.4					Bedding (no break)		40	308														
93.5					Joint	45					x			x			H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

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Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
94.0					Joint	55					x			x			H		S			
94.3					Joint	55	26	007			x			x			H		S			
94.9					Drill Break																	
95.0					Joint	55					x			x			H		S			
95.2					Joint	55					x			x			H		S			
95.7					Joint	15	51	031			x			x			H		S			
95.8					Vein (no break)		64	323														
97.2					Joint	85	16	006					x	x			H		S			H
97.3					Joint	45							x	x			H		S			H
97.7					Joint	45					x			x			H		S			O
98.5					Drill Break																	
98.9					Joint	45					x			x			H		S			O
99.5					Calcite Vein	85					x			x				C	S			H
100.2					Drill Break																	
100.7					Drill Break																	
101.5					Joint	45					x			x					S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

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Drilling Report (Discontinuities)

Borehole: DH09-12
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
102.0					Joint	45					x			x				C	S			H
102.4					Joint	45						x		x			H		S			H
103.6					Joint	40						x		x			H		S			H
104.4					Joint	45					x			x			H		S			O
105.4					Drill Break																	
105.7					Joint	45					x			x			H		S			O
106.0					Joint	45					x			x			H		S			O
106.8					Joint	50					x			x			H		S			O
107.0					Joint	20					x			x			H		S			O
107.9					Drill Break																	
109.4					Vein (no break)		62	292														
110.0					Vein (no break)		37	323														
110.7					Drill Break																	
115.7					Drill Break																	
117.2					Vein (no break)		70	288														
117.6					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

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Drilling Report (Discontinuities)

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Site	Intake Tower
Azimuth (Deg)	65
Inclination (Deg)	60

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
118.0					Vein (no break)		19	008														
119.9					Joint	30							x	x			H		S			O
120.4					Joint	30							x	x			H		M			O
120.5	120.7			x	Fragmented zone																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

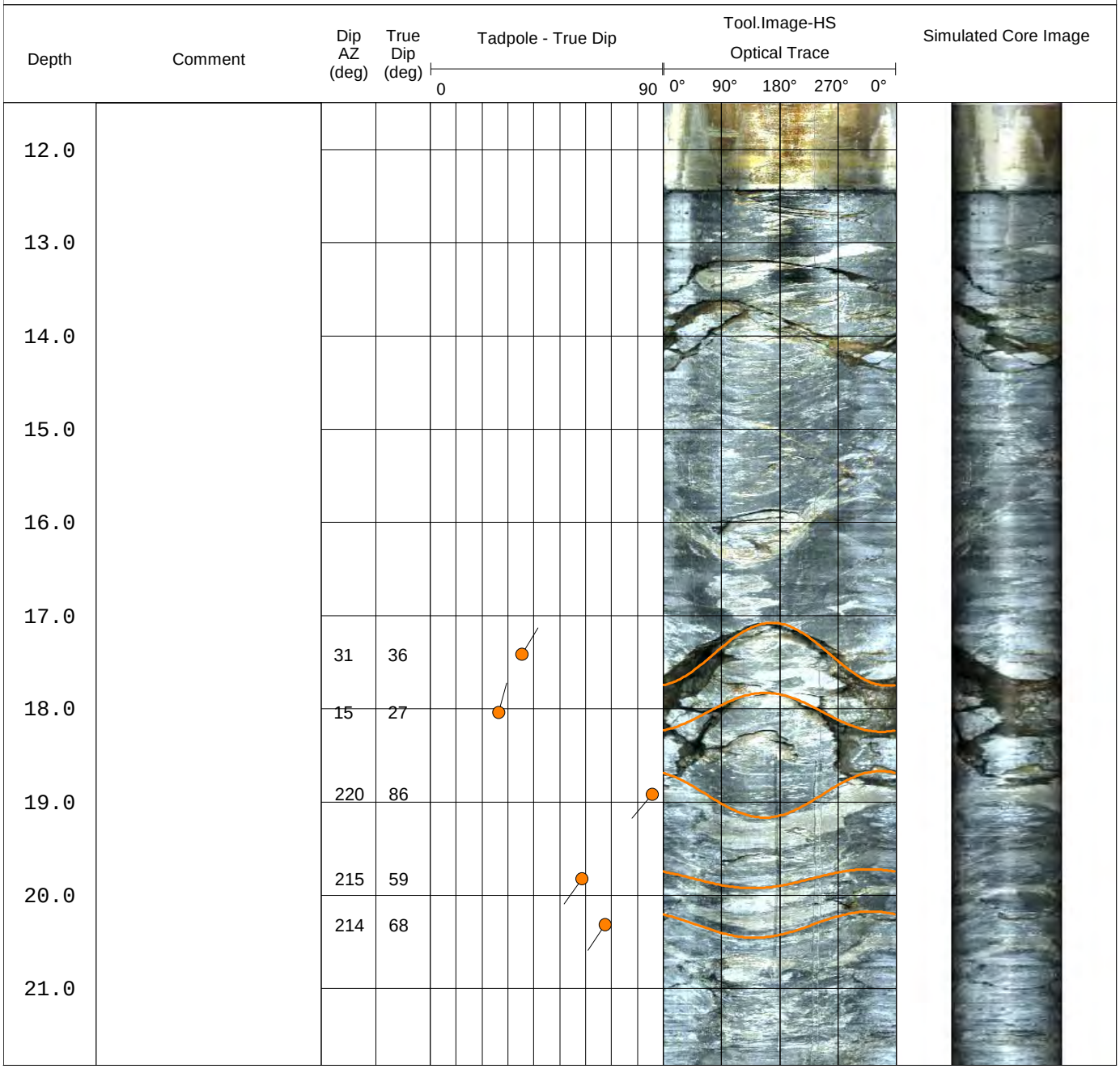
Healed:P-Partially Healed; H-Healed

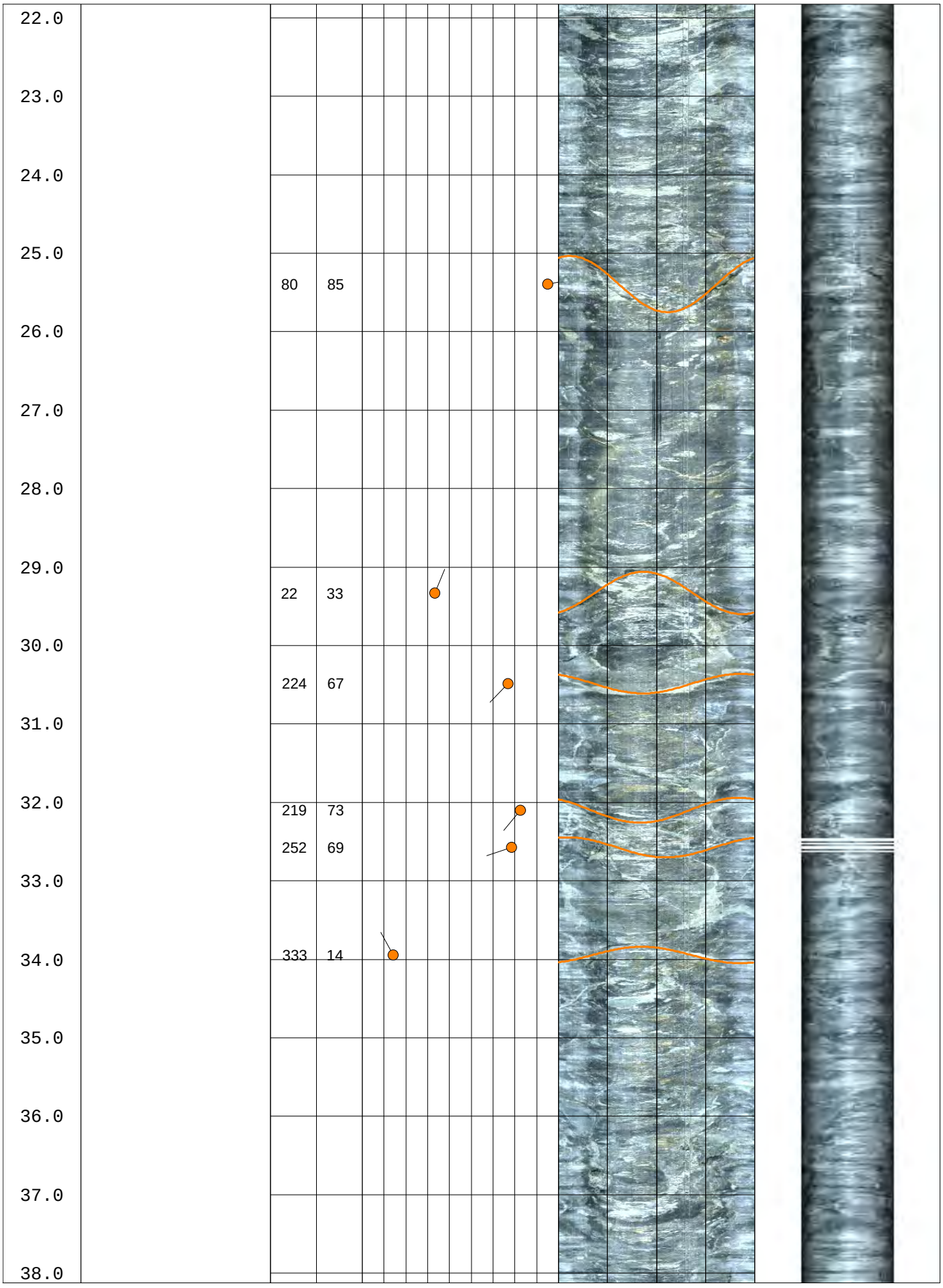
COBL
CRUX Oriented Borehole Logging

Company	City and Borough of Sitka
Location:	Sitka, AK
Project:	Blue Lake Hydroelectric
Date Logged:	October 2, 2009
Borehole ID:	DH09-12
File Name:	DH09-12-1M.wcl
Logged By:	Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from high side.

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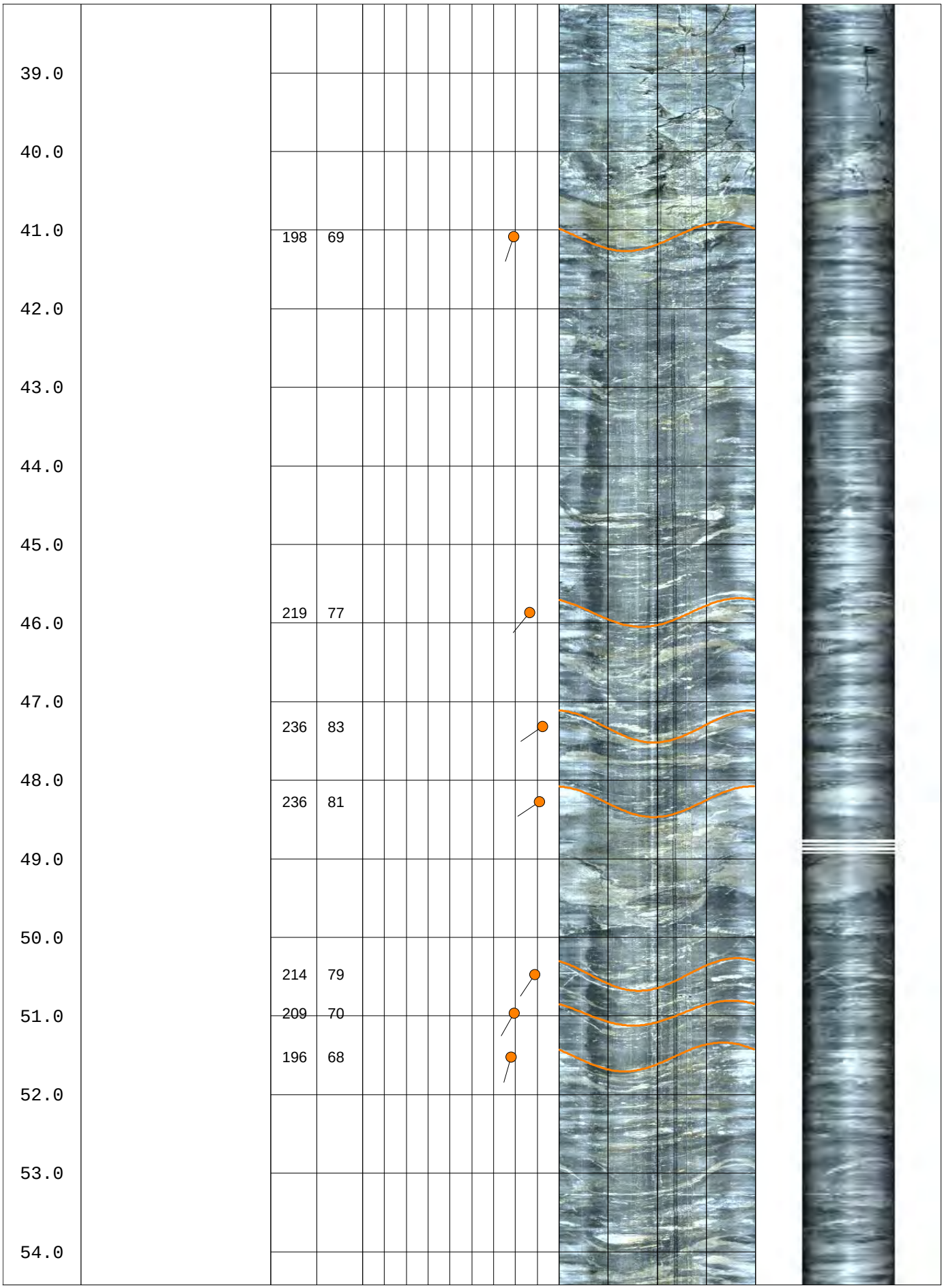
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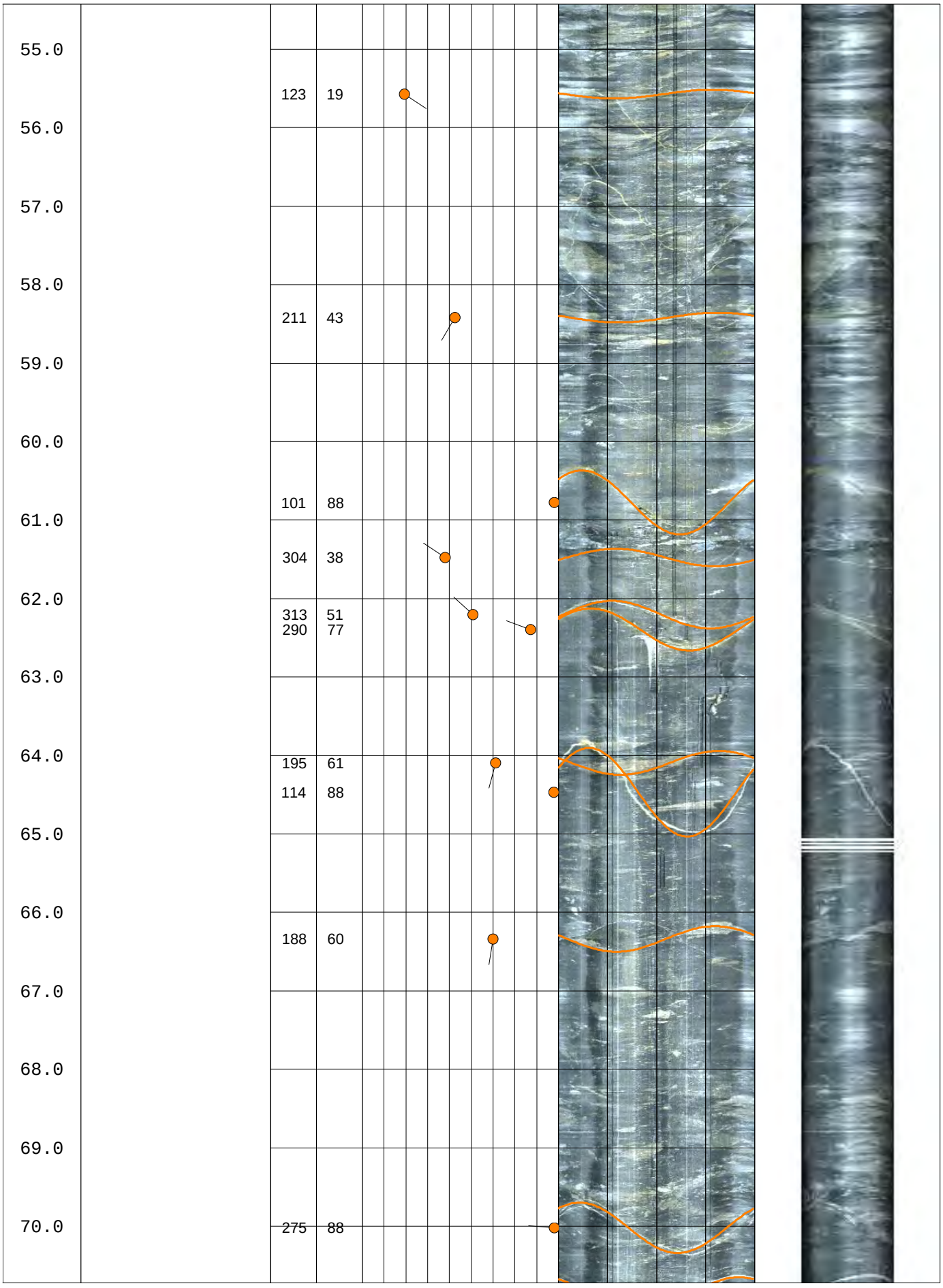
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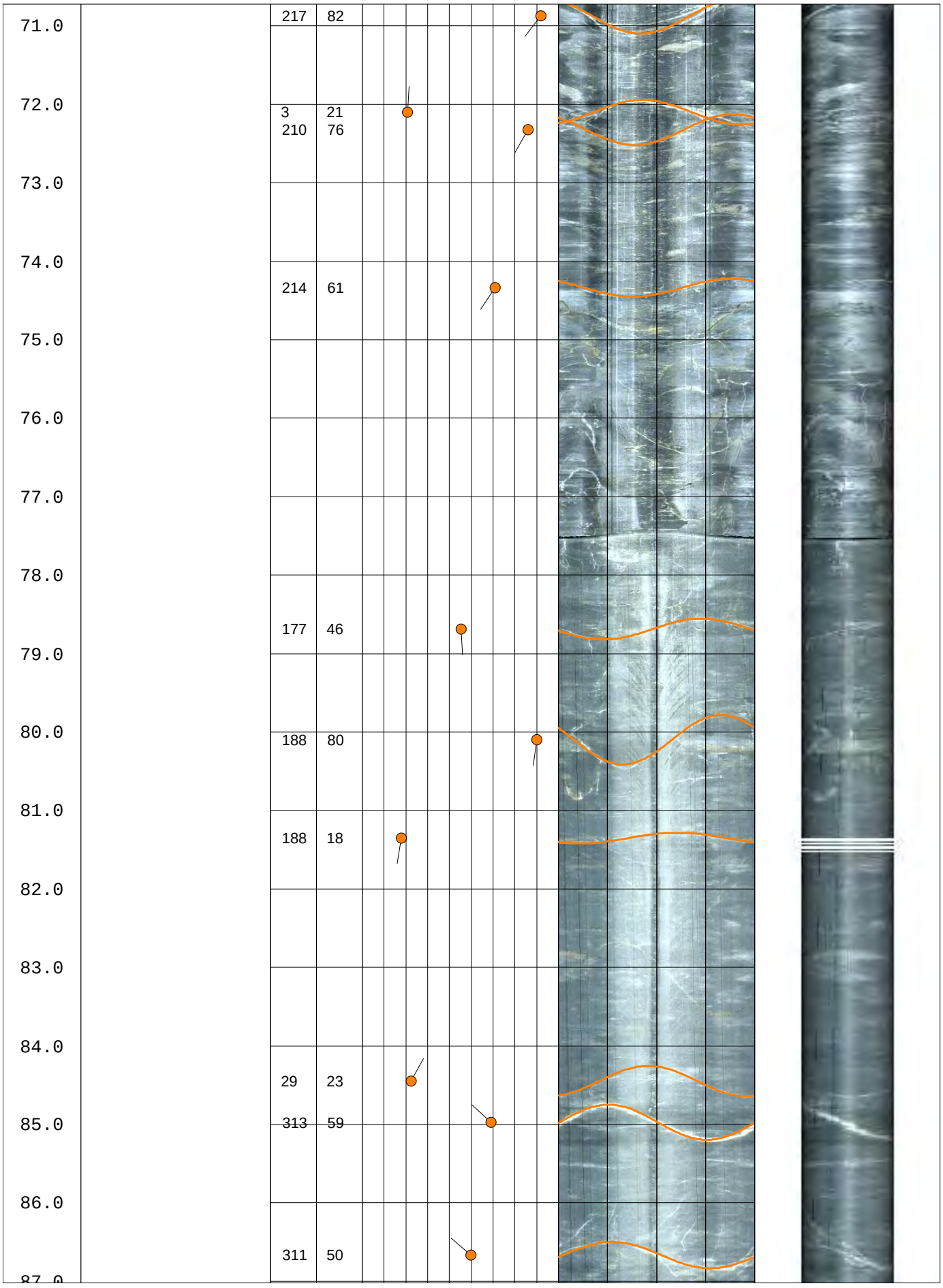
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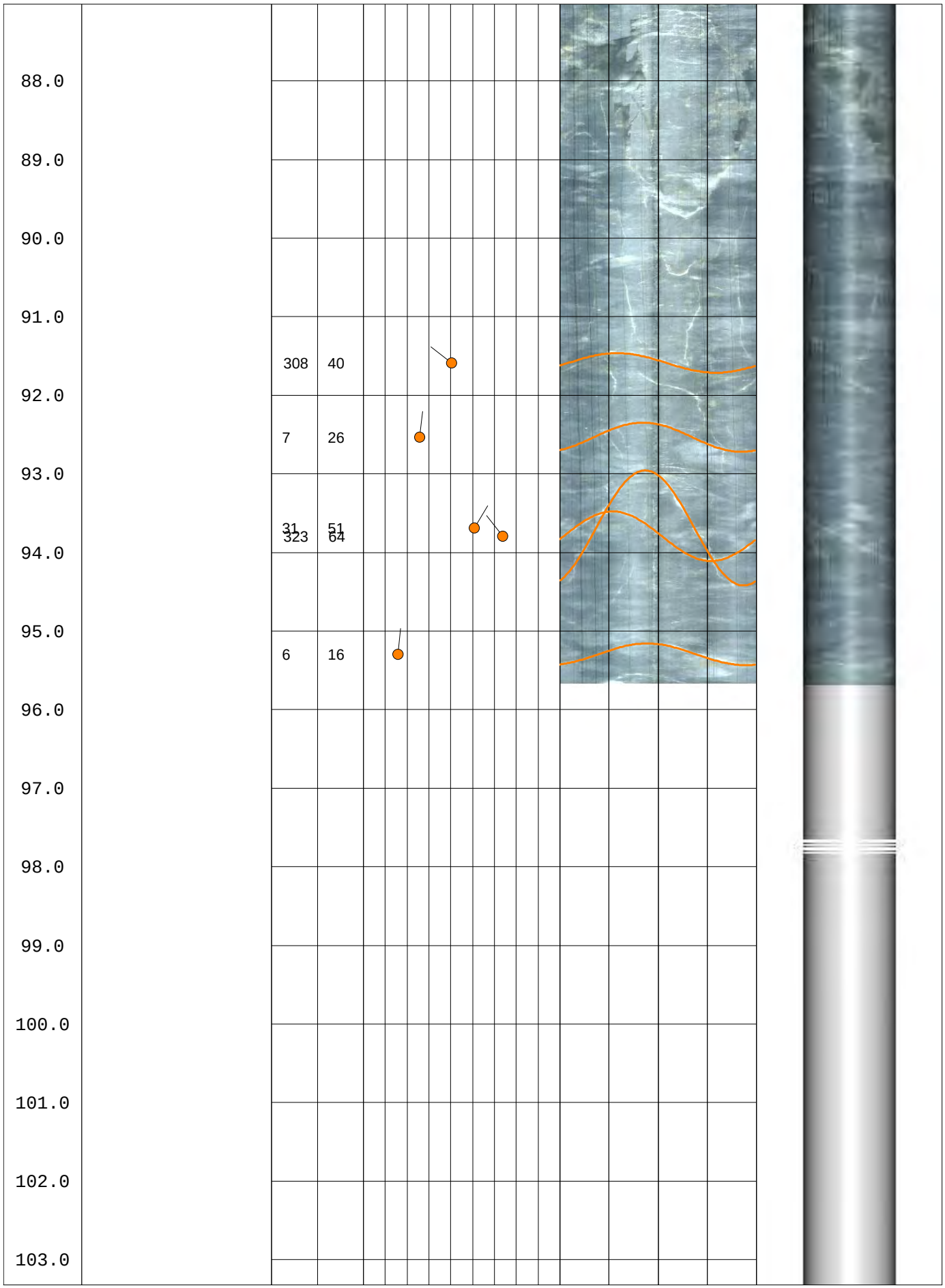
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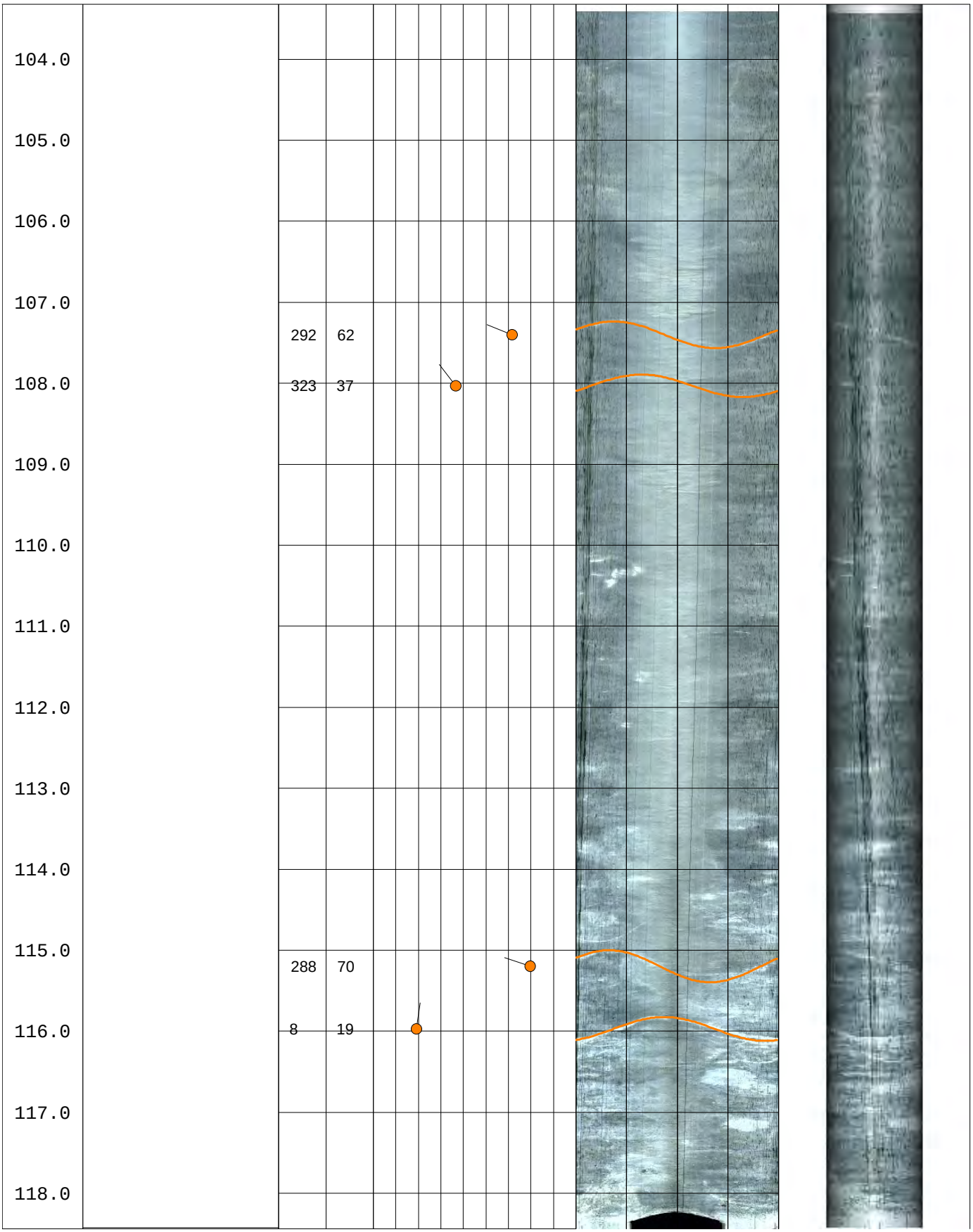
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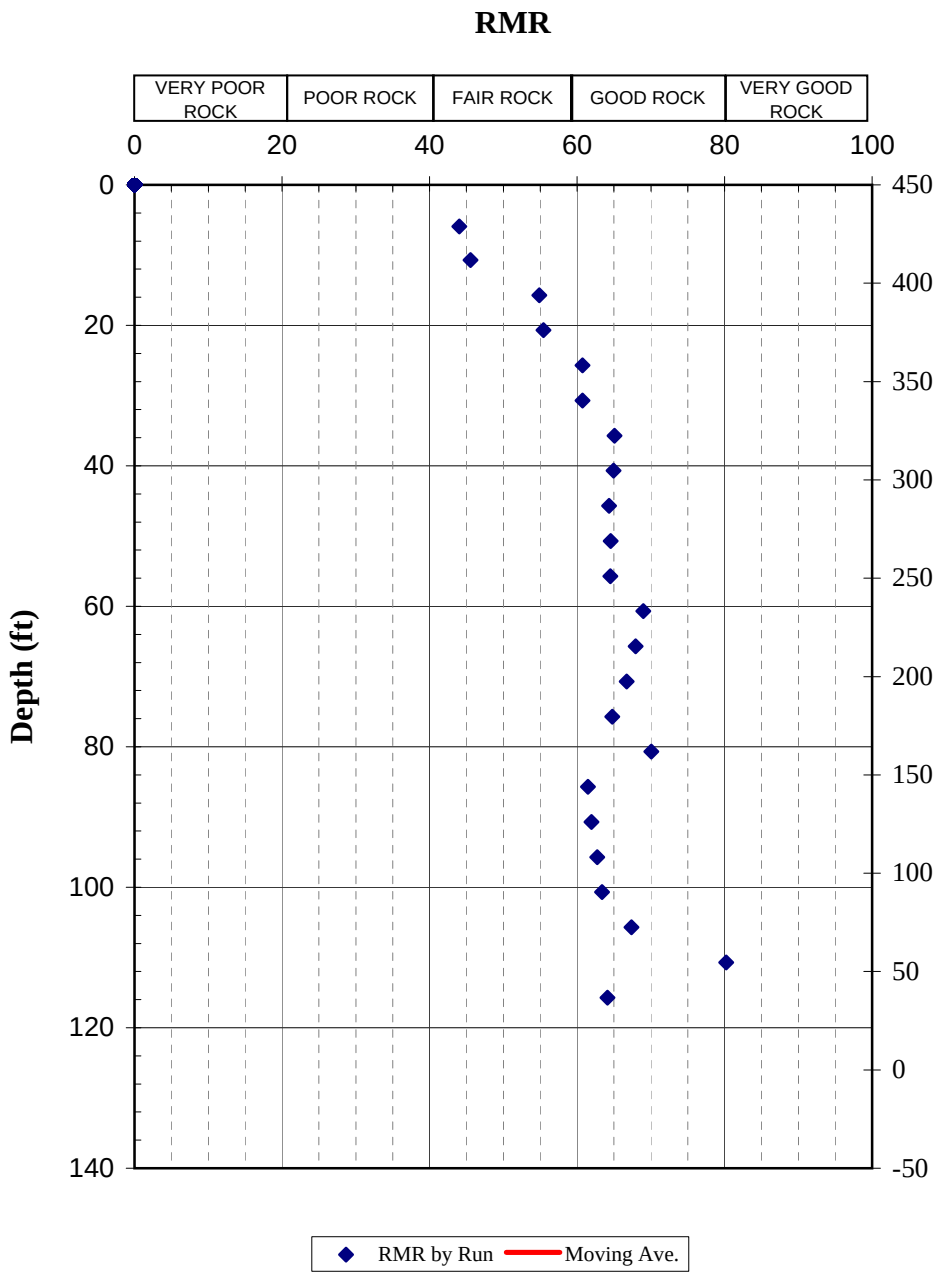
8 19

RMR vs Depth and Elevation DH09-12



Borehole DH09-13

Working Together SAFELY

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BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-13***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 4

SITE: Lower Tunnel, South River Portal

COORDINATES: 1912139.8 N, 2378953 E
DIP DIRECTION: N/A
DIP: 90
ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 317.3
END OF HOLE: 259.4

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 2500
METHOD SOIL: Diamond Drill Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT
CORE: HQ3

STARTED: 9/17/09
FINISHED: 9/18/09
INSPECTOR: M. Bandruzuman
LOGGED BY: P. Friz
REVIEWED: S. Perkins
DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) (□ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN.) (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
317.3													
0.0		0.0 - 17.9 ft: Overburden 0 - 7.1 ft: No recovery, soil and organic matter. 7.1 - 12.9 ft: Weathered boulders 12.9 - 17.9 ft: Grey-brown silty sand, 6" chunk of rock.						1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0				
		17.9 ft TOP OF BEDROCK see next sheet						19.0				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT (W_P) NATURAL MOISTURE CONTENT (W_N) LIQUID LIMIT (W_L)

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-13**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 4

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
299.4 / 17.9		17.9 - 57.9 ft: Metamorphosed Andesitic Siltstone Medium to dark grey colour, texture varies from fine to course grained with conglomeratic clasts up to 3" in dia. 6" to 12" layers of lighter coloured rock. Smaller clasts are comprised of quartz, larger clasts are lithic. Unit is silicified and rock is very strong (100 - 250 MPa). Orientation of banding varies from 5 deg to the core axis to 70 deg to the core axis. Discontinuity spacing widens with depth, average discontinuity spacing of 2.5 ft; RMR = 57 - 76; GSI = 65 - 70		20.2 - 20.4 ft: FRAGMENTED ZONE 21.5 - 22.9 ft: FRAGMENTED ZONE The following general discontinuity characteristic were noted for this hole: 72% of the discontinuities are smooth, 21% are slightly rough, and 7% are rough. 93% of the discontinuities are planar and 7% are curved 92% of the discontinuities have hematite staining and all slightly weathered. 33.7 - 36.2 ft: BROKEN ZONE, Longitudinal fracture, several hammer breaks		4	86	66	19 20 21 22	20 40 60 80	No take 10^-6 10^-5 10^-4 10^-3 / 0.1 1 10 100		
						5	100	96	23 24 25 26 27				
						6	100	100	28				
						7	100	95	29 30 31 32				
						8	100	100	33 34 35 36 37				
						9	100	96	38 39 40 41 42				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-13**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 4

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		47.9 - 48.5 ft: Sample R7-PL = 97 MPa 48.5 - 49.3 ft: Sample R7-UCS (not tested)				10	100	100	44 45 46 47 48	20 40 60 80	0.1 1 10 100 No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						11	100	100	48 49 50 51 52 53				
						12	100	100	53 54 55 56 57				
259.4 57.9		**END OF BOREHOLE**											

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-13

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 4

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at 23.5 ft below the hole collar on September 19, 2009.
7 RMR (Rock Mass Rating) estimation based on visual assessments of exposed outcrops, drill core and laboratory test results on rock and core samples in the vicinity of the intake tunnel, north portal of the lower tunnel and surge chamber as outlined in Bieniawski (1989).
8 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
9 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-13
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Lower Tunnel, South River Portal
Azimuth (Deg)	N/A
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
17.9					Top of bedrock																
18.6					Drill Break																
18.9					Joint	80					x			x			H		S			
19.4					Joint	75						x		x			H		S			H
19.5					Joint	80					x			x			H		S			
20.1					Joint	50						x		x			H/		S			
20.2	20.4			x	Fragmented zone																	
20.4					Joint	45					x			x			H		S			
20.4					Joint	45					x			x			H		S			
20.7					Joint	45					x			x			H		S			
20.7					Drill Break																	
21.5					Joint																	
21.5	22.9			x	Fragmented zone																	
22.9					Drill Break																	
23.9					Joint	40					x			x			H		S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-13
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Lower Tunnel, South River Portal
Azimuth (Deg): N/A
Inclination (Deg): 90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
24.8					Joint	80					x			x			H		S			
25.0					Joint	70						x		x				S				O
25.4					Hammer Break																	
26.1					Hammer Break																	
27.5					Bedding (Drill Break)		55	201														
27.6					Drill Break																	
27.9					Drill Break																	
28.9					Joint	40	55	094			x			x			H		S			
30.5					Drill Break																	
30.6					Drill Break																	
31.1					Drill Break																	
31.6					Joint	70					x			x			H		S			
32.7					Joint	75					x			x			H		S			
32.9					Drill Break																	
33.7	36.2		x		Longitudinal Fracture zone (Hammer Break)	10	82	005					x		x		H	S	H		P	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-13
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Lower Tunnel, South River Portal
Azimuth (Deg) N/A
Inclination (Deg) 90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
37.4					Bedding (no break)		48	247														
37.6					Drill Break																	
37.9					Drill Break																	
38.2					Bedding (no break)		58	238														
39.0					Drill Break																	
39.4					Drill Break																	
39.8					Drill Break																	
40.2					Vein (no break)		81	342														
40.3					Drill Break																	
40.8					Drill Break																	
41.4					Vein (no break)		78	352										Q				
42.7					Joint	40					x			x			H	C	S			H
42.8					Drill Break																	
42.9					Drill Break																	
43.3					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-13
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Lower Tunnel, South River Portal
Azimuth (Deg)	N/A
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
46.0					Vein (no break)		53	147										Q				
47.0					Vein (no break)		46	152														
47.5					Drill Break																	
47.9					Drill Break																	
48.5					Drill Break																	
48.8					Bedding (no break)		44	253														
49.2					Bedding (no break)		47	298														
49.3					Drill Break																	
51.0					Drill Break																	
52.9					Drill Break																	
53.2					Quartz-Carbonate Vein (no break)		22	039														
54.2					Bedding (no break)		49	225														
54.9					Bedding (no break)		60	143														
56.0					Bedding (no break)		30	345														
57.2					Bedding (no break)		44	176														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

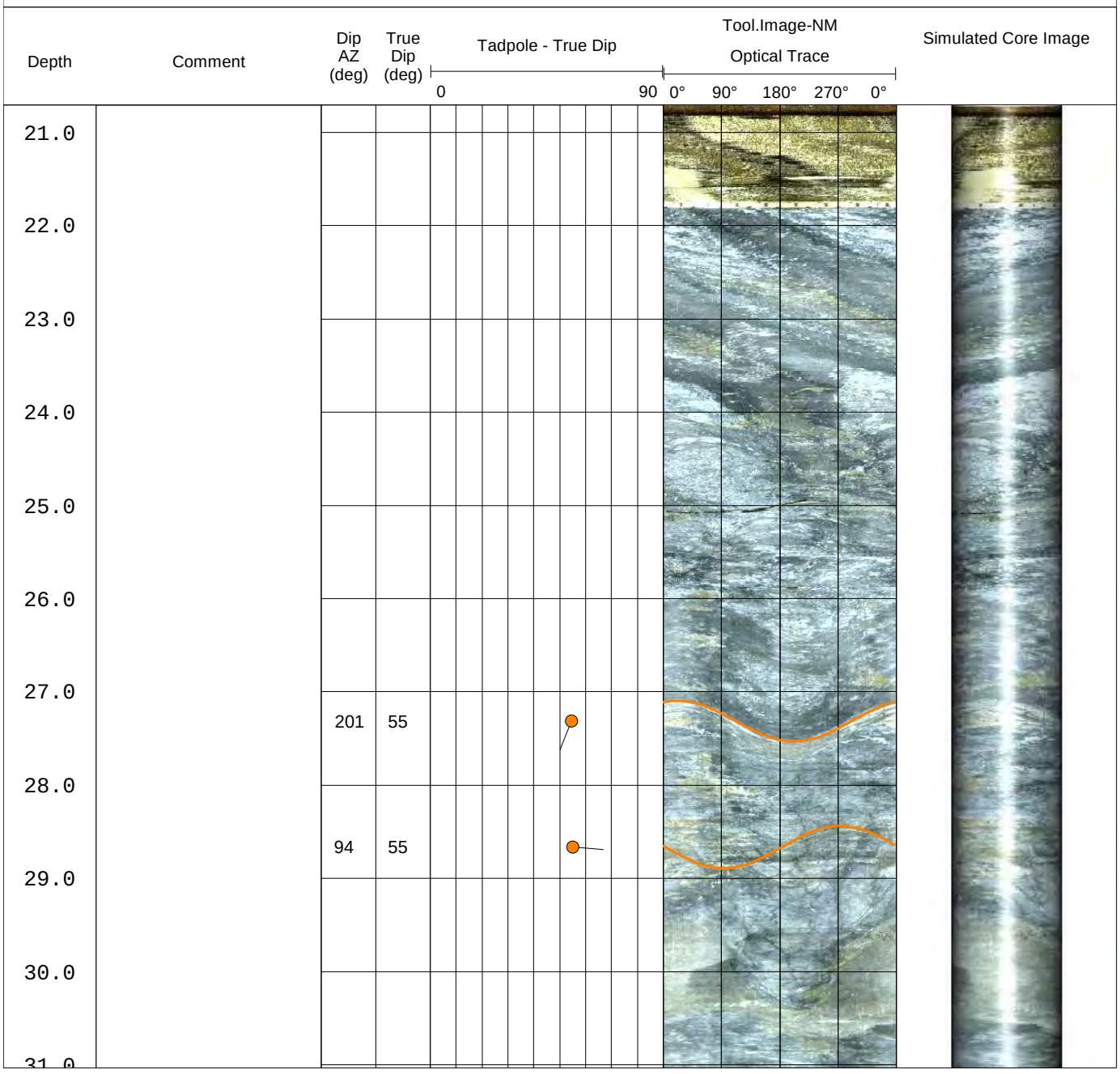
Aperture:O-Open; H-Hairline (<0.5mm)

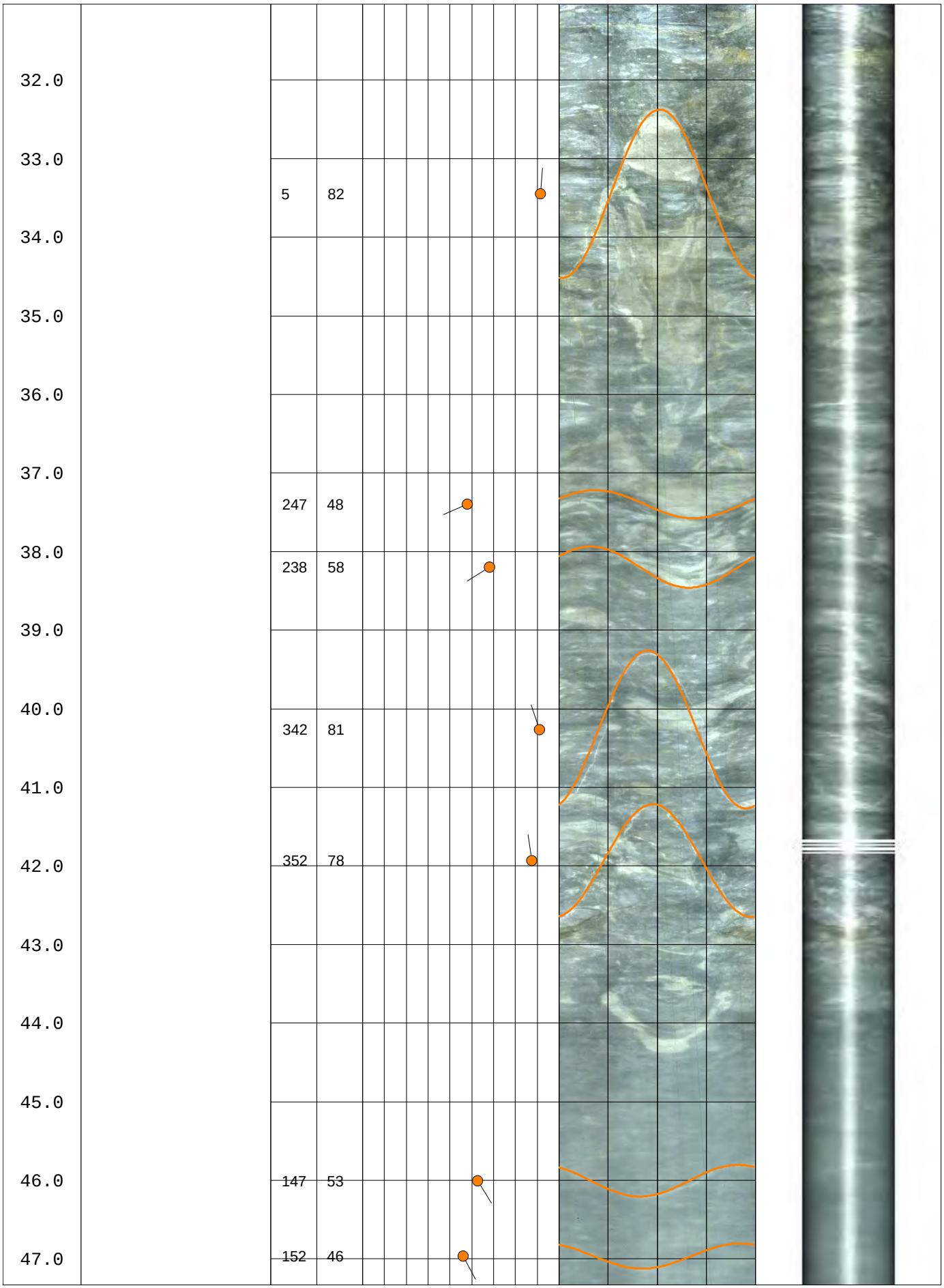
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company City and Borough of Sitka	
	Location: Sitka, AK	
	Project: Blue Lake Hydroelectric	
Date Logged:	September 19, 2009	Borehole ID: DH09-13
File Name:	DH09-13-1M.wcl	Logged By: Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from north.

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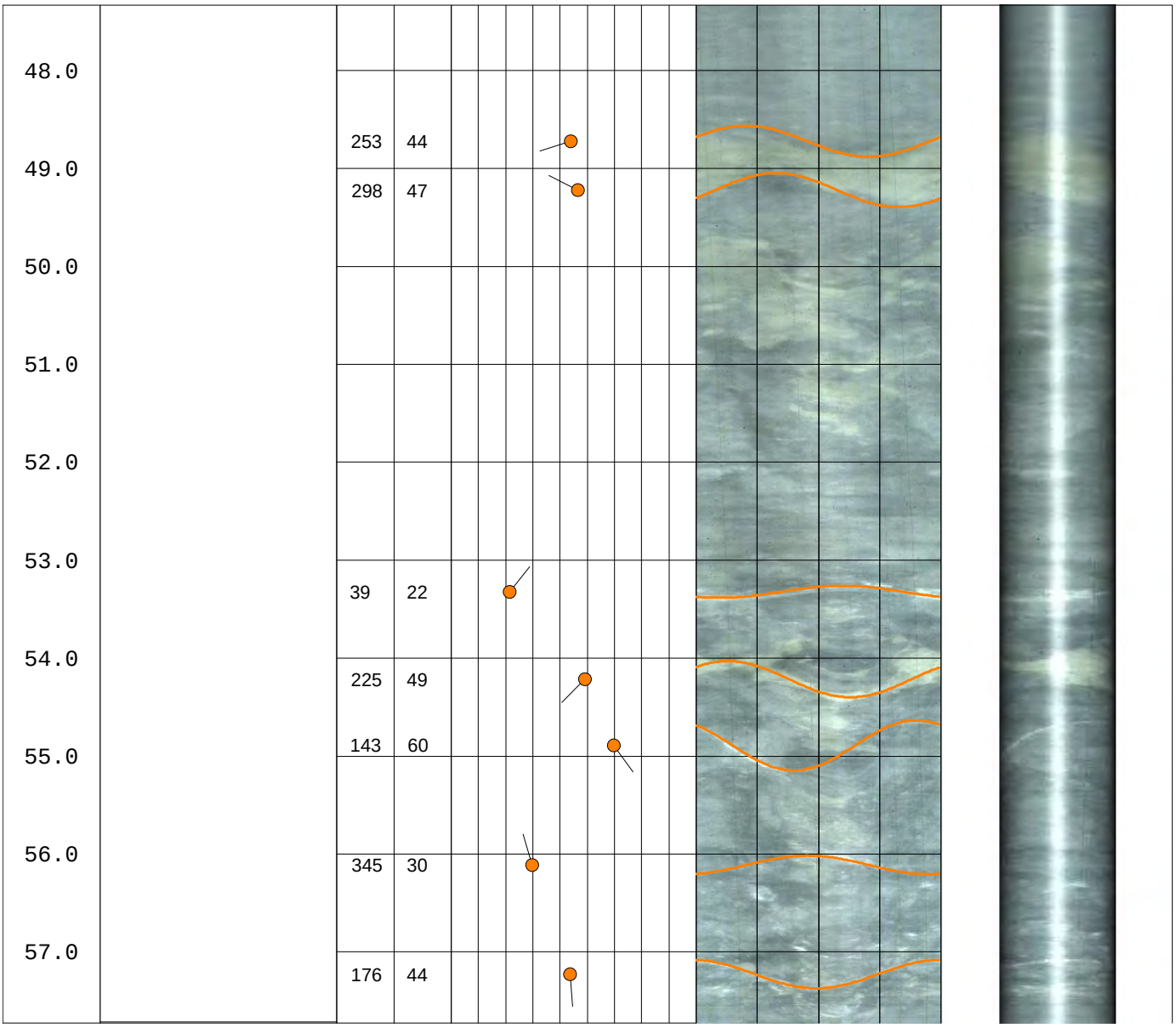
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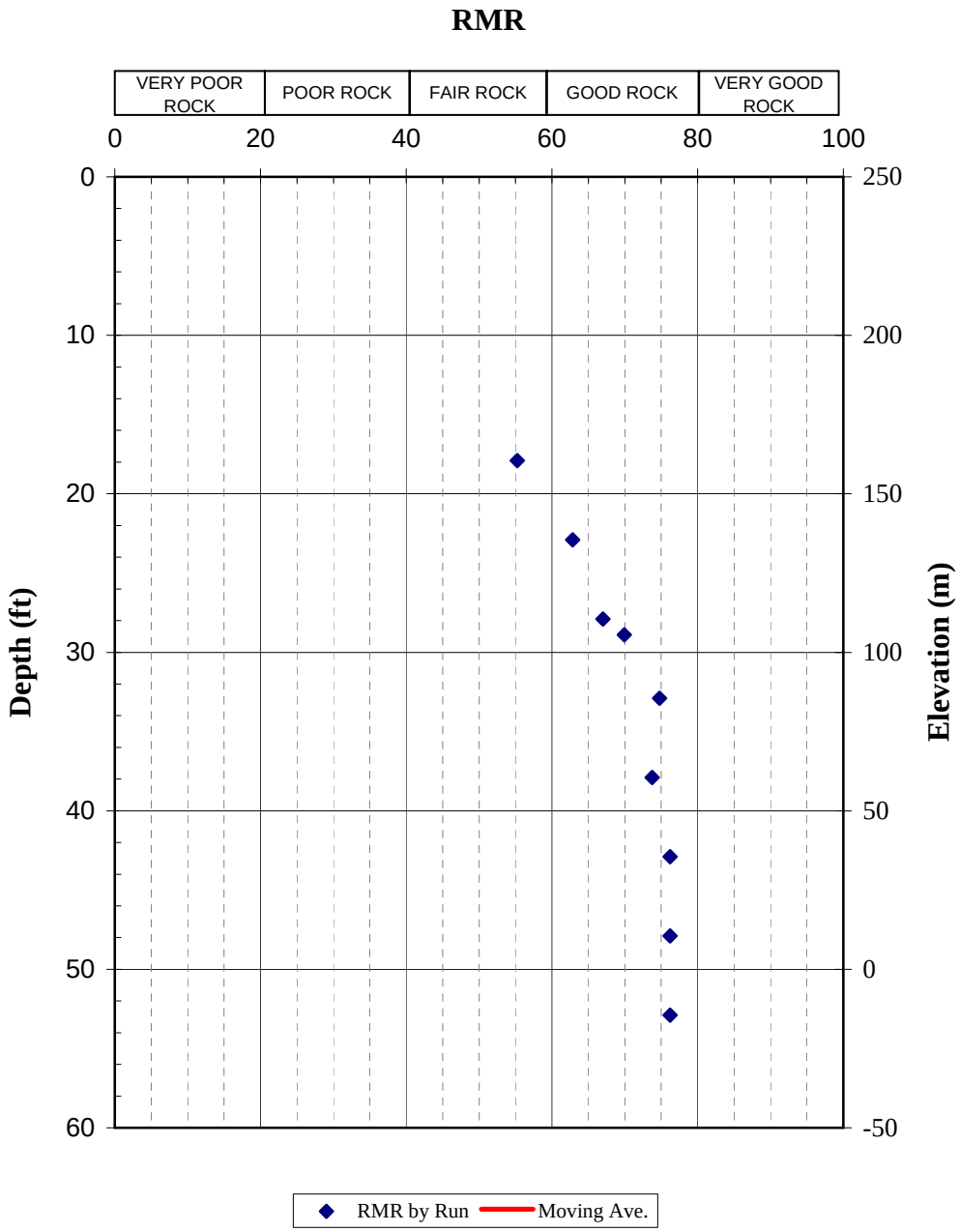
RMR vs Depth and Elevation DH09-13



Borehole DH09-14

Working Together SAFELY

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HATCH

BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-14***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 12

SITE: Surge Chamber

COORDINATES: 1909298.9 N, 2375727.3 E
DIP DIRECTION: 025
DIP: 80

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 479.5
END OF HOLE: 183.1

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 4500
METHOD SOIL: Diamond Drill Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 9/07/09
FINISHED: 11/13/09
INSPECTOR: P. Nolan
LOGGED BY: P. Friz
REVIEWED: S. Perkins

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) (5 10 15 20) □ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN.	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
479.5 0.0		0.0 - 2.0 ft: Overburden - Soil and woody debris						1.0				
		2 ft TOP OF BEDROCK see next sheet						2.0 3.0 4.0				

SAMPLING METHOD

A - Split Tube
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E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT — NATURAL MOISTURE CONTENT — LIQUID LIMIT
W_P W_N W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 12

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
477.52		2.0 - 15.0 ft: Metamorphosed Carbonaceous Andesitic Siltstone Black, fine grained, very strong (100 - 250 MPa), slight banding @ 30 deg to core axis; Fine grained matrix, sub-rounded to rounded clasts are up to 1" in size. Clasts comprised of quartz and lithic fragments, Iron staining on joint surfaces. Average discontinuity spacing of 0.8 ft; RMR = 54 - 67; GSI = 60 - 65 4.3 ft: 40 g removed for sample ARD COMP 1.		2.0 - 6.0 ft: BROKEN ZONE		2	70	0	3 4	20 40 60 80	0.1 1 10 100 No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						3	100	0	5				
				6.9 - 7.7 ft: FRAGMENTED ZONE		4	100	54	6 7 8				
				8.4 - 9.1 ft: FRAGMENTED ZONE		5	100	73	9 10				
						6	100	80	11 12 13 14				
464.715		15.0 - 42.5 ft: Metamorphosed Andesitic Siltstone Grey, fine grained, weakly banded, some quartz veining; very strong (100 - 250 MPa), contains disseminated grains of pyrite. Average discontinuity spacing of 1.7 ft; RMR = 67 - 80; GSI = 65 - 70		15.0 - 16.0 ft: FRAGMENTED ZONE					15 16				
						7	100	86	17 18 19				
				19.8 - 20.4 ft: BROKEN ZONE					20				
				21.0 - 21.8 ft: FRAGMENTED ZONE		8	100	84	21 22 23 24				
				The following general discontinuity characteristic were noted for this hole: 71% of the discontinuities are smooth,17% are slightly rough,7% are rough and 4.3 % are slick. 91% of the discontinuities are planar, 5% are curved		9	100	100	25 26 27 28 29 30 31				

SAMPLING METHOD

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SHIPPING CONTAINER

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Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 12

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
				and 4% are irregular. 39% of the discontinuities have hematite staining, 83% are slightly weathered and 17% are moderately weathered.		10	100	100	33 34 35 36	20 40 60 80	0.1 1 10 100 / No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}		
						11	100	100	37 38 39 40 41				
437.6 42.5		42.5 - 52.5 ft: Metamorphosed Bedded Andesitic Siltstone Distinct horizontal banding, alternating dark and light banding, quart veins pervasive throughout, fine grained. Average discontinuity spacing of 1.0 ft; RMR = 69 - 72; GSI = 65 - 70				12	100	96	42 43 44 45 46				
						13	100	98	47 48 49 50 51				
427.8 52.5		52.5 - 60.0 ft: Metamorphosed Bedded Andesitic Siltstone Flow banding visible, increased concentration of longitudinal quart veins. Fractures parallel the quartz veins. Average discontinuity spacing of 1.2 ft; RMR = 70 - 72; GSI = 65 - 70				14	100	100	52 53 54 55 56				
						15	100	96	57 58 59 60 61				
420.4 60.0													

SAMPLING METHOD

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SHIPPING CONTAINER

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Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 4 **OF:** 12

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		60.0 - 98.3 ft: Metamorphosed Andesitic Siltstone Horizontal banding, conglomeratic texture with clasts up to 0.5 - 1.0 in. in size, quartz veins oriented at 45 deg to the core axis. Average discontinuity spacing of 1.7 ft; RMR = 71 - 78; GSI = 65 - 70				16	100	100	63 64 65 66				
						17	100	100	67 68 69 70				
		71.0 - 74.0 ft: Flow banding				18	100	100	71 72 73 74 75				
		78.0 - 90.0 ft: Numerous 1 - 2 mm wide quartz veins oriented at 80 - 90 deg to the core axis. 80.6 ft: 5 mm wide quartz vein oriented at 45 deg to the core axis.				19	100	100	76 77 78 79 80 81				
		84.0 - 88.0 ft: Flow banding.				20	100	100	82 83 84 85 86				
						21	100	100	87 88 89 90 91				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
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SHIPPING CONTAINER

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Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 5 **OF:** 12

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
		94.5 - 95.5 ft: Flow banding				22	100	98	93				
									94				
									95				
									96				
382.7									97				
98.3		98.0 - 185.6 ft: Metamorphosed Bedded Andesitic Siltstone Grey-black colour; fine grained, alternating dark and light layers 10 mm - 75 mm thick; offsets occur along microfractures parallel and perpendicular to bedding; contains zones with quartz -carbonate vein stockworks associated with pyrite; bedding has an angle to core axis of 30 - 45 deg; Average discontinuity spacing of 2.9 ft; RMR = 65 - 81; GSI = 65 - 70.				23	100	100	98				
									99				
									100				
									101				
						24	100	100	102				
									103				
									104				
									105				
									106				
						25	100	100	107				
									108				
									109				
									110				
									111				
						26	100	98	112				
									113				
									114				
									115				
									116				
						27	100	94	117				
									118				
									119				
		119.7 - 121.0 ft: Quartz - carbonate vein stockwork; small piece removed for ARD COMP 1.							120				
									121				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

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SHIPPING CONTAINER

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Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 6 **OF:** 12

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						28	100	98	123–125				
						29	100	100	126–130				
						30	100	100	131–135				
						31	100	96	136–140				
						32	100	100	141–145				
						33	100	100	146–150				
									151				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

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SHIPPING CONTAINER

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Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 7 **OF:** 12

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
				151.3 - 152.0 ft: Longitudinal Fracture along vein		34	100	100	153				
									154				
									155				
									156				
						35	100	100	157				
									158				
									159				
									160				
									161				
		162.5 - 162.9 ft: Sample R3-PL = 34.10 MPa 163.9 - 164.7 ft: Sample R3-UCS (not tested)				36	100	100	162				
									163				
									164				
									165				
									166				
						37	100	100	167				
									168				
									169				
									170				
									171				
						38	100	94	172				
									173				
									174				
									175				
				175.5 - 175.8 ft: FRAGMENTED ZONE (along veinlets)					176				
						39	100	100	177				
									178				
									179				
									180				
									181				

SAMPLING METHOD

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SHIPPING CONTAINER

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Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 8 **OF:** 12

ELEV. / DEPTH (ft)	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)
296.7 185.6	185.6 - 191.3 ft: Felsic Dyke Medium grained, contains quartz, feldspar and biotite, quartz veins up to 10 mm wide oriented at 55 deg (angle to core axis); dyke contains two longintudinal healed fractures, 0.7 ft and 1.5 ft long, respectively. Fracture infilled with quartz, carbonate and chlorite. Average discontinuity spacing of 0.8 ft; RMR = 75; GSI = 65 - 70				40	100	96
					41	100	100
291.1 191.3					42	100	94
	191.3 - 301.0 ft: Metamorphosed Bedded Andesitic Siltstone Grey-black colour, fine grained, alternating dark (black) and lighter (grey) layers 10 mm - 75 mm thick; parting occurs along bedding planes from drill action. Average discontinuity spacing of 1.3 ft; RMR = 62 - 77; GSI = 65 - 70				43	100	100
					44	100	100
					45	100	100

RECOVERY AND RQD (%): 20 40 60 80

DEPTH (ft): 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

NOTES

PIEZOMETER INSTALLATION

SAMPLING METHOD

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SHIPPING CONTAINER

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U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 9 **OF:** 12

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						46	100	100	213–216				
						47	100	88	216–221				
				220.4 - 221.0 ft: BROKEN ZONE		48	100	100	221–226				
		230.5 - 234.0 ft: Drill core intersects several carbonate veins - angle to core axis of 35 deg, veins contain pyrite.				49	100	100	226–231				
				233.8 - 234.5 ft: BROKEN ZONE (drill induced)		50	100	82	231–236				
				235.8 - 236.0 ft: BROKEN ZONE (drill induced)		51	100	100	236–241				

RECOVERY AND RQD (%): 20 40 60 80

PERMEABILITY (lugeons): 0.1 1 10 100

(cm/sec): No take 10^{-6} 10^{-5} 10^{-4} 10^{-3}

SAMPLING METHOD

A - Split Tube
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SHIPPING CONTAINER

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U - Wooden Box
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Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 10 **OF:** 12

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						52	100	100	243–246				
						52	100	100	246–251				
						53	100	100	251–256				
				254.0 - 256.0 ft: BROKEN ZONE		54	100	78	256–261				
				257.8 - 258.9 ft: FRAGMENTED ZONE		55	98	72	261–266				
				264.6 - 266.2 ft: FRAGMENTED ZONE		56	100	0	266				
		270.5 - 271.0 ft: Quartz - carbonate vein stockwork				57	100	100	266–271				

PERMEABILITY (lugeons): 0.1 1 10 100 — (cm/sec): No take, 10^{-6} 10^{-5} 10^{-4} 10^{-3}

RECOVERY AND RQD (%): 20 40 60 80

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
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F - Wash
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SHIPPING CONTAINER

N - Insert
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Q - Jar
R - Cloth Bag
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U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

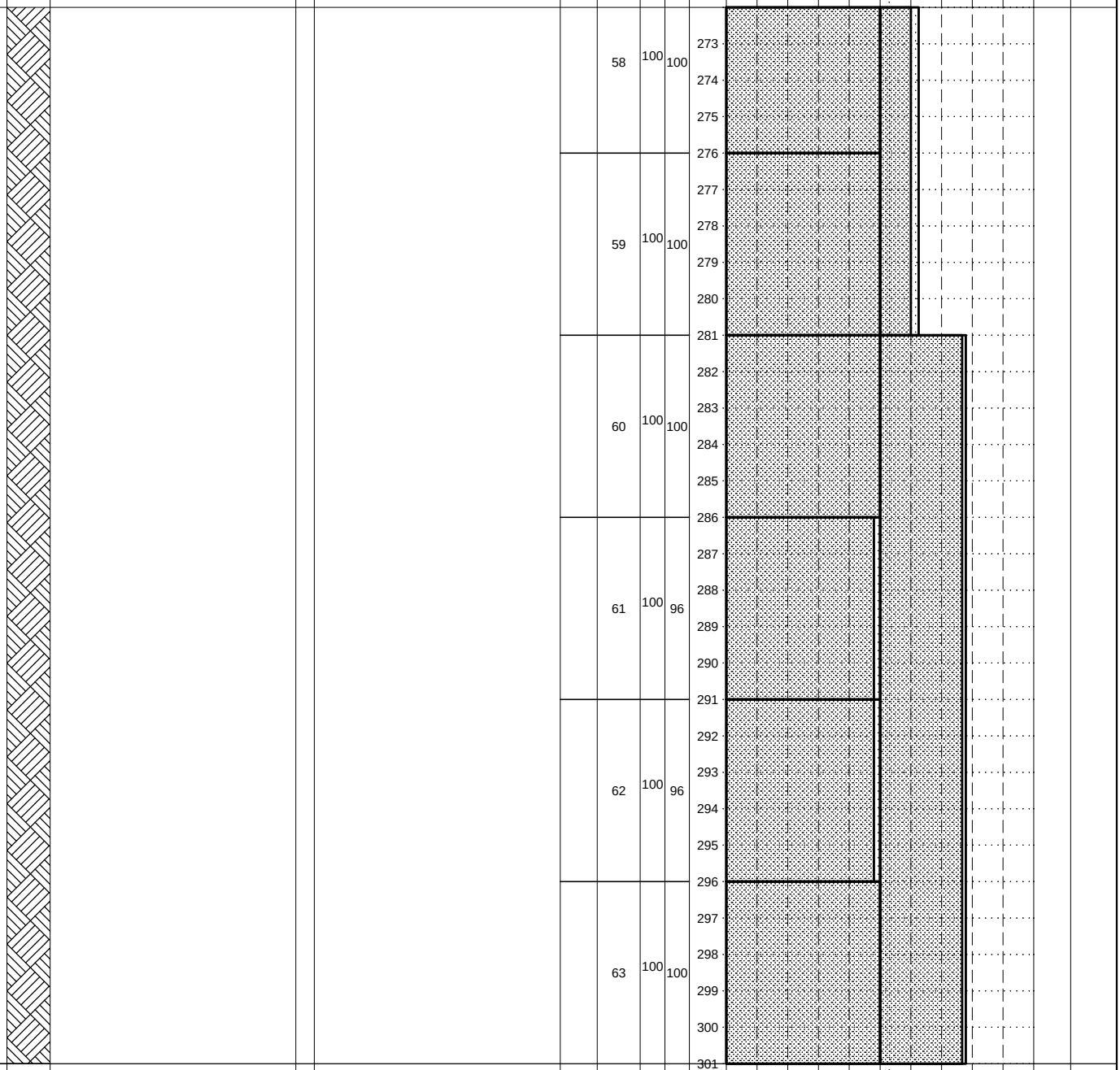
Project: **H-332360**

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-14**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 11 **OF:** 12

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE DEPTH (ft)	SAMPLE TYPE/ NUMBER	SAMPLE REC/SCR (%)	SAMPLE RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
						58	100	100	273–276				
						59	100	100	276–281				
						60	100	100	281–286				
						61	100	96	286–291				
						62	100	96	291–296				
						63	100	100	296–301				
183.1 / 301.0		**END OF BOREHOLE**											



SAMPLING METHOD

A - Split Tube
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D - Core Barrel
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F - Wash
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K - Slotted

SHIPPING CONTAINER

N - Insert
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Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost

Permeability units: RQD, Recovery, Lugeons, cm/sec

Project: **H-332360**

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-14

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 12 **OF:** 12

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at 122 ft below the borehole collar on September 12, 2009.
7 Sample ARD COMP 1 obtained by sampling 30 g pieces of core at 10 ft intervals between a depth of 0.0 ft and 150 ft.
8 Sample ARD COMP2 obtained by sampling 30 g pieces of core at 10 ft intervals between a depth of 150 ft and 301 ft.
9 RMR (Rock Mass Rating) estimation based on visual assessments of exposed outcrops, drill core and laboratory test results on rock and core samples in the vicinity of the intake tunnel, north portal of the lower tunnel and surge chamber as outlined in Bieniawski (1989).
10 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
11 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
2.0	4.3		x		Broken core zone																
4.3	6.0		x		Broken core zone																
5.9					Joint		70	104			x			x			H					O
6.2					Drill Break																	
6.5					Joint						x			x			H	S	S			
6.9	7.7			x	Fragmented zone																	
7.0					Joint		69	173														O
7.1					Joint		20	290														O
7.2					Joint		31	322														O
7.4					Joint		64	199														O
7.8					Joint	60	72	132			x			x			H		S			O
8.2					Drill Break	30					x			x			H		S			
8.2					Joint																	
8.4	9.1			x	Fragmented zone																	
9.1					Joint	20					x			x			H					
9.1					Joint	35					x			x			H					

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
9.6					Drill Break																
9.7					Drill Break																
10.3					Joint	20					x			x			H				
11.1					Drill Break																
11.8					Drill Break																
12.7					Drill Break																
13.4					Drill Break																
13.7					Drill Break																
14.4					Joint		32	356			x			x							O
15.0					Fragmented zone	20					x			x			H				
15.0	16.0			x	Joint																
16.0					Joint		72	111			x			x							
17.1					Drill Break																
17.7					Joint	65	14	192			x			x			H				
18.0					Drill Break																
18.1					Joint	70					x			x			H				

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
18.5					Joint	70	37	337			x			x			H					H
18.6					Drill Break																	
18.9					Joint	20	30	088			x			x			H					
19.4					Drill Break																	
19.8					Joint		32	269														
19.8	20.4		x		Broken core zone																	
20.3					Fracture, healed (no break)		30	342														H
20.4					Fracture, healed (no break)		77	206														H
21.0					Joint	20	87	206			x			x			H					H
21.0	21.8			x	Fragmented zone																	
21.8					Joint	20	69	225				x		x			H	S				
23.0					Joint		50	185			x			x								
24.0					Bedding (no break)		31	145														
25.0					Drill Break																	
26.0					Drill Break																	
26.7					Hammer Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
27.1					Hammer Break																	
27.5					Hammer Break																	
28.0					Hammer Break																	
28.3					Joint		48	347			x			x								
28.8					Drill Break																	
29.6					Drill Break																	
30.1					Drill Break																	
30.4					Drill Break																	
31.0					Drill Break																	
31.4					Drill Break																	
32.0					Bedding (no break)		55	094														
36.0					Joint																	
36.7					Drill Break																	
38.1					Joint	25							x		x						P	
40.0					Drill Break																	
40.6					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Surge Chamber
Azimuth (Deg): 30
Inclination (Deg): 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
41.0					Drill Break																
41.3					Joint	20					x			x							
41.6					Drill Break																
41.7					Drill Break																
42.1					Vein (no break)		27	188										C			H	
42.4					Vein (no break)		26	212										C			H	
42.6					Vein (no break)		32	166										C			H	
42.8					Fracture (Drill Break)		31	328													P	
43.0					Drill Break																
43.3					Drill Break																
43.4					Fracture (Drill Break)		71	141														
43.7					Drill Break																
43.8					Joint	55	58	236			x			x								O
44.2					Joint	55	35	213				x		x			H	S				
44.6					Joint	25	74	140				x		x				S				
45.0					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Surge Chamber
Azimuth (Deg): 30
Inclination (Deg): 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
45.4					Fracture (Drill Break)	15					x			x			H	Q	S		P	H
45.8					Joint	60					x			x			H		S			
46.0					Joint	75					x			x			H		S			
46.7					Fracture, healed (no break)		66	028														
46.7					Fracture, healed (no break)		74	121														
47.8					Joint	40							x	x			H		S		P	
48.8					Drill Break																	
48.9					Fracture (Drill Break)		47	205													P	
49.4					Bedding (no break)		34	209														
49.7					Drill Break																	
50.4					Bedding (no break)		51	216														
50.6					Bedding (no break)		57	207														
51.0					Drill Break																	
51.4					Joint	55					x			x			H		S			
51.8					Drill Break																	
52.3					Bedding (no break)		42	024														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Surge Chamber
Azimuth (Deg): 30
Inclination (Deg): 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
52.6	54.4				Longitudinal Fracture	10	32	085				x		x			H	Q	S		P	H
52.7					Drill Break																	
53.0					Joint	25						x		x			H		S			H
53.4					Bedding (no break)		42	024														
54.0					Joint	45					x			x			H		S			H
54.3					Drill Break																	
55.4					Drill Break																	
56.0					Drill Break																	
56.6					Fracture (no break)		76	048													P	
57.2					Drill Break																	
57.5					Drill Break																	
58.3					Joint	25	55	206			x			x			H	Q	S		P	H
59.0					Drill Break																	
59.8					Vein (no break)		44	217										C			H	
60.1					Drill Break																	
60.5					Joint	45	43	015			x			x			H		S			H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Surge Chamber
Azimuth (Deg): 30
Inclination (Deg): 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
60.7					Joint	30					x			x			H		S			H
61.0					Joint	45					x			x			H		S			H
61.2					Drill Break																	
61.5					Joint	45	48	214				x		x			H	Q	S			H
61.9					Vein (no break)		57	207										C			H	
62.3					Joint	50					x			x			H		S			H
62.8					Joint	50	58	189			x			x			H		S			H
63.7					Vein (no break)		53	089										C			H	
63.9					Vein (no break)		40	109										C			H	
64.4					Drill Break																	
65.2					Fracture (Drill Break)		73	275													P	
66.0					Vein (no break)		18	139										C			H	
66.8					Vein (no break)		13	074										C			H	
67.8					Fracture (no break)		40	095													H	
68.7					Joint	15	72	273			x			x			H	Q	S			H
70.7					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Surge Chamber
Azimuth (Deg): 30
Inclination (Deg): 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
71.0					Joint		35	043			x			x								
72.0					Joint	25	56	030			x			x			H	Q	S			H
73.0					Joint	25	45	047				x			x		H/L	Q	S			H
76.0					Joint		73	117			x			x								
76.5					Joint	20	82	119			x			x			H	Q	S			
78.0					Joint		48	040			x			x								
78.8					Joint	30	82	170			x			x			H	Q	S			
79.2					Drill Break																	
80.2					Vein (no break)		49	174										C			H	
81.0					Drill Break																	
81.9					Drill Break																	
83.8					Drill Break																	
84.6					Joint	30	16	081			x			x			H	Q	S			
85.1					Vein (no break)		58	109										C			H	
86.0					Drill Break																	
86.8					Vein (no break)		64	112										C				

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
87.0					Vein (no break)		58	105										C				
87.2					Joint	25	24	357			x			x				Q	S		P	
87.7					Bedding (no break)		20	137														
88.0					Joint		44	180			x			x								
88.9					Joint		9	152			x			x								
89.2					Bedding (no break)		75	208														
89.7					Bedding (no break)		53	208														
90.2					Drill Break																	
91.0					Drill Break																	
93.0					Vein (no break)		59	107														
95.0					Joint		14	032			x			x								
95.1					Joint		79	129			x			x								
95.2					Bedding (no break)		56	198														
95.3					Bedding (no break)		55	177														
96.2					Joint		14	138			x			x								
96.5					Joint	80	29	173			x			x			H	Q	S			

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

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Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
96.6					Drill Break																	
97.3					Bedding (no break)		19	183														
98.4					Bedding (no break)		13	061														
99.7					Bedding (no break)		62	181														
100.8					Drill Break																	
101.0					Drill Break																	
102.6					Drill Break																	
102.7					Drill Break																	
103.5					Drill Break																	
103.7					Joint	30	55	002			x			x			H	Q	S			
104.0					Drill Break																	
105.5					Bedding (no break)		19	056														
106.0					Joint		25	102			x			x								
106.5					Bedding (no break)		24	116														
107.2					Bedding (no break)		20	077														
107.3					Bedding (no break)		23	095														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
107.6					Bedding (Drill Break)		55	215														
108.0					Bedding (no break)		32	079														
108.5					Bedding (no break)		46	044														
108.6					Bedding (no break)		44	045														
108.9					Bedding (no break)		46	051														
109.3					Bedding (Drill Break)		48	039														
110.0					Drill Break																	
111.0					Drill Break																	
111.4					Vein (Drill Break)		45	119													P	
111.5					Fracture (Drill Break)		82	126										C			P	
111.8					Fracture, healed (no break)		36	230										C			H	
112.6					Fracture (Drill Break)		74	127													P	
113.4					Bedding (no break)		38	050														
113.8					Drill Break																	
114.1					Bedding (no break)		44	072														
114.3					Bedding (no break)		36	062														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
114.9					Microfracture (no break)		17	251														
115.2					Bedding (no break)		45	088														
115.5					Bedding (no break)		42	069														
115.7					Bedding (Drill Break)		46	067														
115.9					Drill Break																	
116.0					Fracture (Drill Break)		45	058														
116.4					Joint	45					x			x				Q	S			H
116.5	117.2				Quartz Vein	70	76	129			x			x				Q	S		P	H
117.3					Drill Break																	
117.6					Bedding (no break)		38	119														
118.0					Drill Break																	
118.1					Drill Break																	
118.6					Fracture (Drill Break)		33	184													P	
118.8					Fracture (Drill Break)		17	023													P	
119.1					Drill Break																	
119.2					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

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Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
119.4					Drill Break																	
119.5	121.0				Calcite Vein System													C			H	H
119.5					Vein (no break)		49	104										C			H	
119.5					Vein (no break)		70	114										C			H	
119.7					Vein (no break)		50	100										C			H	
120.3					Vein (no break)		51	126										C			H	
120.5					Vein (Drill Break)		57	144													H	
120.7					Vein (no break)		59	169										C			H	
121.0					Fracture (Drill Break)		65	187													P	
121.8					Drill Break																	
122.1					Drill Break																	
122.8					Fracture, healed (no break)		33	210										C			H	
123.8					Fracture (Drill Break)		55	158													P	
123.9					Fracture (Drill Break)		81	151													P	
124.4					Drill Break																	
126.0					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Weathering:

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

S-slightly; M-moderately; H-highly

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Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
127.1					Drill Break																	
127.4					Drill Break																	
129.6					Bedding (no break)		37	159														
129.7					Bedding (no break)		39	160														
130.2					Drill Break																	
131.0					Drill Break																	
131.5					Fracture, healed (no break)		32	233										C				
131.8					Drill Break																	
131.9					Drill Break																	
132.2					Fracture (Drill Break)		37	251													P	
133.4					Fracture (Drill Break)		41	261													P	
133.9					Drill Break																	
135.2					Drill Break																	
135.8					Drill Break																	
136.0					Drill Break																	
136.3					Fracture, healed (no break)		28	306										C			H	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
136.8					Fracture, healed (no break)		76	183										C			H	
137.1					Drill Break																	
137.4					Fracture, healed (no break)		24	117										C			H	
137.7					Drill Break																	
138.0					Fracture, healed (no break)		48	196										C			H	
138.4					Drill Break																	
138.9					Fracture (Drill Break)		61	087													P	
139.3					Fracture (Drill Break)		58	083													P	
140.0					Drill Break																	
140.4					Joint	40				x				x					x	x		
140.6					Joint	40	87	160		x				x					x	x		
141.0					Drill Break																	
142.0					Drill Break																	
142.4					Drill Break																	
143.4					Drill Break																	
144.7					Fracture (Drill Break)		61	333													P	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Surge Chamber
Azimuth (Deg): 30
Inclination (Deg): 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
145.3					Drill Break																	
146.0					Drill Break																	
148.4					Drill Break																	
150.2					Fracture (Drill Break)		49	326													P	
150.7					Drill Break																	
151.0					Drill Break																	
151.2					Bedding (Drill Break)		61	208														
151.3	152.0				Longitudinal Fracture													C				
152.1					Drill Break																	
153.4					Vein (Drill Break)	20	71	189			x			x				C	x		H	
153.8					Fracture (Drill Break)		71	191													P	
154.3					Drill Break																	
154.6					Drill Break																	
155.5					Drill Break																	
156.0					Drill Break																	
157.2					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Surge Chamber
Azimuth (Deg): 30
Inclination (Deg): 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
157.6					Fracture, healed (no break)		8	012										C			H	
158.1					Fracture (Drill Break)		67	207													P	
158.5					Drill Break																	
158.7					Joint	40	62	196		x				x					x	x		O
159.3					Drill Break																	
159.4					Drill Break																	
160.0					Fracture, healed (no break)		43	200										C			H	
160.4					Fracture (Drill Break)		51	194													P	
160.7					Fracture (Drill Break)		57	192													P	
160.9					Drill Break																	
161.0					Drill Break																	
161.3					Bedding (no break)		54	198														
161.9					Bedding (no break)		56	209														
162.1					Drill Break																	
162.3					Drill Break																	
162.7					Fracture (Drill Break)		59	211													P	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
162.8					Fracture, healed (no break)		60	212										C			H	
162.9					Fracture (Drill Break)		58	210													P	
163.0					Fracture, healed (no break)		64	202										C			H	
163.5					Fracture, healed (no break)		68	209										C			H	
163.8					Fracture (Drill Break)		66	209													P	
164.3					Bedding (no break)		68	211														
164.7					Drill Break																	
164.9					Drill Break																	
165.7					Drill Break																	
166.0					Drill Break																	
166.3					Bedding (Drill Break)		65	203														
166.7					Bedding (Drill Break)		71	210														
167.0					Drill Break																	
168.2					Bedding (Drill Break)		66	196														
168.5					Bedding (Drill Break)		68	202														
168.7					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
169.1					Drill Break																	
169.7					Bedding (Drill Break)		66	209														
170.2					Bedding (Drill Break)		71	201														
170.8					Bedding (no break)		81	206														
171.0					Fracture (Drill Break)		70	316													P	
171.7					Drill Break																	
172.4					Fracture (Drill Break)		67	305													P	
172.7					Bedding (Drill Break)		56	202														
173.0					Drill Break																	
174.2					Bedding (Drill Break)		73	217														
175.0					Bedding (Drill Break)		50	215														
175.5	175.8			x	Fragmented zone						x					x		C/Q			O
175.8					Bedding (Drill Break)		67	203														
176.0					Fracture (Drill Break)		61	301													P	
176.7					Drill Break																	
177.1					Bedding (Drill Break)		57	200														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
177.5					Vein (Drill Break)	20	81	201					x	x				C	S			O
178.8					Fracture (Drill Break)		47	318													P	
179.1					Drill Break																	
179.6					Fracture (Drill Break)		12	028													P	
180.7					Drill Break																	
181.0					Drill Break																	
181.5					Drill Break																	
183.2					Fracture (Drill Break)		42	177													P	
184.8					Fracture, healed (no break)		41	019										C			H	
185.2					Drill Break																	
185.5					Fracture (Drill Break)		44	357													P	
185.8					Fracture (dike intrusion)	45						x		x				C				H
186.0					Drill Break																	
187.1					Fracture (Drill Break)		1	024													P	
187.5					Fracture, healed (no break)		6	037										C			H	
189.0					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Weathering:
S-slightly; M-moderately; H-highly

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
189.9					Drill Break																
190.3					Fracture, healed (no break)		46	200										C			H	
190.7					Fracture (Drill Break)		9	249														
190.8					Drill Break																	
191.0					Drill Break																	
191.2					Contact zone of dyke (Drill Break)	90	52	208			x			x								H
191.3					Contact zone of dyke (Drill Break)	90	53	189			x			x								H
192.3					Vein (Drill Break)	45	57	195			x			x				C	S			H
192.6					Drill Break																	
193.3					Fracture (Drill Break)		43	036													H	
193.9					Vein (Drill Break)	45	53	315				x		x				C	M	x	H	H
194.1					Drill Break																	
194.4					Fracture (Drill Break)		65	197										C			P	
194.7					Drill Break																	
195.0					Drill Break																	
195.3					Vein (no break)	25					x			x				C	S		H	H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Weathering:

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

S-slightly; M-moderately; H-highly

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Surge Chamber
Azimuth (Deg): 30
Inclination (Deg): 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
195.6					Drill Break																	
196.0					Drill Break																	
196.2					Bedding (no break)		51	195														
196.7					Drill Break																	
197.0					Bedding (Drill Break)		51	196														
197.1					Fracture (Drill Break)		5	232													P	
197.3					Drill Break																	
198.1					Bedding (no break)		66	215														
198.9					Bedding (Drill Break)		70	209														
199.3					Drill Break																	
200.4					Joint	45	69	203			x				x			C	M	x		H
200.6					Joint	45	51	193				x			x			C	M	x		H
200.9					Joint	45					x			x				C	S			H
201.2					Bedding (Drill Break)		64	214														
202.0					Bedding (no break)		62	214														
202.4					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
202.8					Drill Break																	
203.2					Bedding (Drill Break)		73	215														
203.8					Drill Break																	
204.4					Vein (Drill Break)	35	65	199		x				x				C	M	x	H	H
204.7					Fracture (Drill Break)		61	214													P	
205.0					Vein (Drill Break)	45					x			x				C	S	x	H	H
205.3					Drill Break																	
205.8					Vein (Drill Break)	45	50	160				x				x		Q			H	H
208.7					Fracture (Drill Break)		76	243													P	
210.4					Drill Break																	
211.0					Drill Break																	
211.0					Drill Break																	
213.5					Fracture (Drill Break)		50	244														
213.9					Drill Break																	
216.0					Drill Break																	
216.6					Fracture, healed (no break)		74	088										C			H	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
218.3					Fracture (Drill Break)	15	80	122					x			x						
218.4					Bedding (Drill Break)		45	199														
218.8					Bedding (Drill Break)		50	207														
219.3					Drill Break																	
219.8					Drill Break																	
220.4	221.0		x		Broken core zone																	
221.0					Bedding (Drill Break)	60	43	193			x			x								
223.6					Fracture (Drill Break)		13	354														
223.9					Fracture (Drill Break)	45	36	027				x		x				C			P	
224.1					Fracture (Drill Break)	45	59	285				x		x				C			P	
224.4					Fracture, healed (no break)		66	309														
224.6					Fracture, healed (no break)		10	253														
224.9					Drill Break																	
225.5					Vein (Drill Break)		32	304										C			H	
226.0					Drill Break																	
226.3					Fracture (Drill Break)		57	298														

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
226.9					Fracture (Drill Break)	30					x			x				C			P	
227.4					Vein (Drill Break)		63	288														
227.6					Drill Break																	
228.0					Fracture, healed (no break)		66	287										C			H	
229.0					Vein (no break)		59	162										C			H	
229.1					Vein (no break)		64	287										C			H	
230.0					Vein (no break)		46	114										C			H	
230.3					Fracture (Drill Break)	50	48	302				x		x				C				
230.7					Vein (no break)		53	300										C			H	
231.0					Fracture	40	47	299			x			x				C	m	x	H	
231.4					Qtz-Carbonate vein - 2 cm wide	35	41	312				x		x				C		x	H	
231.7					Calcite Vein	20	74	281			x			x				C	m	x	H	
232.2					Drill Break																	
232.8					Vein (no break)		64	180										C			H	
233.2					Vein (Drill Break)	35	65	184			x			x				C	m	x	H	
233.8	234.5	x	x		Broken core zone																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-14
Project: H332360

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
235.5					Fracture, healed (no break)		41	030										C			H	
235.8	236.0	x		x	Fragmented zone																	
236.4					Drill Break																	
237.3					Drill Break																	
238.0					Fracture (Drill Break)		48	182													P	
238.6					Fracture (Drill Break)		56	028														
240.2					Hammer Break																	
240.5					Fracture, healed (no break)		47	137										C			H	
241.0					Drill Break																	
241.6					Fracture (Drill Break)		73	277													P	
242.2					Fracture, healed (no break)		26	216										C			H	
242.7					Joint	20	58	082			x			x				C				H
243.5					Joint	25	74	270			x			x				C				H
244.6					Fracture (Drill Break)		80	281													P	
245.4					Fracture (Drill Break)		31	017													P	
246.0					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Surge Chamber
Azimuth (Deg): 30
Inclination (Deg): 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
246.5					Drill Break																	
248.9					Fracture (Drill Break)		45	149													P	
248.9	249.8				Fracture (Drill Break)	10	71	340					x	x				C			P	H
249.8					Drill Break																	
250.7					Fracture (Drill Break)	10					x			x				C				H
251.0					Drill Break																	
252.2					Fracture (Drill Break)		67	133													P	
252.7					Fracture (Drill Break)	20	35	352			x			x				C				H
253.5					Drill break																	
254.0					Fracture																	
254.0	256.0		x		Drill Break							x		x				C			H	H
255.1					Fracture, healed (no break)		31	300										C			H	
256.0					Drill Break																	
256.5					Drill Break																	
256.8					Fracture, healed (no break)		60	122										C			H	
257.8	258.9			x	Fragmented zone		41	129					x			x		C			H	H

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
261.0					Drill Break																
261.2					Bedding (no break)		80	186													
262.0					Fracture (Drill Break)		40	128													P
262.3					Fracture, healed (no break)		42	129										C			H
262.7					Drill Break																
262.9					Drill Break																
263.3					Fracture, healed (no break)		12	304										C			H
263.5					Drill Break																
263.7					Drill Break																
264.0					Fracture, healed (no break)		13	319													
264.3					Fracture (Drill Break)		52	131													P
264.5					Drill Break																
264.5	266.0			x	Fragmented zone	15	61	231					x		x			C			
266.0	266.1			x	Fragmented zone																
266.1	266.2			x	Fragmented zone																
266.2					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
267.0					Bedding (Drill Break)		66	197													P	
267.8					Fracture, healed (no break)		33	194										C			H	
268.9					Bedding (no break)		25	141														
269.1					Drill Break																	
271.0					Fracture (Drill Break)		75	272													P	
272.3					Vein (no break)		42	036										C			H	
272.9					Fracture (Drill Break)		27	041														
273.4					Vein (no break)		53	143										C			H	
274.7					Fracture (Drill Break)		37	012													P	
274.9					Drill Break																	
276.0					Fracture (Drill Break)		52	144													P	
276.8					Fracture (Drill Break)		48	161													P	
277.9					Vein (no break)		21	039										C			H	
278.4					Vein (no break)		54	249										C			H	
278.7					Fracture (Drill Break)		28	260													P	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
279.0					Drill Break																	
280.0					Drill Break																	
280.5		x	x		Broken core zone																	
281.0					Drill Break																	
281.3					Drill Break																	
281.6					Drill Break																	
282.0					Fracture (Drill Break)		51	208													P	
282.5					Fracture, healed (no break)		69	038										C			H	
282.6					Fracture, healed (no break)		60	147										C			H	
283.0					Fracture (Drill Break)		54	154													P	
283.7					Drill Break																	
284.2					Fracture, healed (no break)		48	184										C			H	
284.5					Drill Break																	
286.0					Drill Break																	
286.8					Drill Break																	
287.0					Fracture, healed (no break)		57	145										C			H	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Surge Chamber
Azimuth (Deg)	30
Inclination (Deg)	80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
287.5					Drill Break																
287.8					Vein (Drill Break)		69	267										C			H	
288.0					Vein (Drill Break)		66	153										C			H	
288.5					Drill Break																	
289.0					Joint	30	74	230				x		x				C			P	H
289.2					Fracture (Drill Break)		28	038										C			H	
289.5					Drill Break																	
289.6					Vein (Drill Break)	60					x			x				C	M	x		O
290.0					Drill Break																	
291.0					Fracture (Drill Break)		42	011										C			H	
291.2					Fracture (Drill Break)		39	039													P	
292.2					Fracture (Drill Break)		66	163										C			P	
292.5					Fracture, healed (no break)		65	030										C			H	
293.3					Fracture (Drill Break)		75	230										C			P	
293.8					Drill Break																	
294.6					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Aperture:O-Open; H-Hairline (<0.5mm)

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Client City and Borough of Sitka
Project Blue Lake Hydroelectric Expansion
Site Surge Chamber
Azimuth (Deg) 30
Inclination (Deg) 80

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape																
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
295.5					Drill Break																	
296.0					Fracture (Drill Break)		37	008										C			P	
296.4					Drill Break																	
296.6					Drill Break																	
297.3					Fracture, healed (no break)		67	279													H	
297.8					Fracture, healed (no break)		58	154													H	
298.2					Fracture, healed (no break)		46	162													H	
299.0					Fracture (Drill Break)		65	322										C			H	
299.4					Fracture (Drill Break)		68	333										C			H	
299.6					Drill Break																	
299.9					Fracture (Drill Break)		22	181										C			H	
300.2					Drill Break																	
300.8					Drill Break																	
301.0					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

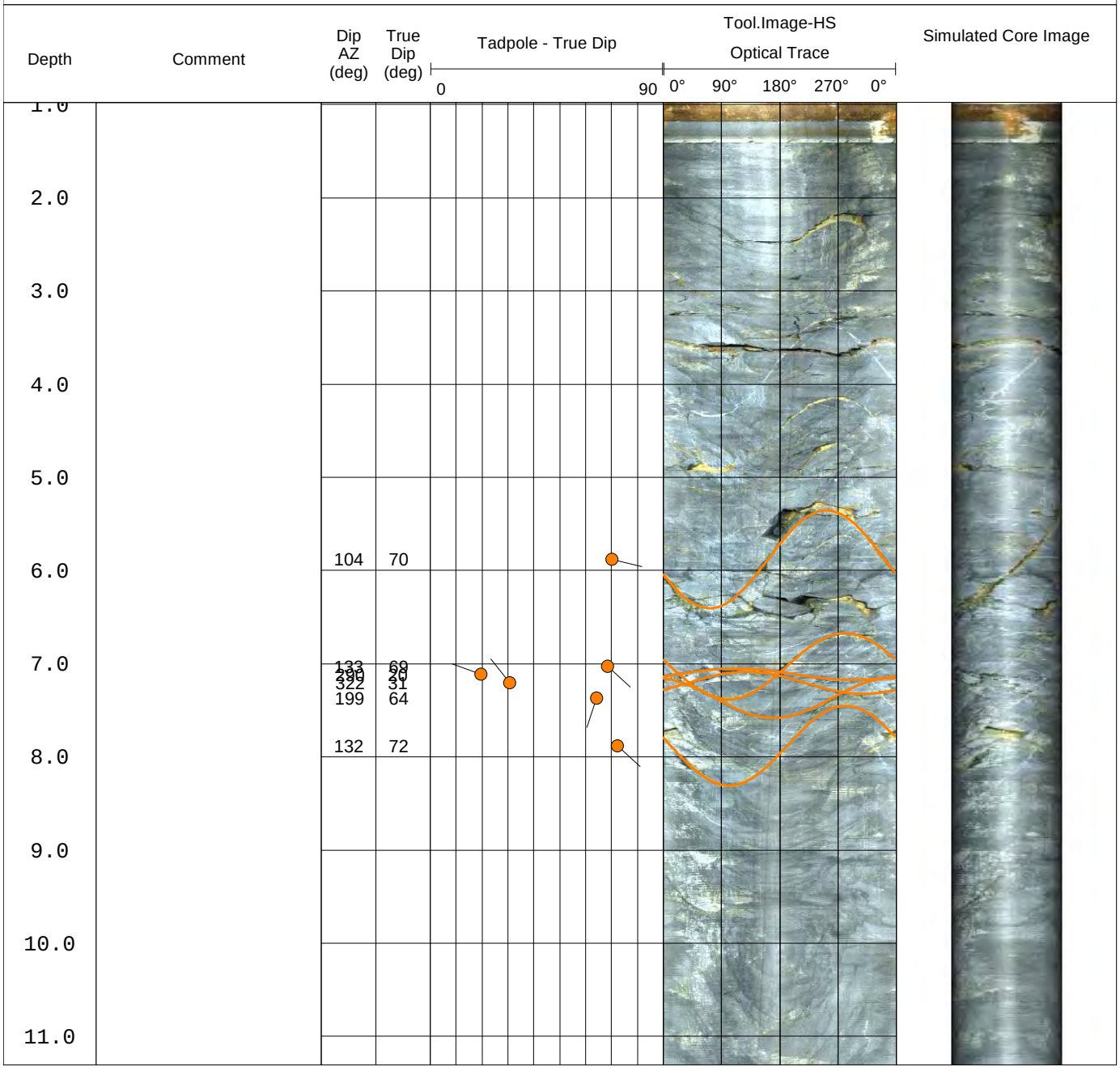
Aperture:O-Open; H-Hairline (<0.5mm)

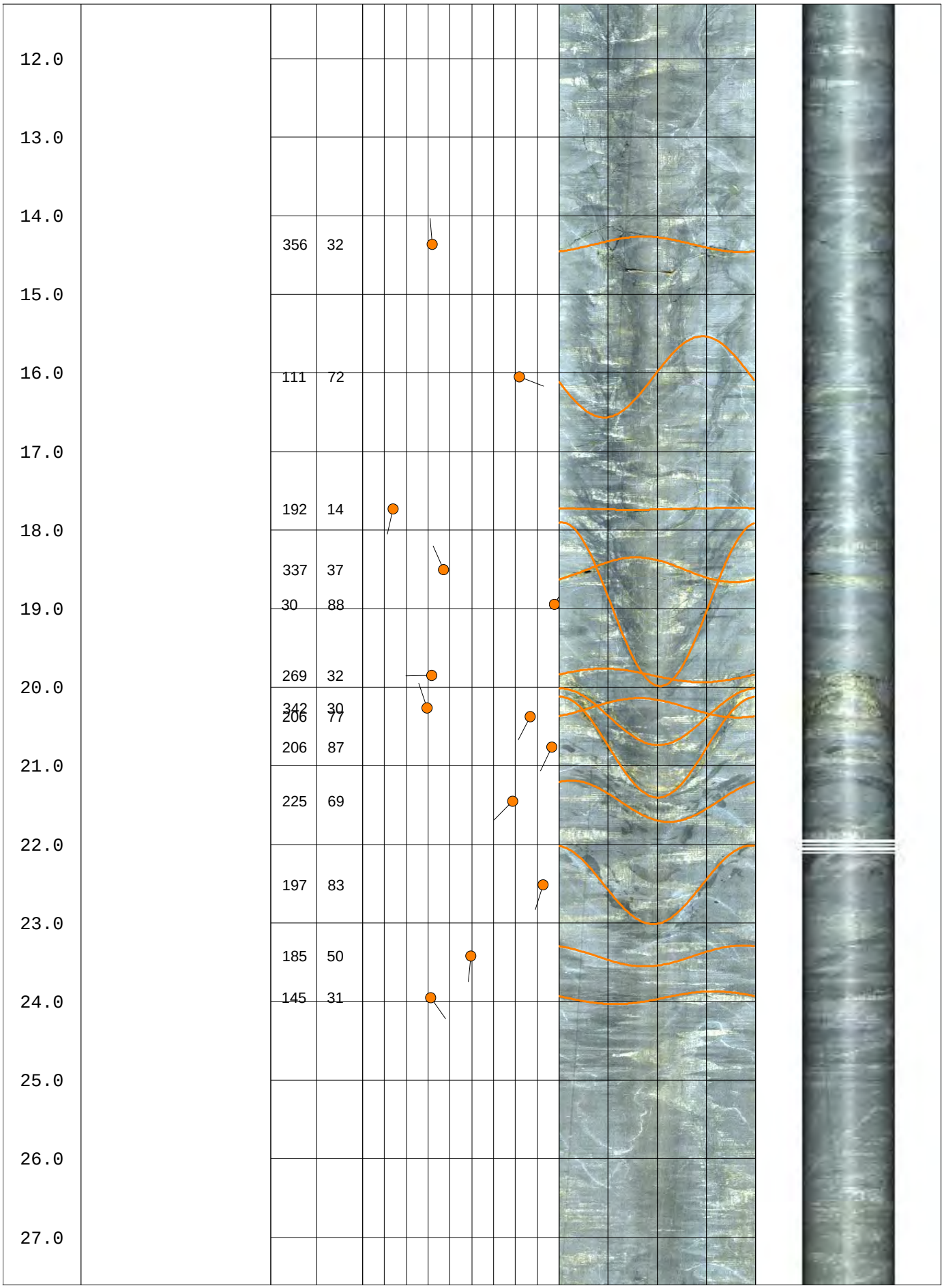
Healed:P-Partially Healed; H-Healed

COBL CRUX Oriented Borehole Logging	Company City and Borough of Sitka	
	Location: Sitka, AK	
	Project: Blue Lake Hydroelectric	
Date Logged:	September 12, 2009	Borehole ID: DH09-14
File Name:	DH09-14-2M.wcl	Logged By: Steve Wilson

Notes:

1) Azimuths reference True North. Magnetic declination of +21 degrees applied.
2) 2.5x Horizontal Exaggeration on Televiewer Images.
3) Dip values presented in degrees from horizontal.
4) Dip direction presented in degrees of azimuth.
5) Simulated Core Image is viewed from north.

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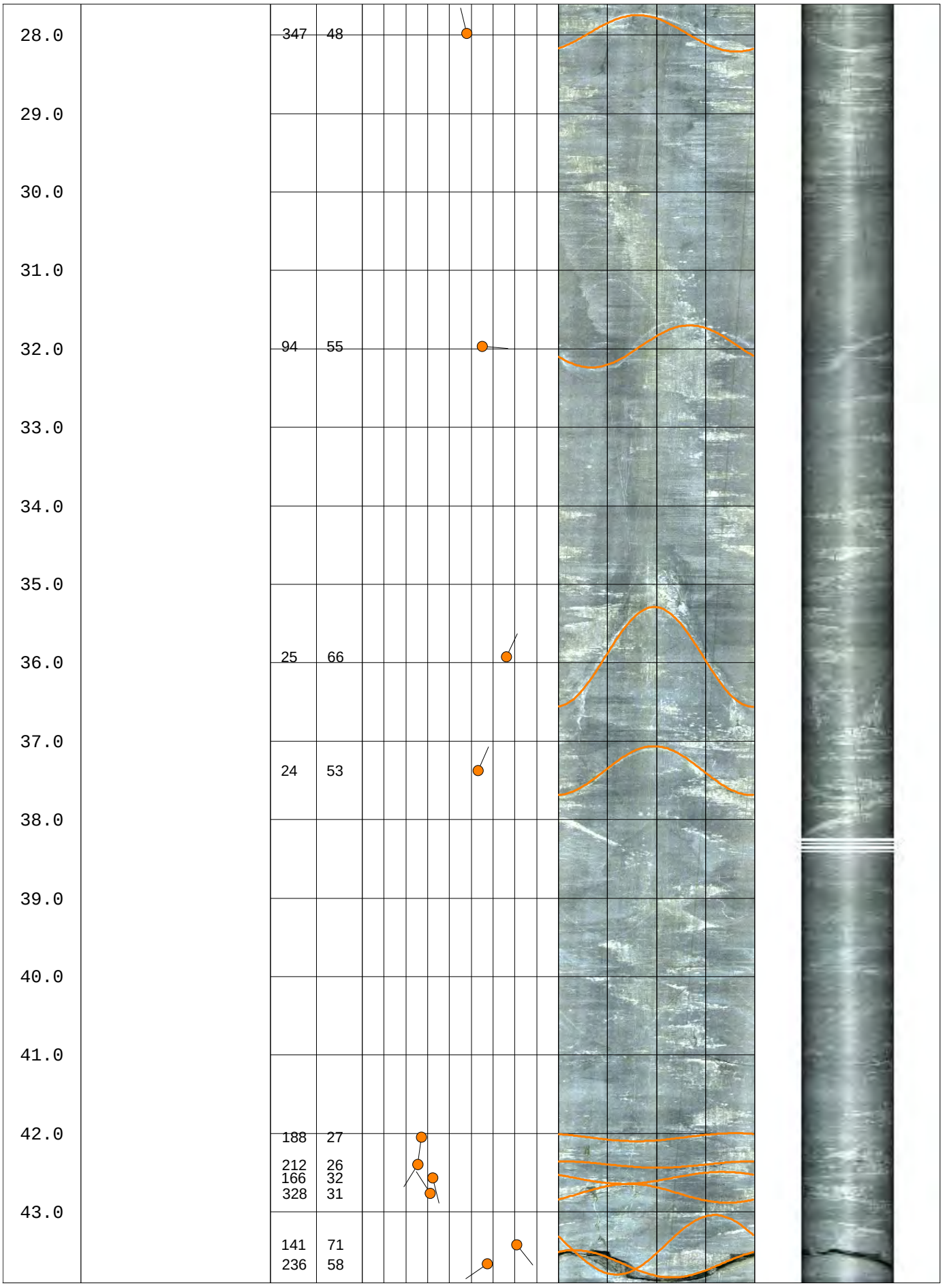
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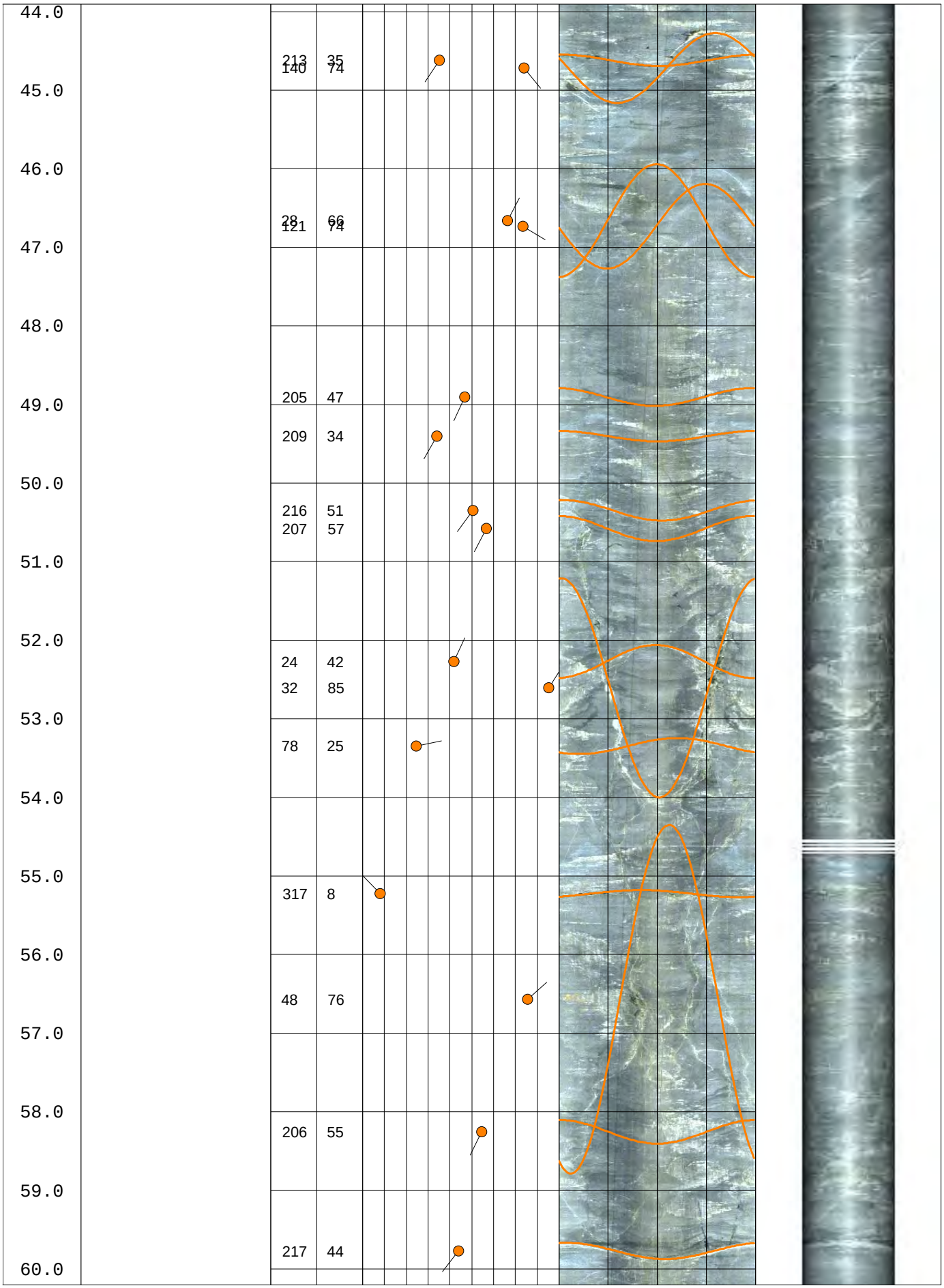
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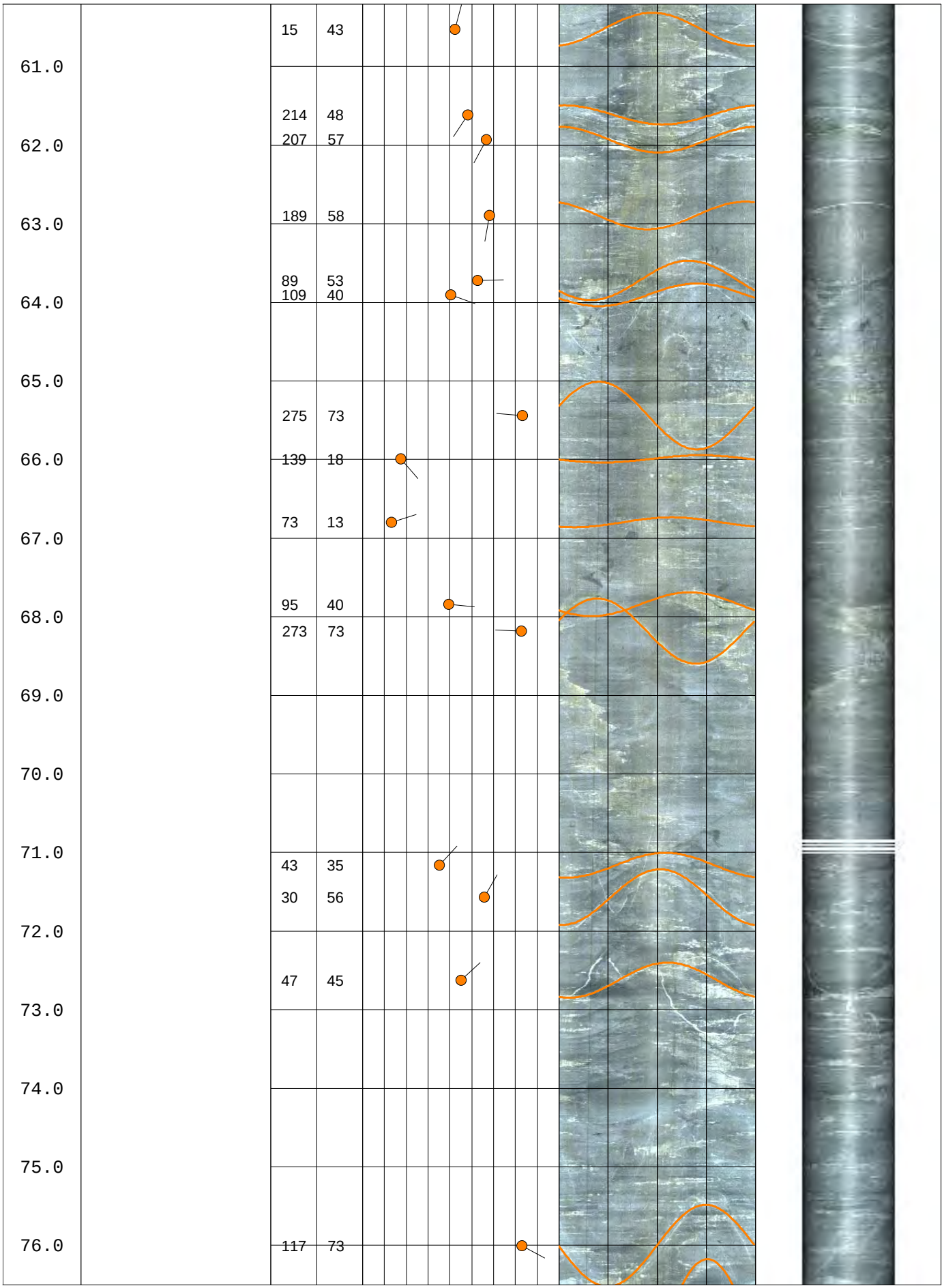
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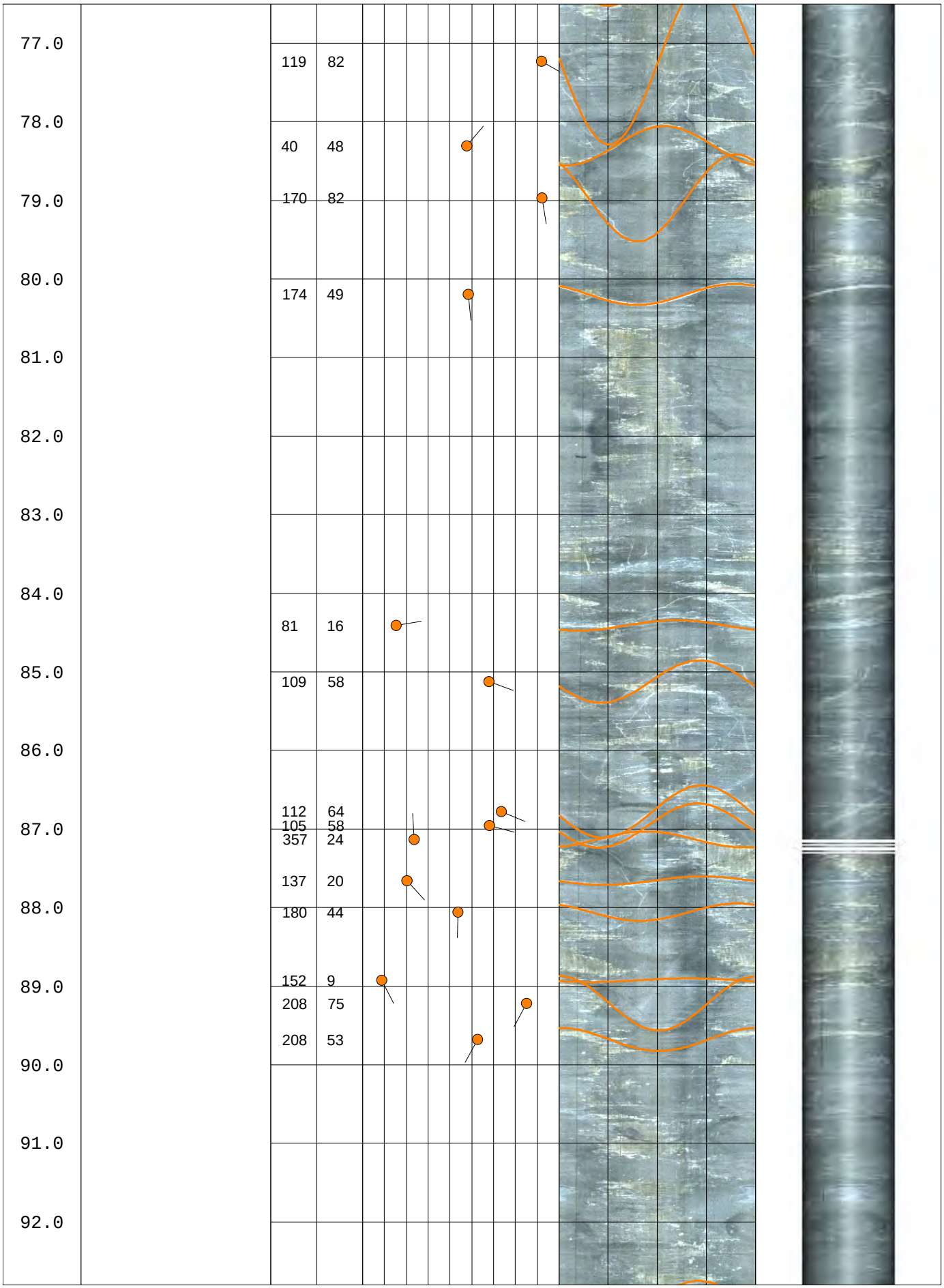
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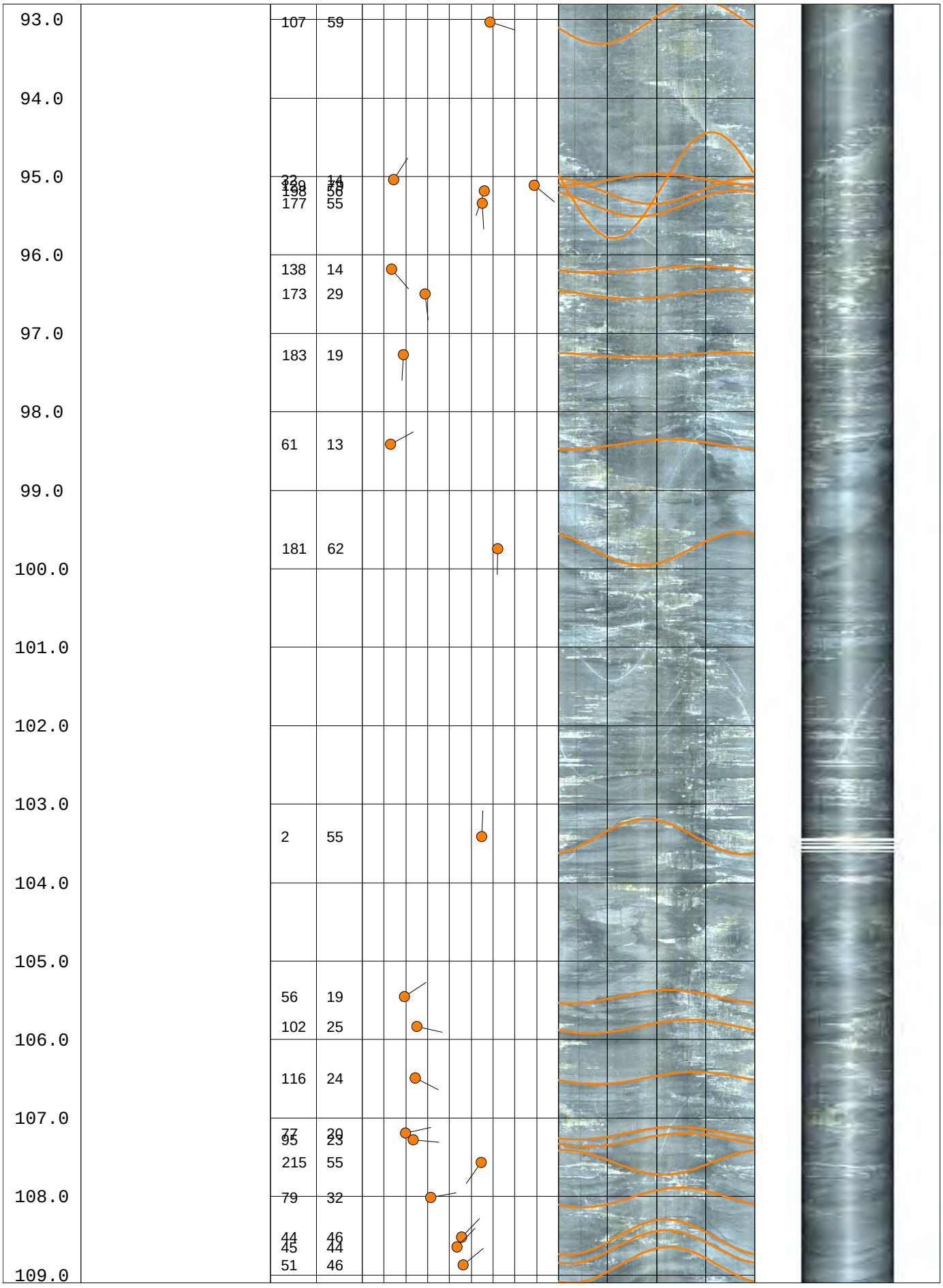
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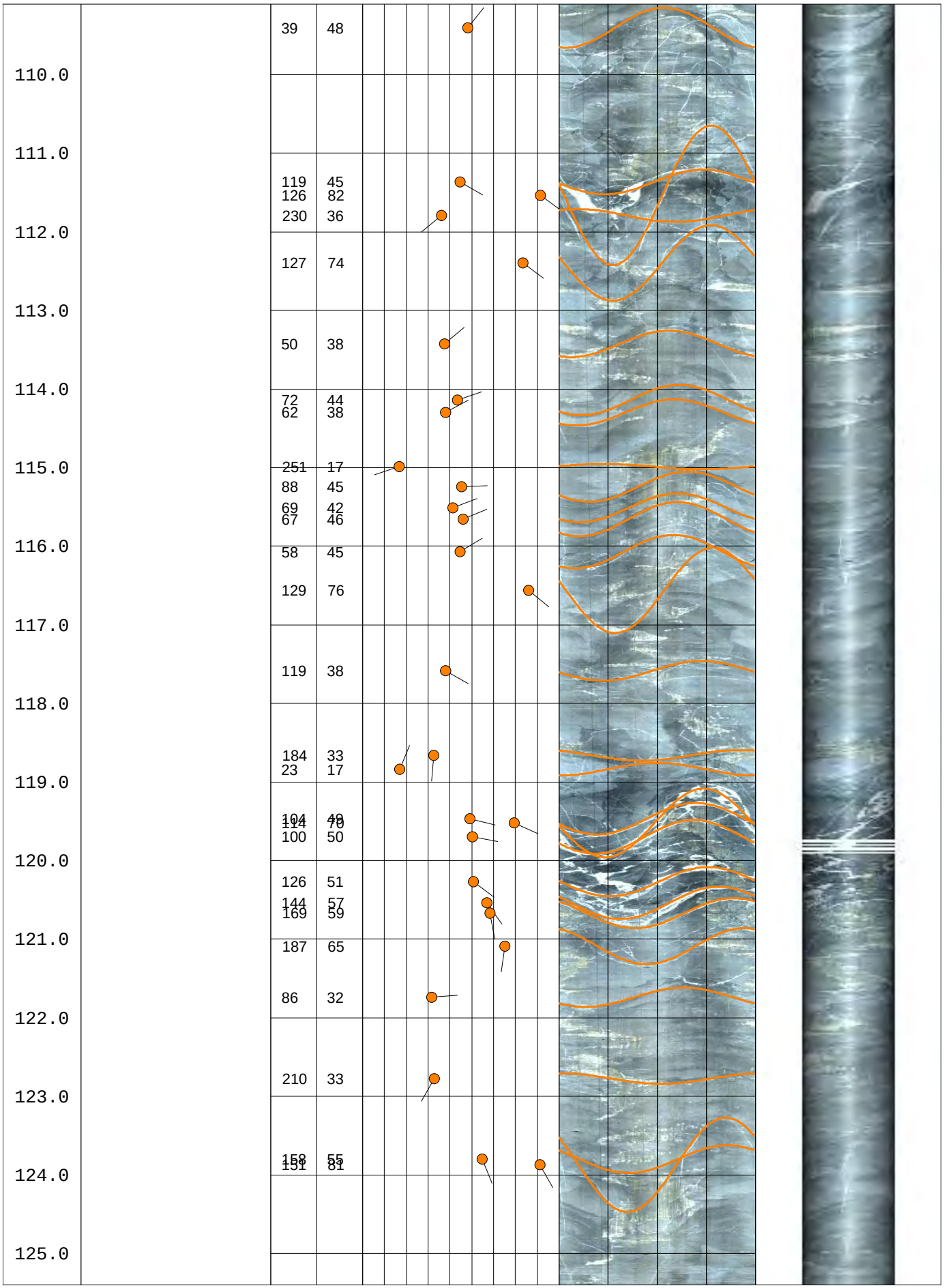
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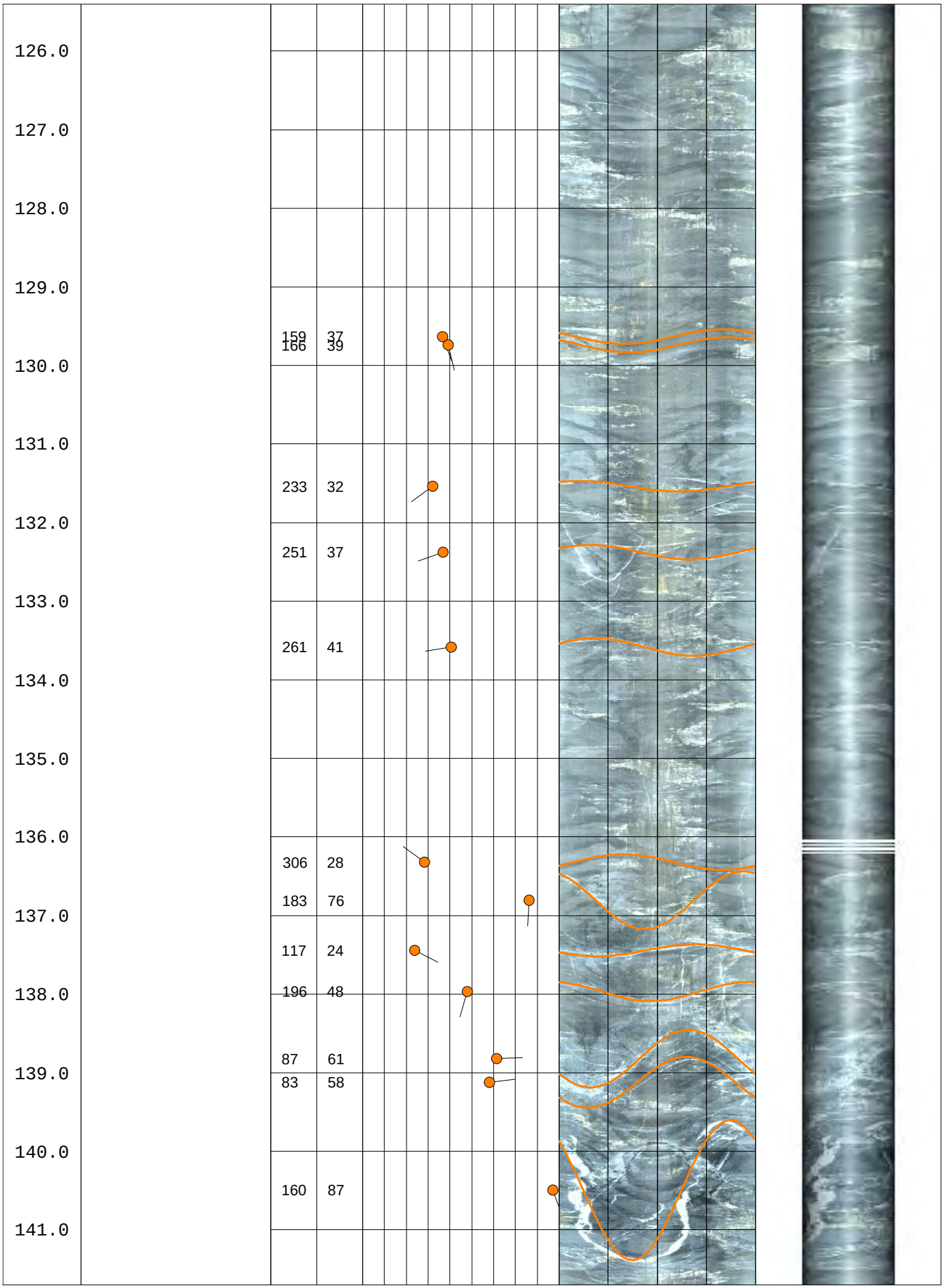
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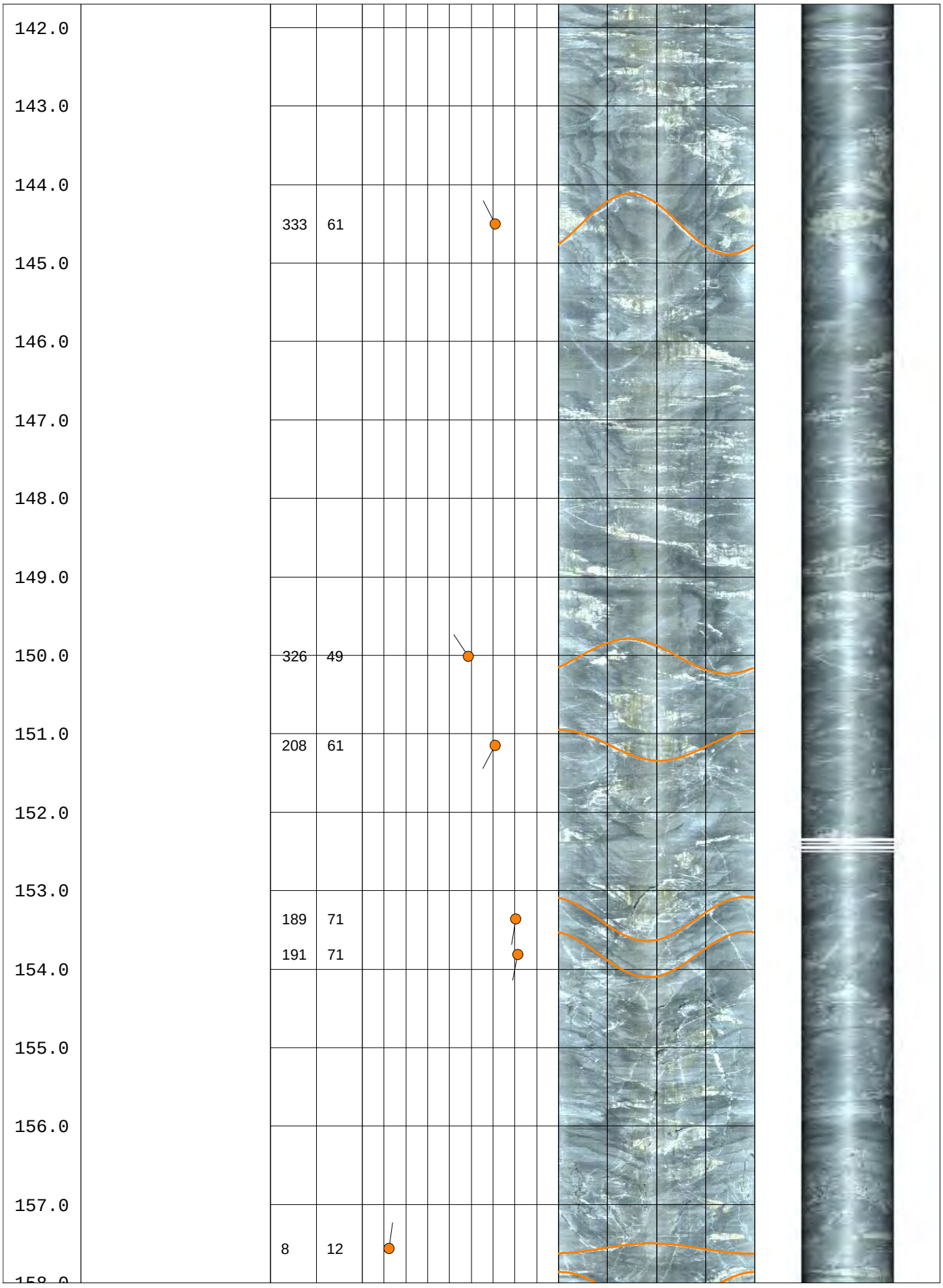
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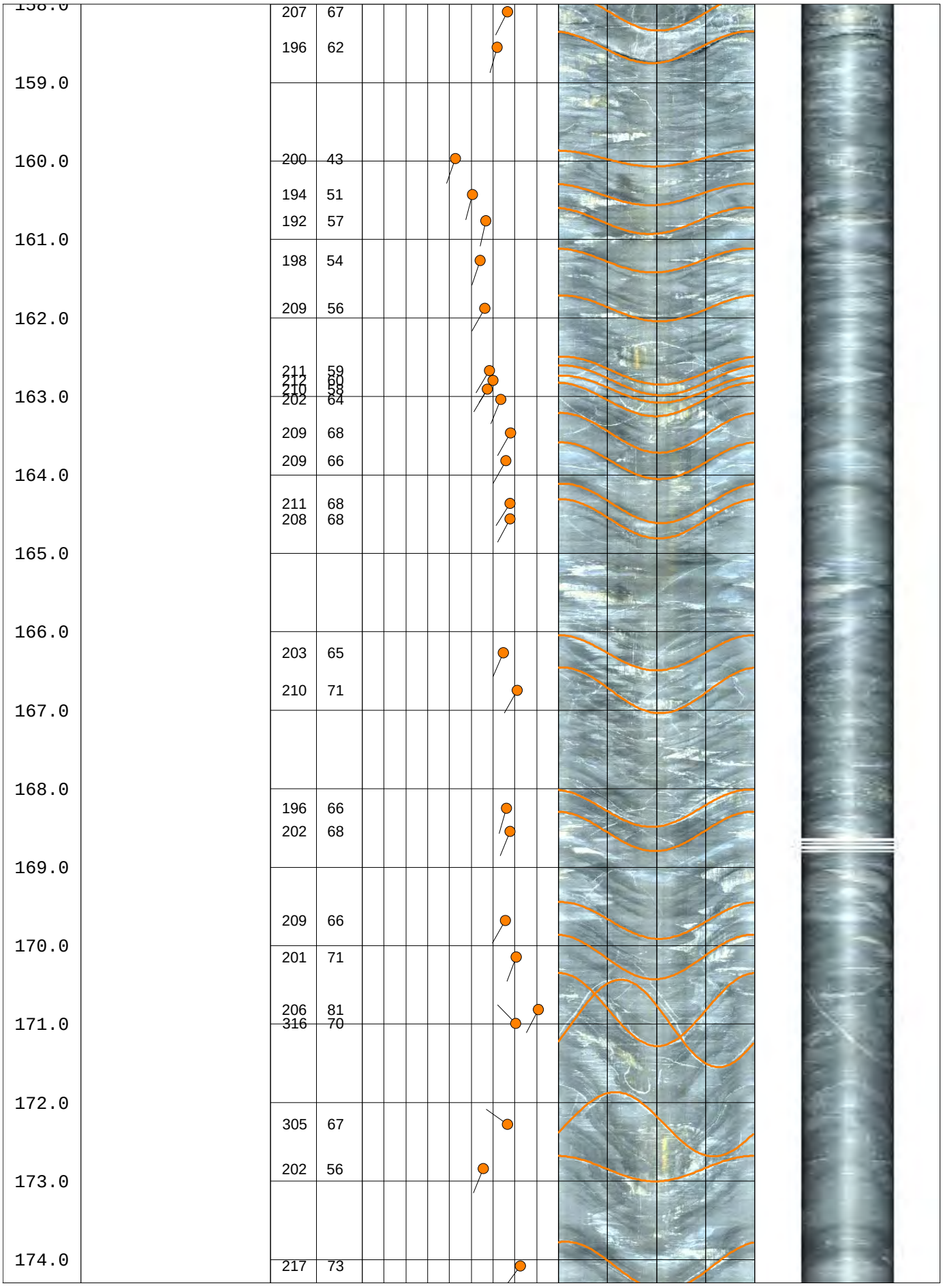
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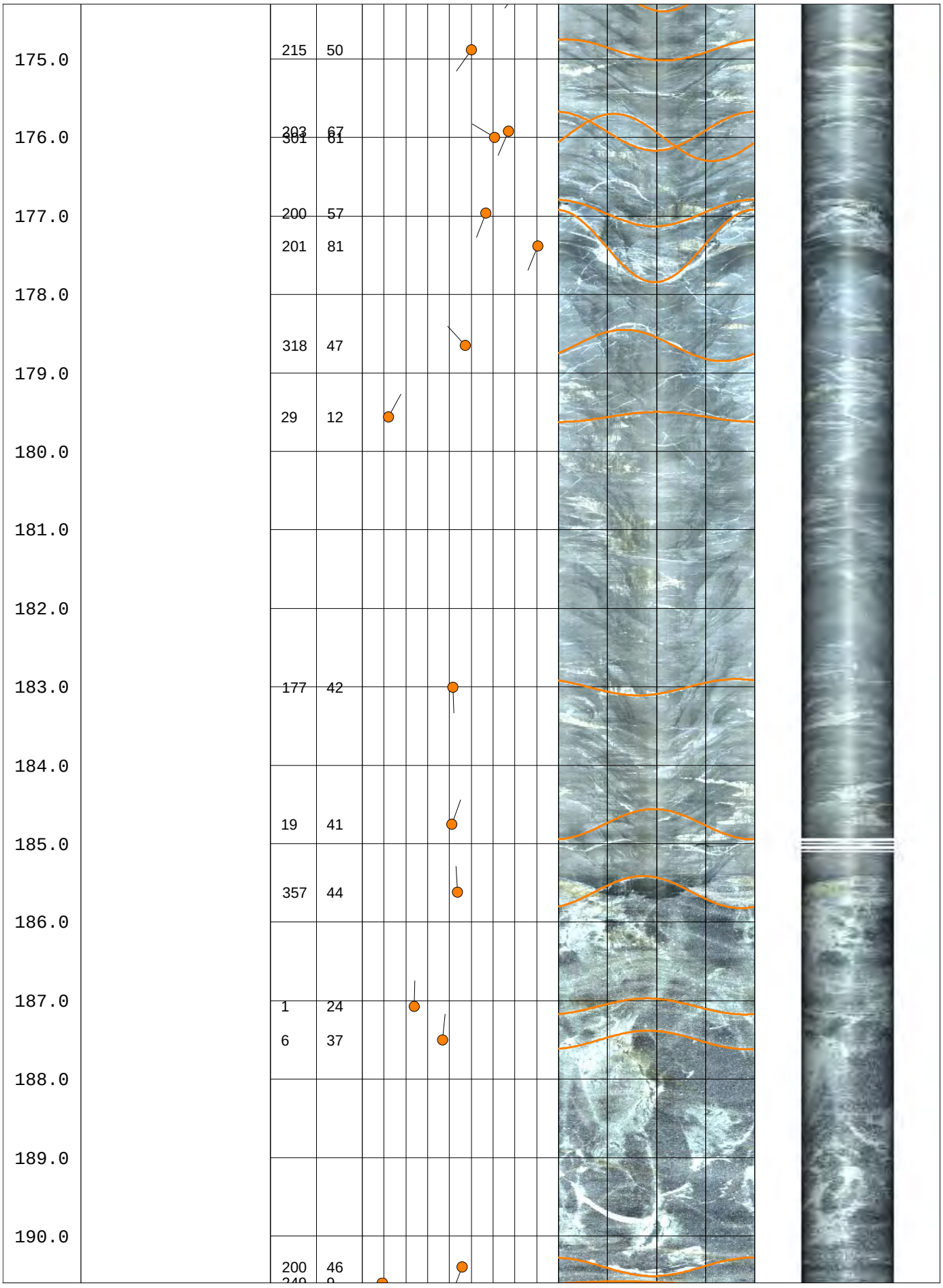
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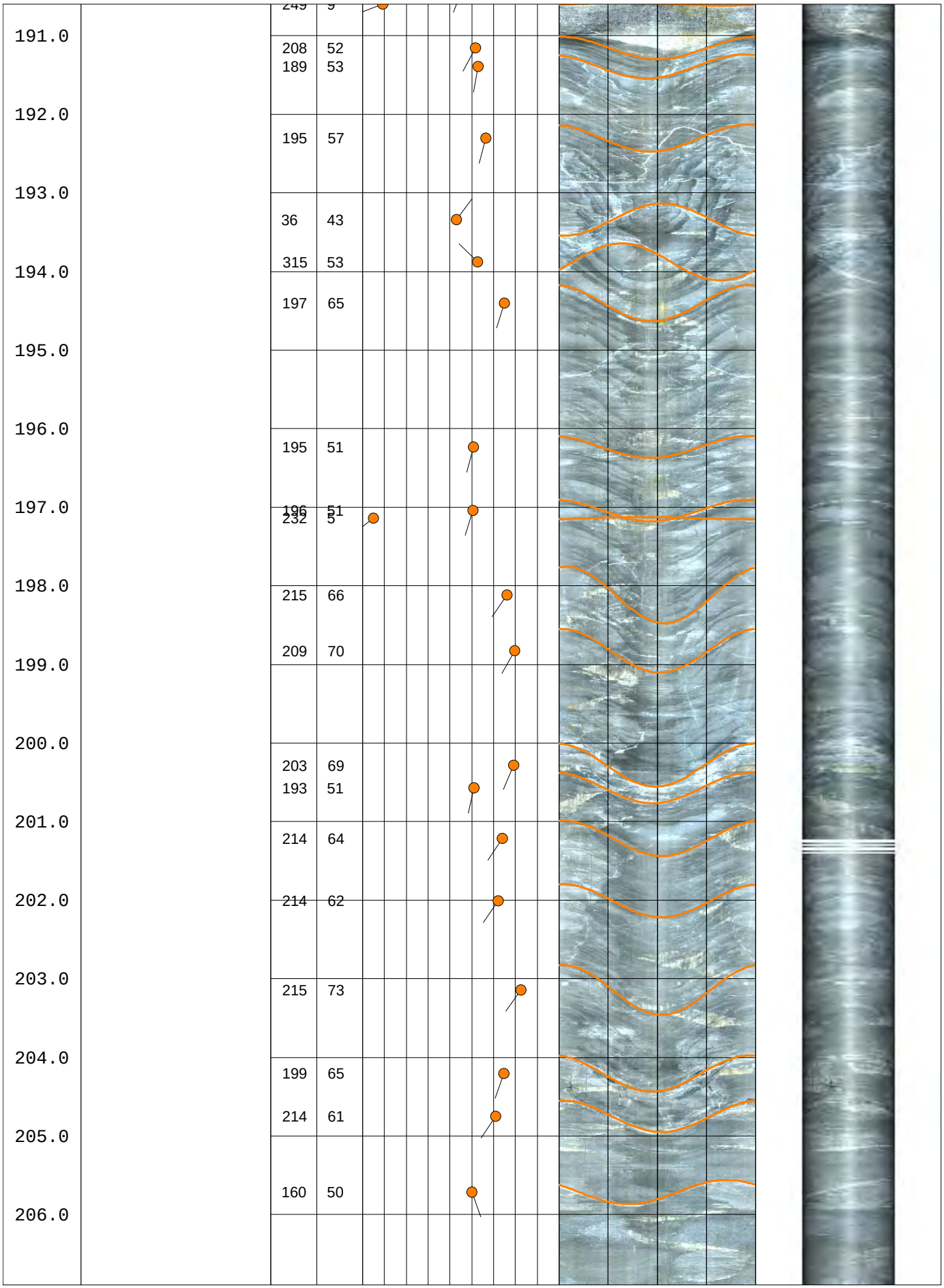
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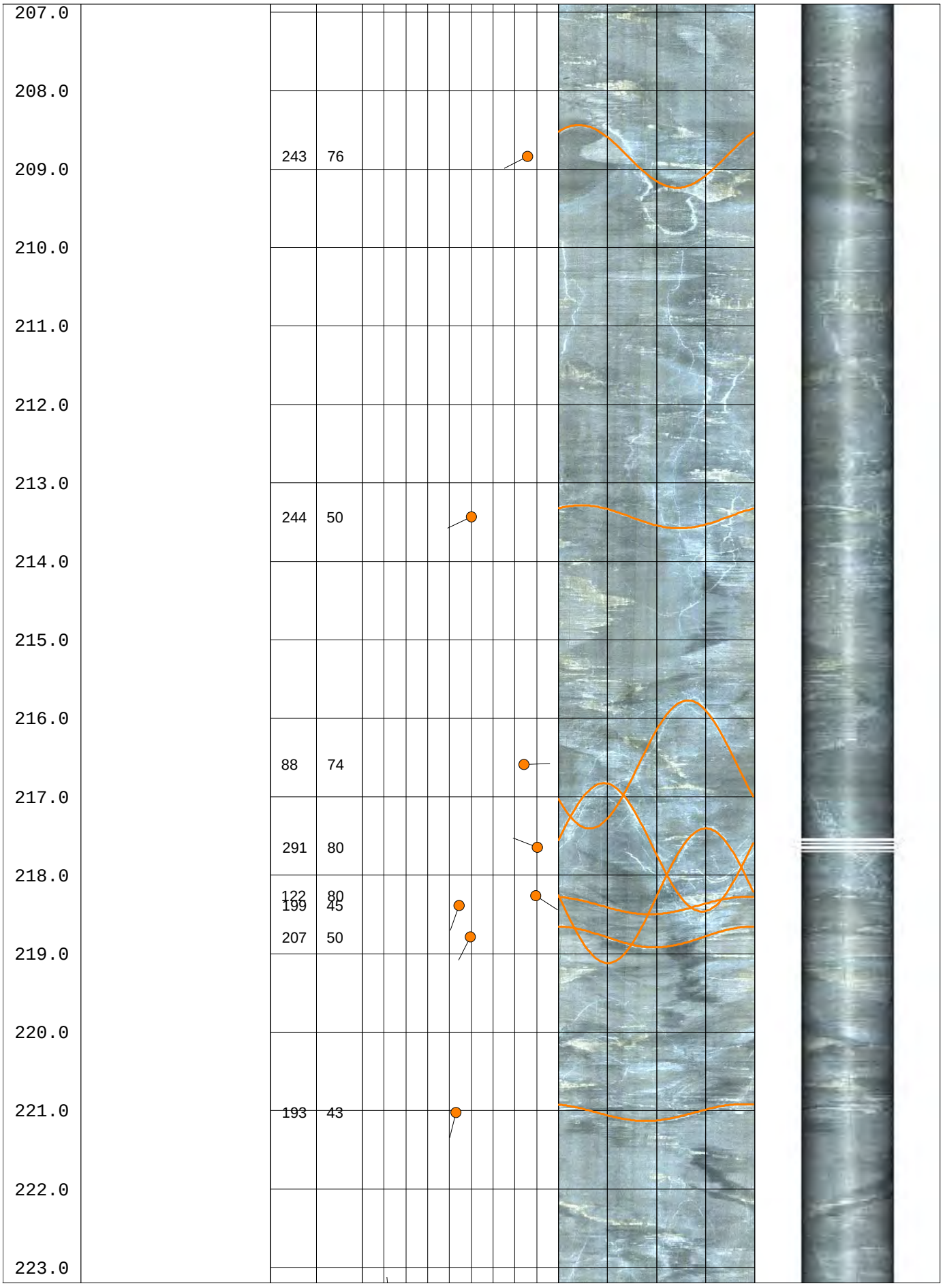
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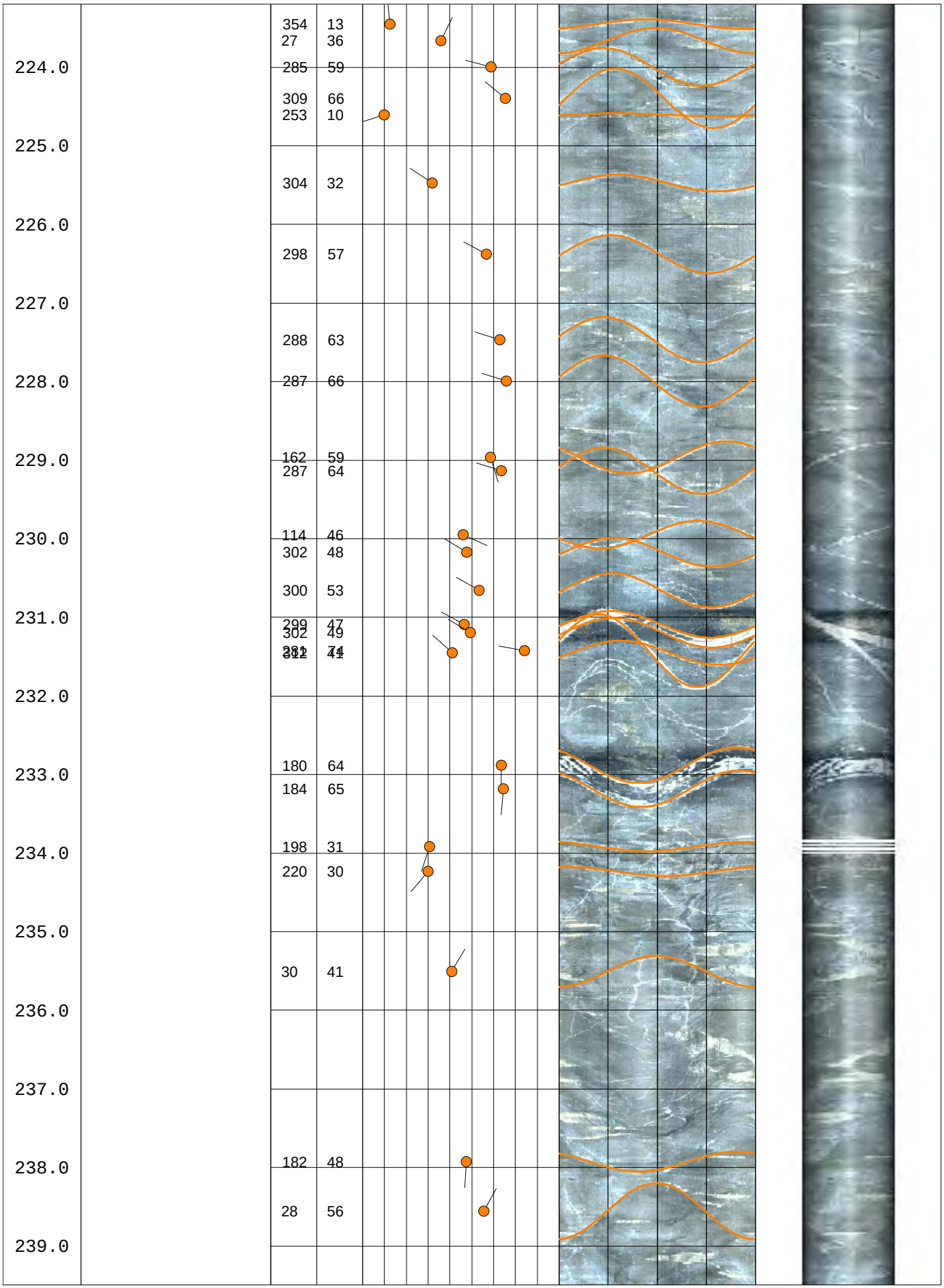
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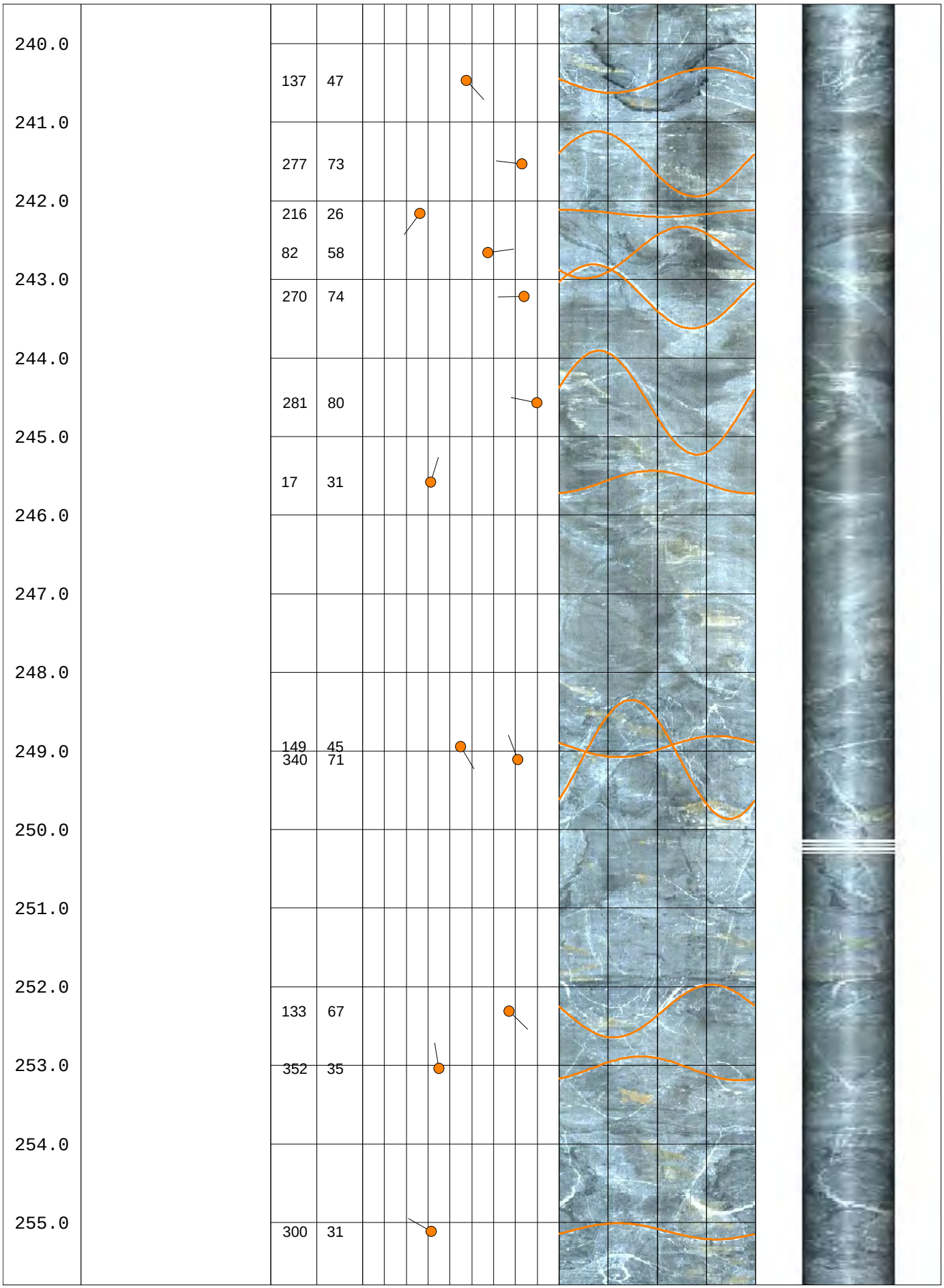
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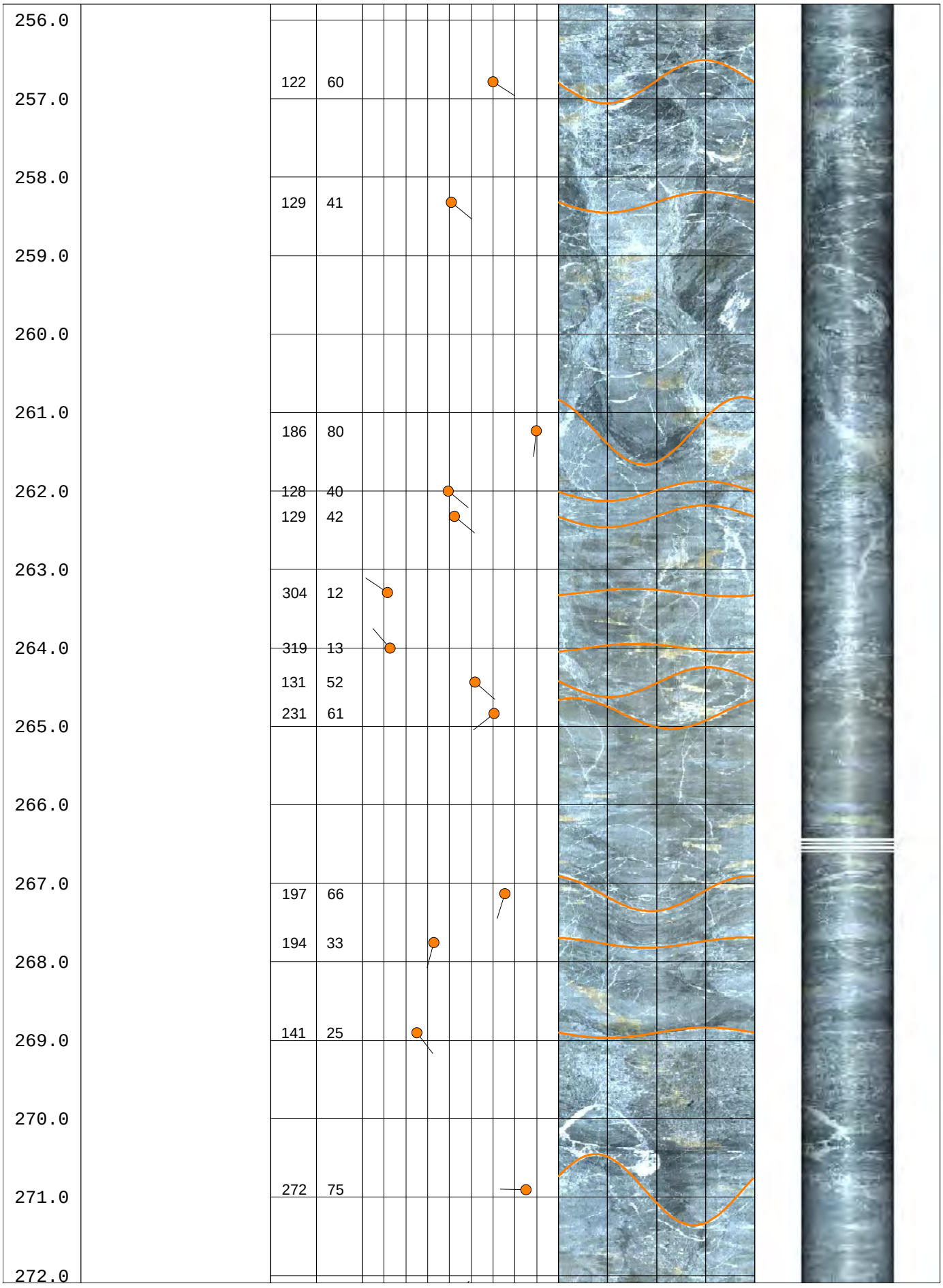
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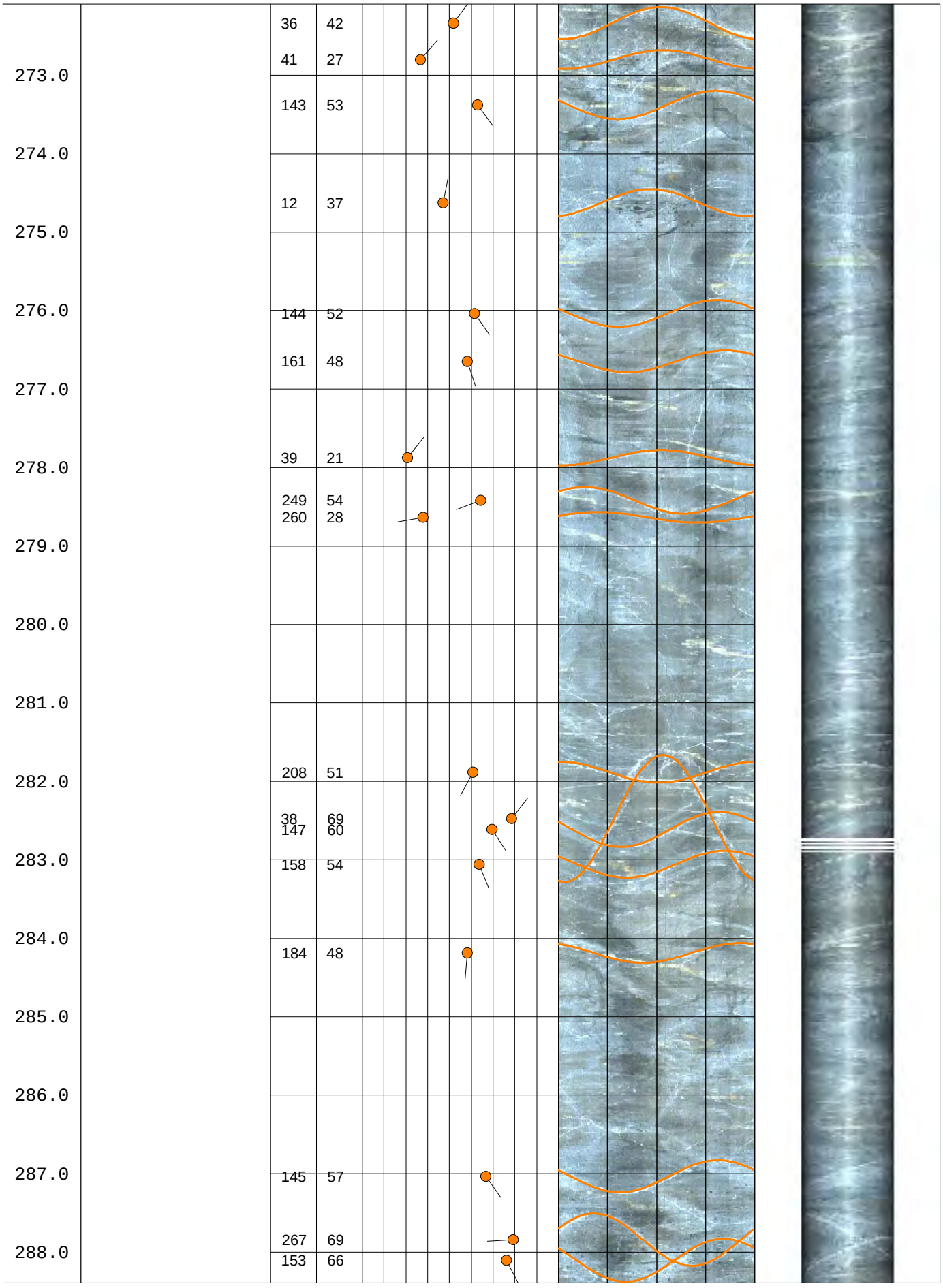
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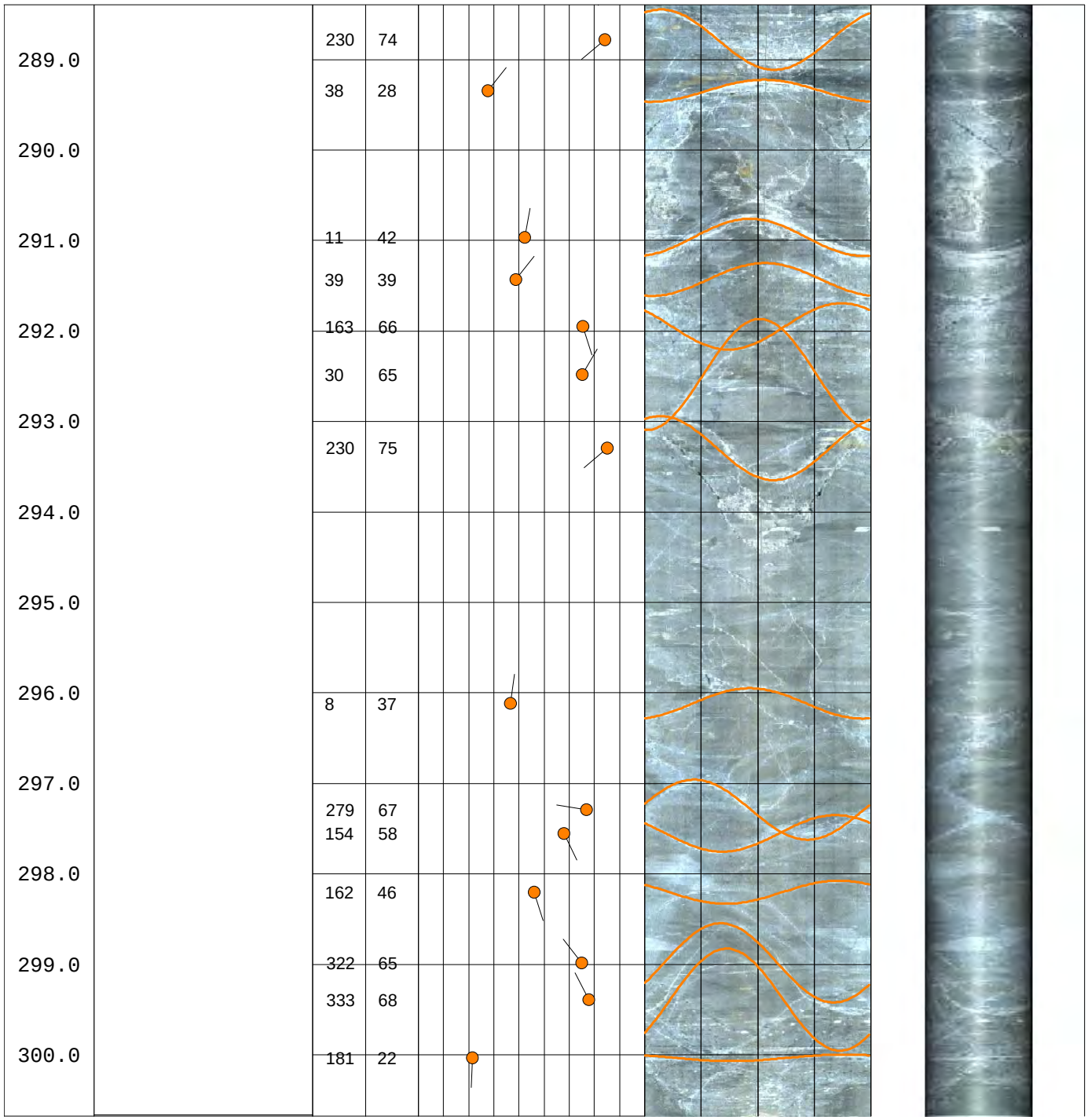
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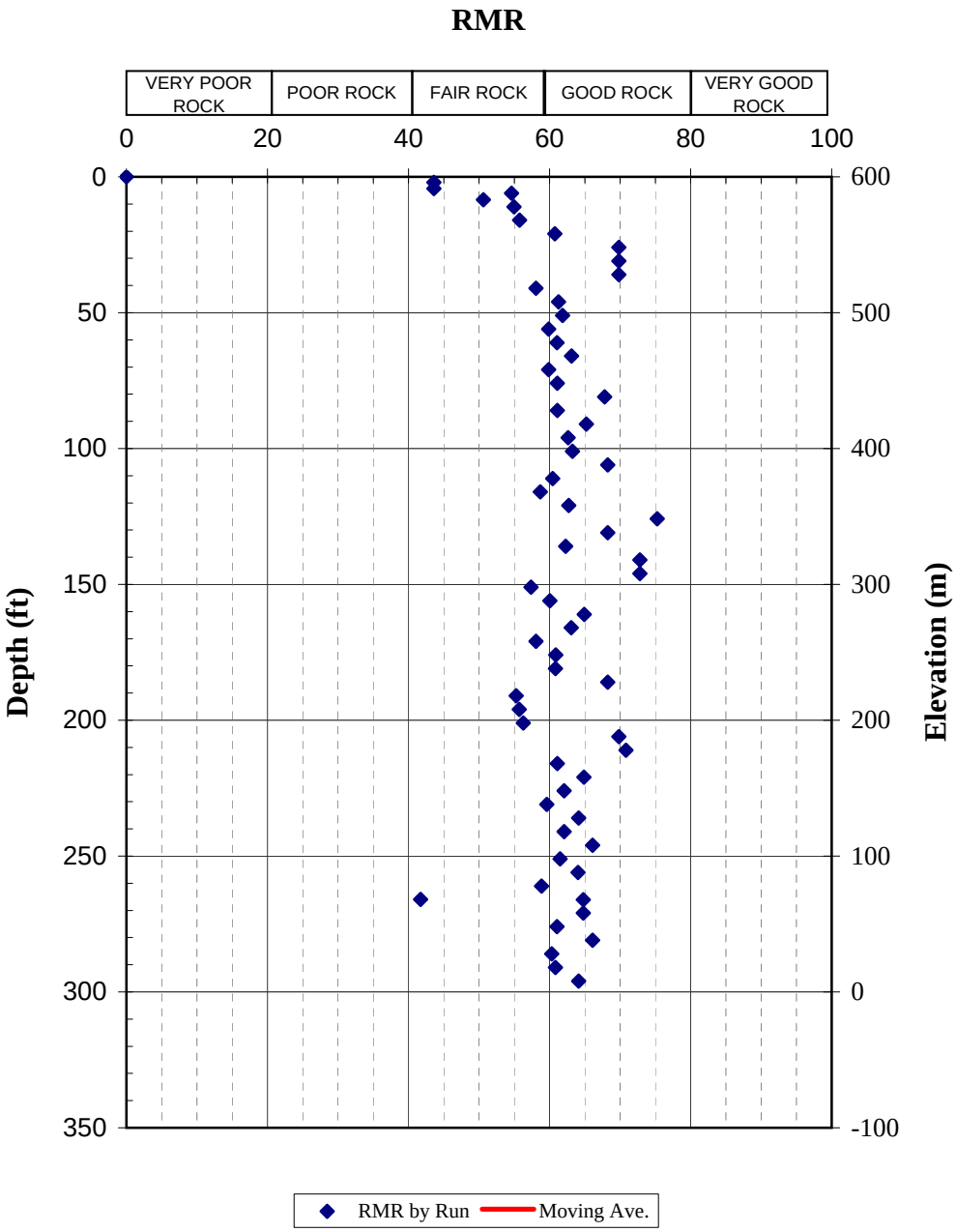
RMR vs Depth and Elevation DH09-14



Borehole DH09-15

Working Together SAFELY

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BOREHOLE REPORT

CLIENT: City and Borough of Sitka

HOLE: ***DH09-15***

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 3

SITE: Powerhouse

COORDINATES: 1908928.1 N, 2374931.4 E
DIP DIRECTION: N/A
DIP: 90

ELEVATIONS
DATUM: Ground
PLATFORM: N/A
GROUND: 28.6
END OF HOLE: -2.1

CONTRACTOR: Crux Subsurface Inc.
DRILL TYPE: Burley 2500
METHOD SOIL: Diamond Drill Casing Advancer
ROCK: Diamond Drill Triple Tube
CASING: HWT

CORE: HQ3

STARTED: 10/01/09
FINISHED: 10/01/09
INSPECTOR: P. Nolan
LOGGED BY: M. Mammoliti
REVIEWED: P. Friz

DATE: 11/20/2009

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: REC'Y (in)	SAMPLE: REC'Y (%)	SAMPLE: BLOW COUNTS	DEPTH (ft)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (psi) (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN.) (5 10 15 20)	HYDRAULIC CONDUCTIVITY (ft/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (10 20 30 (%))	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
28.6 / 0.0		0.0 - 7.7 ft: Overburden 0.0 - 4.4 ft: Rockfill						1.0 2.0 3.0 4.0					
		4.4 - 7.7 ft: Gravel, contains angular fragments						5.0 6.0 7.0					
								8.0 9.0	**7.7 ft TOP OF BEDROCK see next sheet**				

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT | NATURAL MOISTURE CONTENT | LIQUID LIMIT
W_P W_N W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** **DH09-15**

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 2 **OF:** 3

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	NO. of JOINTS	DISCONTINUITY CHARACTERISTICS	SAMPLE: DEPTH (ft)	SAMPLE: TYPE/ NUMBER	SAMPLE: REC/SCR (%)	SAMPLE: RQD (%)	DEPTH (ft)	RECOVERY AND RQD (%)	PERMEABILITY (lugeons) / (cm/sec)	NOTES	PIEZOMETER INSTALLATION
20.9 7.7		7.7 - 30.7 ft: Metamorphosed Fragmental Andesitic Siltstone Dark grey, fine grained, very strong (100 - 250 MPa), light/dark prominent flow banding @ 45 deg to core axis; frequent calcite veins/veinlets; small clasts (<0.5") and several large (2.0-5.0") cobbles within and oriented to banding; Iron staining and pyrite on joint surfaces; Average discontinuity spacing of 1.4 ft; GSI = 55 - 60. Removed 2-3 in. pieces of core @ depths of 10.2 ft, 11.7 ft,14.8 ft and 26.1 ft for samples ARD COMP 4 14.4 - 15.0 ft: Four thick (3-7mm) calcite veins 45-70 deg to core axis 29.9 - 30.1 ft: Sample ARD COMP 4		The following general discontinuity characteristic were noted for this hole: 60% of the discontinuities are smooth, 20% are slightly rough, 13% are slick and 6% are rough 100% of discontinuities are planar, 7% of dicontinuities have hematite staining, 63% are slightly weathered and 37% are moderately weathered. 12.3 - 12.7 ft: FRAGMENTED ZONE 15.3 - 15.5 ft: FRAGMENTED ZONE 20.7 - 20.8 ft: FRAGMENTED ZONE 27.9 - 28.1 ft: FRAGMENTED ZONE 28.4 - 28.7 ft: FRAGMENTED ZONE		1 2 3 4 5	100 100 100 100 100	97 80 100 96 90	8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	20 40 60 80	No take 10^-6 10^-5 10^-4 10^-3 / 0.1 1 10 100		
-2.1 30.7				**END OF BOREHOLE**									

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

Core Condition: Fragmented, Lost, RQD, Recovery

Permeability units: Lugeons, cm/sec

BOREHOLE REPORT

CLIENT: City and Borough of Sitka **HOLE:** DH09-15

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations **PAGE:** 3 **OF:** 3

NOTES/COMMENTS

1 Core recoveries calculated as core length recovered divided by drilled length. Solid core recovery not measured.
2 RQD's caluclated based on joint measurements logged on the discontinuity logs. RQD is measured according to the sum of the total length of the core pieces equal to or greater than 100 mm (3.9") divided by the total run length.
3 Full drill water return except where noted on the log.
4 Horizontal survey control is according to NAD 83.
5 The graphical symbols for fragmented core is also used for broken core.
6 Static water level measured at 10.0 ft below the hole collar on October 1, 2009.
7 GSI (Geological Strength Index) estimation based on visual assessments of rock structure and discontinuity conditions observed at the left abutment, plunge pool, powerhouse, areas of exposed bedrock and drill core based on Hoek and Marinos (2000).
8 This average discontinuity spacing for a specified interval of core is obtained by dividing the length of the interval by the number of discontinuities within that interval excluding breaks caused by drill.

Drilling Report (Discontinuities)

Borehole: DH09-15
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Powerhouse
Azimuth (Deg)	N/A
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
7.7					Top of Bedrock																
8.0					Joint	80							x	x			H		S			
8.4					Drill Break																	
9.3					Drill Break																	
10.0					Drill Break																	
10.1					Joint	30						x		x				C	S	x		O
10.2					Joint	30						x		x				C	S	x		O
10.4					Drill Break																	
10.5					Joint	30						x		x				C	S	x		O
10.7					Drill Break																	
11.4					Drill Break																	
11.8					Joint	40					x			x				C	s	x		O
12.0					Drill Break																	
12.3					Drill Break																	
12.3	12.7			x	Fragmented zone																	
12.7					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-15
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Powerhouse
Azimuth (Deg)	N/A
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
12.9					Joint	30					x			x				C	s	x		O
13.2					Drill Break																	
13.6					Joint	45					x			x				C	s	x		O
13.8					Drill Break																	
14.4					Vein	45					x			x				C	s			
14.7					Vein	55					x			x				C	s			
14.9					Drill Break																	
15.1					Joint (pyrite)	45					x			x				C	s			
15.3	15.5			x	Fragmented zone																	
15.7					Drill Break																	
15.9					Hammer Break																	
16.1					Hammer Break																	
16.5					Drill Break																	
17.0					Drill Break																	
17.8					Drill Break																	
18.3					Drill Break																	

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-15
Project: H332360

Client: City and Borough of Sitka
Project: Blue Lake Hydroelectric Expansion
Site: Powerhouse
Azimuth (Deg): N/A
Inclination (Deg): 90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
18.8					Drill Break																
19.6					Drill Break																
19.9					Drill Break																
20.4					Drill Break																
20.5					Drill Break																
20.7					Drill Break																
20.7	20.8			x	Fragmented zone													m	x		O
20.8					Joint	70					x			x					m	x		O
20.9					Joint	70					x			x					m	x		O
21.0					Drill Break																
21.2					Drill Break																
21.5					Drill Break																
21.7					Drill Break																
22.5					Drill Break																
23.6					Drill Break																
24.3					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Drilling Report (Discontinuities)

Borehole: DH09-15
Project: H332360

Client	City and Borough of Sitka
Project	Blue Lake Hydroelectric Expansion
Site	Powerhouse
Azimuth (Deg)	N/A
Inclination (Deg)	90

Depth (m)		Drill Induced	zone		Description	Discontinuity surface and shape															
from	to		broken	fragmented		Angle to core axis (deg)	Dip	Dip Direction	slickensided	slick	smooth	slightly rough	rough	planar	curved	irregular	staining	filling	weathering	alteration	Healed	aperture
25.3					Drill Break																
25.7					Drill Break																
26.8					Vein	80					x			x				C			P	
27.1					Drill Break																
27.5					Drill Break																
27.9					Joint	45				x				x				C	m	x		H
27.9	28.1			x	Fragmented zone														m	x		O
28.1					Joint	55				x				x				C	m	x		H
28.4	28.7			x	Fragmented zone																
29.2					Hammer Break																
29.7					Hammer Break																
30.2					Hammer Break																
30.7					Drill Break																

Filling: C-carbonate; CL-clay; K-chlorite; O-organics; S-silt

Staining: B-brown; BL-black; G-green; H-hematite; L-limonite

Weathering:
S-slightly; M-moderately; H-highly

Aperture:O-Open; H-Hairline (<0.5mm)

Healed:P-Partially Healed; H-Healed

Test Pit Logs

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TEST PIT REPORT

CLIENT: City and Borough of Sitka

PIT NO: TP-1

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 1

SITE: Powerhouse

COORDINATES: 1908830.7 N, 2374871.9 E

CONTRACTOR: Crux Subsurface Inc.

EXCAVATION METHOD: Excavator

LENGTH: 25 ft

WIDTH: 10 ft

DEPTH 11.5 ft

STARTED: 21/09/2009

FINISHED: 21/09/2009

INSPECTOR: P. Friz

ELEVATIONS

DATUM: 22.7 ft

GROUND: 22.7 ft

BOTTOM OF PIT: 11.2 ft

WATER: 10.5 ft

WEATHER: Cloudy with showers; 55 deg. F

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE SIZE	DEPTH (ft)	SHEAR STRENGTH (kPa) □ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN. 40 80 120 160	WATER CONTENT & ATTERBERG LIMITS 10 20 30 (%)	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0		Roadfill - grey sand and gravel								
1.0		Engineered Fill - brown colour, angular to subrounded boulders (up to 3 ft in diameter), gravel and sand. Pipe at 6.5 ft, thin layer of gravel (4" - 6") around pipe.				1.0 2.0 3.0 4.0 5.0 6.0				
6.5		Poorly consolidated grey sand, gravel and boulders (up to 3 ft in diameter). Water level at 10.5 ft.				7.0 8.0 9.0 10.0				
10.5		Bedrock - bottom of pit								

BOTTOM OF TEST PIT

SAMPLING METHOD AND SHIPPING CONTAINER

G- Shovel
L- Block Sample
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Z - Discarded

LOGGED BY: P.Friz
REVIEWED BY: S. Perkins
DATE

TEST PIT REPORT

CLIENT: City and Borough of Sitka

PIT NO: TP-2

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 1

SITE: Filter plant road

COORDINATES: 1909950.9 N, 2374980.0 E

CONTRACTOR: Crux Subsurface Inc.

EXCAVATION METHOD: Excavator

LENGTH: 20 ft

WIDTH: 5 ft

DEPTH 11.0 ft

STARTED: 21/09/2009

FINISHED: 21/09/2009

INSPECTOR: P.Friz

ELEVATIONS

DATUM: 61.93 ft

GROUND: 61.93 ft

BOTTOM OF PIT: 50.03 ft

WATER: N/A

WEATHER: Cloudy with showers; 55 deg. F

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE SIZE	DEPTH (ft)	SHEAR STRENGTH (kPa) □ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN. 40 80 120 160	WATER CONTENT & ATTERBERG LIMITS 10 20 30 (%)	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0		Roadfill - grey sand and gravel								
1.0		Unstratified Rockfill - brown gravel and boulders with a silty sand matrix. Boulders up to 1.5 ft in diameter.				1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0				
11.0		Bedrock - bottom of pit.				11.0				

BOTTOM OF TEST PIT

SAMPLING METHOD AND SHIPPING CONTAINER

G- Shovel
L- Block Sample
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Z - Discarded

LOGGED BY: P.Friz
REVIEWED BY: S. Perkins
DATE

TEST PIT REPORT

CLIENT: City and Borough of Sitka

PIT NO: TP-3

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 1

SITE: Filter plant road

COORDINATES: 1908732.0 N, 2375182.7 E

CONTRACTOR: Crux Subsurface Inc.

EXCAVATION METHOD: Excavator

LENGTH: 20 ft

WIDTH: 5 ft

DEPTH 16.0 ft

WATER: 14 ft

WEATHER: Cloudy with showers; 55 deg. F

STARTED: 21/09/2009

FINISHED: 21/09/2009

INSPECTOR: P.Friz

See end page for detailed groundwater measurements

ELEVATIONS

DATUM: 89.39 ft

GROUND: 89.39 ft

BOTTOM OF PIT: 72.39 ft

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE SIZE	DEPTH (ft)	SHEAR STRENGTH (kPa) □ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN. 40 80 120 160	WATER CONTENT & ATTERBERG LIMITS 10 20 30 (%)	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0		Topsoil								
0.5		Road Fill - grey sand and gravel.				1.0				
2.0		Unstratified Rockfill - brown colour, silty sand matrix, gravel and angular and sub-rounded boulders (up to 5 ft in diameter), contains wood debris.				2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0				
14.0		Blue - grey silty sand with gravel; water level at 14.0 ft.	14			14.0 15.0				16 59 20 5
16.0		Bottom of pit.				16.0				

BOTTOM OF TEST PIT

SAMPLING METHOD AND SHIPPING CONTAINER

G- Shovel
L- Block Sample
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Z - Discarded

LOGGED BY: P.Friz
REVIEWED BY: S. Perkins
DATE

TEST PIT REPORT

CLIENT: City and Borough of Sitka

PIT NO: TP-4

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 1

SITE: Filter plant-east

COORDINATES: 1909206.3 N, 2375256.1 E

CONTRACTOR: Crux Subsurface Inc.

EXCAVATION METHOD: Excavator

LENGTH: 15 ft

WIDTH: 5 ft

DEPTH 18.0 ft

STARTED: 21/09/2009

FINISHED: 21/09/2009

INSPECTOR: P.Friz

ELEVATIONS

DATUM: 122.6 ft

GROUND: 122.6 ft

BOTTOM OF PIT: 104.8 ft

WATER: N/A

WEATHER: Cloudy with showers; 55 deg. F

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE SIZE	DEPTH (ft)	SHEAR STRENGTH (kPa) □ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN. 40 80 120 160	WATER CONTENT & ATTERBERG LIMITS 10 20 30 (%)	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0										
0.5		Roadfill - grey sand and gravel.				1.0				
		Unstratified Brown fill and debris from mill, includes boulders, gravel sand some ash.				2.0				
						3.0				
						4.0				
4.5		Unstratified and unconsolidated grey gravel fill with angular and sub-rounded boulders (up to 3 ft in diameter), contains pieces of metal.				5.0				
						6.0				
						7.0				
						8.0				
						9.0				
						10.0				
						11.0				
						12.0				
						13.0				
						14.0				
						15.0				
						16.0				
						17.0				
18.0		Bottom of Pit				18.0				

BOTTOM OF TEST PIT

SAMPLING METHOD AND SHIPPING CONTAINER

G- Shovel
L- Block Sample
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Z - Discarded

LOGGED BY: P.Friz
REVIEWED BY: S. Perkins
DATE

TEST PIT REPORT

CLIENT: City and Borough of Sitka

PIT NO: TP-5

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 1

SITE: Filter plant-west

COORDINATES: 1909234.6 N, 2375080.7 E

CONTRACTOR: Crux Subsurface Inc.

EXCAVATION METHOD: Excavator

LENGTH: 40 ft

WIDTH: 10 ft

DEPTH 8.5 ft

STARTED: 21/09/2009

FINISHED: 21/09/2009

INSPECTOR: P.Friz

ELEVATIONS

DATUM: 118.71 ft

GROUND: 118.71 ft

BOTTOM OF PIT: 110.21 ft

WATER: N/A

WEATHER: Cloudy with showers; 55 deg. F

See end page for detailed groundwater measurements

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE: DEPTH	SAMPLE: TYPE/ NUMBER	SAMPLE: SIZE	DEPTH (ft)	SHEAR STRENGTH (kPa): □ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN. 40 80 120 160	WATER CONTENT & ATTERBERG LIMITS: 10 20 30 (%)	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%): GR SA SI CL
0.0		Unstratified fill, contains boulders and gravel (3 - 5 ft diameter), large woody debris, pieces of steel, has a silty sand matrix.				1.0 2.0 3.0 4.0 5.0 6.0 7.0				
7.5		Top of bedrock (depth varies from 6.5 - 8.5 ft)								

BOTTOM OF TEST PIT

SAMPLING METHOD AND SHIPPING CONTAINER

G- Shovel
L- Block Sample
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Z - Discarded

LOGGED BY: P.Friz
REVIEWED BY: S. Perkins
DATE

TEST PIT REPORT

CLIENT: City and Borough of Sitka

PIT NO: TP-6

PROJECT: Blue Lake Hydroelectric Expansion - Geotechnical Subsurface Investigations

PAGE: 1 **OF:** 1

SITE: Filter plant access road

COORDINATES: 1908808.5 N, 2375257.8 E

CONTRACTOR: Crux Subsurface Inc.

EXCAVATION METHOD: Excavator

LENGTH: 20 ft

WIDTH: 5 ft

DEPTH 5.5 ft

WATER: 5.5 ft

WEATHER: Cloudy with showers; 55 deg. F

STARTED: 21/09/2009

FINISHED: 21/09/2009

INSPECTOR: P.Friz

See end page for detailed groundwater measurements

ELEVATIONS

DATUM: 108.2 ft

GROUND: 108.2 ft

BOTTOM OF PIT: 102.7 ft

ELEV. / DEPTH (ft)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE SIZE	DEPTH (ft)	SHEAR STRENGTH (kPa) □ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ✪ POCKET PEN. 40 80 120 160	WATER CONTENT & ATTERBERG LIMITS 10 20 30 (%)	BULK DENSITY (lb/ft3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0		Roadfill - grey sand and gravel.								
0.5		Rockfill - angular blast rock pieces up to 3 ft in diameter				1.0 2.0 3.0 4.0 5.0				
5.5		Top of bedrock (depth varies from 5.0 - 6.5 ft)								

BOTTOM OF TEST PIT

SAMPLING METHOD AND SHIPPING CONTAINER

G- Shovel
L- Block Sample
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Z - Discarded

LOGGED BY: P.Friz
REVIEWED BY: S. Perkins
DATE

DH09-01 Box 1 (0.0 - 18.2 ft)

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DH09-01 Box 2 (18.2 - 31.3 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-01 Box 3 (31.3 - 46.2 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-01 Box 4 (46.2 - 61.1 ft)

© Hatch 2006/03 ⌘

DH09-01 Box 5 (61.1 - 75.75 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-01 Box 6 (75.75 - 84.0 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-02 Box 1 (0.0 - 15.9 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-02 Box 2 (15.9 - 29.8 ft)

© Hatch 2006/03 ⌘

DH09-02 Box 3 (29.8 - 43.3 ft)

Working Together SAFELY
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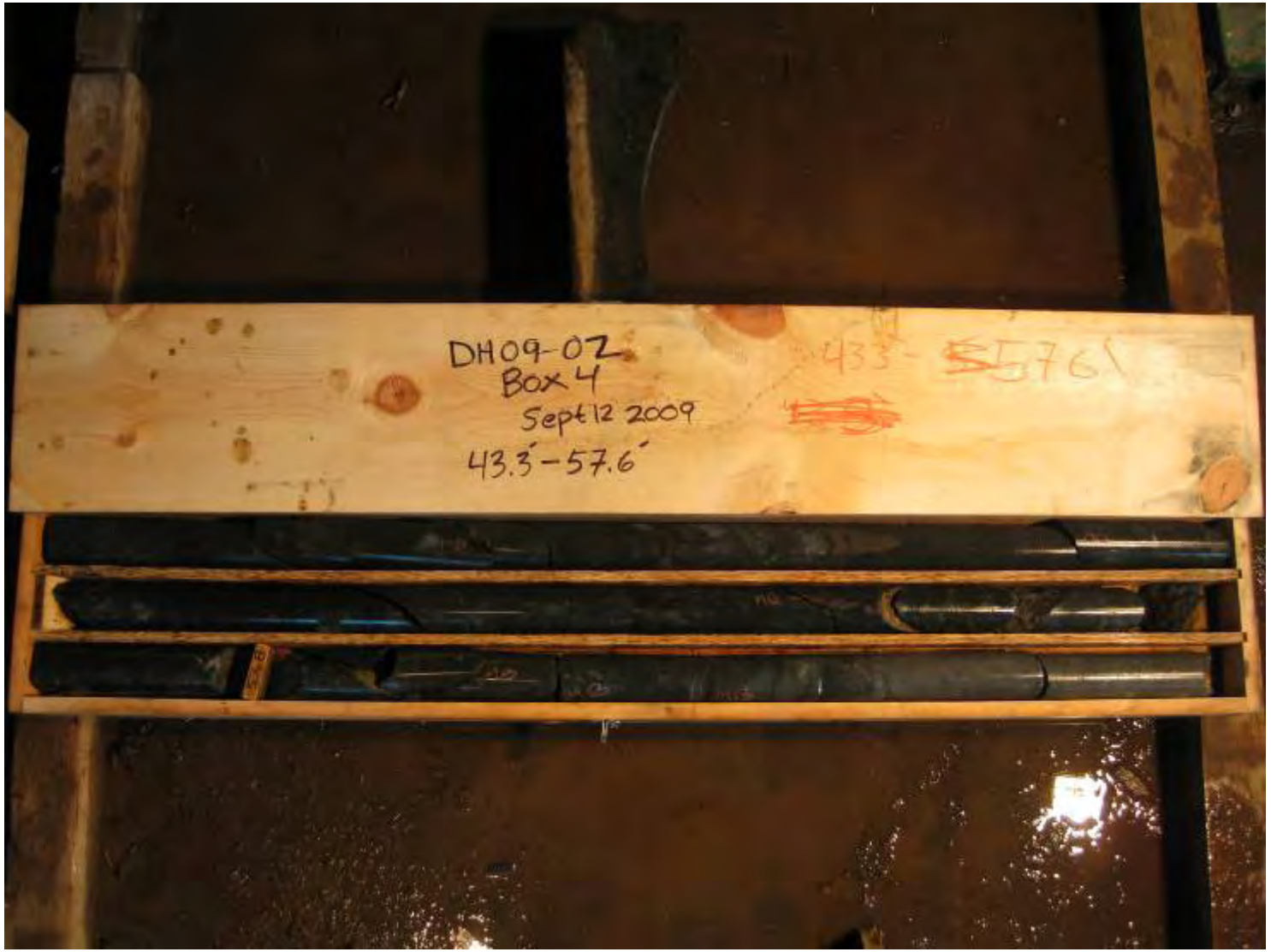

DH09-02 Box 4 (43.3 - 57.6 ft)

Working Together SAFELY
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DH09-02 Box 5 (57.6 - 70.7 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-02 Box 6 (70.7 - 83.9 ft)

Working Together SAFELY

© Hatch 2006/03 ⌘

DH09-02 Box 7 (83.9 - 98.3 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-02 Box 8 (98.3 - 112.5 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-02 Box 9 (112.5 - 118.3 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-03 Box 1 (1.5 - 16.0 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-03 Box 2 (16.0 - 30.4 ft)

WorkingTogether SAFELY
© Hatch 2006/03 ⌘

DH09-03 Box 3 (30.4 - 44.5 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-03 Box 4 (44.5 - 58.1 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-03 Box 5 (58.1 - 62.0 ft)

Working Together SAFELY

© Hatch 2006/03 ⌘

DH09-04 Box 1 (0.0 - 13.6 ft)

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DH09-04 Box 2 (13.6 - 27.3 ft)

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DH09-04 Box 3 (27.3 - 40.8 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-04 Box 4 (40.8 - 55.8 ft)

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DH09-04 Box 5 (55.8 - 70.8 ft)

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DH09-04 Box 6 (70.8 - 85.8 ft)

WorkingTogether SAFELY
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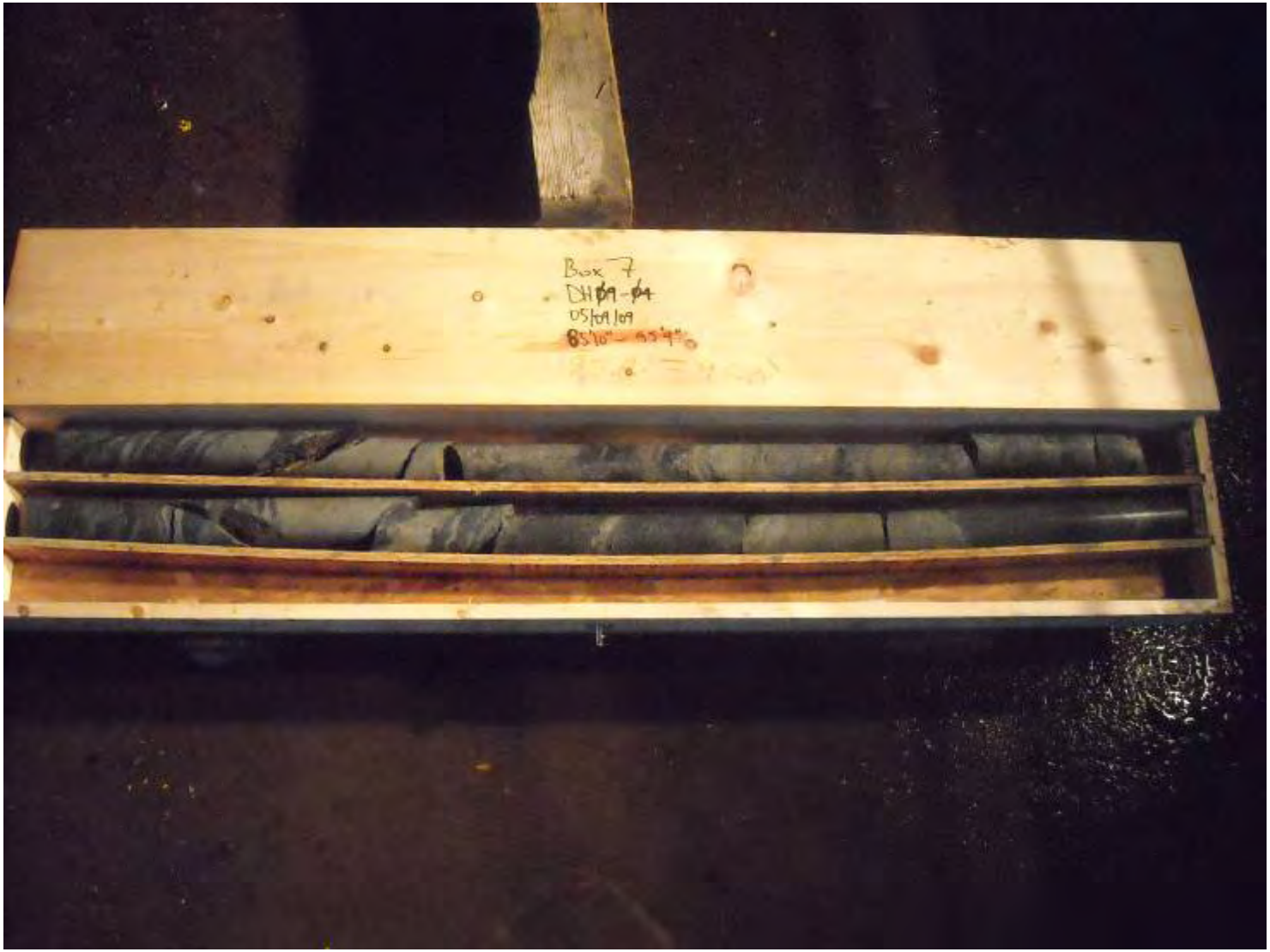

DH09-04 Box 7 (85.8 - 95.8 ft)

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DH09-05 Box 1 (10.0 - 25.1 ft)

Working Together SAFELY

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DH09-05 Box 2 (25.1 - 30.8 ft)

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DH09-06 Box 1 (27.3 - 49.7 ft)

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DH09-06 Box 2 (49.7 - 64.6 ft)

Working Together SAFELY
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DH09-06 Box 3 (64.6 - 71.4 ft)

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DH09-07 Box 1 (0.0 - 18.0 ft)

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DH09-07 Box 2 (18.0 - 32.2 ft)

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DH09-07 Box 3 (32.2 - 46.5 ft)

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DH09-07 Box 4 (46.5 - 60.5 ft)

Working Together SAFELY
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DH09-07 Box 5 (60.5 - 75.0 ft)

Working Together SAFELY
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DH09-07 Box 6 (75.0 - 89.6 ft)

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DH09-07 Box 7 (89.6 - 104.2 ft)

Working Together SAFELY
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DH09-07 Box 8 (104.2 - 118.8 ft)

© Hatch 2006/03 ⌘

DH09-07 Box 9 (118.8 - 133.8 ft)

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DH09-07 Box 10 (133.8 - 148.8 ft)

Working Together SAFELY
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DH09-07 Box 11 (148.8 - 163.8 ft)

Working Together SAFELY
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DH09-07 Box 12 (163.8 - 168.8 ft)

WorkingTogether SAFELY
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DH09-08 Box 1 (0.0 - 15.8 ft)

WorkingTogether SAFELY
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DH09-08 Box 2 (15.8 - 34.1 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-08 Box 3 (34.1 - 48.3 ft)

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DH09-08 Box 4 (48.3 - 62.8 ft)

Working Together SAFELY
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DH09-08 Box 5 (62.8 - 77.1 ft)

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DH09-08 Box 6 (77.1 - 81.0 ft)

Working Together SAFELY
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DH09-09 Box 1 (0.0 - 15.0 ft)

Working Together SAFELY

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DH09-09 Box 2 (15.0 - 30.0 ft)

WorkingTogether SAFELY
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DH09-09 Box 3 (30.0 - 45.0 ft)

Working Together SAFELY
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DH09-09 Box 4 (45.0 - 60.0 ft)

Working Together SAFELY

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DH09-09 Box 5 (60.0 - 75.0 ft)

Working Together SAFELY
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DH09-09 Box 6 (75.0 - 86.0 ft)

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DH09-09 Box 7 (86.0 - 96.1 ft)

Working Together SAFELY
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DH09-09 Box 8 (96.1 - 105.9 ft)

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DH09-09 Box 9 (105.9 - 116.2 ft)

© Hatch 2006/03 ⌘

DH09-09 Box 10 (116.2 - 127.3 ft)

© Hatch 2006/03 ⌘

DH09-09 Box 11 (127.3 - 138.0 ft)

© Hatch 2006/03 ⌘

DH09-09 Box 12 (138.0 - 148.7 ft)

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DH09-09 Box 13 (148.7 - 159.4 ft)

© Hatch 2006/03 ⌘

DH09-09 Box 14 (159.4 - 170.0 ft)

WorkingTogether SAFELY
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DH09-09 Box 15 (170.0 - 184.6 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-09 Box 16 (184.6 - 198.6 ft)

Working Together SAFELY
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DH09-09 Box 17 (198.6 - 212.2 ft)

WorkingTogether SAFELY
© Hatch 2006/03 ⌘

DH09-09 Box 18 (212.2 - 226.7 ft)

© Hatch 2006/03 ⌘

DH09-09 Box 19 (226.7 - 240.9 ft)

Working Together SAFELY
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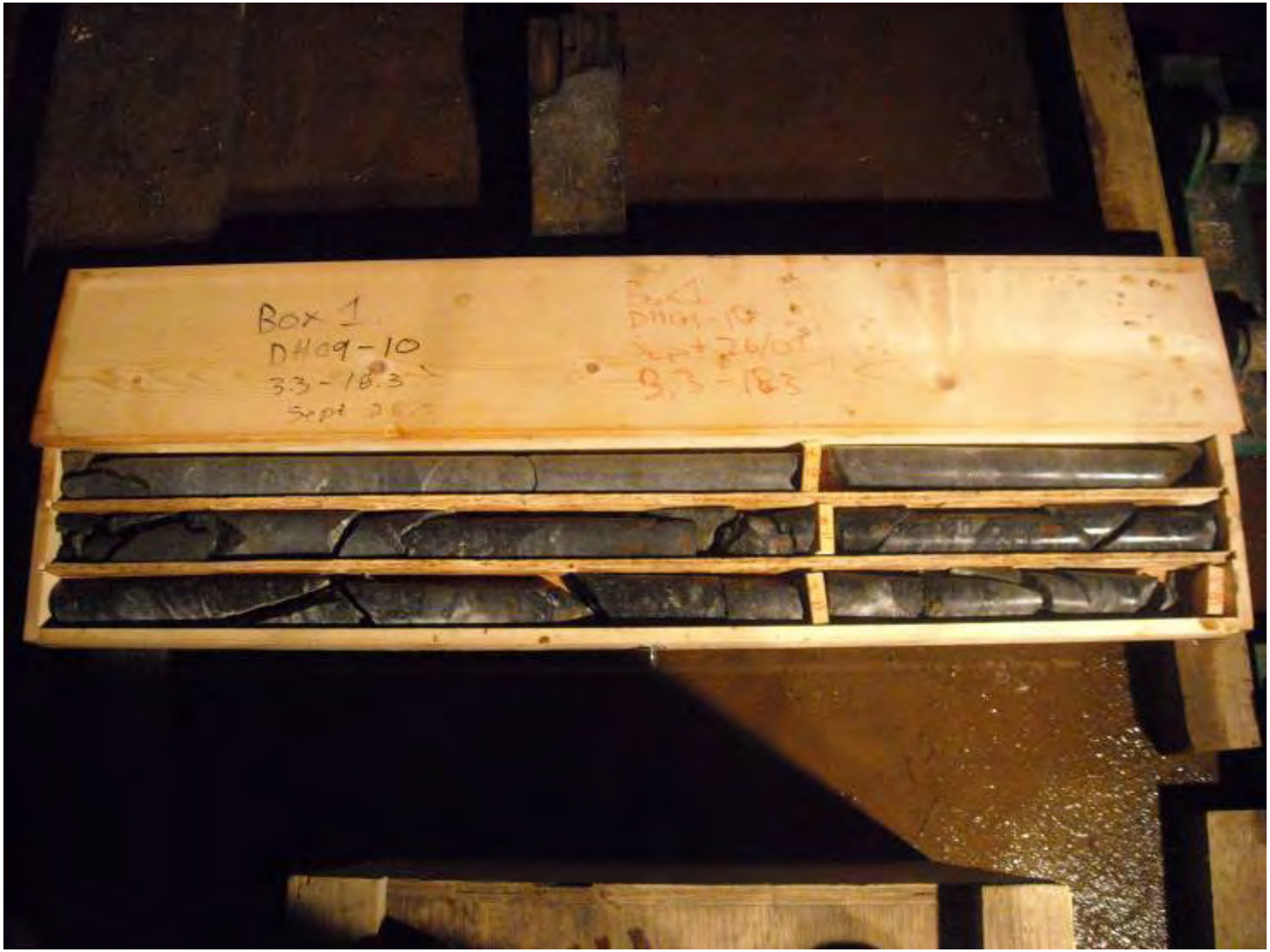
DH09-09 Box 20 (240.9 - 250.0 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘



DH09-10 Box 1 (3.3 - 18.3 ft)

Working Together SAFELY
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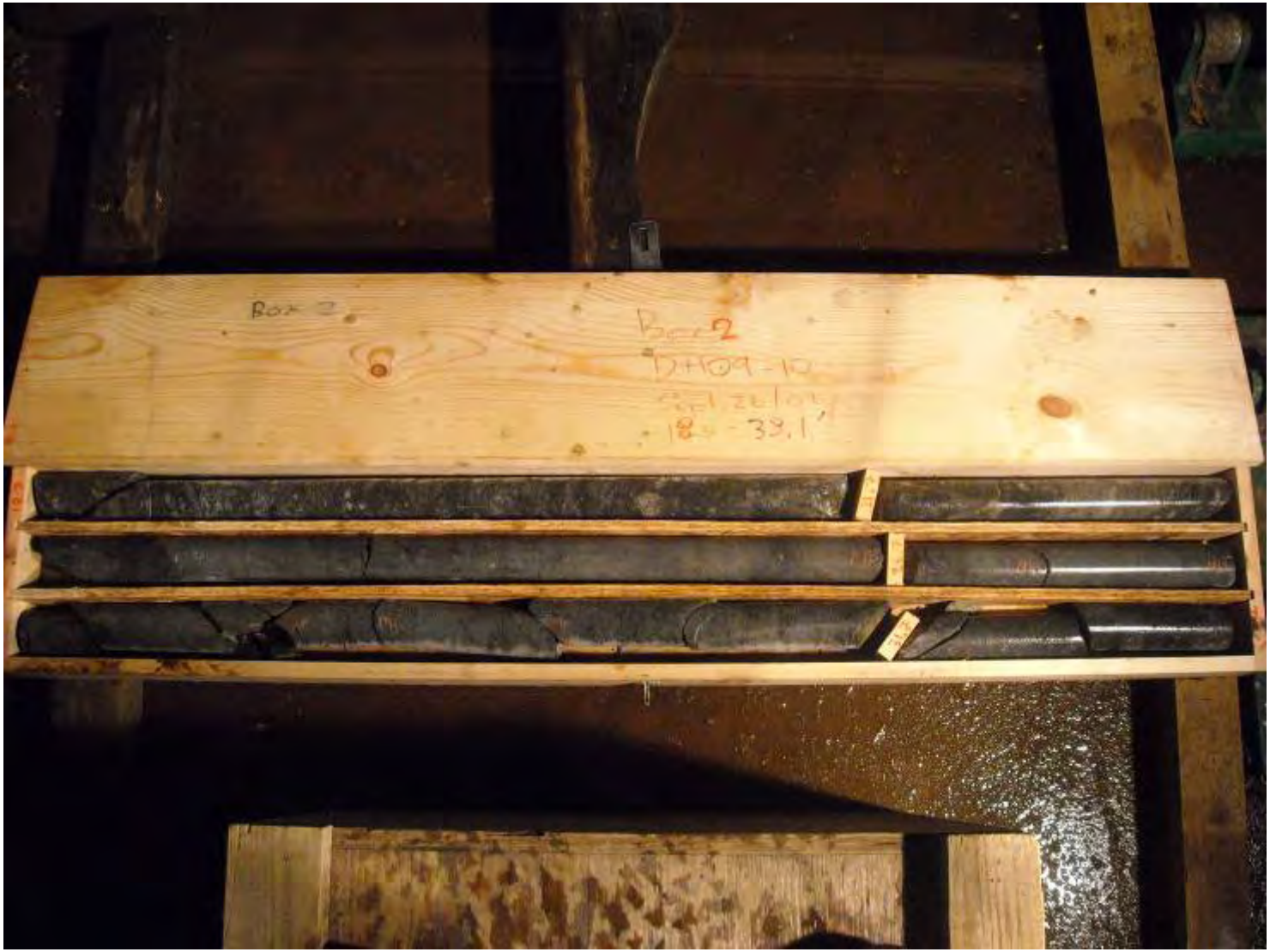

DH09-10 Box 2 (18.3 - 33.1 ft)

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DH09-10 Box 3 (33.1 - 48.2 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-10 Box 4 (48.2 - 62.4 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-10 Box 5 (62.4 - 76.7 ft)

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© Hatch 2006/03 ⌘

DH09-10 Box 6 (76.7 - 91.7 ft)

Working Together SAFELY
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DH09-10 Box 7 (91.7 - 106.7 ft)

WorkingTogether SAFELY
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DH09-10 Box 8 (106.7 - 121.7 ft)

WorkingTogether SAFELY
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DH09-10 Box 9 (121.7 - 136.7 ft)

Working Together SAFELY

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DH09-10 Box 10 (136.7 - 151.7 ft)

Working Together SAFELY
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DH09-10 Box 11 (151.7 - 166.7 ft)

WorkingTogether SAFELY
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DH09-10 Box 12 (166.7 - 181.7 ft)

WorkingTogether SAFELY
© Hatch 2006/03 ⌘

DH09-10 Box 13 (181.7 - 196.7 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-10 Box 14 (196.7 - 211.7 ft)

Working Together SAFELY
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DH09-11 Box 1 (0.0 - 14.7 ft)

Working Together SAFELY
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DH09-11 Box 2 (14.7 - 29.2 ft)

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DH09-11 Box 3 (29.2 - 43.3 ft)

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DH09-11 Box 4 (43.3 - 58.1 ft)

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DH09-11 Box 5 (58.1 - 72.3 ft)

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DH09-11 Box 6 (72.3 - 85.8 ft)

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DH09-11 Box 7 (85.8 - 100.8 ft)

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DH09-11 Box 8 (100.8 - 115.8 ft)

Working Together SAFELY
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DH09-11 Box 9 (115.8 - 130.1 ft)

Working Together SAFELY
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DH09-11 Box 10 (130.1 - 145.3 ft)

Working Together SAFELY
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DH09-11 Box 11 (145.3 - 164.6 ft)

WorkingTogether SAFELY
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DH09-12 Box 1 (1.7 - 24.0 ft)

Working Together SAFELY
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DH09-12 Box 2 (24.0 - 38.2 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-12 Box 3 (38.2 - 52.9 ft)

Working Together SAFELY
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DH09-12 Box 4 (52.9 - 67.9 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-12 Box 5 (67.9 - 82.1 ft)

Working Together SAFELY
© Hatch 2006/03 ⌘

DH09-12 Box 6 (82.1 - 95.7 ft)

Working Together SAFELY
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DH09-12 Box 7 (95.7 - 110.7 ft)

WorkingTogether SAFELY
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DH09-12 Box 8 (110.7 - 120.7 ft)

Working Together SAFELY
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DH09-13 Box 1 (7.1 - 25.9 ft)

WorkingTogether SAFELY
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DH09-13 Box 2 (25.9 - 39.4 ft)

Working Together SAFELY
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DH09-13 Box 3 (39.4 - 52.9 ft)

Working Together SAFELY
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DH09-13 Box 4 (52.9 - 57.9 ft)

Working Together SAFELY
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DH09-14 Box 1 (0.0 - 17.1 ft)

Working Together SAFELY
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DH09-14 Box 2 (17.1 - 31.0 ft)

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DH09-14 Box 3 (31.0 - 46.0 ft)

Working Together SAFELY
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DH09-14 Box 4 (46.0 - 61.0 ft)

Working Together SAFELY
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DH09-14 Box 5 (61.0 - 76.0 ft)

Working Together SAFELY
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DH09-14 Box 6 (76.0 - 91.0 ft)

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DH09-14 Box 7 (91.0 - 106.0 ft)

Working Together SAFELY
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DH09-14 Box 8 (106.0 - 121.0 ft)

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DH09-14 Box 9 (121.0 - 136.0 ft)

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DH09-14 Box 10 (136.0 - 151.0 ft)

Working Together SAFELY
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DH09-14 Box 11 (151.0 - 166.0 ft)

Working Together SAFELY
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DH09-14 Box 12 (166.0 - 181.0 ft)

Working Together SAFELY
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DH09-14 Box 13 (181.0 - 196.0 ft)

Working Together SAFELY
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DH09-14 Box 14 (196.0 - 211.0 ft)

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DH09-14 Box 15 (211.0 - 226.0 ft)

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DH09-14 Box 16 (226.0 - 241.0 ft)

WorkingTogether SAFELY
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DH09-14 Box 17 (241.0 - 256.0 ft)

Working Together SAFELY
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DH09-14 Box 18 (256.0 - 271.0 ft)

Working Together SAFELY
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DH09-14 Box 19 (271.0 - 286.0 ft)

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DH09-14 Box 20 (286.0 - 301.0 ft)

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DH09-15 Box 1 (5.6 - 20.7 ft)

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DH09-15 Box 2 (20.7 - 30.7 ft)

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Appendix G

Permeability Test Results

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Appendix G-1

Falling Head Test Results

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Falling Head Test

Drill Hole	DH09-06	
Depth to bottom of casing (m)	3.109	(10.2 ft)
Static water level (m)*:	10	
2R- intake point radius (mm)	96.00	
r- standpipe radius (mm)	31.75	
A- standard area (mm^2)	3166.92	
F- shape factor	1.7632	
L- length of intake point (mm)	3108.96	

Equation:

$$F = \frac{2\pi L}{\ln L / R} \qquad A = \pi r^2 \qquad k = \frac{r^2}{2L}\ln\left(\frac{L}{R}\right)\left[\frac{\ln h_1 / h_2}{t_2 - t_1}\right]$$

Time elapsed (min)	Depth of water (m)	$h_t = h_o - \Delta h$	h_t/ho head ratio	k (ft/s)
0.00	0.000	10.000	1.000	n/a
0.50	0.000	10.000	1.000	0.0E+00
1.00	0.000	10.000	1.000	0.0E+00
2.00	0.000	10.000	1.000	0.0E+00
4.00	0.003	9.997	1.000	5.5E-09
8.00	0.010	9.990	0.999	6.5E-09
10.00	0.015	9.985	0.999	9.3E-09
12.00	0.020	9.980	0.998	9.3E-09
14.00	0.024	9.976	0.998	7.4E-09
16.00	0.027	9.973	0.997	5.6E-09
18.00	0.033	9.967	0.997	1.1E-08
20.00	0.037	9.963	0.996	7.4E-09
25.00	0.047	9.953	0.995	7.4E-09
30.00	0.057	9.943	0.994	7.4E-09

Average hydraulic conductivity 5.9E-09

* 10 m static water level based on historical measurements

Falling Head Test

Drill Hole	DH09-06	
Depth to bottom of casing (m):	6.16	(20.2 ft)
Static water level (m)*:	10	
2R- intake point radius (mm)	96.00	
r- standpipe radius (mm)	31.75	
A- standard area (mm^2)	3166.92	
F- shape factor	3.2905	
L- length of intake point (mm)	6160	

Equation:

$$F = \frac{2\pi L}{\ln L / R} \qquad A = \pi r^2 \qquad k = \frac{r^2}{2L}\ln\left(\frac{L}{R}\right)\left[\frac{\ln h_1 / h_2}{t_2 - t_1}\right]$$

Time elapsed (min)	Depth of water (m)	$h_t = h_o - \Delta h$	h_t/ho head ratio	k (ft/s)
0.00	0.000	10.000	1.000	n/a
0.50	0.022	9.978	0.998	9.6E-08
1.00	0.031	9.969	0.997	3.9E-08
2.00	0.045	9.955	0.996	3.1E-08
4.00	0.064	9.936	0.994	2.1E-08
8.00	0.099	9.901	0.990	1.9E-08
10.00	0.110	9.890	0.989	1.2E-08
12.00	0.119	9.881	0.988	9.9E-09
14.00	0.125	9.875	0.988	6.6E-09
16.00	0.130	9.870	0.987	5.5E-09
18.00	0.135	9.865	0.987	5.5E-09
20.00	0.138	9.862	0.986	3.3E-09

Average hydraulic conductivity 2.3E-08

* 10 m static water level based on historical measurements

Falling Head Test

Drill Hole	DH09-06	
Depth to bottom of casing (m):	12.25	(40.2 ft)
Static water level (m)*:	10	
2R- intake point radius (mm)	96.00	
r- standpipe radius (mm)	31.75	
A- standard area (mm^2)	3166.92	
F- shape factor	6.1823	
L- length of intake point (mm)	12250	

Equation:

$$F = \frac{2\pi L}{\ln L / R} \qquad A = \pi r^2 \qquad k = \frac{r^2}{2L}\ln\left(\frac{L}{R}\right)\left[\frac{\ln h_1 / h_2}{t_2 - t_1}\right]$$

Time elapsed (min)	Depth of water (m)	$h_t = h_o - \Delta h$	h_t/ho head ratio	k (ft/s)
0.00	0.000	10.000	1.000	n/a
0.50	0.003	9.997	1.000	7.5E-09
1.00	0.014	9.986	0.999	2.7E-08
2.00	0.020	9.980	0.998	7.5E-09
4.00	0.032	9.968	0.997	7.5E-09
8.00	0.052	9.948	0.995	6.3E-09
10.00	0.059	9.941	0.994	4.4E-09
12.00	0.065	9.935	0.994	3.8E-09
14.00	0.068	9.932	0.993	1.9E-09
16.00	0.068	9.932	0.993	0.0E+00

Average hydraulic conductivity 7.4E-09

* 10 m static water level based on historical measurements

Appendix G-2

Results of Permeability Testing in Bedrock

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Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-01
INCLINATION:	70.00
DEPTH TO STATIC WATER LEVEL (ft)[4]:	37.20
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	13.12

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity (ft/s)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)		(Lugeons)
9.3	20.1	433.0	3.29	68.9	10.0	38.55	4	130.68	9.9E-04	3.2E-05	89.6
19.3	30.1	423.6	3.29	68.9	10.0	61.33	15	147.44	1.4E-03	4.6E-05	126.4
29.3	40.1	414.2	3.29	68.9	10.0	2.24	0	190.79	3.9E-05	1.3E-06	3.6
39.3	50.1	404.8	3.29	68.9	10.0	0.35	0	302.18	3.9E-06	1.3E-07	0.4
49.3	60.1	395.4	3.29	68.9	10.0	0.35	0	302.18	3.9E-06	1.3E-07	0.4
59.3	70.1	386.0	3.29	68.9	10.0	0.00	0	302.18	0.0E+00	0.0E+00	0.0
69.3	80.1	376.6	3.29	68.9	10.0	0.00	0	302.18	0.0E+00	0.0E+00	0.0

[1]Top of test interval
[2]Double packers were used
[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4
[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-02
INCLINATION:	70.00
DEPTH TO STATIC WATER LEVEL (ft)[4]:	37.20
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	0.00

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)
FROM	TO	(ft)	LENGTH[2]	(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
13.1	23.9	428.19	3.29	68.9	10.0	30.14	1	173.44	5.8E-04	1.9E-05	52.8
23.1	33.9	418.79	3.29	68.9	10.0	62.03	15	173.48	1.2E-03	3.9E-05	108.6
33.1	43.9	409.40	3.29	68.9	10.0	0.04	0	173.48	6.8E-07	2.2E-08	0.1
43.1	53.9	400.00	3.29	68.9	10.0	0.00	0	173.48	0.0E+00	0.0E+00	0.0
53.1	63.9	390.60	3.29	68.9	10.0	0.00	0	173.48	0.0E+00	0.0E+00	0.0
63.1	73.9	381.2	3.29	68.9	10.0	0.00	0	173.48	0.0E+00	0.0E+00	0.0
73.1	83.9	371.8	3.29	68.9	10.0	0.00	0	173.48	0.0E+00	0.0E+00	0.0
83.1	93.9	362.4	6.40	68.9	10.0	0.00	0	173.48	0.0E+00	0.0E+00	0.0
93.1	103.9	353.0	3.35	34.5	5.0	0.00	0	139.01	0.0E+00	0.0E+00	0.0
93.1	103.9	353.0	3.35	68.9	10.0	0.00	0	173.48	0.0E+00	0.0E+00	0.0
93.1	103.9	353.0	3.35	34.5	5.0	0.00	0	139.01	0.0E+00	0.0E+00	0.0
103.1	113.9	343.6	3.35	68.9	10.0	0.00	0	173.48	0.0E+00	0.0E+00	0.0

[1]Top of test interval

[2]Double packers were used

[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4

[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-03
INCLINATION:	30.00
DEPTH TO STATIC WATER LEVEL (ft):	62.66
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	-36.75

TEST INTERVAL (ft)		Elevation[1]	LENGTH[2]	GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)
FROM	TO	(ft)		(kPa)	(kPa)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
21.2	32	374.7	3.29	193.1	28.02	1.05	0	139.95	2.5E-05	8.1E-07	2.3
31.2	42	357.6	3.29	172.4	25.02	0.00	0	119.26	0.0E+00	0.0E+00	0.0
31.2	42	380.1	3.29	220.6	32.02	1.23	0	167.53	2.4E-05	7.9E-07	2.2
31.2	42	404.0	3.29	179.3	26.02	0.00	0	126.16	0.0E+00	0.0E+00	0.0
41.2	52	385.3	3.29	165.5	24.02	1.05	0	112.37	3.1E-05	1.0E-06	2.8
41.2	52	385.3	3.29	206.8	30.02	1.75	0	153.74	3.8E-05	1.2E-06	3.5
41.2	52	385.3	3.29	248.2	36.03	2.80	0	195.11	4.8E-05	1.6E-06	4.4
41.2	52	385.3	3.35	206.8	30.02	1.75	0	153.74	3.8E-05	1.2E-06	3.5
41.2	52	385.3	3.35	165.5	24.02	0.70	0	112.37	2.1E-05	6.6E-07	1.9

[1]Top of test interval

[2]Double packers were used

[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4

[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-04
INCLINATION:	60.00
DEPTH TO STATIC WATER LEVEL (ft):	10.01
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	1.35

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
4.5	15.3	341.7	3.30	41.4	6.00	0.00	0	139.58	0.0E+00	0.0E+00	0.0
14.5	25.3	333.0	3.30	41.4	6.00	0.19	0	139.58	4.5E-06	1.5E-07	0.4
24.5	35.3	324.4	3.30	55.2	8.01	0.07	0	153.37	1.5E-06	5.0E-08	0.1
24.5	35.3	324.4	3.30	55.2	8.01	0.07	0	153.37	1.5E-06	5.0E-08	0.1
24.5	35.3	324.4	3.30	82.7	12.01	0.00	0	180.95	0.0E+00	0.0E+00	0.0
24.5	35.3	324.4	3.30	55.2	8.01	0.00	0	153.37	0.0E+00	0.0E+00	0.0
24.5	35.3	324.4	3.30	48.3	7.00	0.00	0	146.47	0.0E+00	0.0E+00	0.0
34.5	45.3	315.7	3.30	55.2	8.01	0.07	0	153.37	1.5E-06	5.0E-08	0.1
34.5	45.3	315.7	3.30	82.7	12.01	0.00	0	180.95	0.0E+00	0.0E+00	0.0
34.5	45.3	315.7	3.30	117.2	17.01	0.14	0	215.42	2.2E-06	7.1E-08	0.2
34.5	45.3	315.7	3.30	82.7	12.01	0.00	0	180.95	0.0E+00	0.0E+00	0.0
34.5	45.3	315.7	3.30	62.1	9.01	0.00	0	160.26	0.0E+00	0.0E+00	0.0
44.5	55.3	307.1	3.29	68.9	10.01	0.00	0	167.16	0.0E+00	0.0E+00	0.0
44.5	55.3	307.1	3.29	124.1	18.01	0.00	0	222.32	0.0E+00	0.0E+00	0.0
44.5	55.3	307.1	3.29	186.2	27.02	0.49	0	284.37	5.8E-06	1.9E-07	0.5
44.5	55.3	307.1	3.29	124.1	18.01	0.00	0	222.32	0.0E+00	0.0E+00	0.0
44.5	55.3	307.1	3.29	68.9	10.01	0.00	0	167.16	0.0E+00	0.0E+00	0.0
54.5	65.3	298.4	3.30	48.3	7.00	0.00	0	146.47	0.0E+00	0.0E+00	0.0
54.5	65.3	298.4	3.30	96.5	14.01	0.21	0	194.74	3.6E-06	1.2E-07	0.3
54.5	65.3	298.4	3.30	151.7	22.02	4.73	-1	249.89	6.3E-05	2.1E-06	5.7
54.5	65.3	298.4	3.30	96.5	14.01	1.12	0	194.74	1.9E-05	6.3E-07	1.7
54.5	65.3	298.4	3.30	48.3	7.00	0.14	0	146.47	3.2E-06	1.0E-07	0.3

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
64.5	75.3	289.7	3.30	82.7	12.01	4.38	-1	180.95	8.1E-05	2.6E-06	7.3
64.5	75.3	289.7	3.30	165.5	24.02	7.85	-1	263.68	9.9E-05	3.3E-06	9.0
64.5	75.3	289.7	3.30	248.2	36.03	18.22	-1	346.42	1.8E-04	5.8E-06	15.9
64.5	75.3	289.7	3.30	165.5	24.02	8.76	-1	263.68	1.1E-04	3.6E-06	10.1
64.5	75.3	289.7	3.30	82.7	12.01	4.21	-1	180.95	7.7E-05	2.5E-06	7.0
74.5	85.3	281.1	3.30	96.5	14.01	1.40	0	194.74	2.4E-05	7.9E-07	2.2
74.5	85.3	281.1	3.30	193.1	28.02	5.99	-1	291.26	6.9E-05	2.3E-06	6.2
74.5	85.3	281.1	3.30	289.6	42.03	14.02	-1	387.79	1.2E-04	4.0E-06	11.0
74.5	85.3	281.1	3.30	193.1	28.02	8.90	-1	291.26	1.0E-04	3.3E-06	9.3
74.5	85.3	281.1	3.30	96.5	14.01	5.05	-1	194.74	8.6E-05	2.8E-06	7.9
84.5	95.3	272.4	3.30	103.4	15.01	1.40	0	201.63	2.3E-05	7.6E-07	2.1
84.5	95.3	272.4	3.30	206.8	30.02	2.52	0	305.05	2.8E-05	9.0E-07	2.5
84.5	95.3	272.4	3.30	310.3	45.03	5.15	-1	408.47	4.2E-05	1.4E-06	3.8
84.5	95.3	272.4	3.30	206.8	30.02	3.29	0	305.05	3.6E-05	1.2E-06	3.3
84.5	95.3	272.4	3.30	103.4	15.01	1.54	0	201.63	2.6E-05	8.4E-07	2.3

[1]Top of test interval

[2]Double packers were used

[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4

[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-05
INCLINATION:	90.00
DEPTH TO STATIC WATER LEVEL (ft)[4]:	30.80
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	2.50

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
12.5	30.8	411.3	5.58	34.5	5.00	0.00	0	361.15	0.0E+00	0.0E+00	0.0
19.5	30.8	411.3	3.44	68.9	10.01	0.00	0	395.62	0.0E+00	0.0E+00	0.0
19.5	30.8	411.3	3.44	34.5	5.00	0.00	0	361.15	0.0E+00	0.0E+00	0.0
19.5	30.8	411.3	3.44	34.5	5.00	0.00	0	361.15	0.0E+00	0.0E+00	0.0

[1]Top of test interval
[2]Double packers were used
[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4
[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-06
INCLINATION:	90.00
DEPTH TO STATIC WATER LEVEL (ft)[4]:	30.81
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	3.00

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
47.6	58.4	403.3	3.29	55.1	8	0.00	0	386.80	0.0E+00	0.0E+00	0.0
47.6	58.4	403.3	3.29	110.2	16	0.00	0	441.92	0.0E+00	0.0E+00	0.0
47.6	58.4	403.3	3.29	158.5	23	0.00	0	490.15	0.0E+00	0.0E+00	0.0
47.6	58.4	403.3	3.29	110.2	16	0.00	0	441.92	0.0E+00	0.0E+00	0.0
47.6	58.4	403.3	3.29	55.1	8	0.00	0	386.80	0.0E+00	0.0E+00	0.0
56.6	67.4	394.3	3.29	62.0	9	0.00	0	393.69	0.0E+00	0.0E+00	0.0
56.6	67.4	394.3	3.29	124.0	18	0.00	0	455.70	0.0E+00	0.0E+00	0.0
56.6	67.4	394.3	3.29	192.9	28	0.00	0	524.60	0.0E+00	0.0E+00	0.0
56.6	67.4	394.3	3.29	124.0	18	0.00	0	455.70	0.0E+00	0.0E+00	0.0
56.6	67.4	394.3	3.29	62.0	9	0.00	0	393.69	0.0E+00	0.0E+00	0.0

[1]Top of test interval
[2]Double packers were used
[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4
[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-07
INCLINATION:	70.00
DEPTH TO STATIC WATER LEVEL (ft)[4]:	20.01
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	2.00

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
37.2	48	433.1	3.29	41.3	6	0.00	0	245.46	0.0E+00	0.00	0.0
37.2	48	433.1	3.29	82.7	12	0.00	0	286.80	0.0E+00	0.00	0.0
37.2	48	433.1	3.29	124.0	18	0.00	0	328.14	0.0E+00	0.00	0.0
37.2	48	433.1	3.29	82.7	12	0.00	0	286.80	0.0E+00	0.00	0.0
37.2	48	433.1	3.29	41.3	6	0.00	0	245.46	0.0E+00	0.00	0.0
47.2	58	423.7	3.29	48.2	7	0.00	0	252.35	0.0E+00	0.00	0.0
47.2	58	423.7	3.29	96.5	14	0.00	0	300.58	0.0E+00	0.00	0.0
47.2	58	423.7	3.29	144.7	21	0.00	0	348.81	0.0E+00	0.00	0.0
47.2	58	423.7	3.29	96.5	14	0.00	0	300.58	0.0E+00	0.00	0.0
47.2	58	423.7	3.29	48.2	7	0.00	0	252.35	0.0E+00	0.00	0.0
57.2	68	414.3	3.29	68.9	10	0.00	0	273.02	0.0E+00	0.00	0.0
57.2	68	414.3	3.29	137.8	20	0.00	0	341.92	0.0E+00	0.00	0.0
57.2	68	414.3	3.29	206.7	30	0.00	0	410.82	0.0E+00	0.00	0.0
57.2	68	414.3	3.29	137.8	20	0.00	0	341.92	0.0E+00	0.00	0.0
57.2	68	414.3	3.29	68.9	10	0.00	0	273.02	0.0E+00	0.00	0.0
67.2	78	405.0	3.29	68.9	10	0.00	0	273.02	0.0E+00	0.00	0.0
67.2	78	405.0	3.29	137.8	20	0.00	0	341.92	0.0E+00	0.00	0.0
67.2	78	405.0	3.29	206.7	30	0.00	0	410.82	0.0E+00	0.00	0.0
67.2	78	405.0	3.29	137.8	20	0.00	0	341.92	0.0E+00	0.00	0.0
67.2	78	405.0	3.29	68.9	10	0.00	0	273.02	0.0E+00	0.00	0.0
77.2	88	395.6	3.29	68.9	10	1.05	0	273.02	1.3E-05	0.00	1.2
77.2	88	395.6	3.29	137.8	20	3.85	-1	341.92	3.8E-05	0.00	3.4
77.2	88	395.6	3.29	206.7	30	15.77	-1	410.82	1.3E-04	0.00	11.7
77.2	88	395.6	3.29	137.8	20	8.41	-1	341.92	8.2E-05	0.00	7.5
77.2	88	395.6	3.29	68.9	10	4.55	-1	273.02	5.6E-05	0.00	5.1
87.2	98	386.2	3.29	62.0	9	0.00	0	266.13	0.0E+00	0.00	0.0
87.2	98	386.2	3.29	124.0	18	0.00	0	328.14	0.0E+00	0.00	0.0
87.2	98	386.2	3.29	192.9	28	0.00	0	397.04	0.0E+00	0.00	0.0

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
87.2	98	386.2	3.29	124.0	18	0.00	0	328.14	0.0E+00	0.00	0.0
87.2	98	386.2	3.29	62.0	9	0.00	0	266.13	0.0E+00	0.00	0.0
97.2	108	376.8	3.29	62.0	9	0.00	0	266.13	0.0E+00	0.00	0.0
97.2	108	376.8	3.29	124.0	18	0.00	0	328.14	0.0E+00	0.00	0.0
97.2	108	376.8	3.29	186.0	27	0.00	0	390.15	0.0E+00	0.00	0.0
97.2	108	376.8	3.29	124.0	18	0.00	0	328.14	0.0E+00	0.00	0.0
97.2	108	376.8	3.29	62.0	9	0.00	0	266.13	0.0E+00	0.00	0.0
107.2	118	367.4	3.29	62.01	9	0.00	0	266.13	0.0E+00	0.00	0.0
107.2	118	367.4	3.29	124.02	18	0.00	0	328.14	0.0E+00	0.00	0.0
107.2	118	367.4	3.29	186.03	27	0.00	0	390.15	0.0E+00	0.00	0.0
107.2	118	367.4	3.29	124.02	18	0.00	0	328.14	0.0E+00	0.00	0.0
107.2	118	367.4	3.29	62.01	9	0.00	0	266.13	0.0E+00	0.00	0.0
117.2	128	358.0	3.29	62.01	9	0.00	0	55.12	0.0E+00	0.00	0.0
117.2	128	358.0	3.29	124.02	18	0.00	0	110.24	0.0E+00	0.00	0.0
117.2	128	358.0	3.29	186.03	27	0.00	0	172.25	0.0E+00	0.00	0.0
117.2	128	358.0	3.29	124.02	18	0.00	0	110.24	0.0E+00	0.00	0.0
117.2	128	358.0	3.29	62.01	9	0.00	0	55.12	0.0E+00	0.00	0.0
127.2	138	348.6	3.29	55.12	8	0.00	0	259.24	0.0E+00	0.00	0.0
127.2	138	348.6	3.29	110.24	16	0.00	0	314.36	0.0E+00	0.00	0.0
127.2	138	348.6	3.29	172.25	25	0.00	0	376.37	0.0E+00	0.00	0.0
127.2	138	348.6	3.29	110.24	16	0.00	0	314.36	0.0E+00	0.00	0.0
127.2	138	348.6	3.29	55.12	8	0.00	0	259.24	0.0E+00	0.00	0.0
137.2	148	339.2	3.29	55.12	8	0.00	0	259.24	0.0E+00	0.00	0.0
137.2	148	339.2	3.29	110.24	16	0.00	0	314.36	0.0E+00	0.00	0.0
137.2	148	339.2	3.29	165.36	24	0.00	0	369.48	0.0E+00	0.00	0.0
137.2	148	339.2	3.29	110.24	16	0.00	0	314.36	0.0E+00	0.00	0.0
137.2	148	339.2	3.29	55.12	8	0.00	0	259.24	0.0E+00	0.00	0.0
147.2	158	329.8	3.29	55.12	8	0.00	0	259.24	0.0E+00	0.00	0.0
147.2	158	329.8	3.29	110.24	16	0.00	0	314.36	0.0E+00	0.00	0.0
147.2	158	329.8	3.29	165.36	24	0.00	0	369.48	0.0E+00	0.00	0.0
147.2	158	329.8	3.29	110.24	16	0.00	0	314.36	0.0E+00	0.00	0.0
147.2	158	329.8	3.29	55.12	8	0.00	0	259.24	0.0E+00	0.00	0.0
157.7	168.5	319.9	3.29	55.12	8	0.00	0	259.24	0.0E+00	0.00	0.0
157.7	168.5	319.9	3.29	110.24	16	0.00	0	314.36	0.0E+00	0.00	0.0
157.7	168.5	319.9	3.29	158.47	23	0.00	0	362.59	0.0E+00	0.00	0.0
157.7	168.5	319.9	3.29	110.24	16	0.00	0	314.36	0.0E+00	0.00	0.0
157.7	168.5	319.9	3.29	55.12	8	0.00	0	259.24	0.0E+00	0.00	0.0

[1]Top of test interval

[2]Double packers were used

[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4

[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-08
INCLINATION:	90.00
DEPTH TO STATIC WATER LEVEL (ft):	9.78
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (m):	0.00

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(kPa)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
24.1	34.1	131.1	3.05	68.9	10.01	96.38	46	164.86	2.1E-03	6.8E-05	191.8
30.2	41	125	3.29	68.9	10.01	0.00	0	164.86	0.0E+00	0.0E+00	0.0
30.2	41	125	3.29	103.4	15.01	0.00	0	199.33	0.0E+00	0.0E+00	0.0
30.2	41	125	3.29	68.9	10.01	0.00	0	164.86	0.0E+00	0.0E+00	0.0
40.2	51	115	3.29	68.9	10.01	0.00	0	164.86	0.0E+00	0.0E+00	0.0
40.2	51	115	3.29	103.4	15.01	0.00	0	199.33	0.0E+00	0.0E+00	0.0
40.2	51	115	3.29	137.9	20.01	0.00	0	233.81	0.0E+00	0.0E+00	0.0
40.2	51	115	3.29	103.4	15.01	0.00	0	199.33	0.0E+00	0.0E+00	0.0
40.2	51	115	3.29	68.9	10.01	0.00	0	164.86	0.0E+00	0.0E+00	0.0
50.2	61	105	3.29	68.9	10.01	0.00	0	164.86	0.0E+00	0.0E+00	0.0
50.2	61	105	3.29	137.9	20.01	0.00	0	233.81	0.0E+00	0.0E+00	0.0
50.2	61	105	3.29	172.4	25.02	0.00	0	268.28	0.0E+00	0.0E+00	0.0
50.2	61	105	3.29	137.896	20.01	0	0	233.81	0.0E+00	0.0E+00	0.0
50.2	61	105	3.29	68.948	10.01	0	0	164.86	0.0E+00	0.0E+00	0.0
60.2	71	95	3.29	103.422	15.01	0	0	199.33	0.0E+00	0.0E+00	0.0
60.2	71	95	3.29	172.37	25.02	0	0	268.28	0.0E+00	0.0E+00	0.0
60.2	71	95	3.29	206.844	30.02	0	0	302.76	0.0E+00	0.0E+00	0.0
60.2	71	95	3.29	137.896	20.01	0	0	233.81	0.0E+00	0.0E+00	0.0
60.2	71	95	3.29	68.948	10.01	0	0	164.86	0.0E+00	0.0E+00	0.0
71	81	84.2	3.05	68.948	10.01	0	0	164.86	0.0E+00	0.0E+00	0.0
71	81	84.2	3.05	172.37	25.02	0.140185185	0	268.28	1.9E-06	6.1E-08	0.2
71	81	84.2	3.05	241.318	35.02	0.28037037	0	337.23	2.9E-06	9.7E-08	0.3
71	81	84.2	3.05	172.37	25.02	0	0	268.28	0.0E+00	0.0E+00	0.0
71	81	84.2	3.05	68.948	10.01	0	0	164.86	0.0E+00	0.0E+00	0.0

[1]Top of test interval
[2]Double packers were used
[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-09
INCLINATION:	60.00
DEPTH TO STATIC WATER LEVEL (ft):	4.59
HOLE DIAMETER (cm):	6.11
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	3.75

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
148.7	169.5	263.3	6.34	137.9	452.41	0.00	0	213.71	0.0E+00	0.0E+00	0.0
148.7	169.5	263.3	6.34	310.3	1017.93	0.00	0	386.08	0.0E+00	0.0E+00	0.0
148.7	169.5	263.3	6.34	448.2	1470.35	0.00	0	523.97	0.0E+00	0.0E+00	0.0
148.7	169.5	263.3	6.34	310.3	1017.93	0.00	0	386.08	0.0E+00	0.0E+00	0.0
148.7	169.5	263.3	6.34	137.9	452.41	0.00	0	213.71	0.0E+00	0.0E+00	0.0
168.7	189.5	246.0	6.34	172.4	565.52	0.00	0	248.18	0.0E+00	0.0E+00	0.0
168.7	189.5	246.0	6.34	344.7	1131.04	0.00	0	420.55	0.0E+00	0.0E+00	0.0
168.7	189.5	246.0	6.34	517.1	1696.56	0.00	0	592.92	0.0E+00	0.0E+00	0.0
168.7	189.5	246.0	6.34	344.7	1131.04	0.00	0	420.55	0.0E+00	0.0E+00	0.0
168.7	189.5	246.0	6.34	172.4	565.52	0.00	0	248.18	0.0E+00	0.0E+00	0.0
188.7	209.5	228.7	6.34	206.8	678.62	0.00	0	282.65	0.0E+00	0.0E+00	0.0
188.7	209.5	228.7	6.34	379.2	1244.14	0.00	0	455.02	0.0E+00	0.0E+00	0.0
188.7	209.5	228.7	6.34	586.058	1922.76	0.00	0	661.87	0.0E+00	0.0E+00	0.0
188.7	209.5	228.7	6.34	379.214	1244.14	0.00	0	455.02	0.0E+00	0.0E+00	0.0
188.7	209.5	228.7	6.34	206.844	678.62	0.00	0	282.65	0.0E+00	0.0E+00	0.0
208.7	229.5	211.4	6.34	220.6336	723.86	0.00	0	296.44	0.0E+00	0.0E+00	0.0
208.7	229.5	211.4	6.34	441.2672	1447.73	0.00	0	517.08	0.0E+00	0.0E+00	0.0
208.7	229.5	211.4	6.34	655.006	2148.97	0.00	0	730.82	0.0E+00	0.0E+00	0.0
208.7	229.5	211.4	6.34	441.2672	1447.73	0.00	0	517.08	0.0E+00	0.0E+00	0.0
208.7	229.5	211.4	6.34	220.6336	723.86	0.00	0	296.44	0.0E+00	0.0E+00	0.0
228.7	249.5	194.0	6.34	241.318	791.73	0.00	0	317.13	0.0E+00	0.0E+00	0.0
228.7	249.5	194.0	6.34	482.636	1583.45	0.00	0	558.45	0.0E+00	0.0E+00	0.0
228.7	249.5	194.0	6.34	723.954	2375.18	0.35	0	799.76	9.6E-07	3.1E-08	0.1
228.7	249.5	194.0	6.34	482.636	1583.45	0.00	0	558.45	0.0E+00	0.0E+00	0.0
228.7	249.5	194.0	6.34	241.318	791.73	0.00	0	317.13	0.0E+00	0.0E+00	0.0

[1]Top of test interval
[2]Double packers were used
[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4
[4]Depth to water level was taken immediately after borehole was flushed and could not be measured accurately due to low permeability of the rock

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-10
INCLINATION:	60.00
DEPTH TO STATIC WATER LEVEL (ft)[4]:	26.80
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	2.30

TEST INTERVAL (ft)		Elevation[1]	LENGTH[2]	GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)		(kPa)	(kPa)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
56.5	77.3	372.6	6.34	68.9	10.00	0.00	0	319.11	0.0E+00	0.0E+00	0.0
56.5	77.3	372.6	6.34	137.8	20.00	0.00	0	388.01	0.0E+00	0.0E+00	0.0
56.5	77.3	372.6	6.34	206.7	30.00	0.00	0	456.91	0.0E+00	0.0E+00	0.0
56.5	77.3	372.6	6.34	137.8	20.00	0.00	0	388.01	0.0E+00	0.0E+00	0.0
56.5	77.3	372.6	6.34	68.9	10.00	0.00	0	319.11	0.0E+00	0.0E+00	0.0
86.3	107.1	346.8	6.34	96.5	14.00	0.00	0	346.67	0.0E+00	0.0E+00	0.0
86.3	107.1	346.8	6.34	192.9	28.00	0.00	0	443.13	0.0E+00	0.0E+00	0.0
86.3	107.1	346.8	6.34	289.4	42.00	0.00	0	539.59	0.0E+00	0.0E+00	0.0
86.3	107.1	346.8	6.34	192.9	28.00	0.00	0	443.13	0.0E+00	0.0E+00	0.0
86.3	107.1	346.8	6.34	96.5	14.00	0.00	0	346.67	0.0E+00	0.0E+00	0.0
126.3	147.1	312.1	6.34	82.7	12.00	0.00	0	332.89	0.0E+00	0.0E+00	0.0
126.3	147.1	312.1	6.34	172.3	25.00	0.00	0	422.46	0.0E+00	0.0E+00	0.0
126.3	147.1	312.1	6.34	254.93	37.00	0.00	0	505.14	0.0E+00	0.0E+00	0.0
126.3	147.1	312.1	6.34	172.25	25.00	0.00	0	422.46	0.0E+00	0.0E+00	0.0
126.3	147.1	312.1	6.34	82.68	12.00	0.00	0	332.89	0.0E+00	0.0E+00	0.0
146.3	167.1	294.8	6.34	82.68	12.00	0.00	0	332.89	0.0E+00	0.0E+00	0.0
146.5	167.1	294.6	6.28	165.36	24.00	0.00	0	415.57	0.0E+00	0.0E+00	0.0
146.5	167.1	294.6	6.28	241.15	35.00	0.00	0	491.36	0.0E+00	0.0E+00	0.0
146.5	167.1	294.6	6.28	165.36	24.00	0.00	0	415.57	0.0E+00	0.0E+00	0.0
146.5	167.1	294.6	6.28	82.68	12.00	0.00	0	332.89	0.0E+00	0.0E+00	0.0
166.3	187.1	277.5	6.34	75.79	11.00	0.00	0	326.00	0.0E+00	0.0E+00	0.0
166.3	187.1	277.5	6.34	151.58	22.00	0.00	0	401.79	0.0E+00	0.0E+00	0.0

TEST INTERVAL (ft)		Elevation[1]	LENGTH[2]	GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)		(kPa)	(kPa)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
166.3	187.1	277.5	6.34	227.37	33.00	0.00	0	477.58	0.0E+00	0.0E+00	0.0
166.3	187.1	277.5	6.34	151.58	22.00	0.00	0	401.79	0.0E+00	0.0E+00	0.0
166.3	187.1	277.5	6.34	75.79	11.00	0.00	0	326.00	0.0E+00	0.0E+00	0.0
186.3	207.1	260.2	6.34	68.9	10.00	0.00	0	319.11	0.0E+00	0.0E+00	0.0
186.3	207.1	260.2	6.34	137.8	20.00	0.00	0	388.01	0.0E+00	0.0E+00	0.0
186.3	207.1	260.2	6.34	206.7	30.00	0.00	0	456.91	0.0E+00	0.0E+00	0.0
186.3	207.1	260.2	6.34	137.8	20.00	0.00	0	388.01	0.0E+00	0.0E+00	0.0
186.3	207.1	260.2	6.34	68.9	10.00	0.00	0	319.11	0.0E+00	0.0E+00	0.0

[1]Top of test interval

[2]Double packers were used

[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-11
INCLINATION:	70.00
DEPTH TO STATIC WATER LEVEL (ft):	30.68
HOLE DIAMETER (cm):	6.11
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	2.13

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH	(kPa)	(kPa)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
34.5	45.3	452.2	3.29	68.9	10.01	0.00	0	372.65	0.0E+00	0.0E+00	0.0
34.5	45.3	452.2	3.29	103.4	15.01	0.18	0	407.12	1.6E-06	5.2E-08	0.1
34.5	45.3	452.2	3.29	68.9	10.01	0.00	0	372.65	0.0E+00	0.0E+00	0.0
44.5	55.3	442.8	3.29	48.3	7.00	0.00	0	351.97	0.0E+00	0.0E+00	0.0
44.5	55.3	442.8	3.29	89.6	13.01	0.18	0	393.33	1.6E-06	5.4E-08	0.1
44.5	55.3	442.8	3.29	137.9	20.01	0.70	0	441.60	5.9E-06	1.9E-07	0.5
44.5	55.3	442.8	3.29	89.6	13.01	0.18	0	393.33	1.6E-06	5.4E-08	0.1
44.5	55.3	442.8	3.29	48.3	7.00	0.00	0	351.97	0.0E+00	0.0E+00	0.0
54.5	65.3	433.4	3.29	55.2	8.01	19.45	0	358.86	2.0E-04	6.6E-06	16.5
54.5	65.3	433.4	3.29	117.2	17.01	26.99	0	420.91	2.4E-04	7.8E-06	19.5
54.5	65.3	433.4	3.29	158.6	23.02	34.35	2	462.28	2.7E-04	9.0E-06	22.6
54.5	65.3	433.4	3.29	117.2	17.01	27.34	1	420.91	2.4E-04	7.9E-06	19.7
54.5	65.3	433.4	3.29	55.2	8.01	15.77	0	358.86	1.6E-04	5.3E-06	13.4
66.5	77.3	422.1	3.29	82.7	12.01	0.00	0	386.44	0.0E+00	0.0E+00	0.0
66.5	77.3	422.1	3.29	124.1	18.01	0.00	0	427.81	0.0E+00	0.0E+00	0.0
66.5	77.3	422.1	3.29	158.6	23.02	0.00	0	462.28	0.0E+00	0.0E+00	0.0
66.5	77.3	422.1	3.29	124.1	18.01	0.00	0	427.80	0.0E+00	0.0E+00	0.0
66.5	77.3	422.1	3.29	82.7	12.01	0.00	0	386.44	0.0E+00	0.0E+00	0.0
76.5	87.3	412.7	3.29	62.1	9.01	0.00	0	365.76	0.0E+00	0.0E+00	0.0
76.5	87.3	412.7	3.29	110.3	16.01	0.00	0	414.02	0.0E+00	0.0E+00	0.0
76.5	87.3	412.7	3.29	144.8	21.01	0.00	0	448.49	0.0E+00	0.0E+00	0.0

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH	(kPa)	(kPa)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
76.5	87.3	412.7	3.29	110.3	16.01	0.00	0	414.02	0.0E+00	0.0E+00	0.0
76.5	87.3	412.7	3.29	62.1	9.01	0.00	0	365.76	0.0E+00	0.0E+00	0.0
86.5	97.3	403.3	3.29	68.9	10.01	0.00	0	372.65	0.0E+00	0.0E+00	0.0
86.5	97.3	403.3	3.29	103.4	15.01	0.00	0	407.12	0.0E+00	0.0E+00	0.0
86.5	97.3	403.3	3.29	137.9	20.01	0.00	0	441.60	0.0E+00	0.0E+00	0.0
86.5	97.3	403.3	3.29	103.4	15.01	0.00	0	407.12	0.0E+00	0.0E+00	0.0
86.5	97.3	403.3	3.29	68.9	10.01	0.00	0	372.65	0.0E+00	0.0E+00	0.0
96.5	107.3	393.9	3.29	89.6	13.01	0.00	0	393.33	0.0E+00	0.0E+00	0.0
96.5	107.3	393.9	3.29	124.1	18.01	0.00	0	427.81	0.0E+00	0.0E+00	0.0
96.5	107.3	393.9	3.29	89.6	13.01	0.00	0	393.33	0.0E+00	0.0E+00	0.0
106.5	117.3	384.5	3.29	82.7	12.01	0.00	0	386.44	0.0E+00	0.0E+00	0.0
106.5	117.3	384.5	3.29	117.2	17.01	0.00	0	420.91	0.0E+00	0.0E+00	0.0
106.5	117.3	384.5	3.29	82.7376	12.01	0	0	386.44	0.0E+00	0.0E+00	0.0
116.5	127.3	375.1	3.29	68.948	10.01	0	0	372.65	0.0E+00	0.0E+00	0.0
116.5	127.3	375.1	3.29	110.3168	16.01	0	0	414.02	0.0E+00	0.0E+00	0.0
116.5	127.3	375.1	3.29	68.948	10.01	0	0	372.65	0.0E+00	0.0E+00	0.0
126.5	137.3	365.7	3.29	103.422	15.01	0	0	407.12	0.0E+00	0.0E+00	0.0
136.5	147.3	356.3	3.29	103.422	15.01	0	0	407.12	0.0E+00	0.0E+00	0.0
146.5	157.3	346.9	3.29	75.8428	11.01	0	0	379.54	0.0E+00	0.0E+00	0.0
156.5	167.3	337.5	3.29	68.948	10.01	0	0	372.65	0.0E+00	0.0E+00	0.0

[1]Top of test interval

[2]Double packers were used

[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4

[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-12
INCLINATION:	60.00
DEPTH TO STATIC WATER LEVEL (ft)[4]:	40.03
HOLE DIAMETER (cm):	6.11
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	2.00

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH	(kPa)	(kPa)	(l/min)	(KPa)	(kPa)	(cm/s)	(cm/s)	(Lugeons)
21.5	42.3	394.5	6.34	68.9	10.01	25.93	0	428.63	1.3E-04	4.3E-06	9.5
36.5	57.3	381.5	6.34	68.9	10.01	1.75	0	428.63	9.0E-06	2.9E-07	0.6
36.5	57.3	381.5	6.34	103.4	15.01	1.75	0	463.11	8.3E-06	2.7E-07	0.6
36.5	57.3	381.5	6.34	68.9	10.01	1.19	0	428.63	6.1E-06	2.0E-07	0.4
56.5	77.3	364.2	6.34	68.9	10.01	0.00	0	428.63	0.0E+00	0.0E+00	0.0
56.5	77.3	364.2	6.34	110.3	16.01	0.91	0	470.00	4.2E-06	1.4E-07	0.3
56.5	77.3	364.2	6.34	68.9	10.01	0.00	0	428.63	0.0E+00	0.0E+00	0.0
76.5	97.3	346.8	6.34	55.2	8.01	0.00	0	414.84	0.0E+00	0.0E+00	0.0
76.5	97.3	346.8	6.34	89.6	13.01	0.00	0	449.32	0.0E+00	0.0E+00	0.0
76.5	97.3	346.8	6.34	55.2	8.01	0.00	0	414.84	0.0E+00	0.0E+00	0.0
96.5	117.3	329.5	6.34	68.9	10.01	47.31	7	428.63	2.4E-04	7.9E-06	17.4

[1]Top of test interval
[2]Double packers were used
[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4
[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-13
INCLINATION:	90.00
DEPTH TO STATIC WATER LEVEL (ft):	23.49
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	0.00

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(kPa)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
28.2	39	289.1	3.29	48.3	7.00	0.00	0	278.71	0.0E+00	0.0E+00	0.0
28.2	39	289.1	3.29	89.6	13.01	0.00	0	320.08	0.0E+00	0.0E+00	0.0
28.2	39	289.1	3.29	110.3	16.01	0.00	0	340.76	0.0E+00	0.0E+00	0.0
28.2	39	289.1	3.29	82.7	12.01	0.00	0	313.18	0.0E+00	0.0E+00	0.0
28.2	39	289.1	3.29	55.2	8.01	0.00	0	285.60	0.0E+00	0.0E+00	0.0
38.2	49	279.1	3.29	62.1	9.01	1.05	0	292.50	1.2E-05	3.9E-07	1.1
38.2	49	279.1	3.29	89.6	13.01	1.40	0	320.08	1.5E-05	4.8E-07	1.3
38.2	49	279.1	3.29	137.9	20.01	2.45	0	368.34	2.2E-05	7.3E-07	2.0
38.2	49	279.1	3.29	103.4	15.01	1.54	0	333.87	1.5E-05	5.1E-07	1.4
38.2	49	279.1	3.29	68.9	10.01	1.05	0	299.39	1.2E-05	3.8E-07	1.1
45.4	57.9	271.9	3.81	68.9	10.01	0.00	0	299.39	0.0E+00	0.0E+00	0.0
45.4	57.9	271.9	3.81	103.4	15.01	0.00	0	333.87	0.0E+00	0.0E+00	0.0
45.4	57.9	271.9	3.81	172.4	25.02	0.18	0	402.81	1.3E-06	4.3E-08	0.1
45.4	57.9	271.9	3.81	137.9	20.01	0.07	0	368.34	5.7E-07	1.9E-08	0.1
45.4	57.9	271.9	3.81	68.9	10.01	0.00	0	299.39	0.0E+00	0.0E+00	0.0

[1]Top of test interval
[2]Single packer for interval 45.4-57.9 ft.
[3]Flow was corrected using a flow meter calibration factor of 5/5.4

Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-14
INCLINATION:	80.00
DEPTH TO STATIC WATER LEVEL (ft):	122.05
HOLE DIAMETER (cm):	9.61
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	1.84

TEST INTERVAL (ft)		Elevation[1]	LENGTH[2]	GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)		(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
13.1	33.9	466.6	6.34	68.9	10.01	0.00	0	1266.07	0.0E+00	0.0E+00	0.0
53.1	73.9	427.2	6.34	55.2	8.01	0.53	0	1252.28	8.4E-07	2.8E-08	0.1
53.1	73.9	427.2	6.34	110.3	16.01	12.41	0	1307.43	1.9E-05	6.2E-07	1.5
53.1	73.9	427.2	6.34	172.4	25.02	16.26	0	1369.49	2.4E-05	7.8E-07	1.9
53.1	73.9	427.2	6.34	110.3	16.01	9.32	0	1307.43	1.4E-05	4.7E-07	1.1
53.1	73.9	427.2	6.34	55.2	8.01	1.12	0	1252.28	1.8E-06	5.9E-08	0.1
113.1	133.9	368.1	6.34	124.1	18.01	1.33	0	1321.22	2.0E-06	6.6E-08	0.2
113.1	133.9	368.1	6.34	248.2	36.03	10.37	0	1445.33	1.4E-05	4.7E-07	1.1
113.1	133.9	368.1	6.34	379.2	55.04	9.15	0	1576.33	1.2E-05	3.8E-07	0.9
113.1	133.9	368.1	6.34	248.2	36.03	5.96	0	1445.33	8.3E-06	2.7E-07	0.7
113.1	133.9	368.1	6.34	124.1	18.01	3.43	0	1321.22	5.2E-06	1.7E-07	0.4
173.1	193.9	309.0	6.34	179.3	26.02	12.69	0	1376.38	1.8E-05	6.1E-07	1.5
173.1	193.9	309.0	6.34	386.1	56.04	16.33	0	1583.23	2.1E-05	6.8E-07	1.6
173.1	193.9	309.0	6.34	586.1	85.06	16.37	0	1783.18	1.8E-05	6.0E-07	1.4
173.1	193.9	309.0	6.34	386.1	56.04	11.14	0	1583.23	1.4E-05	4.6E-07	1.1
173.1	193.9	309.0	6.34	179.3	26.02	6.66	0	1376.38	9.7E-06	3.2E-07	0.8
193.1	213.9	289.3	6.34	220.6	32.02	0.88	0	1417.75	1.2E-06	4.1E-08	0.1
193.1	213.9	289.3	6.34	441.3	64.04	1.82	0	1638.38	2.2E-06	7.3E-08	0.2
193.1	213.9	289.3	6.34	655.0	95.07	19.07	0	1852.12	2.1E-05	6.8E-07	1.6
193.1	213.9	289.3	6.34	441.3	64.04	6.13	0	1638.38	7.5E-06	2.5E-07	0.6
193.1	213.9	289.3	6.34	220.6	32.02	0.21	0	1417.75	3.0E-07	9.8E-09	0.0
241	261.8	242.2	6.34	275.8	40.03	6.90	0	1472.91	9.4E-06	3.1E-07	0.7
241	261.8	242.2	6.34	551.6	80.06	8.34	0	1748.70	9.6E-06	3.1E-07	0.8

TEST INTERVAL (ft)		Elevation[1]	LENGTH[2]	GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)		(kPa)	(psi)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
241	261.8	242.2	6.34	827.4	120.08	10.02	0	2024.49	9.9E-06	3.3E-07	0.8
241	261.8	242.2	6.34	551.6	80.06	6.10	0	1748.70	7.0E-06	2.3E-07	0.6
241	261.8	242.2	6.34	275.8	40.03	3.61	0	1472.91	4.9E-06	1.6E-07	0.4
261	281.8	222.5	6.34	289.6	42.03	0.00	0	1486.70	0.0E+00	0.0E+00	0.0
261	281.8	222.5	6.34	579.2	84.06	0.56	0	1776.28	6.3E-07	2.1E-08	0.0
261	281.8	222.5	6.34	861.9	125.09	1.12	0	2058.97	1.1E-06	3.6E-08	0.1
261	281.8	222.5	6.34	579.2	84.06	0.28	0	1776.28	3.2E-07	1.0E-08	0.0
261	281.8	222.5	6.34	289.6	42.03	0.00	0	1486.70	0.0E+00	0.0E+00	0.0
281	301	202.8	6.10	296.5	43.03	31.47	1	1493.59	4.4E-05	1.4E-06	3.3
281	301	202.8	6.10	620.5	90.06	40.02	4	1817.65	4.6E-05	1.5E-06	3.5
281	301	202.8	6.10	896.3	130.09	36.90	3	2093.44	3.6E-05	1.2E-06	2.8
281	301	202.8	6.10	599.8	87.06	26.64	0	1796.97	3.1E-05	1.0E-06	2.3
281	301	202.8	6.10	296.5	43.03	19.63	0	1493.59	2.7E-05	8.9E-07	2.1

[1]Top of test interval

[2]Double packers were used except a single packer was used on test interval 281 - 301

[3]Flow was corrected based on a flow meter calibration factor of 5/5.4

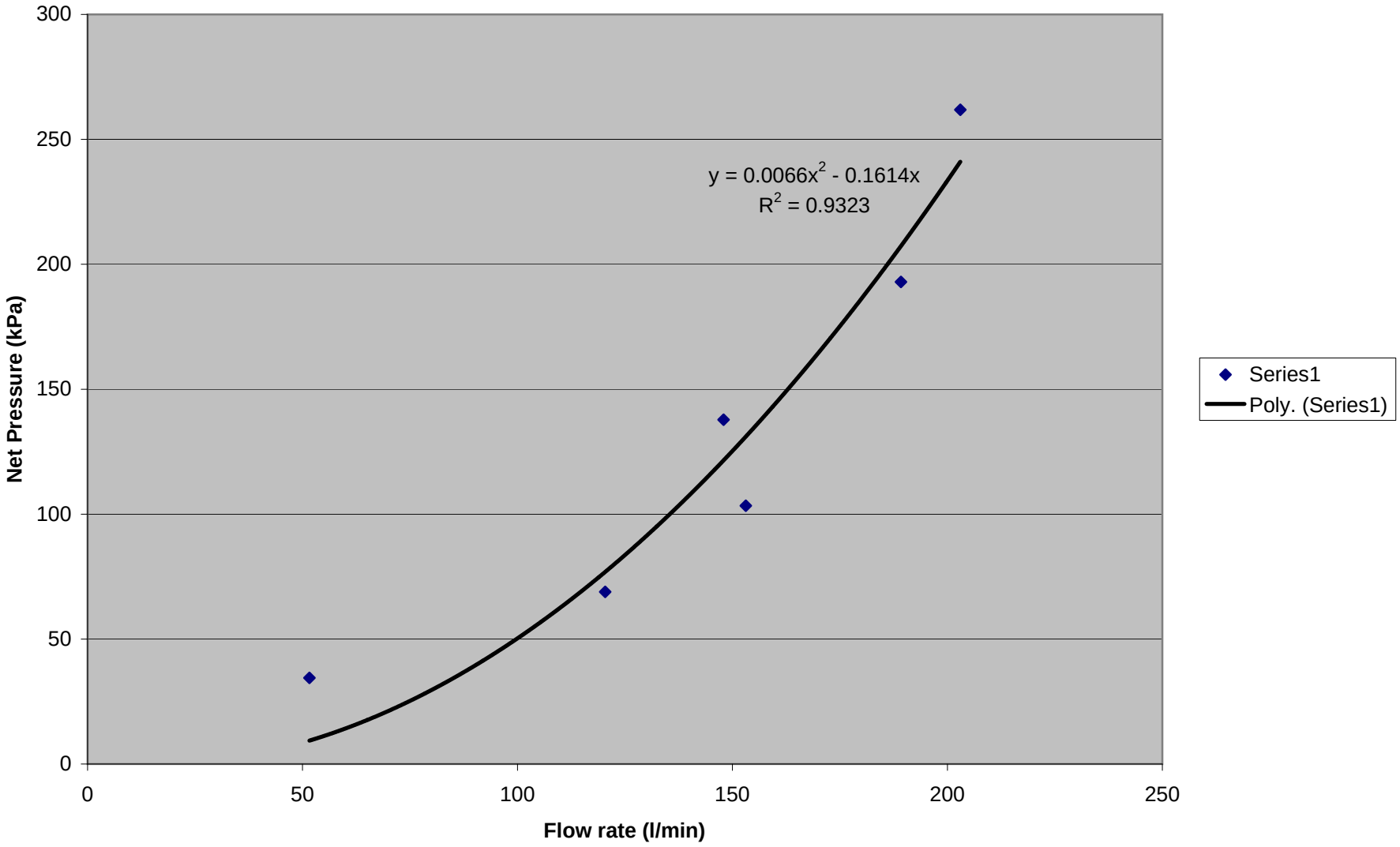
Appendix G-2: Packer Test Results

Blue Lake Expansion Project
Summary of Bedrock Pemeability

BOREHOLE NUMBER:	DH09-15
INCLINATION:	90.00
DEPTH TO STATIC WATER LEVEL (ft)[4]:	10.01
HOLE DIAMETER (cm):	6.11
GAUGE HEIGHT ABOVE HOLE COLLAR (ft):	0.98

TEST INTERVAL (ft)		Elevation[1]		GAUGE PRESSURE	GAUGE PRESSURE	FLOW[3]	Headloss Correction	APPLIED PRESSURE IN TEST SECTION	HYDRAULIC CONDUCTIVITY (k)	HYDRAULIC CONDUCTIVITY (k)	Hydraulic Conductivity
FROM	TO	(ft)	LENGTH[2]	(kPa)	(kPa)	(l/min)	(KPa)	(kPa)	(cm/s)	(ft/s)	(Lugeons)
12.5	30.7	16.1	5.55	68.9	10.01	0.00	0	176.77	0.0E+00	0.0E+00	0.0
12.5	30.7	16.1	5.55	103.4	15.01	0.35	0	211.24	4.0E-06	1.3E-07	0.3
12.5	30.7	16.1	5.55	68.9	10.01	0.00	0	176.77	0.0E+00	0.0E+00	0.0

[1]Top of test interval
[2]Double packers were used
[3]Flow was corrected based on a reading of using a flow meter calibration factor of 5/5.4
[4]Due to the low permeability of the rock this is likely a depth to the residual drill water and not representative of the static water levels in the rockmass.


Headloss correction
Net Pressure (kPa)
Flow rate (l/min)
y = 0.0066x2 - 0.1614x
R2 = 0.9323
Series1
Poly. (Series1)
0
50
100
150
200
250
300

Appendix H

Laboratory Test Results

Working Together SAFELY
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Appendix H-1

Vancouver Petrographics Ltd.
R1-RL, R3-PL and R5-PL Sample Results

Working Together SAFELY
© Hatch 2006/03 ⌘

Report 090699 for:
Sam Sisodraker,
Suite 400, Oceanic Plaza,
1066 West Hastings Street
Vancouver, BC V6E 3X2 **November 2009**
ssisodraker@hatch.ca

Samples: **R1-PL (Phyllite), R3-PL (Phyllite), R5-PL (Greywacke)**

Summary:

Sample R1-PL is of metamorphosed carbonaceous andesitic siltstone/mudstone that is dominated by plagioclase with abundant dusty opaque. A large vein and several veinlets are dominated by calcite with lesser quartz, K-feldspar, and chlorite. Some smaller fracture-filling veinlets are dominated by quartz, and numerous ones consist of quartz, chlorite, and K-feldspar in widely varying proportions. Pyrite is present in a few of the veinlets.

Sample R3-PL is of metamorphosed bedded andesitic siltstone and contains two main sedimentary zones. One is a coarser andesitic siltstone dominated by plagioclase (altered slightly to moderately to sericite) with lesser biotite and quartz fragments and minor ones of opaque in a sparse groundmass dominated by sericite. The other is a finer, somewhat carbonaceous andesitic siltstone/mudstone of similar composition that shows graded beds indicating tops towards the coarser grained layer. A few veinlets are of biotite and sericite/plagioclase. A wispy veinlet is of calcite.

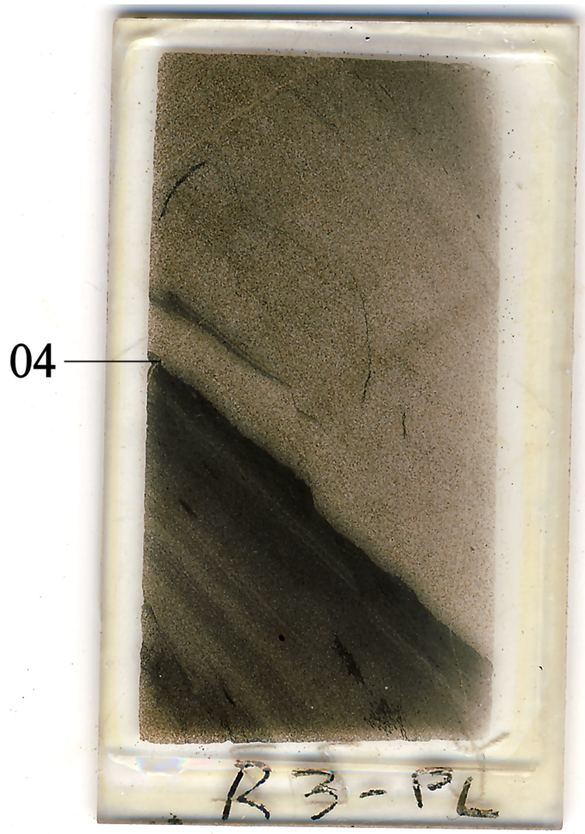
Sample R5-PL is of metamorphosed fragmental andesitic siltstone. It contains fragments mainly from 0.5-5 mm in size of coarser grained siltstone in a groundmass of finer grained siltstone/ mudstone that contains moderately abundant carbonaceous opaque. Siltstone is dominated by plagioclase with much less abundant biotite, sericite, and quartz, and minor carbonaceous opaque. The texture suggests soft-sediment slumping rather than metamorphic or fault brecciation. Numerous wispy veinlets are of biotite, with or without quartz and/or sericite, and a few wider veinlets are of quartz with minor biotite.

Photographic Notes:

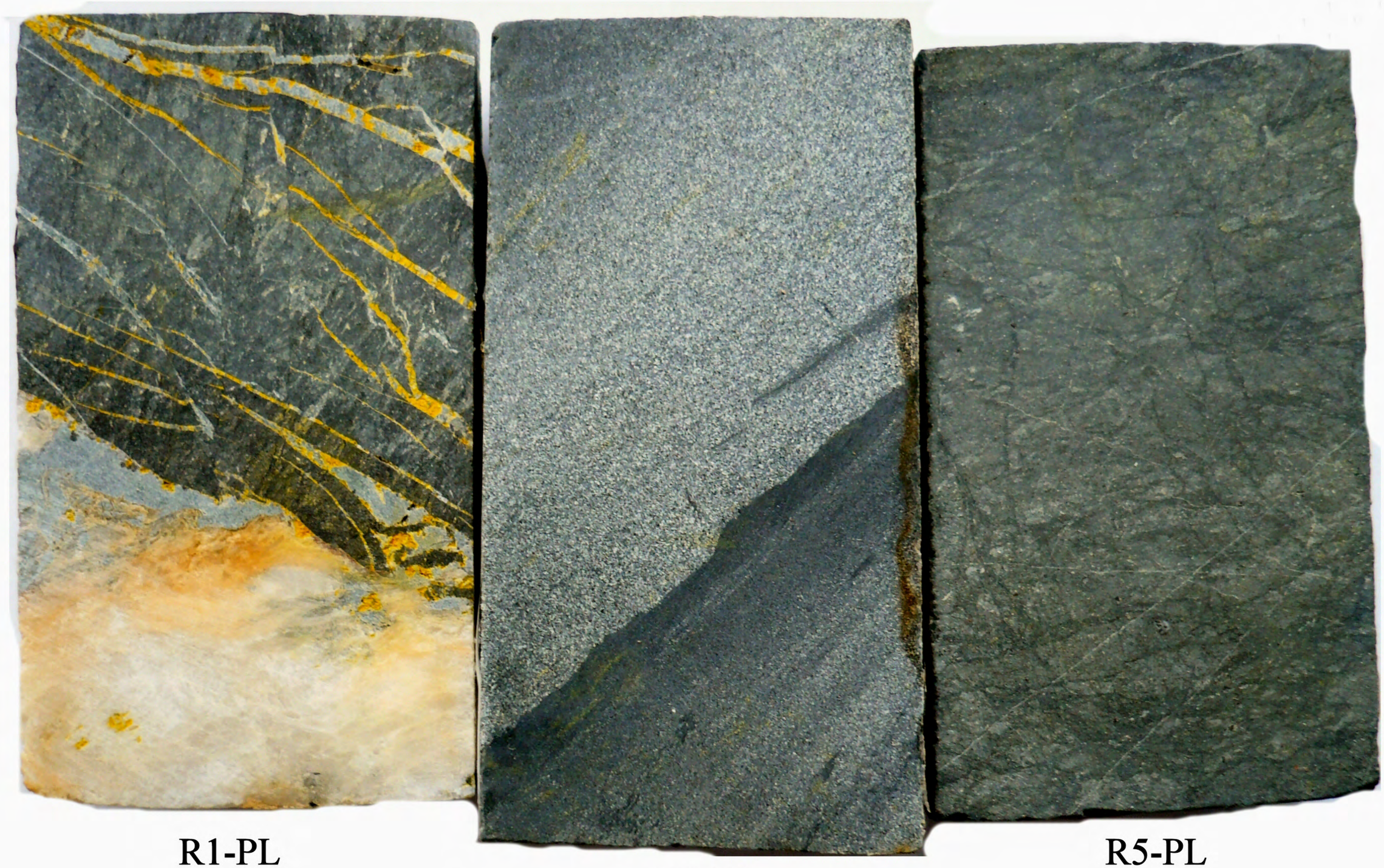
The scanned section shows the gross textural features of the sections; these features are seen much better on the digital image than on the printed image. Photo numbers are shown in the lower left corner of the photographs. The letter in the lower right-hand corner indicates the lighting conditions: P = plane light, X = plane light in crossed nicols, R = reflected light, RP = reflected light and plane light, RX = reflected light and plane light in almost crossed nicols, and XR = reflected light in crossed nicols. Locations of photographs are shown on the scanned sections. Descriptions of the photographs are at the end of the report.

Sample R1-PL **Metamorphosed Andesitic Siltstone/Mudstone**

090699 hatch sections



090699 hatch blocks



R1-PL

R3-PL

R5-PL

Veins/Veinlets: K-feldspar-Quartz-Chlorite; Calcite-K-feldspar-Quartz-Chlorite

The sample is of metamorphosed carbonaceous andesitic siltstone/mudstone that is dominated by plagioclase with abundant dusty opaque. A large vein and several veinlets are dominated by calcite with lesser quartz, K-feldspar, and chlorite. Some smaller fracture-filling veinlets are dominated by quartz, and numerous ones consist of quartz, chlorite, and K-feldspar in widely varying proportions. Pyrite is present in a few of the veinlets.

mineral	**percentage**	**main grain size range (mm)**
plagioclase	40-45%	0.01-0.05 (a few up to 0.15 mm)
quartz	2- 3	0.02-0.05
carbonaceous opaque	4- 5	amorphous
phlogopite/biotite	2- 3	0.02-0.03
veins, veinlets		
1) K-feldspar-chlorite-pyrite-quartz	3- 4	0.3-1.5 (Kf); 0.05-0.1 (py); 0.02-0.05 (qz, cl)
2) calcite-quartz-K-feldspar-chlorite	25-30	0.5-3 (ct); 0.1-2 (qz), 0.5-2 (Kf), 0.03-0.05 (cl)

The rock contains disseminated grains of plagioclase and lesser quartz from 0.03-0.05 mm in size. A few coarser grains of plagioclase are up to 0.15 mm in size.

These are set in a much finer grained groundmass containing variable amounts of carbonaceous opaque, which obscures the optical properties of the other minerals. The groundmass probably consists of plagioclase and lesser phlogopite/biotite, with much less abundant quartz and calcite. The distribution of carbonaceous opaque varies moderately in irregular lenses and patches, commonly oriented parallel to a weak foliation. Where carbonaceous opaque is abundant, it obscures completely to optical properties of the other minerals.

A few patches up to 1 mm in size are relatively free of carbonaceous opaque. These consist of intimate intergrowths of anhedral to locally subhedral prismatic plagioclase and much less abundant phlogopite/biotite (pleochroism from pale to light brown).

A set of fracture-filling veinlets mainly from 0.05-0.2 mm in width consists of variable amounts of chlorite, K-feldspar, quartz, and pyrite. Chlorite commonly occurs in the cores of veinlets as clusters of equant pale green flakes. K-feldspar occurs in cores of veinlets as grains up to 0.5 mm in size and along some margins of veinlets as grains from 0.03-0.1 mm in size. Quartz occurs along margins of chlorite-rich parts of veinlets and forms a few lenses in the cores of veinlets consisting of grains up to 0.15 mm in size. Pyrite forms clusters up to 1 mm in size in cores of veinlets; a few of these were replaced by red-brown hematite. These veinlets probably formed after fractures had completely developed.

A few fracture-filling, slightly braided veinlets up to 0.6 mm wide consist mainly of quartz as irregular to prismatic grains oriented perpendicular to vein walls, with wispy seams of chlorite and opaque oriented parallel to veinlet walls. These veinlets probably grew as fractures were being formed. Some also contain minor patches up to 0.2 mm in size of chlorite.

The large vein consists mainly of calcite with patches up to several mm across of each of K-feldspar and quartz, and a few patches up to 1.5 mm in size of chlorite. Calcite grains commonly are strained and partly recrystallized to finer, unoriented, subgrain aggregates. Large quartz grains were strained moderately and some were recrystallized slightly to much finer subgrains.

Sample R3-PL **Metamorphosed Bedded Andesitic Siltstone**
Veinlets: Biotite-Sericite; Calcite

The sample contains two main sedimentary zones. One is a coarser andesitic siltstone dominated by plagioclase (altered slightly to moderately to sericite) with lesser biotite and quartz fragments and minor ones of opaque in a sparse groundmass dominated by sericite. The other is a finer, somewhat carbonaceous andesitic siltstone/mudstone of similar composition that shows graded beds indicating tops towards the coarser grained layer. A few veinlets are of biotite and sericite/plagioclase. A wispy veinlet is of calcite.

mineral	**percentage**	**main grain size range (mm)**
plagioclase	65-70%	0.03-0.05
biotite	10-12	0.03-0.05
quartz	5- 7	0.03-0.05
sericite	5- 7	0.01-0.03
opaque	2- 3	0.01-0.03
muscovite	0.2	0.07-0.12
veinlets		
1) biotite-sericite/plagioclase	0.3	0.03-0.05
2) calcite	minor	0.01-0.03

In the coarser grained siltstone, plagioclase forms equant anhedral grains, many of which were altered slightly to moderately to sericite.

Biotite forms ragged flakes with pleochroism from pale to light brown.

Quartz forms equant disseminated grains.

Sericite forms disseminated flakes and wispy patches of flakes, probably mainly as replacement of plagioclase, and probably partly as groundmass to the detrital grains.

Opaque, probably in large part carbonaceous, forms disseminated wispy patches. A few patches from 0.03-0.06 mm in size with more sharply defined outlines probably are of iron oxides and/or ilmenite.

Muscovite forms scattered commonly slender flakes.

In the finer grained siltstone/mudstone interval, a sequence of a few beds up to several mm thick is graded indicating tops towards the coarser siltstone layer. Composition of fragments is generally similar to that in the coarser siltstone. The finer grained parts of the zone contain more abundant wispy carbonaceous opaque in the groundmass. As well, the finer grained parts of this zone contain 2-3% platy opaque grains (0.05-0.15 mm long), whose texture suggests that they are ilmenite.

Carbonaceous opaque is concentrated moderately to strongly in a few lensy to irregular patches up to several mm long. Those in the coarser grained layer are at a high angle to bedding and curved slightly. Most of those in the finer grained siltstone are elongated at a low angle to bedding.

Two subparallel irregular veinlet 0.05-0.08 mm wide are of plagioclase (altered strongly to sericite) with lesser biotite and minor quartz; they are distinguished from the coarser grained siltstone mainly because they lacks carbonaceous opaque.

A wispy veinlet 0.02 mm wide of calcite cuts the coarser grained siltstone near one end of the section.

Sample R5-PL **Metamorphosed Fragmental Andesitic Siltstone**
Veinlets: Biotite-(Quartz); Quartz-(Biotite)

Fragments mainly from 0.5-5 mm in size of coarser grained siltstone are set in a groundmass of finer grained siltstone/mudstone that contains moderately abundant carbonaceous opaque. Siltstone is dominated by plagioclase with much less abundant biotite, sericite, and quartz, and minor carbonaceous opaque. The texture suggests soft-sediment slumping rather than metamorphic or fault brecciation. Numerous wispy veinlets are of biotite, with or without quartz and/or sericite, and a few wider veinlets are of quartz with minor biotite.

mineral	**percentage**	**main grain size range (mm)**	
fragments			
plagioclase	40-45%	0.03-0.07	(a few up to 0.12 mm across)
quartz	3- 4	0.03-0.07	(a few up to 0.1 mm across)
biotite	3- 4	0.03-0.05	
pyrite	0.5	0.02-0.1	
opaque	1	dusty	
groundmass			
plagioclase	20-25	0.01-0.02	
sericite	3- 4	0.01-0.02	
biotite	2- 3	0.01-0.02	
carbonaceous opaque	4- 5	dusty	
veinlets			
1) biotite-quartz-sericite	1- 2	0.02-0.05	
2) quartz-(biotite)	1	0.03-0.07	

Angular, equant to elongate fragments, mainly from 0.5-2 mm in size, with a few up to 5 mm long, consist of siltstone, dominated by plagioclase (altered slightly to sericite and dusty opaque) with lesser biotite and much less abundant quartz. Biotite is pleochroic from pale to light orangish brown; it probably is intermediate in composition between biotite and phlogopite, i.e., low in iron. Siltstone ranges moderately in grain size, with average detrital fragment size ranging from 0.03-0.05 in some to 0.05-0.07 in other. These fragments are set in a sparse groundmass dominated by plagioclase (altered strongly to sericite) and carbonaceous opaque. Pyrite forms replacement patches up to 1 mm in size in a few fragments.

The groundmass is of moderately to much finer grained siltstone/mudstone consisting of plagioclase with lesser biotite, sericite, and quartz, and which contains much more abundant carbonaceous opaque that in the fragments. Borders of fragments range from diffuse to sharp.

Numerous wispy veinlets from 0.01-0.03 mm wide are dominated by biotite with lesser sericite. some of these contain minor to moderately abundant quartz.

A few veinlets from 0.07-0.2 mm wide are of quartz with much less abundant biotite.

List of Photographs

Photo	Section	Description
01	R1-PL	patches of plagioclase-biotite intergrown with patches of plagioclase-biotite containing minor to very abundant carbonaceous opaque; veinlets dominated by quartz and others dominated by chlorite.
02	R1-PL	phyllite: plagioclase-biotite-carbonaceous opaque; cut by banded quartz-rich veinlet with quartz grains oriented perpendicular to the walls and wispy seams of chlorite and opaque parallel to the walls; larger veinlet of K-feldspar (mainly in the core) with lesser quartz and chlorite and a few patches of pyrite.
03	R1-PL	main vein: patches dominated by K-feldspar, by chlorite, by calcite (in part strained and recrystallized), and by quartz.
04	R3-Pl	contact: above is coarser grained siltstone with detrital grains of plagioclase and much less abundant ones of quartz and biotite, with wispy seams and patches of mainly carbonaceous opaque; below is the top of one of the finer layers, here a mudstone with detrital grains of plagioclase and lesser ones of quartz and elongate patches of ilmenite? in a groundmass of sericite and carbonaceous opaque; a veinlet, mainly in the finer grained layer, is of biotite and sericite (probably after plagioclase).
05	R5-PL	fragments of fine siltstone (outlined in dashed yellow lines) containing fragments of plagioclase and lesser ones of biotite and quartz, and a few fragments of extremely fine grained material (X) in a groundmass of very fine grained carbonaceous siltstone/mudstone; veinlets of quartz-biotite.

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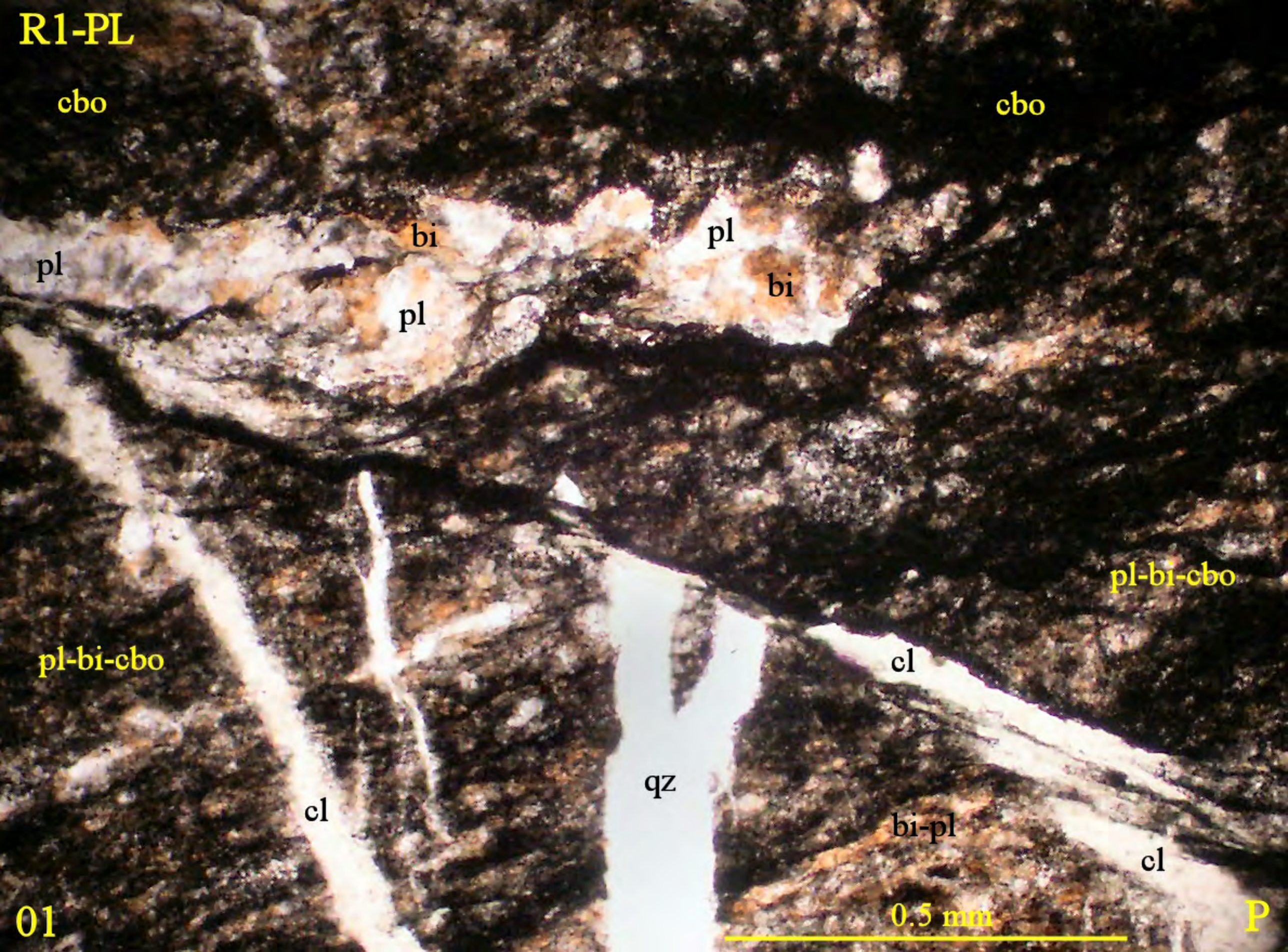
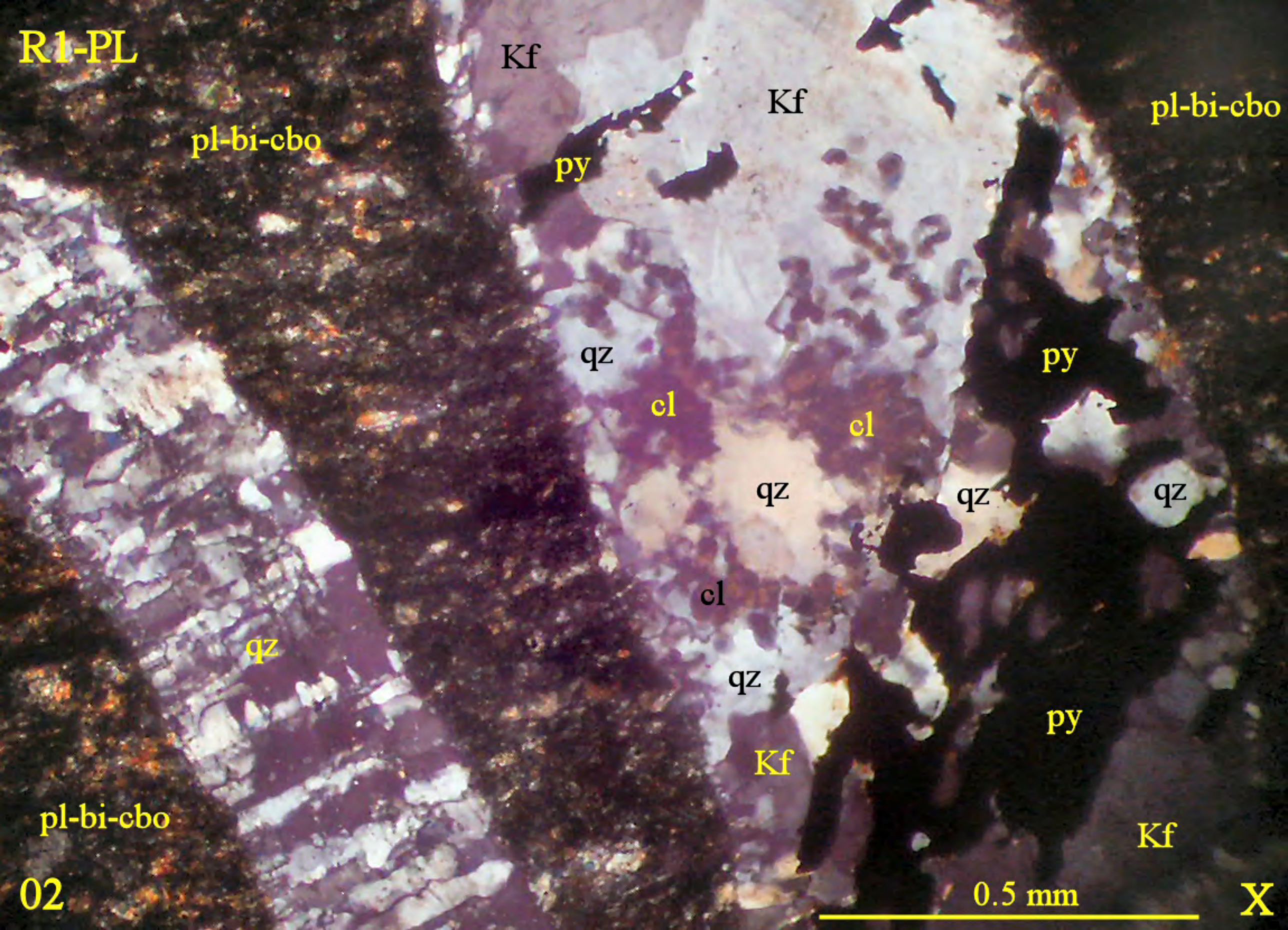

R1-PL
cbo
cbo
bi
pl
pl
pl
bi
pl-bi-cbo
pl-bi-cbo
cl
cl
qz
bi-pl
cl
01
0.5 mm
P


R1-PL
pl-bi-cbo
Kf
Kf
pl-bi-cbo
py
qz
cl
cl
py
qz
qz
qz
cl
qz
qz
py
pl-bi-cbo
Kf
Kf
02
0.5 mm
X

R1-PL

cl

ct

cl

ct

Kf

ct

qz

qz

qz

Kf

ct

Kf

ct

ct

qz

cl

ct

qz

03

1.0 mm

X

R3-PL
qz
bi
pl
pl/se
pl
qz
pl
pl
bi
pl
pl
pl
pl
qz
qz
qz
qz
bi
se
il?
pl-(qz-bi-cbo-se)
04
se
0.5 mm
P

R5-PL

bi

py

qz

X

X

bi

py

qz-bi

1.0 mm

05

P

Appendix H-2

Point Load and UCS Test Results

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Sample	Rock type	Location	Uncorrected Point Load Stength (MPa)	Uncorrected Load, P (MN)	I_S (Mpa)		$I_{S(50)}$ (Mpa)		UCS (Mpa)	
							Min.	Max.	Min.	Max.
Right abutment - 1	Graywacke	Right abutment, base of dam	22.20	0.02	5.85	13.15	6.37	11.84	140.19	260.44
Right abutment - 2	Graywacke	Right abutment, base of dam	13.80	0.01	3.63	8.18	3.96	7.36	87.14	161.89
Left abutment - 1	Graywacke	Left abutment El. 440	6.40	0.01	1.69	3.79	1.84	3.41	40.41	75.08
Left abutment - 2	Graywacke	Left abutment, base of dam	11.50	0.01	3.03	6.81	3.30	6.13	72.62	134.91
Left Abutment - 3	Graywacke	Left abutment, base of dam	12.30	0.01	3.24	7.29	3.53	6.56	77.67	144.30
Intake	Graywacke	Intake area	12.50	0.01	3.29	7.41	3.59	6.67	78.93	146.64
Surge shaft	Graywacke	Cliff face, adjacent to filter plant	16.90	0.02	4.45	10.01	4.85	9.01	106.72	198.26
R8-1	Greenstone	Lower tunnel, upstream portal area	22.60	0.02	5.95	13.39	6.49	12.05	142.71	265.13
R8-2	Greenstone	Lower tunnel, upstream portal area	13.80	0.01	3.63	8.18	3.96	7.36	87.14	161.89
R6	Graywacke - displays some erosion, can be gouged with geological pick.	Lower tunnel, upstream portal area	1.00	0.00	0.26	0.59	0.29	0.53	6.31	11.73
R7-1	Greenstone	Lower tunnel, upstream portal area	11.00	0.01	2.90	6.52	3.16	5.87	69.46	129.05
R7-2	Greenstone	Lower tunnel, upstream portal area	8.80	0.01	2.32	5.21	2.53	4.69	55.57	103.24
R5	Graywacke	Lower tunnel, upstream portal area	10.00	0.01	2.63	5.93	2.87	5.33	63.15	117.32
R1- LT	Graywacke	Lower tunnel, portal area	14.20	0.01	3.74	8.41	4.08	7.57	89.67	166.59
R1 - UT	Graywacke	Upper tunnel	20.00	0.02	5.27	11.85	5.74	10.67	126.29	234.63
R2 - UT	Graywacke	Upper tunnel	6.40	0.01	1.69	3.79	1.84	3.41	40.41	75.08
R3 - UT	Graywacke	Upper tunnel	9.90	0.01	2.61	5.87	2.84	5.28	62.52	116.14
SP-1	Graywacke	Lower tunnel, upstream portal slope	26.23	0.02	6.91	15.54	7.53	13.99	165.64	307.72
SP-2	Graywacke	Lower tunnel, upstream portal slope	14.67	0.01	3.86	8.69	4.21	7.82	92.64	172.10
LT-1	Graywacke	Lower tunnel, downstream portal	8.84	0.01	2.33	5.24	2.54	4.71	55.82	103.71
LT-2	Graywacke	Lower tunnel, downstream portal	21.50	0.02	5.66	12.74	6.17	11.46	135.77	252.23
LT-3	Graywacke	Lower tunnel, dam, downstream portal	19.10	0.02	5.03	11.32	5.48	10.19	120.61	224.07

Sample	Borehole	Depth (ft)	Rock type	Uncorrected Point Load Stength (MPa)	Uncorrected Load, P (MN)	I_S (Mpa)	$I_{S(50)}$ (Mpa)	UCS (Mpa)
R1-PL	DH09-04	17.1 - 17.7	Graywacke - Metamorphosed carbonaceous andesitic siltstone/mudstone	23.48	0.02	5.52	6.13	134.80
R2-PL	DH09-04	19.9 - 20.1	Graywacke - Metamorphosed andesitic siltstone	16.74	0.02	3.94	4.37	96.11
R3-PL	DH09-14	162.5 - 162.9	Graywacke - Metamorphosed bedded andesitic siltsone	5.94	0.01	1.40	1.55	34.10
R3-PL (2)	DH09-14	162.5 - 162.9	Graywacke - Metamorphosed bedded andesitic siltsone	35.90	0.03	8.44	9.37	206.11
R4-PL	DH09-02	90.5 - 90.9	Graywacke - Metamorphosed fragmental andesitic siltstone	15.82	0.01	3.72	4.13	90.83
R5-PL	DH09-02	112.3 - 112.7	Graywacke - Metamorphosed fragmental andesitic siltstone	25.16	0.02	5.92	6.57	144.45
R6-PL	DH09-01	77.8 - 78.2	Graywacke - Metamorphosed fragmental andesitic siltstone	14.58	0.01	3.43	3.80	83.71
R7-PL	DH09-13	47.9-48.5	Graywacke - Metamorphosed andesitic siltstone	16.82	0.02	3.95	4.39	96.57
R7-PL (2)	DH09-13	47.9-48.5	Graywacke - Metamorphosed andesitic siltstone	16.82	0.02	3.95	4.39	96.57
R8-PL	DH09-12	106.0-106.8	Graywacke - Metamorphosed fragmental andesitic siltstone	10.68	0.01	2.51	2.79	61.32
R9-PL	DH09-09	118.0 - 118.6	Graywacke - Metamorphosed andesitic siltstone	21.24	0.02	4.99	5.54	121.94
R10-PL	DH09-11	96.9-97.2	Graywacke - Metamorphosed fragmental andesitic siltstone	21.64	0.02	5.09	5.65	124.24
R11-PL	DH09-11	166.5-166.8	Graywacke - Metamorphosed fragmental andesitic siltstone	40.00	0.04	9.40	10.44	229.65
R12-PL	DH09-03	10.8 - 11.2	Graywacke - Metamorphosed bedded to fragmental andesitic siltstone	24.08	0.02	5.66	6.28	138.25
R13-PL	DH09-03	56.2 - 56.4	Graywacke - Metamorphosed carbonaceous andesitic siltstone	7.10	0.01	1.67	1.85	40.76

Sample	Borehole	Depth (ft)	Rock type	UCS (Mpa)
R2	DH09-04	19.1-19.9	Graywacke - Metamorphosed andesitic siltstone	144
R4	DH09-02	90.9-91.7	Graywacke - Metamorphosed fragmental andesitic siltstone	83
R6	DH09-01	78.2-79	Graywacke - Metamorphosed fragmental andesitic siltstone	198
R8	DH09-12	106.0-106.8	Graywacke - Metamorphosed andesitic siltstone	69
R9	DH09-09	118.6-119.3	Graywacke - Metamorphosed andesitic siltstone	77.5
R10	DH09-10	97.4-98.6	Graywacke - Metamorphosed andesitic siltstone	127.4
R11	DH09-10	165.8-166.5	Graywacke - Metamorphosed andesitic siltstone	103
R12	DH09-03	11.2-12.0	Graywacke - Metamorphosed bedded andesitic siltstone	134
C1	DH09-04	0.3-0.9	Concrete	42.7
C2	DH09-04	3.4-4.1	Concrete	34.6
C3	DH09-04	7.2-7.8	Concrete	55.3

Appendix H-3

Direct Shear Test Results

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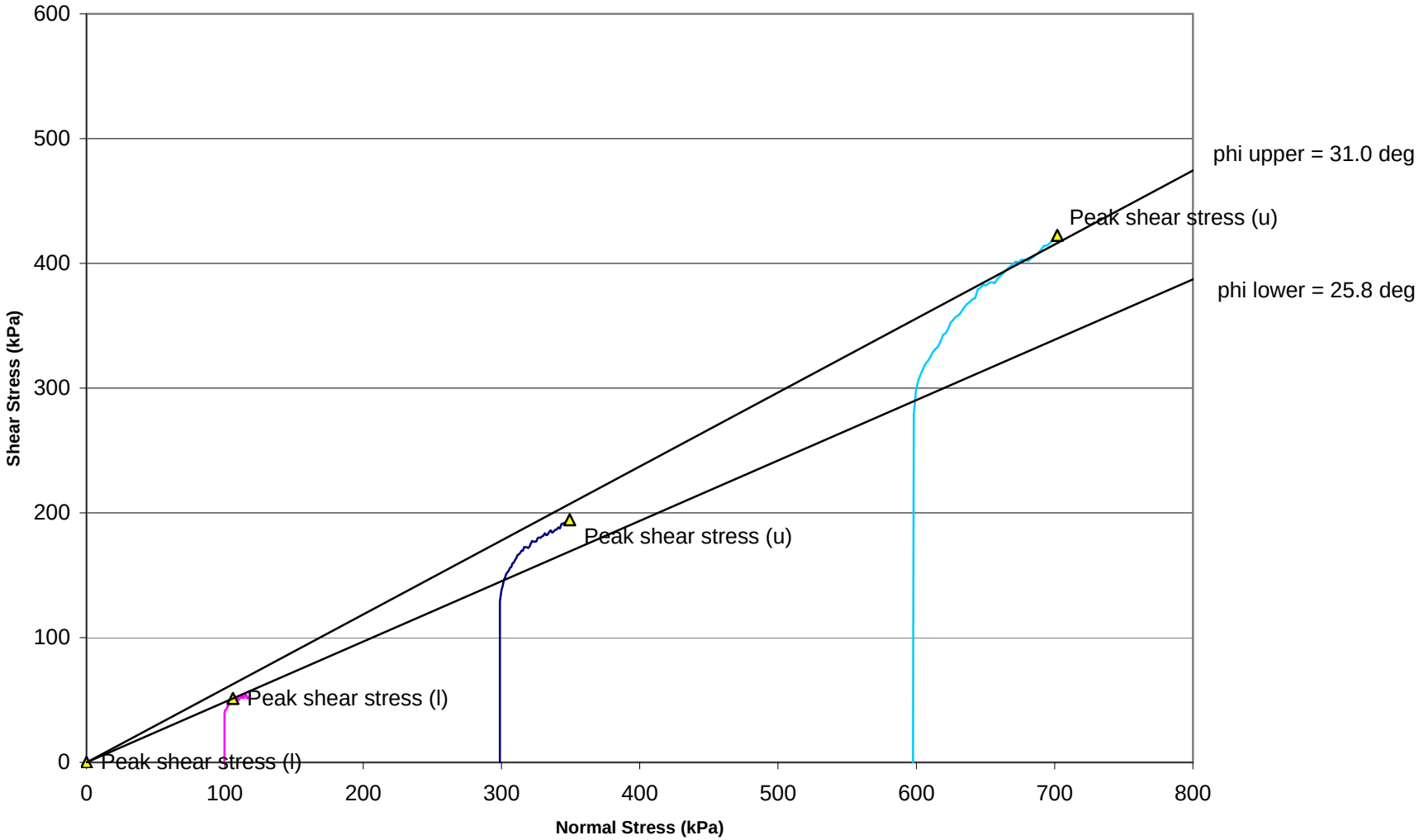
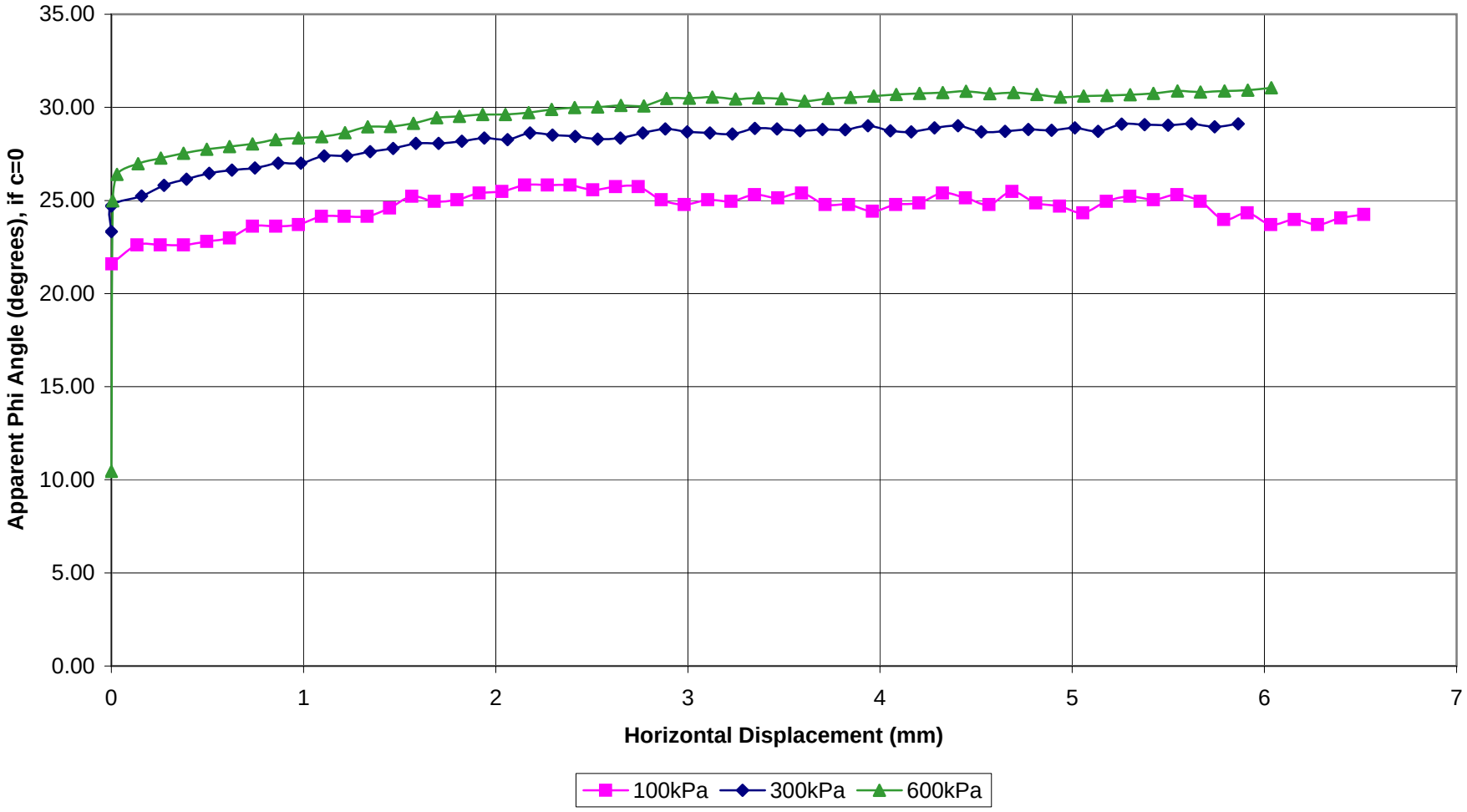
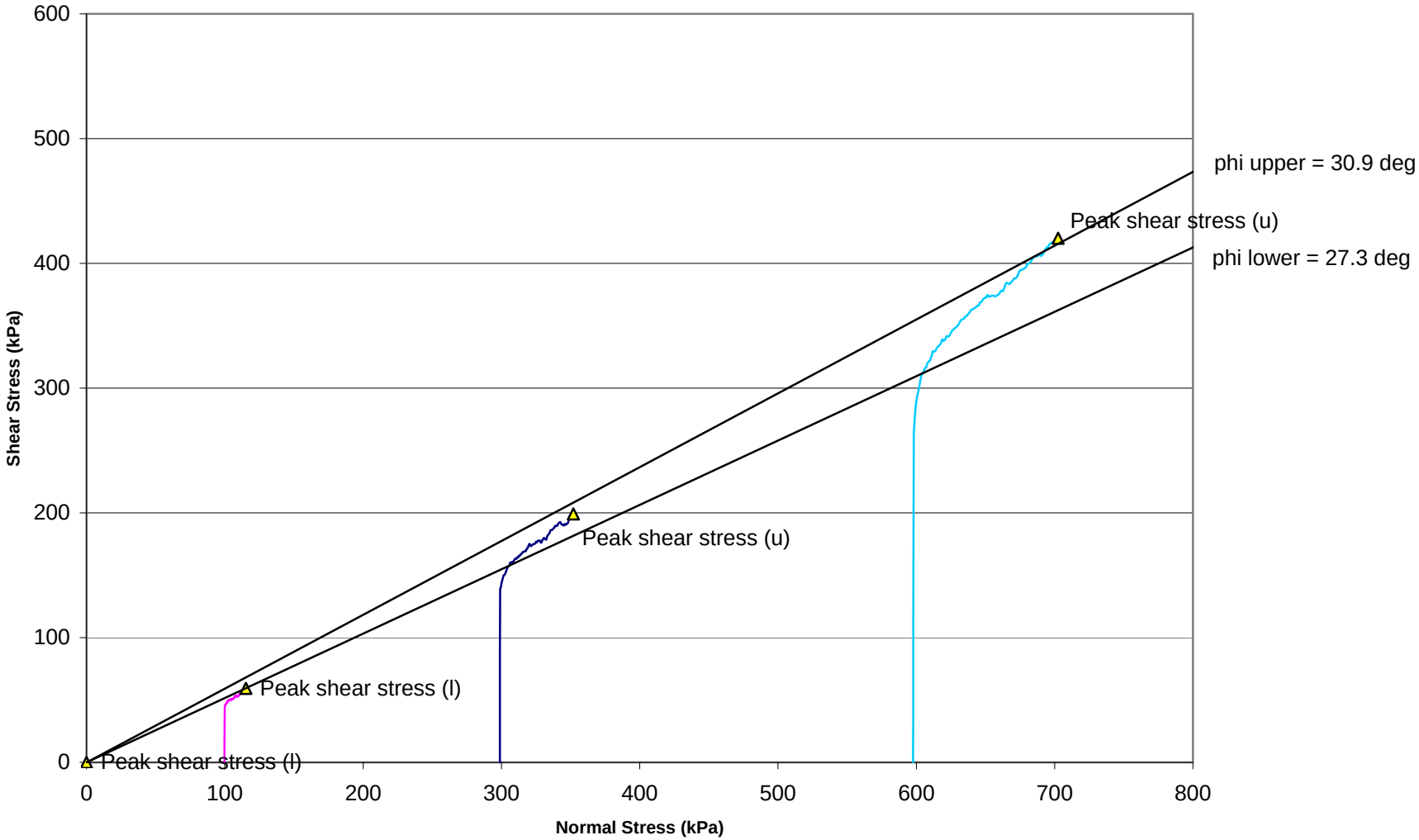
Direct Shear Test Results - Blue Lake Expansion
R12/R6 Rock on Rock



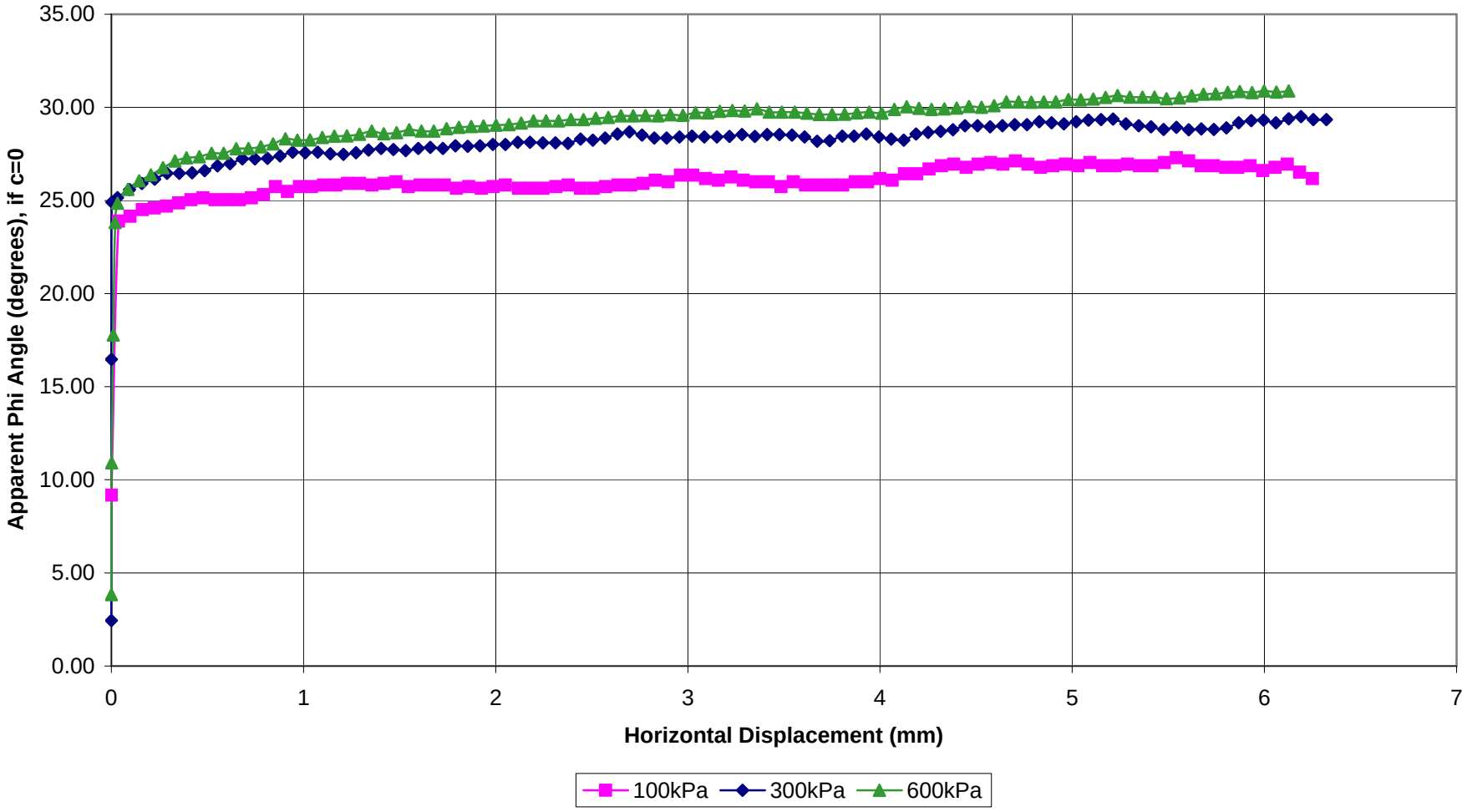
Direct Shear Test Results
Blue Lake R6 / R12 Bedrock on Bedrock
100, 300 and 600 kPa



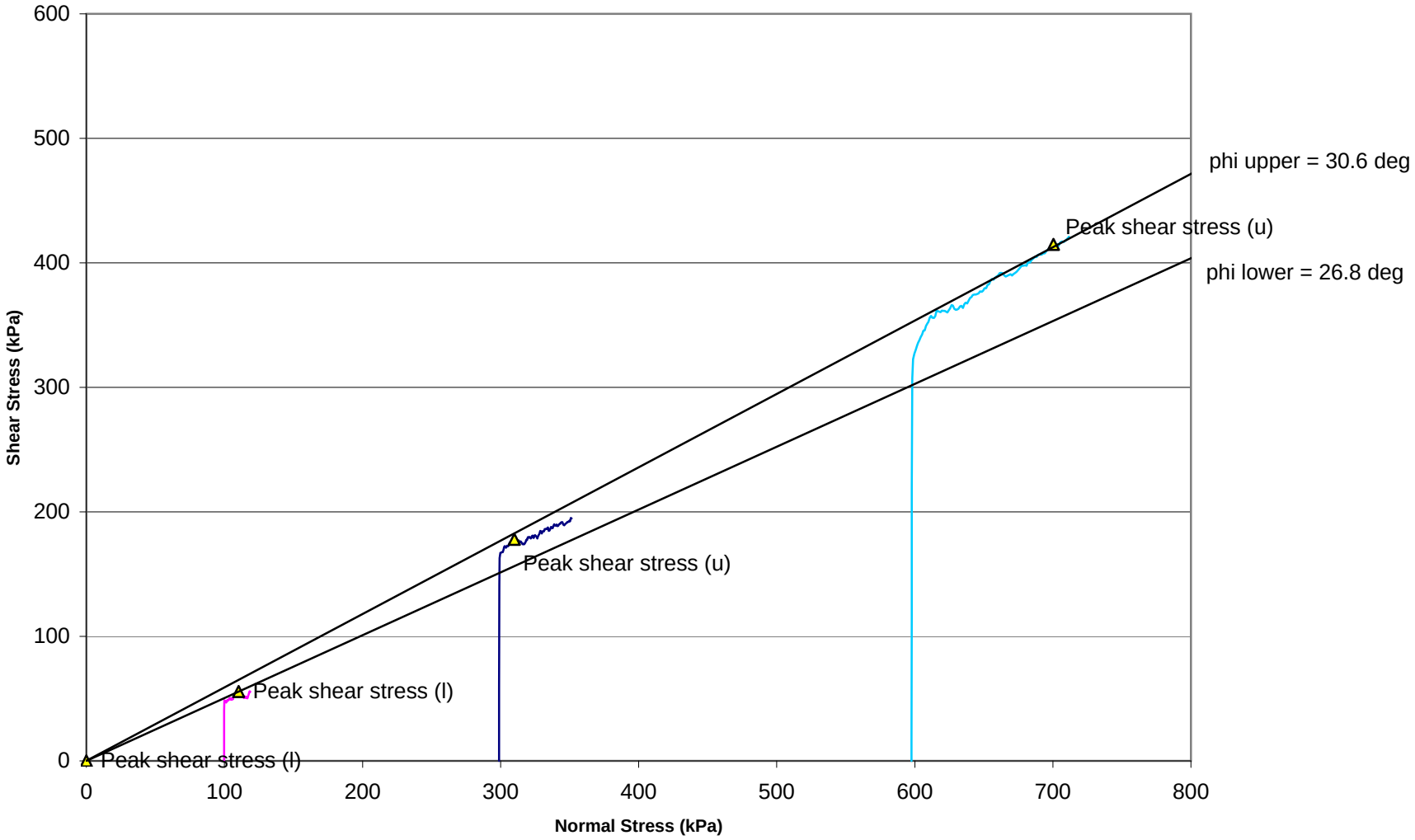
Direct Shear Test Results - Blue Lake Expansion
C1/R2 Concrete on Rock



Direct Shear Test Results
Blue Lake C1 / R2 Concrete on Bedrock
100, 300 and 600 kPa



Direct Shear Test Results - Blue Lake Expansion
C2/R6 Concrete on Rock



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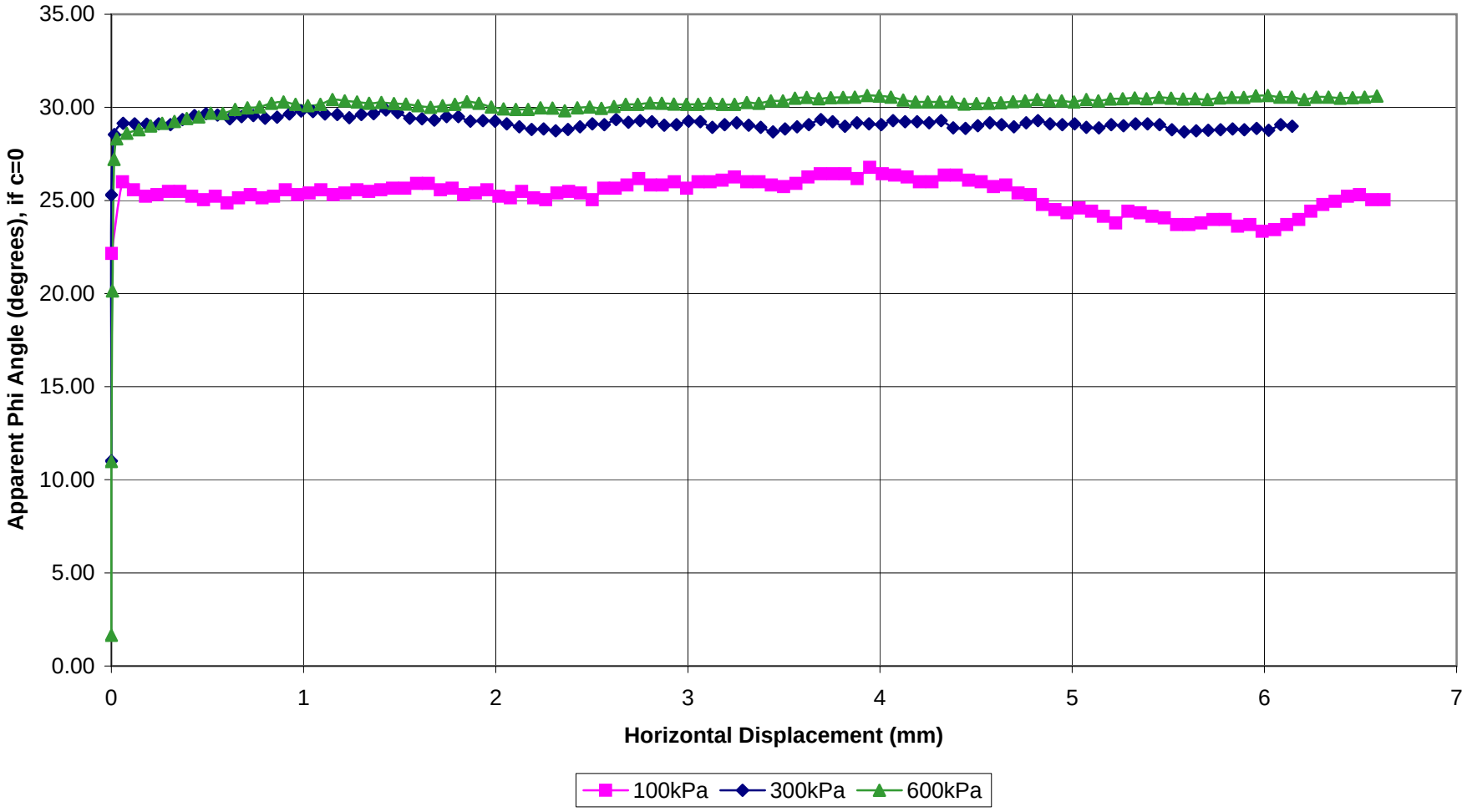
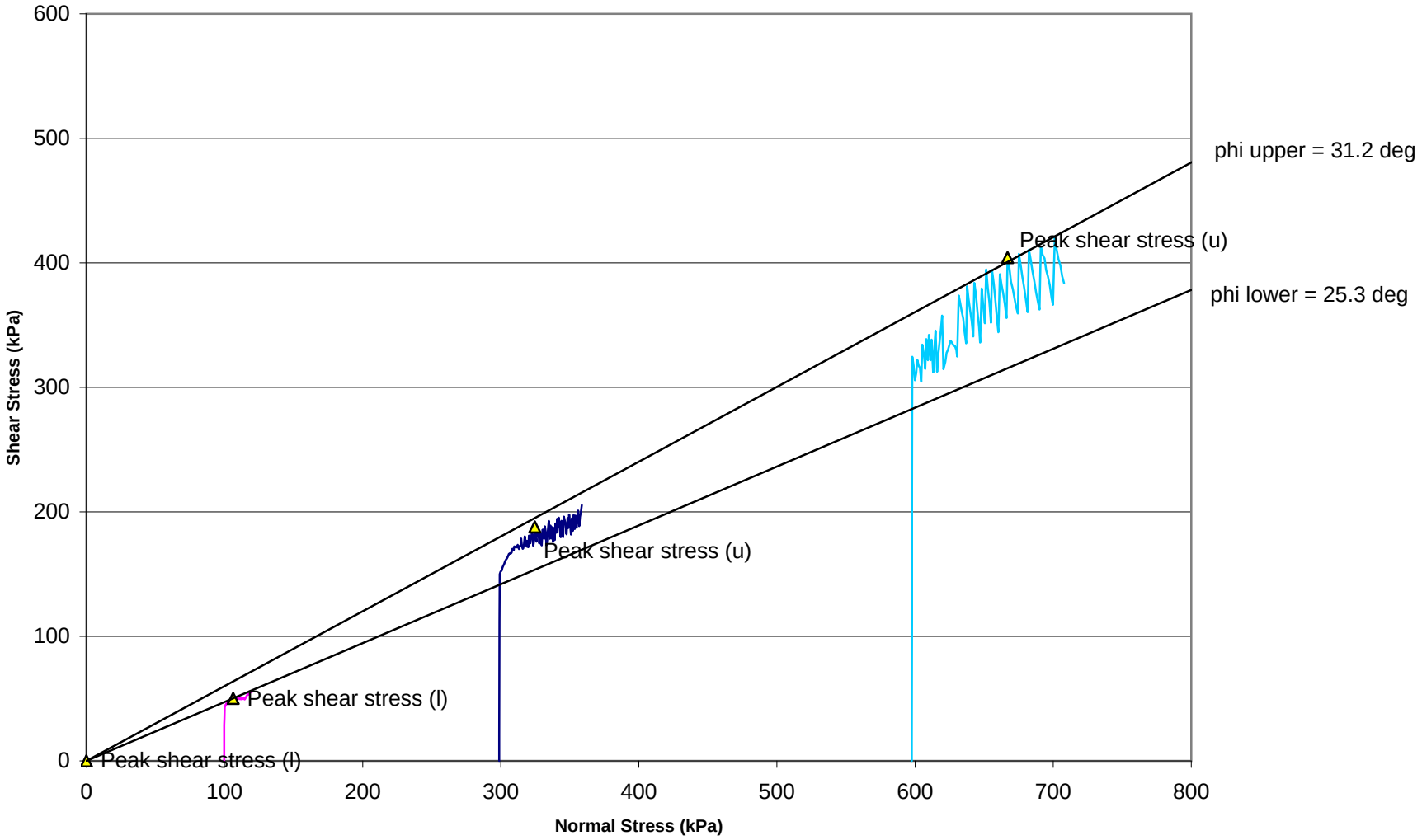
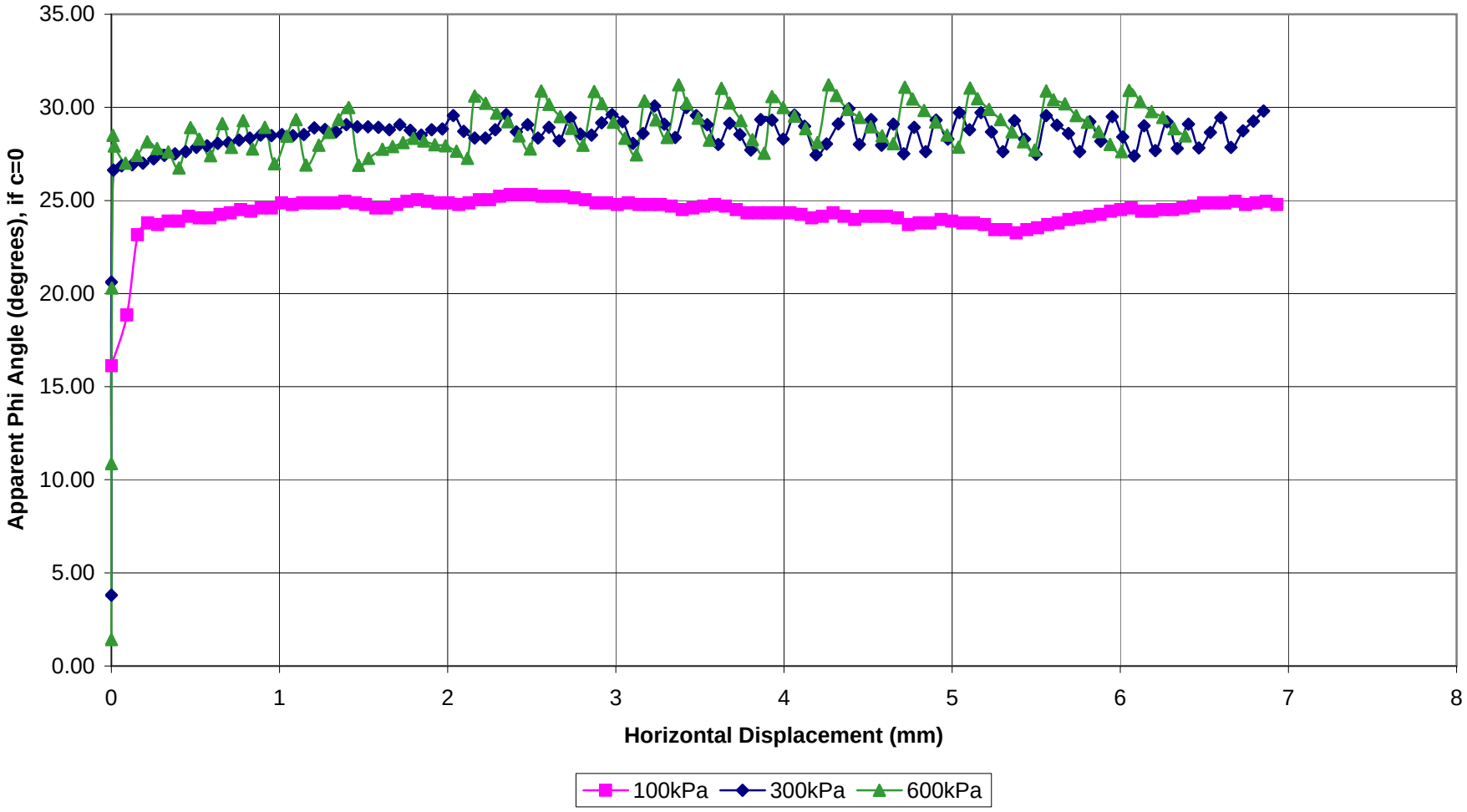


Direct Shear Test Results - Blue Lake Expansion
C3/R12 Concrete on Rock



Direct Shear Test Results
Blue Lake C3 / R12 Concrete on Bedrock
100, 300 and 600 kPa



Appendix H-4

CANTEST Ltd. ABA Test Results

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CANTEST Ltd. 4606 Canada Way, Burnaby, BC Canada V5G 1K5 Tel: 604 734 7276 Fax: 604 731 2386 www.cantest.com

Reported to Peter Friz on 9-Nov-09

Table 1: ABA Test Results for 8 Blue Lake Hydro (332360) samples - November 2009

			Acme				Std. Sobek NP		
S. No.	**Sample ID**	**Paste pH**	**Total Sulphur (Wt.%)**	**Sulphate Sulphur (Wt.%)**	**Sulphide Sulphur* (Wt.%)**	**Maximum Potential Acidity** (Kg CaCO3/Tonne)**	**Neutralization Potential (Kg CaCO3/Tonne)**	**Net Neutralization Potential*** (Kg CaCO3/Tonne)**	**Fizz Rating**
1	ARD COMP-1	8.3	0.19	0.01	0.18	5.6	22.4	16.8	Slight
2	ARD COMP-2	8.9	0.09	<0.01	0.09	2.8	20.8	18.0	Slight
3	ARD COMP-3	9.2	0.15	<0.01	0.15	4.7	67.5	62.8	Moderate
4	ARD COMP-4	9.2	0.38	<0.01	0.38	11.9	105.0	93.1	Strong
5	ARD COMP-5	8.6	0.08	<0.01	0.08	2.5	30.3	27.8	Slight
6	ARD COMP-6	9.7	0.28	<0.01	0.28	8.8	145.0	136.3	Strong
7	ARD COMP-7	9.2	0.10	<0.01	0.10	3.1	71.3	68.1	Moderate
8	ARD COMP-8	8.9	0.50	<0.01	0.50	15.6	23.6	7.9	Slight
Detection Limits		*0.5*	*0.02*	*0.01*	*0.02*	*0.6*			
CANTEST SOP No:		7160	LECO	7410	Calculation	Calculation	7110	Calculation	7110

Notes:

Total sulphur by Leco done at Acme labs.

Calculations:

*Sulphide sulphur is based on difference between total sulphur and sulphate sulphur.

**MPA (Maximum Potential Acidity) is based on sulphide sulphur .

*** NNP (Net Neutralization Potential) is based on difference between Neutralization Potential (NP) and MPA.

References:

Reference for Std. Sobek NP method (Cantest SOP No. 7110): Sobek NP Method (EPA 600 Method - described in Sobek et al. 1978)

CANTEST Ltd. 4606 Canada Way, Burnaby, BC Canada V5G 1K5 Tel: 604 734 7276 Fax: 604 731 2386 www.cantest.com

Table 2: QAQC for 8 Blue Lake Hydro (332360) samples - November 2009

Table 2a: QA/QC for Paste pH & NP Determination

Sample ID	Paste pH (pH Units)	
QAQC- Paste pH		
Reference Material		
KZK-1 Reference (Paste pH = 8.83)	8.8	
Sample ID	**Neutralization Potential (KgCaCO3/Tonne)**	
QAQC - Std. Sobek NP		
Reference Material		
KZK-1 Reference (NP = 64.8) for moderate fizz rating	70.0	

Table 2b: QA/QC for Sulphur Speciation

Sample ID	Total Sulphur (Wt.%)	
QAQC - Total Sulphur		
Reference Material		
CANTEST Ref. (0.11% S)	0.11	
STD CSC (4.25% S)	4.28	4.22
STD OREAS76A (18.00% S)	17.85	17.13
Sample ID	**Sulphate Sulphur (Wt.%)**	
QAQC - Sulphate Sulphur		
Reference Material		
CANTEST Ref. (0.27% SO4-S)	0.24	

Table 3: Trace Metals Using Aqua Regia Digestion with ICP-MS Finish for 8 Blue Lake Hydro (332360) samples - November 2009

S. No.	Sample ID	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppb	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %	Na %	K %	W ppm	Hg ppm	Sc ppm	Tl ppm	Ga ppm	Se ppm
1	ARD COMP-1	4.0	33.5	4.2	104	<0.1	34.0	16.6	484	4.16	3.9	0.5	<0.5	1.8	38	0.2	0.2	0.2	137	0.62	0.077	4	86	1.55	471	0.218	<20	2.66	0.038	1.40	<0.1	<0.01	7.2	0.3	9	<0.5
2	ARD COMP-2	3.1	26.8	3.4	102	<0.1	28.9	15.0	467	4.05	11.1	0.5	0.8	1.8	51	0.1	0.1	0.1	121	0.57	0.078	4	83	1.50	242	0.189	<20	2.52	0.033	0.84	0.1	<0.01	6.2	0.2	9	<0.5
3	ARD COMP-3	3.5	54.7	1.6	93	<0.1	42.3	19.8	968	4.45	3.0	0.1	<0.5	0.4	27	<0.1	0.1	<0.1	99	1.09	0.074	2	110	1.94	489	0.227	<20	2.75	0.019	0.99	<0.1	<0.01	2.5	0.2	7	0.7
4	ARD COMP-4	4.1	39.8	4.5	85	<0.1	27.7	14.5	854	3.94	8.0	0.7	1.8	2.2	41	0.1	0.4	<0.1	121	2.26	0.117	4	84	1.61	112	0.137	<20	2.11	0.027	0.25	0.3	<0.01	5.8	0.1	8	0.8
5	ARD COMP-5	4.3	54.2	2.0	92	<0.1	59.9	19.9	903	4.47	4.0	0.1	0.8	0.5	20	<0.1	<0.1	0.1	97	0.73	0.097	2	109	2.22	423	0.202	<20	2.93	0.021	0.89	0.2	<0.01	1.5	0.1	8	<0.5
6	ARD COMP-6	2.3	73.1	1.2	112	<0.1	64.6	43.6	1221	6.32	19.5	<0.1	<0.5	0.1	46	<0.1	<0.1	<0.1	150	2.09	0.122	<1	151	1.54	620	0.266	<20	3.08	0.023	1.54	<0.1	<0.01	7.1	0.4	10	<0.5
7	ARD COMP-7	2.1	40.1	0.9	74	<0.1	21.6	15.1	761	3.89	0.8	<0.1	<0.5	0.3	27	<0.1	0.1	<0.1	87	1.03	0.066	2	58	1.51	263	0.166	<20	2.29	0.020	0.60	0.2	<0.01	1.3	0.1	7	<0.5
8	ARD COMP-8	3.2	69.4	3.9	103	0.1	29.3	15.2	656	4.23	2.1	0.1	<0.5	0.3	105	<0.1	<0.1	0.2	123	0.55	0.092	2	76	1.83	770	0.190	<20	2.65	0.029	1.62	0.2	<0.01	2.4	0.2	8	1.1
QAQC																																				
Reference Material (1)																																				
STD OREAS45PA		0.9	585.5	20.1	118	0.3	288.8	110.9	1151	16.04	3.6	1.1	41.1	6.5	14	<0.1	0.2	0.2	225	0.26	0.036	17	847	0.10	195	0.136	<20	3.32	0.003	0.08	<0.1	0.03	46.0	<0.1	17	0.9
True Value STD OREAS45PA		**0.9**	**600**	**19**	**119**	**0.3**	**281**	**104**	**1130**	**16.559**	**4.2**	**1.2**	**43**	**6**	**14**	**0.09**	**0.13**	**0.18**	**221**	**0.2411**	**0.034**	**16.2**	**873**	**0.095**	**187**	**0.124**		**3.34**	**0.011**	**0.0665**	**0.011**	**0.03**	**43**	**0.07**	**16.8**	**0.54**
Percent Difference		0.0	-2.4	5.8	-0.8	0.0	2.8	6.6	1.9	-3.1	-14.3	-8.3	-4.4	8.3	0.0	<0.1	53.8	11.1	1.8	7.8	5.9	4.9	-3.0	5.3	4.3	9.7		-0.6	-72.7	20.3	<0.1	0.0	7.0	<0.1	1.2	<0.5
Reference Material (2)																																				
STANDARD DS7		22.4	108.2	72.9	417	0.8	60.5	9.6	641	2.41	53.6	5.6	52.7	4.2	74	5.6	4.1	4.8	83	0.99	0.077	13	216	1.07	418	0.120	35	1.06	0.102	0.44	3.4	0.18	2.5	4.2	5	2.8
True Value STD DS7		**20.5**	**109**	**70.6**	**411**	**0.9**	**56.0**	**9.7**	**627**	**2.4**	**48.2**	**4.9**	**70.0**	**4.4**	**68.7**	**6.4**	**4.6**	**4.5**	**84.0**	**0.9**	**0.1**	**11.7**	**179**	**1.1**	**370**	**0.1**	**39**	**1.0**	**0.1**	**0.44**	**3.4**	**0.2**	**2.5**	**4.2**	**4.6**	**3.5**
Percent Difference		9.3	-0.7	3.3	1.5	-10.1	8.0	-1.0	2.2	0.8	11.2	14.3	-24.7	-4.5	7.7	-12.2	-10.9	6.4	-1.2	6.5	-3.8	11.1	20.7	1.9	12.9	-3.2	-10.3	10.5	14.6	0.0	0.0	-10.0	0.0	0.2	8.7	-20.0
Detection Limits		0.1	0.1	0.1	1	0.1	0.1	0.1	1	0.01	0.5	0.1	0.5	0.1	1	0.1	0.1	0.1	2	0.01	0.001	1	1	0.01	1	0.001	20	0.01	0.001	0.01	0.1	0.01	0.1	0.1	1	0.5
Method		1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX

Analysis Method:

Analysis done at Acme Labs.

A pulp sample split of 0.5g is leached in hot (95 ˚C) aqua regia. Refractory and graphitic samples can limit Au solubilityy.

CANTEST Ltd. 4606 Canada Way, Burnaby, BC Canada V5G 1K5 Tel: 604 734 7276 Fax: 604 731 2386 www.cantest.com

Sample Summary: Hatch Limited - Blue Lake Hydro (332360), 19-Oct-09

Date Samples Received: 19-Oct-09
Date Instructions Received: 16-Oct-09 from Satyan (Sam) Sisodraker by email + COC that arrived with the samples on 19-Oct-09.

Sample Prep: ABA Metals: Cone crushed, split & pulverized to >80% of <200 mesh.

Date of Analysis: ABA: 3-Nov-09; SO4-S: 6-Nov-09

Client: Hatch Limited
Name of Project: Blue Lake Hydro
Client Project No: 332360

Contact Person (s): Peter Friz

E-mail Addresses: pfriz@hatch.ca

Billing Address: **Attn: Peter Friz, Hatch Limited**
400 Oceanic Plaza, 1066 West Hastings, Vancouver BC V6E 3X2.

Contact No: 604-630-7354

Fax No: 604-689-3918

Sign:

Report Released by: Ivy Rajan
Position: Lab Manager, ARD Division, CANTEST Ltd.
Report Verified by: John Chiang
Position: Senior Analyst, ARD Division, CANTEST Ltd.
Report Validated by: Tim O'Hearn
Position: Director, ARD Division, CANTEST Ltd.

CANTEST Project No: 2-21-900

Contact No: 604-734-7276 x5029; Direct: 604-638-5029 (Ivy Rajan)
Contact No: 604-734-7276 x2219 (John Chiang)
Contact No: 604-734-7276 x5031; Direct: 604-638-5031 (Tim O'Hearn)

Sample List:

S. No.	Sample ID	Dry Sample Wt. (Kg)	Sample Type & Condition
1	ARD Comp-1	2.05	Dry Drill Core Rock
2	ARD Comp-2	2.01	Dry Drill Core Rock
3	ARD Comp-3	2.12	Dry Drill Core Rock
4	ARD Comp-4	1.99	Dry Drill Core Rock
5	ARD Comp-5	1.60	Dry Drill Core Rock
6	ARD Comp-6	3.14	Dry Drill Core Rock
7	ARD Comp-7	1.17	Dry Drill Core Rock
8	ARD Comp-8	1.00	Dry Drill Core Rock

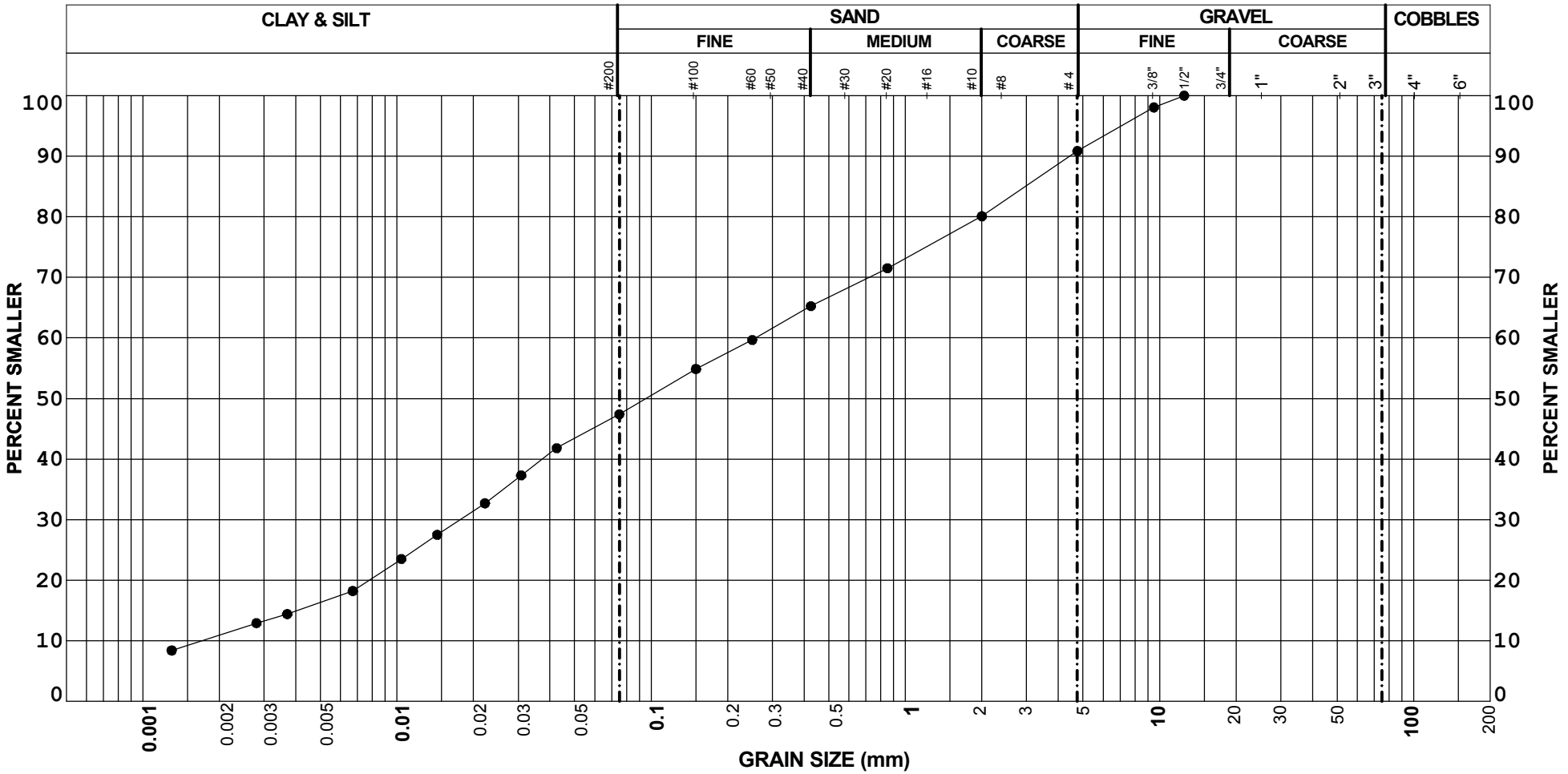
Total wt. of sample rec'd: 15.1 Kg
Wt. > 8 Kg: **7.1** Kg

Appendix H-5

Grain Size Plots

Working Together SAFELY
© Hatch 2006/03 ⌘

UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● DH090603		1.00	9	43	47		

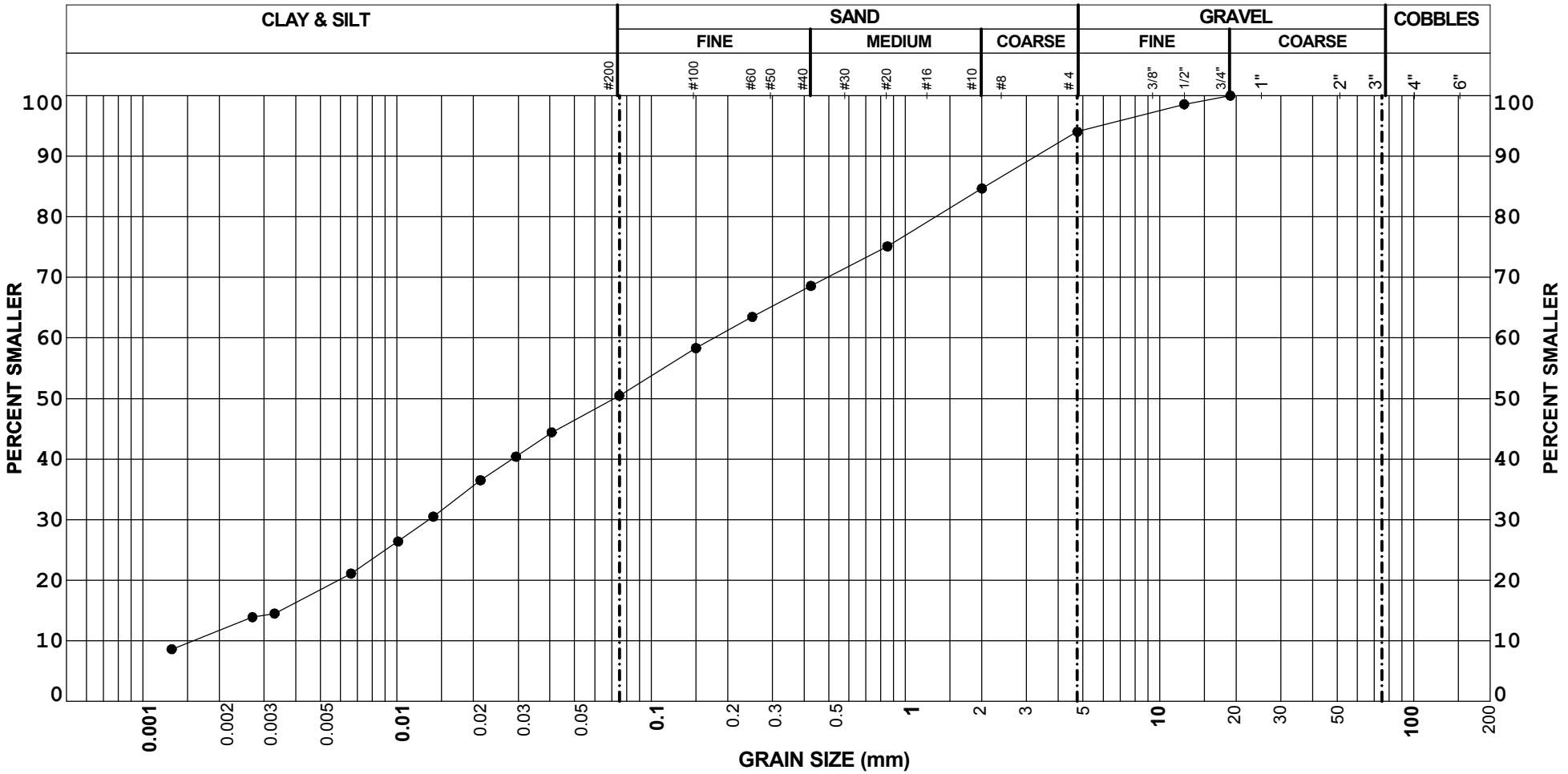
GRAIN SIZE DISTRIBUTION

Blue Lake

HATCH

Project H/332360

UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

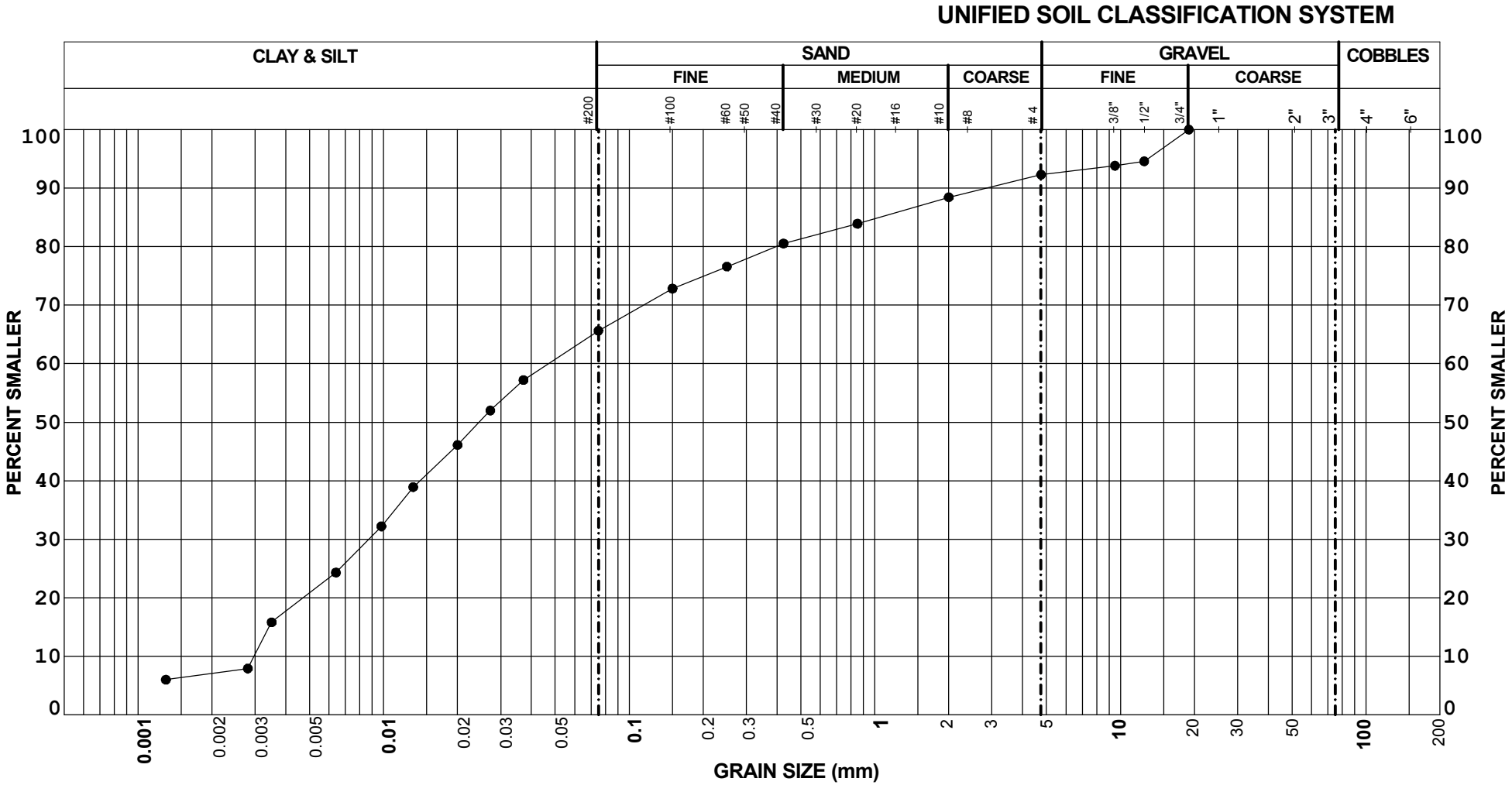
BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● DH090604		1.00	6	44	50		

GRAIN SIZE DISTRIBUTION

Blue Lake

HATCH

Project H/332360



REMARKS:

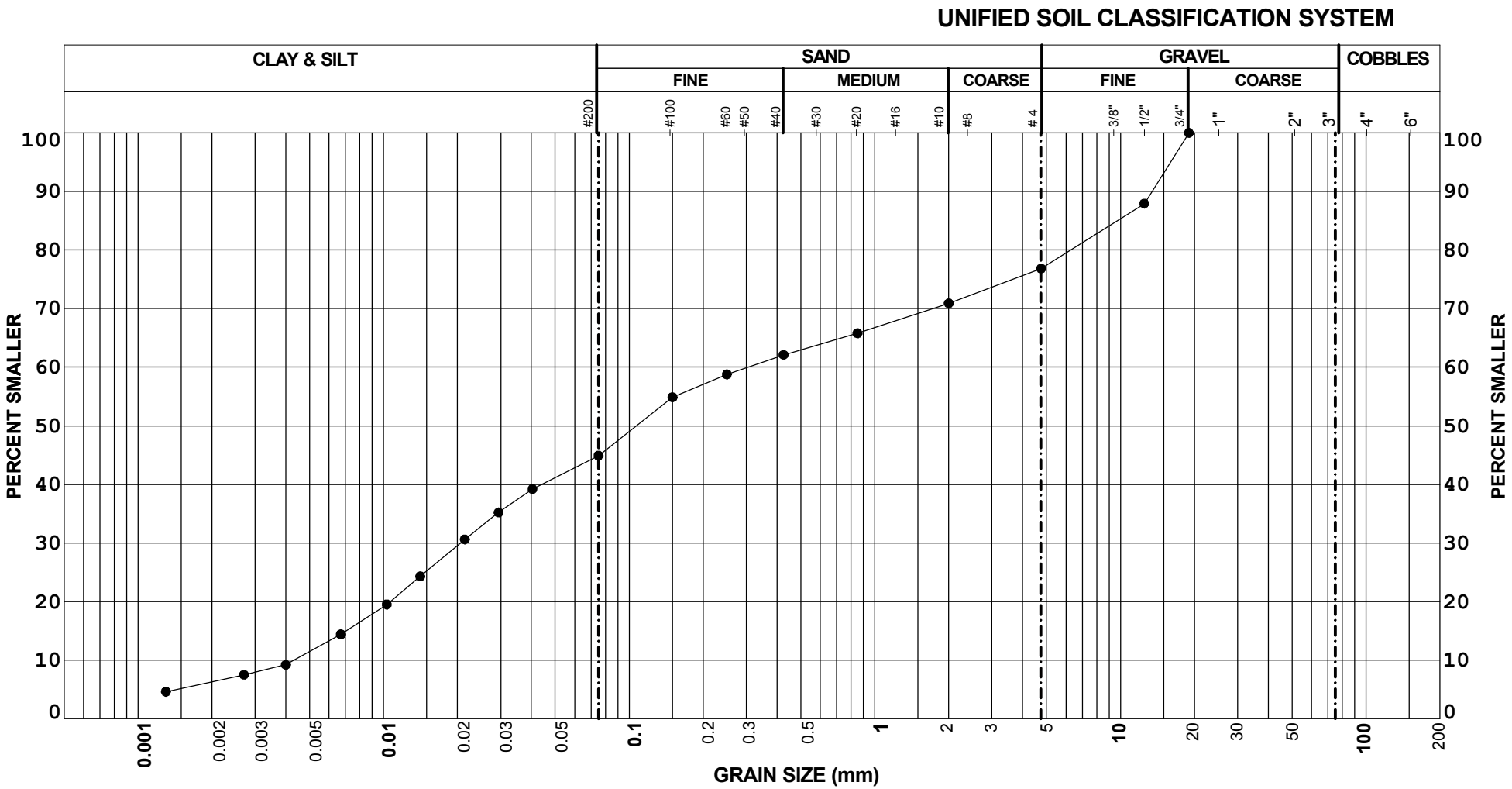
BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● DH090606		1.00	8	27	66		

GRAIN SIZE DISTRIBUTION

Blue Lake

HATCH

Project H/332360



REMARKS:

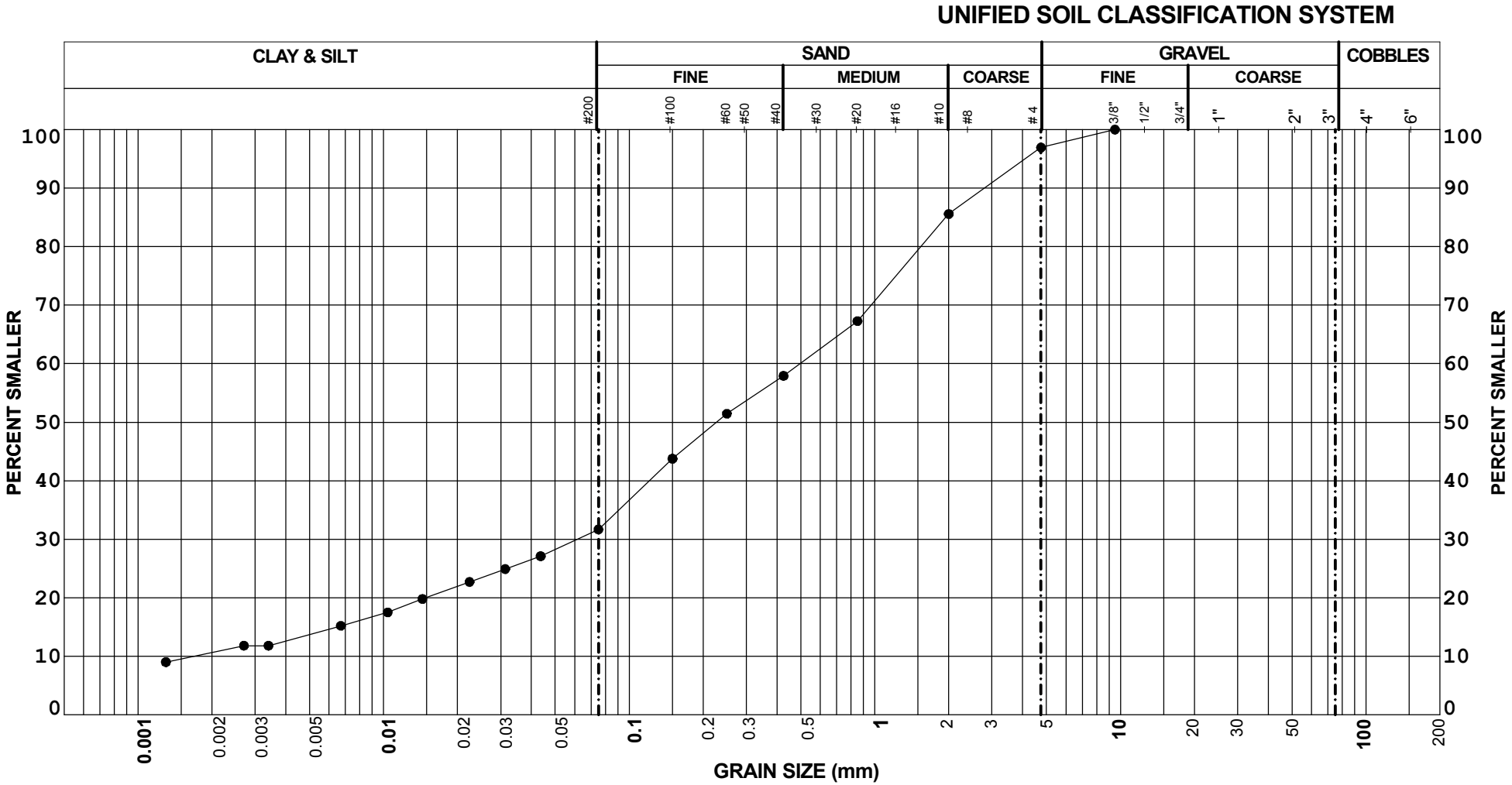
BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● DH090607		1.00	23	32	45		

GRAIN SIZE DISTRIBUTION

Blue Lake

HATCH

Project H/332360



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● DH090609		1.00	3	65	32		

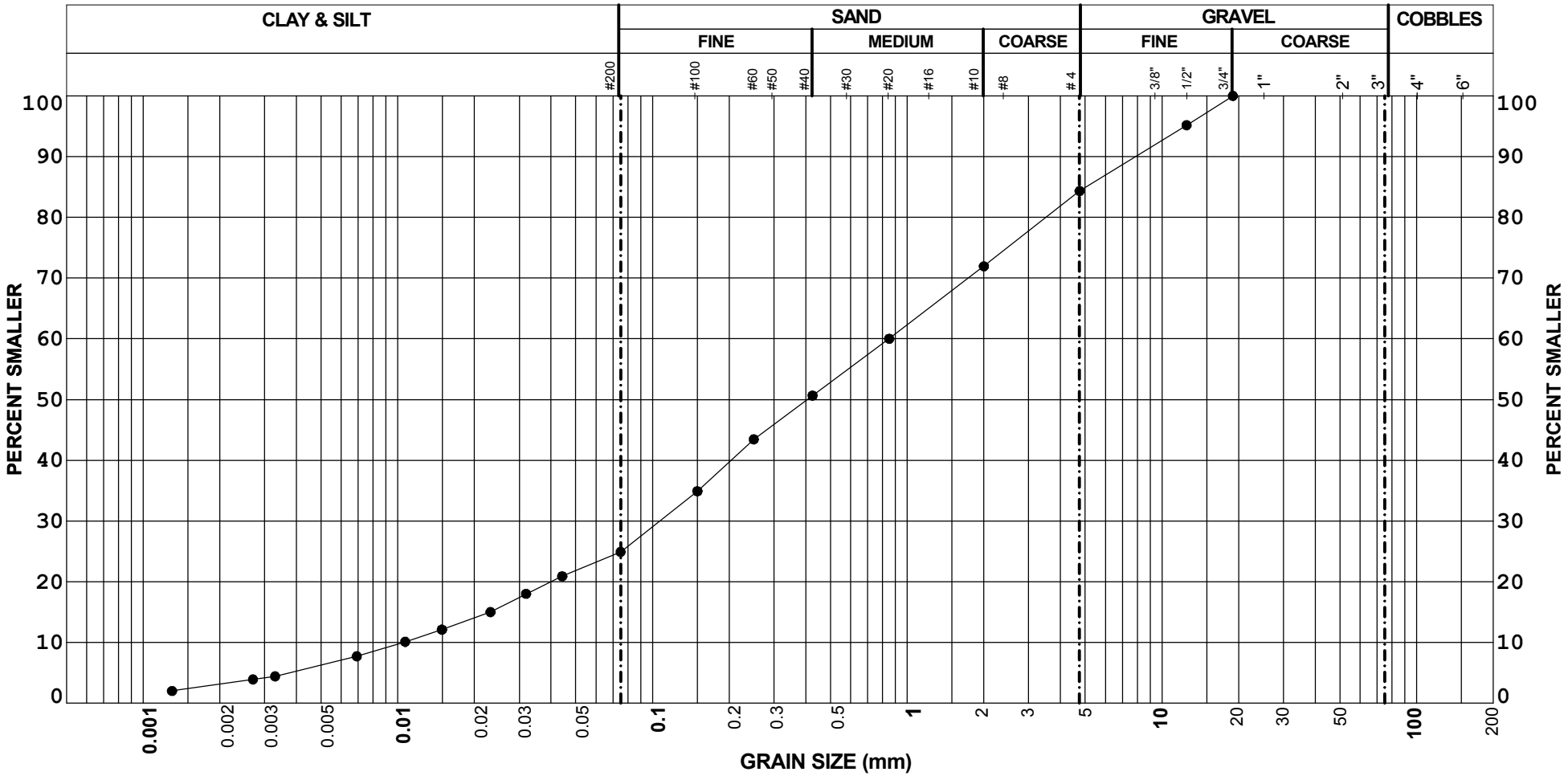
GRAIN SIZE DISTRIBUTION

Blue Lake

HATCH

Project H/332360

UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● TP3		1.00	16	59	25		

GRAIN SIZE DISTRIBUTION

Blue Lake

HATCH

Project H/332360

Piezometer Readings - DH09-08

Parameter	Symbol	Value	Unit
Linear calibration factor	C.F	0.00057	MPa/B unit
Initial pressure reading	Li	8494	B unit
Temperature correction factor	Tk	0.000284	MPa/Deg C rise
Initial Temperature reading	Ti	11	deg
Barometric pressure - initial reading	Bi	1001	kPa
Current pressure reading	Lc		
Current temperature reading	Tc		
Current barometric pressure reading	Bc		

P (MPa) = C.F*(Li-Lc) - Tk(Ti-Tc)+0.00010*(Bi-Bc)

Borehole Collar elevation	155.16
Depth of piezometer tip	20.5
Piezometer elevation	134.66

Date	Tc	Bc	Lc	Pressure (MPa)	Pressure (ft H20)	Calculated Plunge Pool Elevation (ft)	Remarks
9/10/2009 10:38	7.22	1005	8368.59	0.07	23.41	158.07	
9/11/2009 10:38	7.51	1015	8369.41	0.07	22.94	157.60	
9/12/2009 10:38	7.33	1008	8370.63	0.07	22.93	157.59	
9/13/2009 10:38	7.14	1008	8368.18	0.07	23.38	158.04	
9/14/2009 10:38	7.1	1011	8362.48	0.07	24.36	159.02	
9/15/2009 10:38	7.1	1008	8358.41	0.08	25.24	159.90	
9/16/2009 10:38	7.08	1003	8356.38	0.08	25.79	160.45	
9/17/2009 10:38	7.1	1004	8344.19	0.08	28.08	162.74	
9/18/2009 10:38	7.08	999	8336.89	0.09	29.64	164.30	
9/19/2009 10:38	7.07	1003	8331.62	0.09	30.51	165.17	
9/20/2009 10:38	7.07	1014	8324.34	0.09	31.52	166.18	
9/20/2009 11:54	7.13	1014	8324.34	0.09	31.53	166.19	
9/21/2009 11:54	7.06	999	8317.06	0.10	33.41	168.07	
9/22/2009 11:54	7.06	999	8305.37	0.11	35.64	170.30	
9/23/2009 11:54	7.06	1003	8301.34	0.11	36.28	170.94	
9/24/2009 11:54	7.08	1007	8291.68	0.11	37.98	172.64	Plunge pool filled to spill via low level outlet after reading taken
9/25/2009 11:54	7.03	992	8178.68	0.18	60.02	194.68	
9/26/2009 11:54	7.03	1006	8141.79	0.20	66.58	201.24	
9/27/2009 11:54	7.03	1019	8143.35	0.20	65.85	200.51	
9/28/2009 11:54	7.03	1006	8149.61	0.19	65.09	199.75	
9/29/2009 11:54	7.01	985	8153.53	0.19	65.04	199.70	
9/30/2009 11:54	7.03	988	8160.99	0.19	63.52	198.18	
10/1/2009 11:54	7.03	1013	8153.14	0.19	64.18	198.84	
10/2/2009 11:54	7.03	1019	8151.18	0.19	64.35	199.01	
10/3/2009 11:54	7.05	1026	8153.14	0.19	63.75	198.41	
10/4/2009 11:54	7.05	1019	8159.81	0.19	62.71	197.37	
10/5/2009 11:54	7.04	1023	8175.14	0.18	59.65	194.31	

Date	Tc	Bc	Lc	Pressure (MPa)	Pressure (ft H20)	Calculated Plunge Pool Elevation (ft)	Remarks
10/6/2009 11:54	7.04	1026	8143.35	0.20	65.61	200.27	
10/7/2009 11:54	7.03	1026	8145.31	0.20	65.24	199.90	
10/8/2009 10:07	7.09	1026	8148.44	0.19	64.65	199.31	
10/8/2009 10:16	7.11	1026	8148.44	0.19	64.65	199.31	
10/9/2009 10:16	7.03	1026	8152.75	0.19	63.82	198.48	
10/10/2009 10:16	7.05	1022	8159.02	0.19	62.76	197.42	
10/11/2009 10:16	7.06	1016	8173.96	0.18	60.12	194.78	
10/12/2009 10:16	7.07	1010	8184.98	0.17	58.22	192.88	
10/13/2009 10:16	7.06	1003	8189.32	0.17	57.62	192.28	
10/14/2009 10:16	7.06	999	8191.3	0.17	57.38	192.04	
10/15/2009 10:16	7.08	1003	8193.27	0.17	56.87	191.53	
10/16/2009 10:16	7.06	1002	8195.24	0.17	56.53	191.19	
10/17/2009 10:16	7.07	1010	8194.85	0.17	56.34	191.00	
10/18/2009 10:16	7.08	1013	8196.03	0.17	56.01	190.67	
10/19/2009 10:16	7.07	1016	8196.43	0.17	55.83	190.49	
10/20/2009 10:16	7.08	1006	8198.8	0.17	55.72	190.38	
10/21/2009 10:16	7.09	999	8203.55	0.16	55.05	189.71	
10/22/2009 10:16	7.09	999	8200.38	0.17	55.65	190.31	
10/23/2009 10:16	7.09	1003	8198.01	0.17	55.97	190.63	
10/24/2009 10:16	7.08	1007	8195.24	0.17	56.36	191.02	
10/25/2009 10:16	7.08	992	8198.01	0.17	56.34	191.00	
10/26/2009 10:16	7.08	1006	8152.75	0.19	64.49	199.15	
10/27/2009 10:16	7.08	1019	8150.4	0.19	64.51	199.17	
10/28/2009 10:16	7.08	1006	8153.53	0.19	64.35	199.01	
10/29/2009 10:16	7.09	985	8161.77	0.19	63.48	198.14	
10/30/2009 10:16	7.09	988	8166.48	0.19	62.48	197.14	

Piezometer Readings - DH09-13

Parameter	Symbol	Value	Unit
Linear calibration factor	C.F	0.00027653	MPa/B unit
Initial pressure reading	Li	8812.9	B unit
Temperature correction factor	Tk	0.000022	MPa/Deg C rise
Initial Temperature reading	Ti	9.67	deg
Barometric pressure - initial reading	Bi	1014	kPa
Current pressure reading	Lc		
Current temperature reading	Tc		
Current barometric pressure reading	Bc		

P (MPa) = C.F*(Li-Lc) - Tk(Ti-Tc)+0.00010*(Bi-Bc)

Borehole Collar elevation	317.3
Depth of piezometer tip	57.4
Piezometer elevation	259.9

Date	Tc	Bc	Lc	Pressure (MPa)	Pressure (ft H20)	Calculated water elevation
9/21/2009 9:08	5.77	999	8454.85	0.10	33.60	293.50
9/22/2009 9:08	5.56	999	8442.45	0.10	34.74	294.64
9/23/2009 9:08	5.33	1003	8454.44	0.10	33.50	293.40
9/24/2009 9:08	5.25	1007	8454.44	0.10	33.36	293.26
9/25/2009 9:08	5.21	992	8458.58	0.10	33.48	293.38
9/26/2009 9:08	5.18	1006	8404.17	0.11	38.05	297.95
9/27/2009 9:08	5.16	1019	8429.25	0.11	35.29	295.19
9/28/2009 9:08	5.15	1006	8454.85	0.10	33.36	293.26
9/29/2009 9:08	5.15	985	8460.24	0.10	33.56	293.46
9/30/2009 9:08	5.14	988	8461.89	0.10	33.31	293.21
10/1/2009 9:08	5.14	1013	8424.3	0.11	35.95	295.85
10/2/2009 9:08	5.14	1019	8436.26	0.10	34.64	294.54
10/3/2009 9:08	5.14	1026	8450.3	0.10	33.11	293.01
10/4/2009 9:08	5.14	1019	8455.27	0.10	32.89	292.79
10/5/2009 9:08	5.15	1023	8459.41	0.10	32.37	292.27
10/6/2009 9:08	5.15	1026	8426.77	0.11	35.29	295.19
10/7/2009 9:08	5.16	1026	8447.82	0.10	33.34	293.24
10/8/2009 9:08	5.16	1026	8455.27	0.10	32.65	292.55
10/9/2009 9:08	5.17	1026	8456.92	0.10	32.50	292.40
10/10/2009 9:08	5.17	1022	8458.99	0.10	32.44	292.34
10/11/2009 9:08	5.18	1016	8462.31	0.10	32.33	292.23

Date	Tc	Bc	Lc	Pressure (MPa)	Pressure (ft H20)	Calculated water elevation
10/12/2009 9:08	5.18	1010	8465.21	0.10	32.27	292.17
10/13/2009 9:08	5.19	1003	8468.11	0.10	32.23	292.13
10/14/2009 9:08	5.19	999	8472.26	0.10	31.98	291.88
10/15/2009 9:08	5.2	1003	8469.77	0.10	32.08	291.98
10/16/2009 9:08	5.2	1002	8473.51	0.09	31.77	291.67
10/17/2009 9:08	5.21	1010	8470.19	0.10	31.81	291.71
10/18/2009 9:08	5.21	1013	8470.6	0.09	31.67	291.57
10/19/2009 9:08	5.22	1016	8469.77	0.09	31.64	291.54
10/20/2009 9:08	5.22	1006	8471.02	0.10	31.86	291.76
10/21/2009 9:08	5.23	999	8477.25	0.09	31.52	291.42
10/22/2009 9:08	5.23	999	8472.68	0.10	31.94	291.84
10/23/2009 9:08	5.24	1003	8471.02	0.10	31.96	291.86
10/24/2009 9:08	5.24	1007	8454.44	0.10	33.36	293.26
10/25/2009 9:08	5.25	992	8466.87	0.10	32.72	292.62
10/26/2009 9:08	5.25	1006	8430.89	0.11	35.58	295.48
10/27/2009 9:08	5.26	1019	8439.56	0.10	34.34	294.24
10/28/2009 9:08	5.27	1006	8452.78	0.10	33.55	293.45
10/29/2009 9:08	5.27	985	8463.97	0.10	33.22	293.12
10/30/2009 9:08	5.28	988	8467.28	0.10	32.81	292.71