DES Waste Management Division
29 Hazen Drive; PO Box 95
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March 2021
DRAFT DOWNHOLE GEOPHYSICS AND PACKER SAMPLINGINTERVAL RECOMMENDATIONS: MW-25 COAKLEY LANDFILL SUPERFUND SITE
North Hampton and Greenland
New Hampshire

NHDES Site #: 198712001

Prepared For:
New Hampshire Department of Environmental Services
29 Hazen Drive
Concord, New Hampshire 03302-0095

Suzanne Yerina

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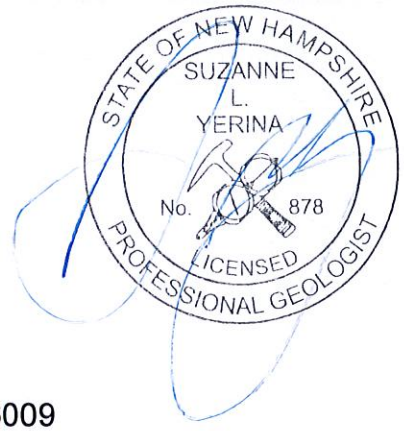

Prepared By:
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Date of Work Plan: (March 16, 2021)

HALEY WARD
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FORMERLY: CES INC

To: Peter Britz - Coakley Landfill Group

From: Christopher Buckman, PG – Haley Ward, Inc.

Re: DRAFT Downhole Geophysics and Packer Sampling Interval Recommendations: MW-25

Date: March 16, 2021

Data obtained through characterization of geochemical, hydrogeologic, and structural conditions in existing bedrock open boreholes installed during the Remedial Investigation (RI) for the Coakley Landfill Site are being used in conjunction with other Deep Bedrock Investigation activities (i.e., new deep bedrock well installation) to assess potential contaminant migration pathways in groundwater. These data are being used to continue to refine the Conceptual Site Model (CSM).

As part of work requested by the United States Environmental Protection Agency (USEPA) in support of the Deep Bedrock Investigation Work Plan Addendum (Work Plan Addendum) and Deep Bedrock Investigation Pumping Test Work Plan (Pumping Test Work Plan), the installation of the boring at MW-25, completion of borehole geophysics, and interval packer sampling was to be completed prior to the initiation of the pumping test. The Work Plan Addendum and Pumping Test Work Plan were conditionally approved by the USEPA on August 4, 2020 and December 15, 2020, respectively.

The installation of MW-25 was completed, in part, to better understand the interconnection of fractures within bedrock west/southwest of the landfill and to address a data gap associated with the southern migration pathway within deep bedrock. This data gap was identified, in part, by reported concentrations of per- and polyfluoroalkyl substances (PFAS) and 1,4-dioxane in shallow bedrock monitoring well GZ-105 located approximately 55 ft west of MW-25 (**Figure 1**). For example, results for recent samples collected from GZ-105 (Fall 2020) were 45 micrograms per liter (ug/L) and 424 nanograms

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per liter (ng/L) for 1,4-dioxane and PFOS/PFOA combined, respectively. Sample results from nearby bedrock monitoring wells FPC-3B, FPC-4B, and FPC-8B ranged from Non-

Detect (ND) to 0.41 ug/L for 1,4-dioxane and ND to 3.44 ng/L for PFOS/PFOA combined. These results may be due, in part, from differences in well construction. However, interconnection of fractures within bedrock and preferential pathways within overburden sediments in hydraulic connection with shallow bedrock may also be responsible for the reported variations in 1,4-dioxane and PFAS concentrations at these wells.

The location of MW-25 was selected based on the results of surface geophysical surveying completed in accordance with the Work Plan Addendum. The survey results were documented in the *Surface Geophysical Results and MW-25 Well Locating Memorandum* dated October 7, 2020. Concurrence of the final well location was performed with the USEPA and NHDES during an on-site meeting held on October 14, 2020. The completion of the boring at MW-25 was performed January 18 to January 22, 2021 with a subsequent remobilization to clear a blockage on February 17, 2021. The boring log for MW-25 was completed at the time of installation and is included as **Attachment 1**. Property access for MW-25 was established via a temporary access agreement with the New Hampshire Department of Transportation (NHDOT). The location of the well is shown on **Figure 1**.

Packer sampling efforts will supplement those completed in bedrock reconnaissance wells investigated previously and documented in the memorandum *Draft Deep Bedrock Reconnaissance Well Interval Packer Sampling Results: GZ-108, GZ-109, GZ-110, GZ-116, GZ-119, GZ-122, GZ-125, GZ-130, and MW-24* and *MW-6 Interval Packer Sampling Results and Pumping Test Viability Memorandum* submitted to the USEPA and New Hampshire Department of Environmental Services (NHDES) on September 10, 2019 and August 18, 2020, respectively.

The results of the borehole geophysical survey are evaluated below to provide recommended packer sampling intervals to examine possible variability in contaminants through the length of the open bedrock borehole.

WATER LEVEL MONITORING

During installation, water levels were monitored in nearby bedrock monitoring wells GZ-105, MW-2, MW-5S, MW-5D, MW-6, FPC-2B, FPC-3B, and FPC-8B (**Figure 1**) in accordance with the conditional approval of the *Pumping Test Work Plan*. This was performed to monitor the effects, if any, that the drilling of MW-25 may have on surrounding wells through interconnection of bedrock fractures. Pressure transducers were deployed prior to drilling and monitored from January 16, 2021 through January 22, 2021. The installation

of the well was initiated using 10-inch diameter sonic tooling to advance through the overburden and shallow bedrock to a depth of 40 feet below ground surface (bgs). Bedrock was encountered at a depth of 30 feet and a permanent 6-inch diameter steel casing was installed 10-ft into bedrock. Once the grout had cured (24-hours), air hammer/air rotary drilling methods were used to advance the well from 40 feet bgs to 283 feet bgs.

Table 1 and **Table 2** indicate the timeline of drilling and distances between the observation wells and MW-25, respectively. Hydrographs included as **Attachment 2** illustrate the response of water levels in the wells to drilling activities, with Plot 1 illustrating pressure readings collected through the entire period. Plot 2 illustrates readings during drilling with a focus on wells GZ-105, FPC-8B, and FPC-3B due to an observed greater response to drilling. Plot 3 illustrates water level readings recorded during drilling with a focus on wells MW-6, MW-5S, MW-5D, MW-2, and FPC-2B. The readings were corrected for barometric pressure using a barometric logger deployed at MW-6 and the offset from initial static water conditions of each well was calculated. Noted on the plots are times of relevant site observations, including the start time and stop time of drilling activities each day.

Table 1 | MW-25 Installation Timeline – January 18, 2021 through January 22, 2021.

Date/Time	Drilling Notes
1/18/2021 13:15	Begin Drilling, Sonic
1/18/2021 15:00	Stop Drilling
1/19/2021 8:15	Begin Drilling, Sonic
1/19/2021 13:10	Casing to 40 Ft finished grouting
1/19/2021 12:30 -15:30	Field personnel checks transducers
1/20/2021 8:20	Start Air Hammer at 40 ft bgs
1/20/2021 12:00	Pause Drilling at 173 ft bgs
1/20/2021 13:10	Resume Drilling
1/20/2021 16:15	Finish Drilling to 233 ft bgs
1/21/2021 7:45	Start Air Hammer at 233 ft bgs
1/21/2021 10:25	Drill to 253 ft bgs pull rods to change bit
1/22/2021 7:50	Start Air Hammer at 253 ft bgs
1/22/2021 10:45	Finish hole to 283 ft bgs, air hammer off

*Note times are approximate.

The observation wells exhibited a variety of responses to the drilling activities and environmental conditions. As expected, the largest response was observed in the closest well, GZ-105, located 55-ft to the west, while wells located further away exhibited smaller or delayed responses to drilling.

Table 2 | Monitoring Well Distance from MW-25.

Monitoring Well	Distance/Direction
GZ-105	55 ft W
FPC-8B	380 ft NE
MW-2	800 ft E
FPC-3B	850 ft S
MW-6	900 ft E
MW-5S	925 ft E
MW-5D	930 ft E
FPC-2B	1,000 ft SE

GZ-105

- GZ-105 is a 1.5-inch diameter shallow bedrock well (15-ft screen within uppermost 18-ft of bedrock) located approximately 55-ft to the west of MW-25.
- GZ-105 was only well to show a response during overburden and shallow bedrock drilling with the largest response to drilling of wells monitored.
  - Several examples of an increase in water level (up to one foot) and gradual return to static.
- During deep bedrock drilling, an initial rise in water level was observed (up to approximately three feet above static) followed by a drop in water level and gradual return to static after drilling activities ceased.
  - Initial application of air pressure following addition of drill rods likely created a localized rise in the water table; however, as water is discharged during drilling, the water level decreased within GZ-105.
  - A maximum drawdown of almost 7-ft from the static water level was observed on January 20, 2021.
  - Water levels are sensitive to the startup and shutdown of the air compressor and or changing of rods as indicated in the variability observed during drilling activities.
- Recovery following the end of air hammer drilling on January 18, 2021 and January 21, 2021, illustrated a smooth recovery to level slightly greater than observed at the onset of drilling.

FPC-8B

- FPC-8B is a 2-inch diameter shallow bedrock well (15-ft screen within uppermost 22-ft of bedrock) and is the second closest well to MW-25 (850-ft northeast) having an illustrated response to bedrock drilling.

- This well exhibited a relatively gradual decrease in water level during drilling (dewatering of MW-25) followed by a gradual recovery after the cessation of bedrock drilling.
    - Drawdown on January 20, January 21, and January 22, 2021 was observed to be roughly 1-ft, 0.7-ft, and 1.1-ft, respectively.
    - Drawdown on January 20, 2021 occurred gradually with the first response observed approximately one hour following the onset of bedrock drilling (80 to 90-ft bgs).
    - Recovery on January 20, 2021 had a similar delay in response before recovery occurred (approximately one hour following end of bedrock drilling).
    - The response on January 21 and January 22, 2021, when drilling was advanced deeper into bedrock, illustrated a more immediate response to the onset of drilling. This included a response to the completion of drilling with a faster recovery observed on January 21, 2021.

FPC-3B

- FPC-3B is a 2-inch diameter shallow bedrock well (15-ft screen within uppermost 25-ft of bedrock) located 850-ft to the south of MW-25 and illustrated a response to bedrock drilling.
- An offset of roughly 0.5-ft was observed around 3:30 PM on January 19, 2021, when field personnel conducted an inspection of the transducer resulting in its redeployment at a slightly different elevation than the initial deployment on January 16, 2021.
- FPC-3B exhibited a response to water level during drilling (dewatering of MW-25) followed by a relatively gradual recovery following the cessation of drilling.
    - The drawdown on January 20, 2021 was not observed at the initial start of drilling; however, a response was observed roughly one hour after the start of drilling. Drilling was advanced to roughly 80 to 90-ft below grade by this time.
    - This well was more responsive to the start and/or ending of daily drilling activities than was observed in FPC-8B.

MW-2

- MW-2 is a 1.25-inch diameter shallow bedrock well (10-ft screen within uppermost 16-ft of bedrock) located 800-ft east of MW-25 and adjacent to the southern margin of the landfill. No response to overburden or bedrock drilling operations was observed.

- As illustrated on Plot 1 (**Attachment 2**), the water level rose immediately following deployment on January 16, 2021, and gradually subsided over several days following.
    - Barometric pressure measured at this time (MW-6) indicated a drop in atmospheric pressure from 14.7 pounds per square inch (psi) to 14.3 psi, corresponding to this rise in water level. The return to 14.7 psi over the following four days corresponded to the gradual return of the water level to static conditions.

MW-6

- MW-6 is a 6-inch diameter open borehole deep bedrock well (178-ft into bedrock) located 900-ft east of MW-25 (**Figure 1**) and approximately 400-ft from the southern boundary of the Coakley Landfill and MW-5S/-5D.
- MW-6 exhibits slightly variable water levels that rise and fall in roughly six-hour increments. This is likely a response to tidal influence and is consistent with water levels observed in MW-6 from September 22, 2020 to December 8, 2020.
- This well exhibited subdued fluctuations in water level corresponding to the start/end of drilling on January 21, 2021 (233-ft to 253-ft bgs) and January 22, 2021 (253-ft to 283-ft bgs) of up to 0.1-ft, while exhibiting no noticeable fluctuation in water level during drilling operations completed at shallower bedrock intervals.
- An offset of roughly 0.1-ft was observed around 12:30 PM on January 19, 2021 when field personnel conducted an inspection on the transducer that resulted in its replacement at a slightly different elevation than the initial deployment on January 16, 2021.

MW-5S

- MW-5S is a 2-inch diameter shallow bedrock well (30-ft screen within uppermost 66 ft of bedrock) located 925-ft east of MW-25, immediately adjacent to the southern perimeter of the landfill.
- MW-5S exhibits slightly variable water levels that rise and fall in roughly six-hour increments, likely a subdued response to tidal influence. This coincides with water levels monitored from June 30, 2020 to September 22, 2020 during the evaluation of MW-6.
- Influence from drilling was observed during daily drilling activities from January 21 through January 23, 2021, when the water level lowers with onset of bedrock drilling activities and water level recovery when drilling operations cease.
- An offset of roughly 0.1-ft was observed around 2:30 PM on January 19, 2021 when field personnel completed an inspection of the transducer resulting in its redeployment at a different elevation than that of the initial deployment on January 16, 2021.

MW-5D

- MW-5D is a 2-inch diameter deep bedrock well (20-ft screen within uppermost 151.5 ft of bedrock) located 930-ft east of MW-25 and adjacent to the southern margin of the landfill.
- MW-5D exhibits slightly variable water levels that rise and fall in roughly six-hour increments, likely a subdued response to tidal influence. This coincides with water levels monitored from June 30, 2020 to September 22, 2020 during the evaluation of MW-6.
- Influence from drilling was observed on January 21, January 22, and January 23, 2021, when the water level lowers with onset of bedrock drilling activities and water level recovery when drilling operations cease.

FPC-2B

- FPC-2B is a 2-inch diameter shallow bedrock well (15-ft screen within uppermost 22 ft of bedrock) located approximately 1,000-ft southeast of MW-25, and 1,100 ft south of the Coakley Landfill.
- Influence from drilling was observed on January 22, 2021, where a lowering of the water level was observed. This response was associated with the lowermost 30-ft of bedrock drilling.
- An offset of roughly 0.1-ft was observed around 3:15 PM on January 19, 2021, when field personnel conducted an inspection on the transducer that resulted in its replacement at a slightly different elevation than the initial deployment on January 16, 2021.

DOWNHOLE GEOPHYSICS

Haley Ward retained Northeast Geophysical Services, Inc. (NGS) to complete downhole geophysical logging of the well. NGS performed borehole geophysics during a single mobilization to the Site on February 23, 2021. The following geophysical logging suites were completed:

- Borehole Caliper
- Fluid Temperature
- Fluid Conductivity
- Heat Pulse Flowmeter (static and pumping)
- Acoustic Televiewer
- Optical Televiewer

The pumping rates recorded during heat pulse flowmeter testing were estimated using a graduated five-gallon bucket and stopwatch and are considered representative of an *average* rate. It should be noted that pumping rates may have fluctuated due to variations in pump efficiency (resulting from changes in drawdown) and battery voltage.

Based on data generated from the downhole logging efforts (**Attachment 3**) and information available for MW-25, a brief summary of conditions at the well is provided below. Recommended intervals for sampling are highlighted on **Table 3**.

MW-25

MW-25 is a 5-inch diameter deep bedrock monitoring well located within the GMZ, approximately 800-ft south of the landfill boundary and 50-ft east of GZ-105 (**Figure 1**). The boring was advanced to a total depth of 283-ft from January 18, 2021 to January 22, 2021, with bedrock encountered at approximately 30-ft below ground surface (bgs) and steel casing installed to a depth of 43-ft bgs. It should be noted that the boring log references the depth bgs while the borehole geophysical results reference depths below top of steel casing (3.25 ft above ground surface). Well yield was estimated at over 100 gallons per minute (gpm) following completion using an air lifted estimate. These estimated yields should be considered with caution as they represent "air lift" rates completed by the driller and do not represent sustained yields. Based on a review of provided borehole geophysical data, the following results were obtained:

1) Ten features are interpreted to be either a "likely transmissive zone" (Feature Nos. 1-2, 26-27, 96-98, 111-112, 133, and 140) or "possible transmissive zone" (Feature Nos. 4-5, 8-9, 87, and 123-125), meaning that flow meter testing suggested some flow entering or exiting the borehole from fractures identified by the downhole logging (**Attachment 3**).
2) With the exception of no measurable flow (NF) at the bottom of the borehole (280-ft), heat pulse flowmeter data indicate upward ambient (natural) flow within the boring at all intervals investigated ranging from 0.02 to 0.59 gpm. Heat pulse flowmeter data under pumping conditions (1.5 gpm pumping rate) was upward at rates between 0.02 and 0.81 gpm.
3) Fractures are well distributed within the borehole with some related to changes in lithology, intersecting fractures, and/or bedrock competency.
4) Fluid conductivity within this well averaged 620 microSiemens per centimeter (uS/cm), greater than the average fluid conductivity observed within most deep bedrock wells surveyed as part of the deep bedrock investigation (240 uS/cm). A sharp decrease in measured conductivity from 217-ft to total depth (283-ft) is indicative of water movement at this interval.
5) Based on optical televiewer data, the rock type appears highly foliated and is visually consistent with rock types observed in deep bedrock wells located south

(GZ-125), northwest (MW-22), and east (MW-6) of MW-25. Televiewer data for these wells was provided in the *Deep Bedrock Investigation Interim Report* dated November 25, 2019.

6) Structural information (strike/dip) obtained from interpreted optical and acoustic televiewer data show a predominant NNE-SSW orientation of fractures and westerly high-angle (50-80 degrees) dip direction, generally consistent with deep bedrock wells MW-6, GZ-125, and GZ-130.

SAMPLING INTERVAL RECOMMENDATIONS

A primary reason for completing downhole geophysical logging was to identify hydraulically active fractures or fracture zones for interval packer sampling (i.e., an upper and lower packer separated with perforated pipe or screen) and to isolate transmissive zones so that groundwater samples can be collected for analytical testing.

Interval packer sampling will consist of isolating specific sections of the bedrock boreholes with an inflatable packer assembly to facilitate collection of water-quality samples. Additionally, aquifer characteristics (Transmissivity) will be calculated by recording water levels within the isolated interval prior to, during the sampling/pumping, and post sampling during water level recovery in the interval being sampled. Intervals exhibiting insufficient recharge, as discussed in standard operating procedure (SOP) *SOP-14 Straddle Packer Testing,* will be noted on field forms and will not be sampled.

Packer sampling interval recommendations for MW-25 are provided in **Table 3** and are based on geophysical logging data as supplied by NGS and included as **Attachment 3**. Borehole geophysical logs include interpreted structural information (e.g., strike/dip), fracture aperture size, and plots illustrating a summary of interpreted fracture information within the boring. Because fractures in some intervals are in close proximity, it is likely that some interconnection exists, and these will be considered a composite fracture "zone". As such, the sampling of individual fractures within these "zones" is not practical. Individual fractures or zones will be isolated and sampled using a straddle packer system with either a 6-ft or 14-ft separation between inflatable packers or a single packer depending on the length of interpreted fracture interval. Sampling of seven intervals is recommended in **Table 3**.

PACKER SAMPLING PROCEDURE

Interval packer sampling will be performed in accordance with the project Sampling and Analysis Plan (SAP) and adhere to *SOP-14*. NGS will provide inflatable packer equipment for interval sampling of groundwater from the selected test zones. Following the inflation of packers, a minimum of three packer interval volumes will be removed subsequent to

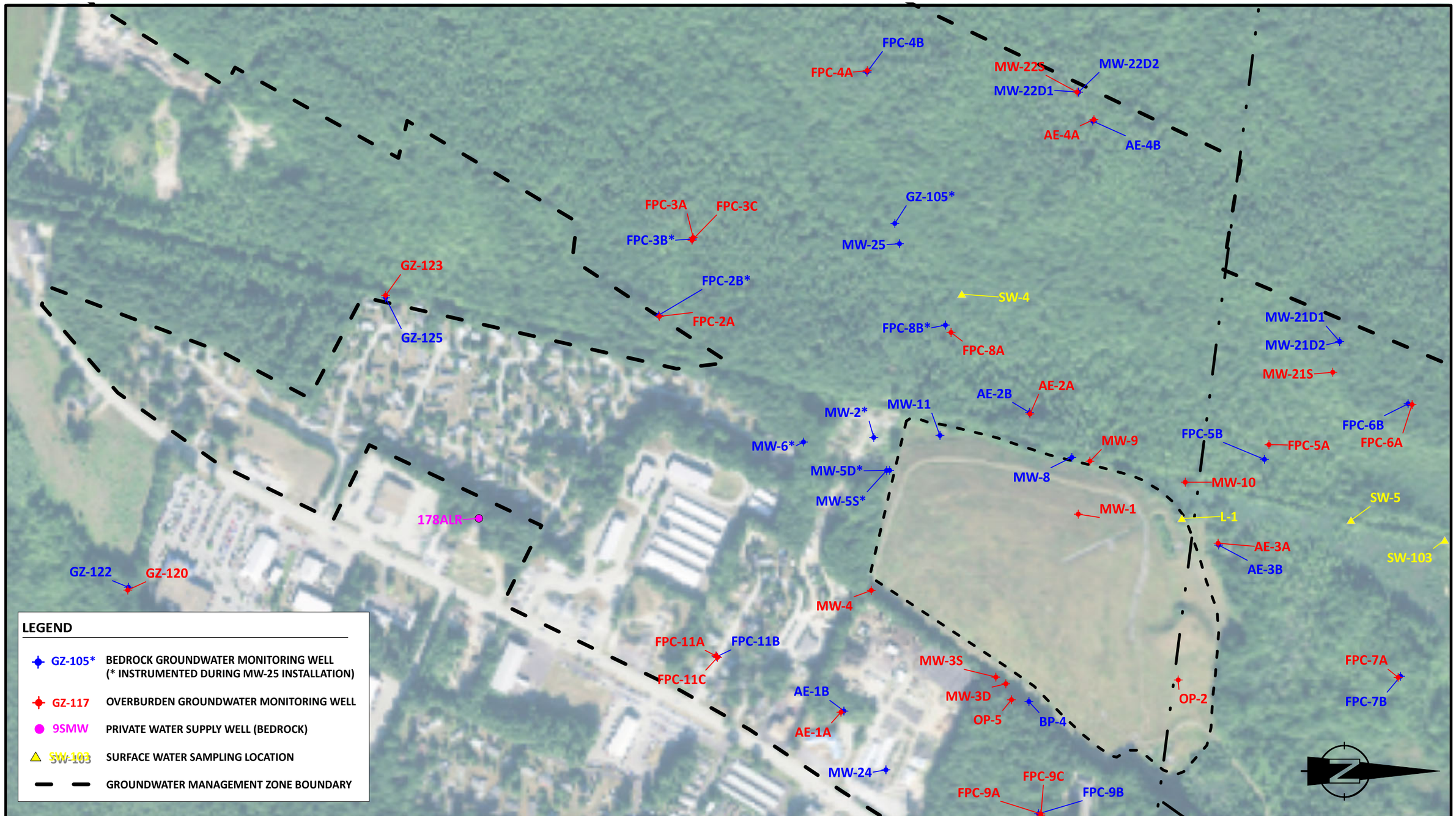
the purging of the water volume located above the packer string. Water levels will be recorded inside the packer string and within the well annulus prior to any pumping and will be monitored during the sampling process. Water levels will also be monitored for a period of time following cessation of pumping (i.e., recovery period) and the information generated will be used in the estimation of bedrock aquifer hydraulic characteristics. Water quality parameters will be recorded during the sampling and well recharge rates determined after pumping has been completed to estimate hydraulic conductivity and transmissivity of the formation intervals.

Groundwater samples will be collected directly from the pump discharge into pre-preserved, laboratory-supplied containers, and chilled to approximately 4°C for delivery to the analytical laboratory. Collected samples will be submitted to Alpha Analytical Laboratories (Alpha) of Westborough, Massachusetts for analysis of PFAS (26 compound list), 1,4-dioxane, arsenic, manganese, and general landfill parameters (ammonia, chemical oxygen demand, chloride, hardness, and nitrate). Alpha has been selected to complete the laboratory analysis due to their ability to perform all analyses at a single location.

TABLE 1
DRAFT Summary of MW-25 Interval Packer Sampling Recommendations
Coakley Landfill Superfund Site - North Hampton and Greenland, New Hampshire

MW-25				
Packer Interval	**Depth (bgs)**	**Feature No.**	**Packer Length**	**Comments/Rationale**
Zone 1	60 ft	1-10	Single Packer	Location of "likely" and "possible" transmissive zones. Location of large open fractures. Packer length and placement designed to evaluate seal of open hole immediately below casing and characterize hydraulic interconnection with overburden.
Zone 2	68.5-82.5 ft	20-30	14 ft	Location of a likely transmissive zone and represents an area of enlarged fractures based on caliper and televiewer (optical and acoustic) logs. Observed changes in resistivity, fluid conductivity, and natural gamma logs.
Zone 3	157-163 ft	93-101	6 ft	Location of likely transmissive zone (Feature Nos. 96-98). Changes in recorded fluid temperature begin at this interval indicating water movement at this interval with changes/inflection in fluid conductivity, natural gamma, and electrical resistivity logs.
Zone 4	168.5-182.5 ft	103-114	14 ft	Location of likely transmissive zone with enlarged fractures from caliper and televiewer data. Water flow under ambient conditions changes from 0.24 gpm to 0.48 gpm under ambient conditions and from 0.28 gpm to 0.59 gpm under pumping conditions. Observed changes in resistivity, fluid temperature, fluid conductivity, and natural gamma instrument response. Potential change in lithology from 170-178 ft.
Zone 5	198-204 ft	121-126	6 ft	Location of possible transmissive zone with several open fractures from 201 to 202 ft.
Zone 6	214-220 ft	132-135	6 ft	Location of likely transmissive fracture with sharp inflection in fluid conductivity. Increase in ambient flow from 0.05 gpm to 0.26 gpm and from 0.13 gpm to 0.26 gpm under pumping conditions. Gradual increase in fluid temperature (0.3 deg Celcius) from this interval to bottom of borehole.
Zone 7	265 ft	153-169	Single Packer	Evaluate the overall contribution and general water quality of fractures located below those with measurable ambient groundwater flow within the well. This interval includes transition from no measurable flow to measurable flow from 275 ft to 280 ft below top of casing.

Note:
Selected intervals were based on borehole geophysical data provided by Northeast Geophysical Services, Inc. and from observations made during installation.



PROJECT TITLE: COAKLEY LANDFILL SUPERFUND SITE NORTH HAMPTON & GREENLAND, NEW HAMPSHIRE	DWG:	BY: CFB	REV:	NOTE: APPROXIMATE SCALE 1:4,200 0 FT 350 FT 700 FT	HALEY WARD
SHEET TITLE: MW-25 INSTALLATION SITE PLAN	JN: 10424.016	DATE: 2021-03-11	REV DATE:		
	SCALE: AS SHOWN	APPROVED BY: CFB	ISSUE:		
		CHECKED BY:	ISSUE DATE:		

ATTACHMENT 1
BORING LOG: MW-25

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BORING LOG

Project: Coakley Landfill Deep Bedrock Program	**Project No:** 10424.016	**Date:** 1/18/21 – 1/22/21
Boring: MW-25		
Driller: Glacier Drilling, Inc. **Operator:** Mark Schock	**CES Personnel:** RJO	**Notes:** Total depth = 283 ft. BGS

Date	Run #	Depth below ground surface (ft. BGS)	Lithology Description	Notes/Comments	Drill Rate (min/ft.)	Gallons Per Minute (GPM)
1/18/21	NA	0-1	PT – Organic wetland soils.		NA	NA
1/18/21	NA	1-24.5	CH – Grey clay, very hard 1-14 ft and becomes softer between 14-20 ft with increased water content, high plasticity. Light brown staining on some surfaces		NA	NA
1/18/21	NA	24.5-30.5	Till – Clayey Sand and Gravel, light gray clay matrix with well sorted fine to coarse sands, angular to subangular pebble to cobble sized clasts, composed of dark grey, fine grained, foliated metasediment (MS). Saturated		NA	NA
1/18/21	NA	30.5-40	Rock chips and pulverized weathered bedrock. Rock chips are Dark grey, fine grained, MS rock interbedded with thinly foliated quartzite, with minor pyrite on fracture surfaces.		NA	NA
1/18/21	NA	35-40	6-to-12-inch sections of core with angular rock chips. Dark grey, fine grained, MS interbedded with thinly foliated quartzite, with minor pyrite on fracture surfaces. Rock cores show deformation as s folds with thicker quartzite thickness on fold hinges	Driller reports more difficult to advance through 35-40 feet indicating competent bedrock, set 6-inch casing from 30-40 feet BGS	NA	NA
1/20/21	1 and 2	40-45	Dark grey, fine grained MS, trace pyrite	Begin Air hammer at 40 feet, 1st run used 5 feet of rod advanced to 43 feet below grade	0.6	N/A
1/20/21	2	45-50	Dark Grey, fine grained MS, with trace pyrite and quartz	Rock chips up to a half inch in diameter, second run 43-53 feet	0.6	N/A

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BORING LOG

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Boring: MW-25		
Driller: Glacier Drilling, Inc. **Operator:** Mark Schock	**CES Personnel:** RJO	**Notes:** Total depth = 283 ft. BGS

Date	Run #	Depth below ground surface (ft. BGS)	Lithology Description	Notes/Comments	Drill Rate (min/ft.)	Gallons Per Minute (GPM)
1/20/21	2 and 3	50-55	Dark Grey, fine grained MS and thinly foliated and deformed quartzite, foliation < 1 mm thick	Fracture at 51 ft, producing large volume of water, discharge estimate is approx. value, chips are up to 2-inch diameter	0.6	Approx. 50
1/20/21	3	55-60	Dark Grey, fine grained MS, minor pyrite, trace quartz	Chips are elongate and up to 0.5 inch in width	0.6	50
1/20/21	3 and 4	60-65	Dark Grey fine-grained MS, trace pyrite			50
1/20/21	4	65-70	Same as above	Chip diameter 1-2 mm, up to 3-4 mm	0.86	50
1/20/21	4 and 5	70-75	Same as above			50
1/20/21	5	75-80	Slightly lighter grey metasediment, trace pyrite	Driller reports a change in rate from 76-80	1	50
1/20/21	5 and 6	80-85	Dark grey, fine grained MS, minor light grey, minor quartz, trace talc			50
1/20/21	6	85-90	Dark grey, fine grained MS, minor talc, trace quartz, trace pyrite		1	50
1/20/21	6 and 7	90-95	Same as above			50
1/20/21	7	95-100	Same as above		1.15	50
1/20/21	7 and 8	100-105	Same as above			50
1/20/21	8	105-110	Same as above		1.35	50
1/20/21	8 and 9	110-115	Same as above			50
1/20/21	9	115-120	Half dark MS/Half light grey, fine grained quartzite. Larger chips indicate thin foliated interbedded layers.	See more quartzite at 115 and discharge from cyclone lightens in color	1.6	50
1/20/21	9 and 10	120-125	Dark grey fine-grained MS, minor quartzite, trace quartz			50
1/20/21	10	125-130	Same as above		1.55	50
1/20/21	10 and 11	130-135	Same as above			50
1/20/21	11	135-140	Same as above		1.55	50
1/20/21	11 and 12	140-145	Dark Grey MS, trace quartz, trace pyrite			50
1/20/21	12	145-150	Same as above		1.1	50

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Project: Coakley Landfill Deep Bedrock Program	**Project No:** 10424.016	**Date:** 1/18/21 – 1/22/21	**Boring:** MW-25
Driller: Glacier Drilling, Inc. **Operator:** Mark Schock	**CES Personnel:** RJO	**Notes:** Total depth = 283 ft. BGS	

Date	Run #	Depth below ground surface (ft. BGS)	Lithology Description	Notes/Comments	Drill Rate (min/ft.)	Gallons Per Minute (GPM)
1/20/21	13	155-160	Half black fine-grained MS, half medium grained mica schist, trace quartz, trace clay, trace talc	Driller reports fracture around 160 feet due to hammer drop	1.3	Approx. 60
1/20/21	13 and 14	160-165	Same as above			60
1/20/21	14	165-170	Same as above			60
1/20/21	14 and 15	170-175	Light grey, medium grained, Mica schist, trace black fine-grained MS, trace quartz			60
1/20/21	15	175-180	Same as above	Reduction of hose length to cyclone associated with increase in water discharge	1.5	Approx. 80
1/20/21	15 and 16	180-185	Same as above			
1/20/21	16	185-190	Same as above		2	
1/20/21	16 and 17	190-195	Same as above			
1/20/21	17	195-200	Half light grey and half dark grey medium grained mica schist, trace quartz		2	80
1/20/21	17 and 18	200-205	Same as above			80
1/20/21	18	205-210	Same as above		3.15	80
1/20/21	18 and 19	210-215	Same as above			80
1/20/21	19	215-220	Light to dark grey, medium grained mica schist, minor quartz, trace pyrite		3.15	80
1/20/21	19 and 20	220-225	Same as above			80
1/20/21	20	225-230	Same as above		3.2	80
1/21/21	20 and 21	230-235	Same as above			80
1/21/21	21	235-240	Same as above		3.3	80
1/21/21	21 and 22	240-245	Same as above			80
1/21/21	22	245-250	Same as above		3.5	80
1/21/21 to 1/22/21	22 and 23	250-255	Same as above but with slightly higher proportion of quartz	5-inch Drill bit swapped out at 253, with a 4-7/8-inch bit. Additional 400 cfm/200 psi added to ensure cuttings are flushed, discharged.		120
1/22/21	23	255-260	Same as above		3.5	120

HALEY WARD ENGINEERING | ENVIRONMENTAL | SURVEYING	BORING LOG	Page 4 of 4

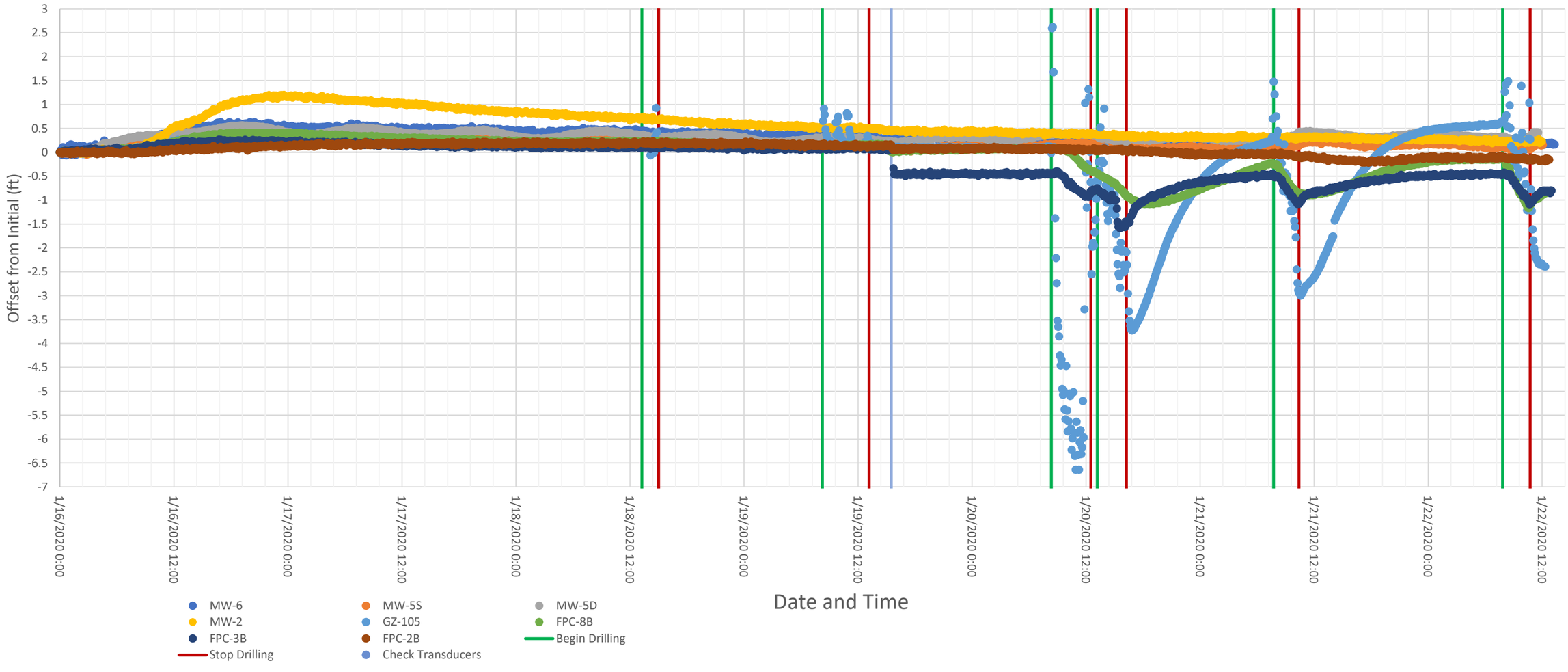
Project: Coakley Landfill Deep Bedrock Program	**Project No:** 10424.016	**Date:** 1/18/21 – 1/22/21	**Boring:** MW-25
Driller: Glacier Drilling, Inc. **Operator:** Mark Schock	**CES Personnel:** RJO	**Notes:** Total depth = 283 ft. BGS	

Date	Run #	Depth below ground surface (ft. BGS)	Lithology Description	Notes/Comments	Drill Rate (min/ft.)	Gallons Per Minute (GPM)
1/22/21	23 and 24	260-265	Same as above except trace quartz			120
1/22/21	24	265-270	75% medium grained mica schist with trace quartz and 25% thinly foliated fine grained, light grey	Driller notes softer material around 267 feet	3.1	120
1/22/21	24 and 25	270-275	75% MC and 25% mica schist			120
1/22/21	25	275-283	95% light grey fine-grained metacarbonate	283 is end of borehole	3	120

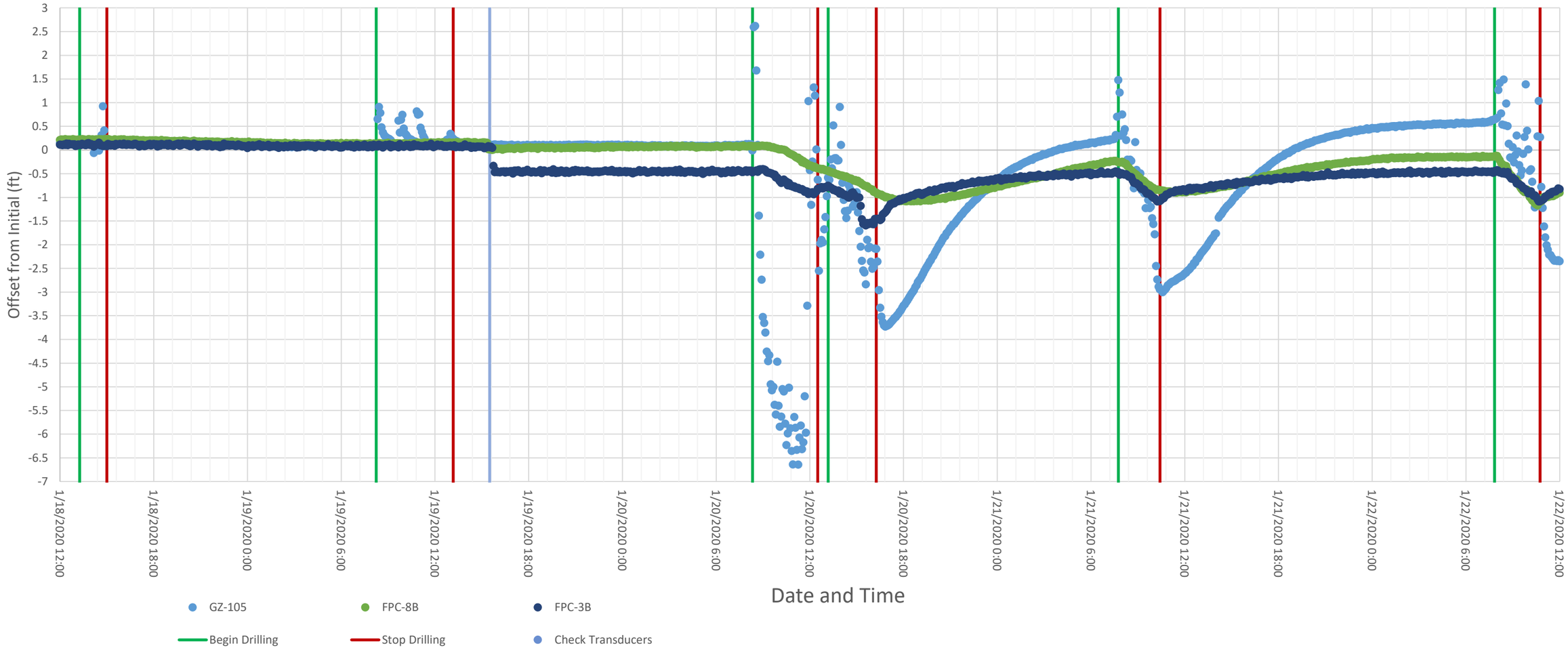
BGS - Below Ground Surface
MS – Metasediment

ATTACHMENT 2
HYDROGRAPHS: INSTRUMENTED BEDROCK MONITORING WELLS

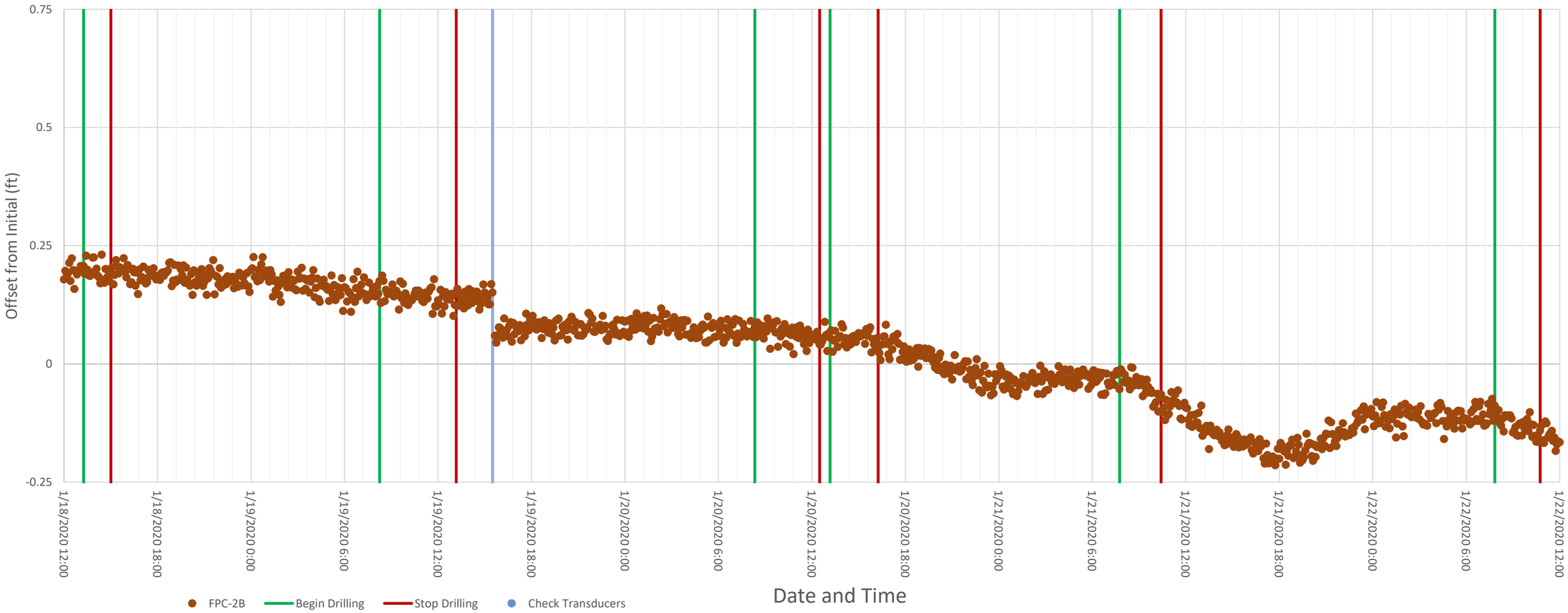
Plot 1: Water Levels in Monitoring Wells Preceding and During Drilling of MW-25 January 16th to January 22, 2021



Plot 2: Water Levels in Monitoring Wells During Drilling of MW-25 January 18th to January 22, 2021



Plot 3: Water Levels in Monitoring Well FPC-2B During Drilling of MW-25 January 18th to January 22, 2021

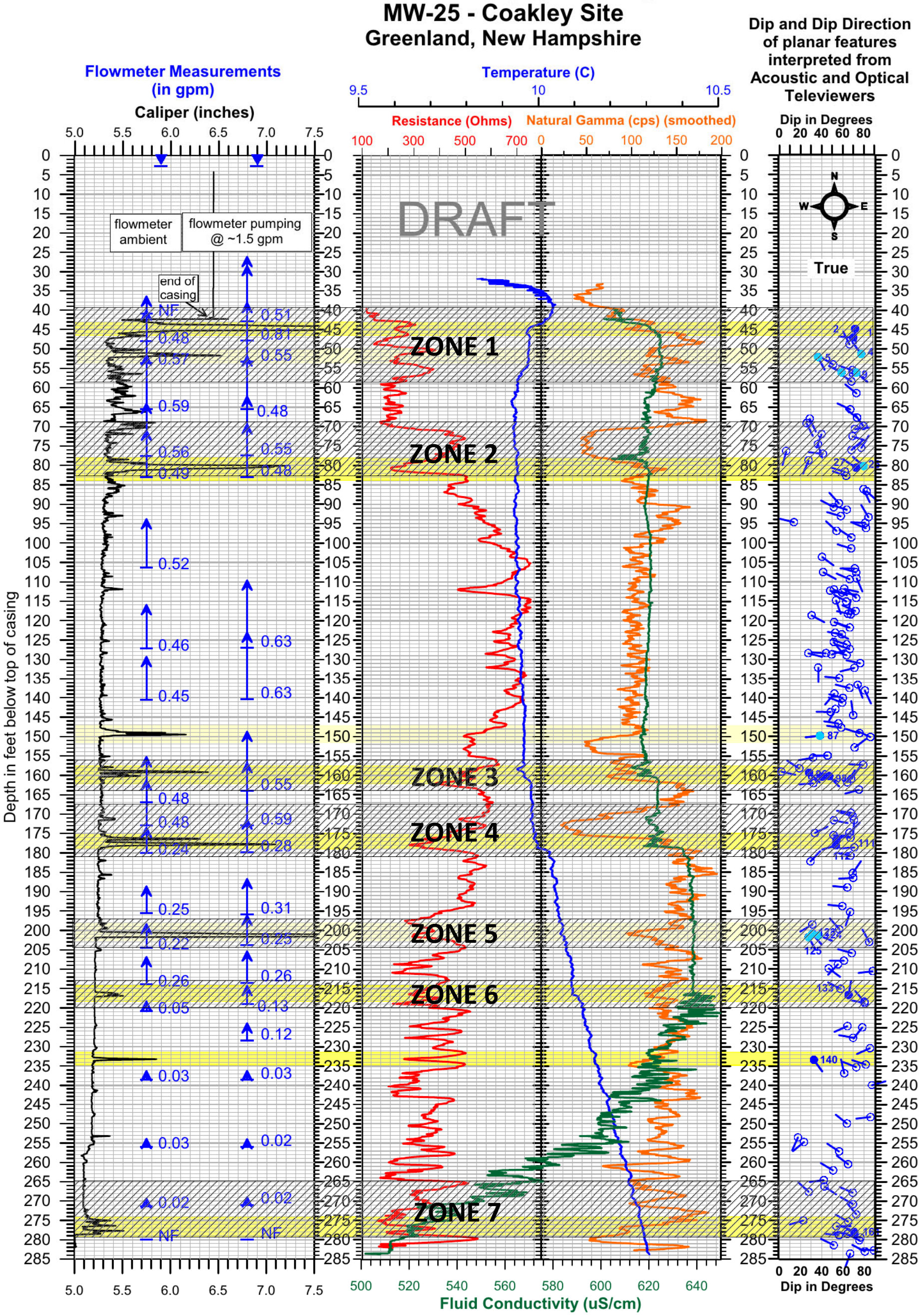


ATTACHMENT 3
BOREHOLE GEOPHYSICAL RESULTS: MW-25

Northeast Geophysical Services

PLATE O-1
Borehole Geophysical Log
MW-25 - Coakley Site
Greenland, New Hampshire

Date logged: 2/23/21



= Likely transmissive zone

= Possible transmissive zone

PLATE O-1
Borehole Geophysical Log
MW-25 - Coakley Site
Greenland, New Hampshire

Tadpole tail indicates dip direction.
The solid tadpoles with a feature number are the ones interpreted to be likely or possibly transmissive.

Northeast Geophysical Services
4 Union Street Bangor, Maine 04401
Tel. 207-942-2700
email: ngsinc@negeophysical.com

Log: Plate O-4 Televiewer & Caliper Logs

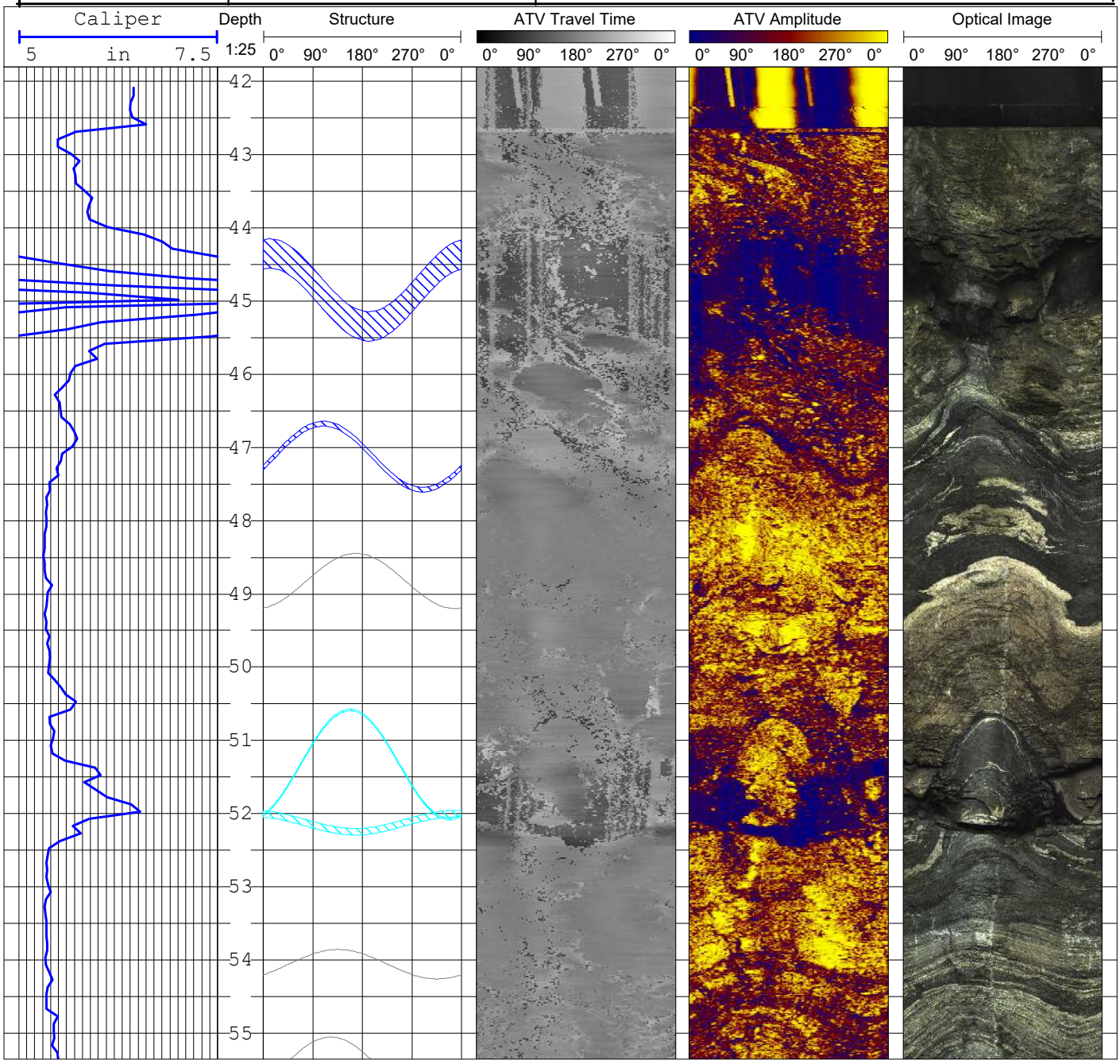
Well: MW-25

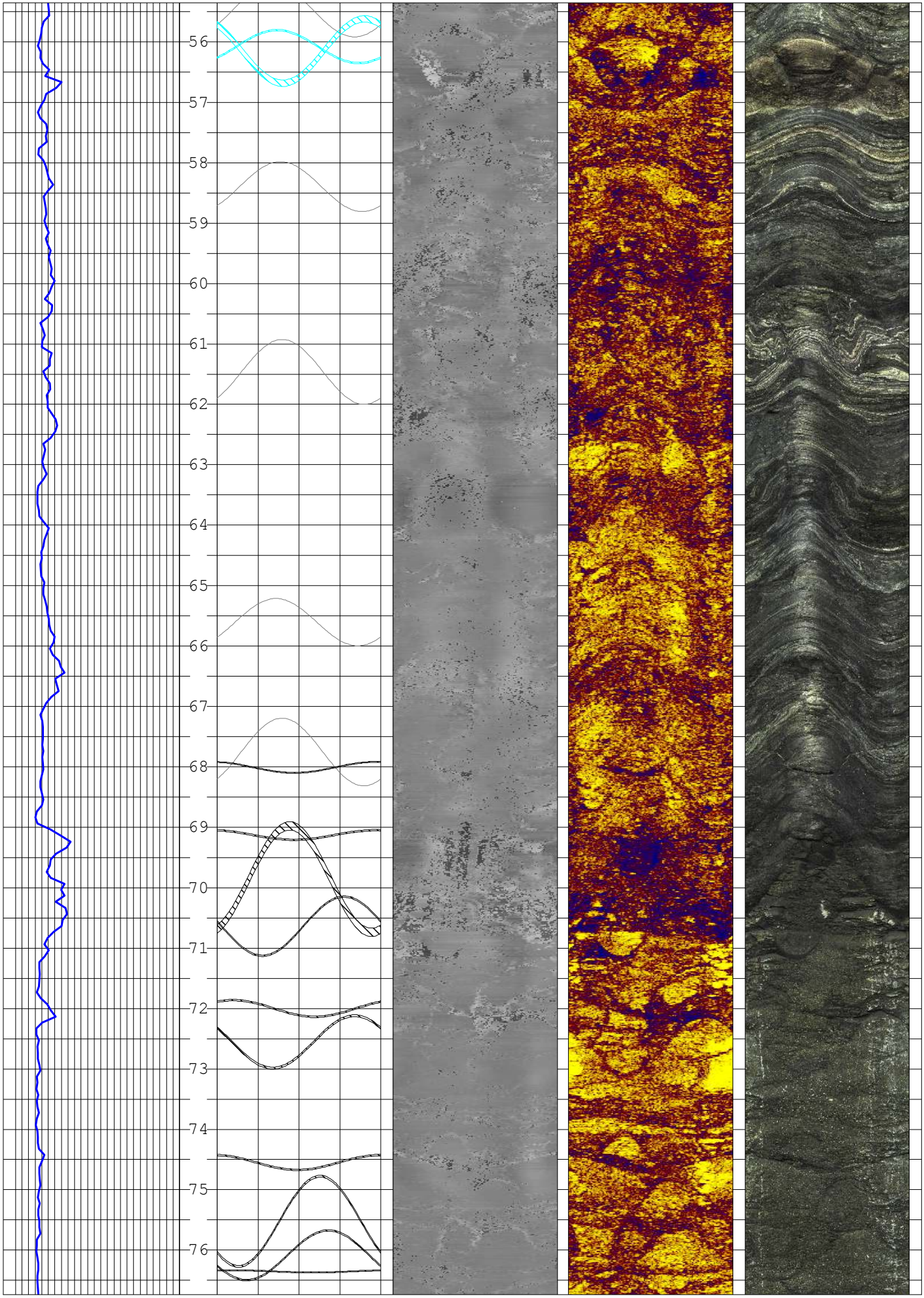
Site: Coakley Landfill

Location: Greenland, New Hampshire

Date:	2/23/2021		
Casing Depth	42.6 ft.	**For:**	CES
Casing Type:	6 inch steel	**Logged by:**	R Rawcliffe
Boring Depth:	284.3 ft.	**Orientation:**	magnetic north
Meas. From:	Top of casing		
Stickup:	3.25 ft.		
Water Level:	2.71 ft.		

Structure Plots:
black = planar features (faults, foliation, bedding, joints, etc)
light blue = possible transmissive fracture
dark blue = likely transmissive fracture

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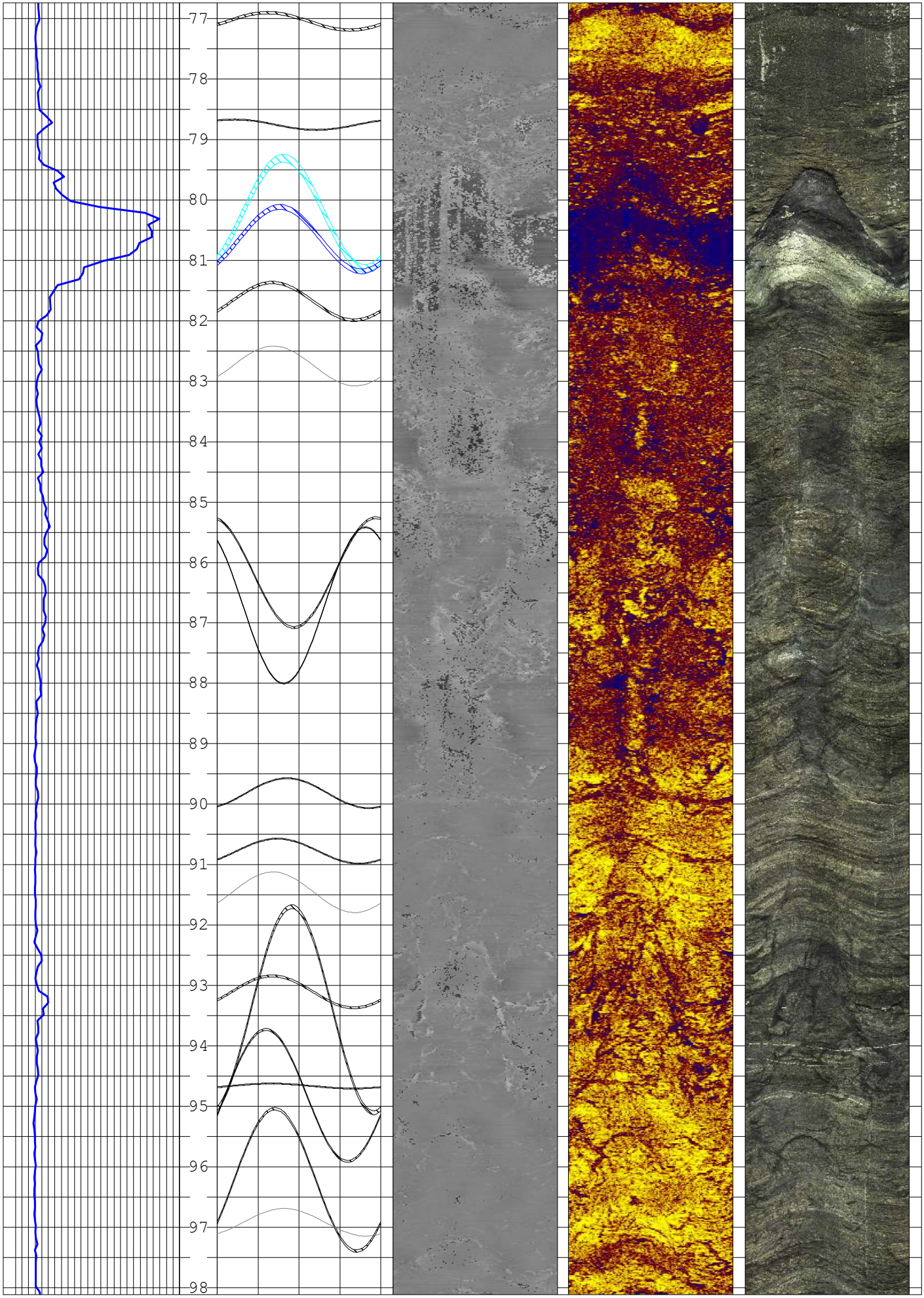
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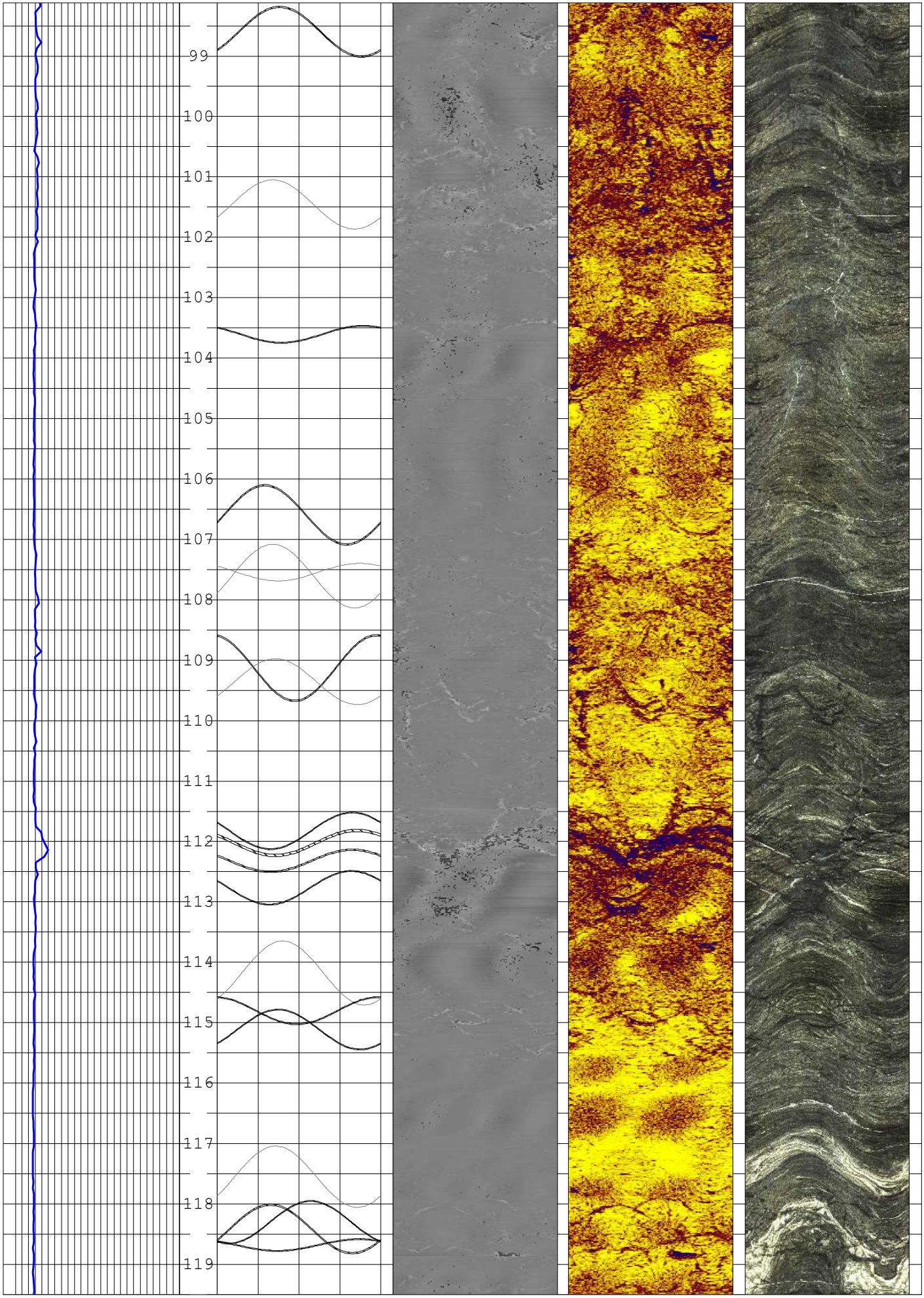
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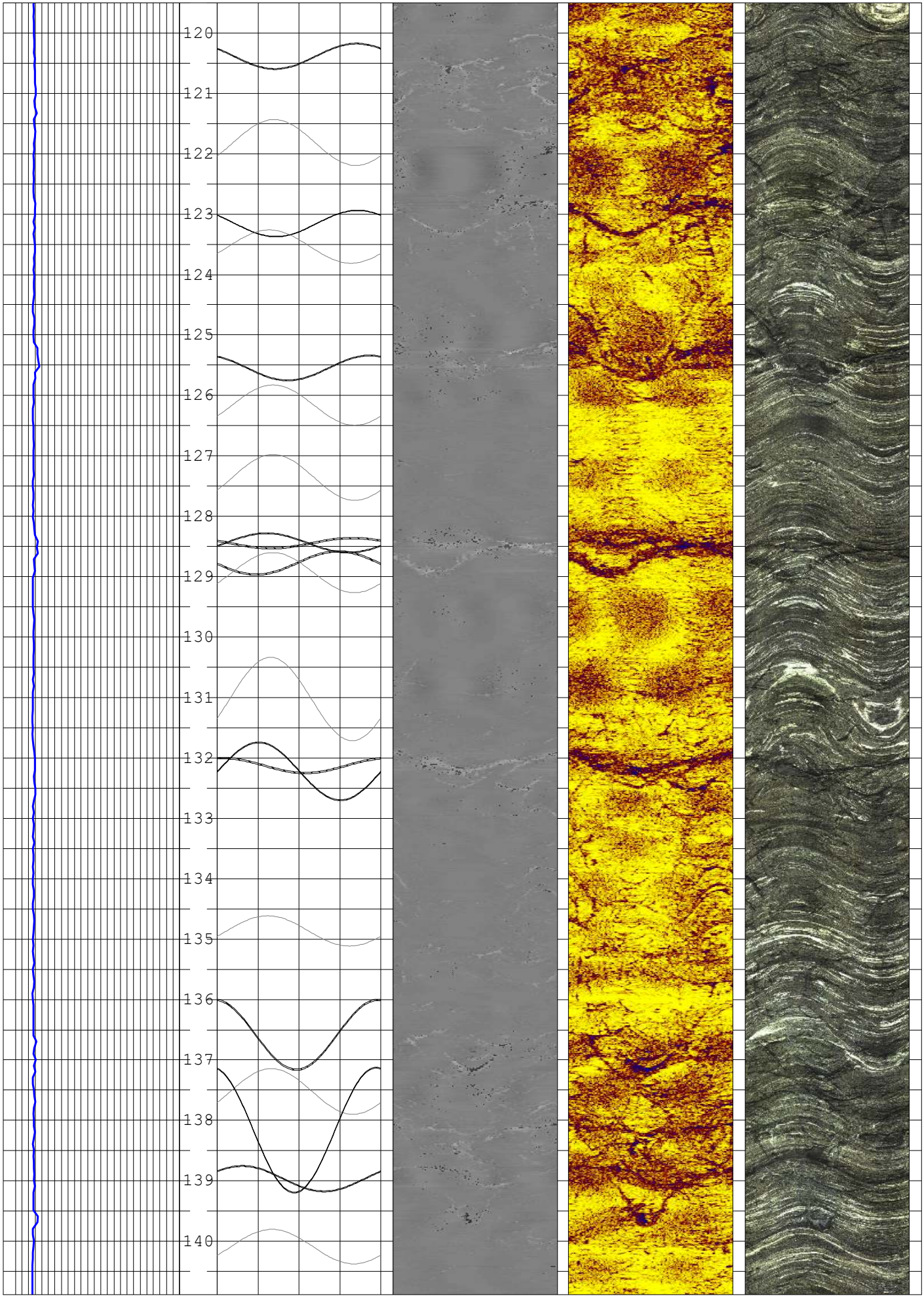
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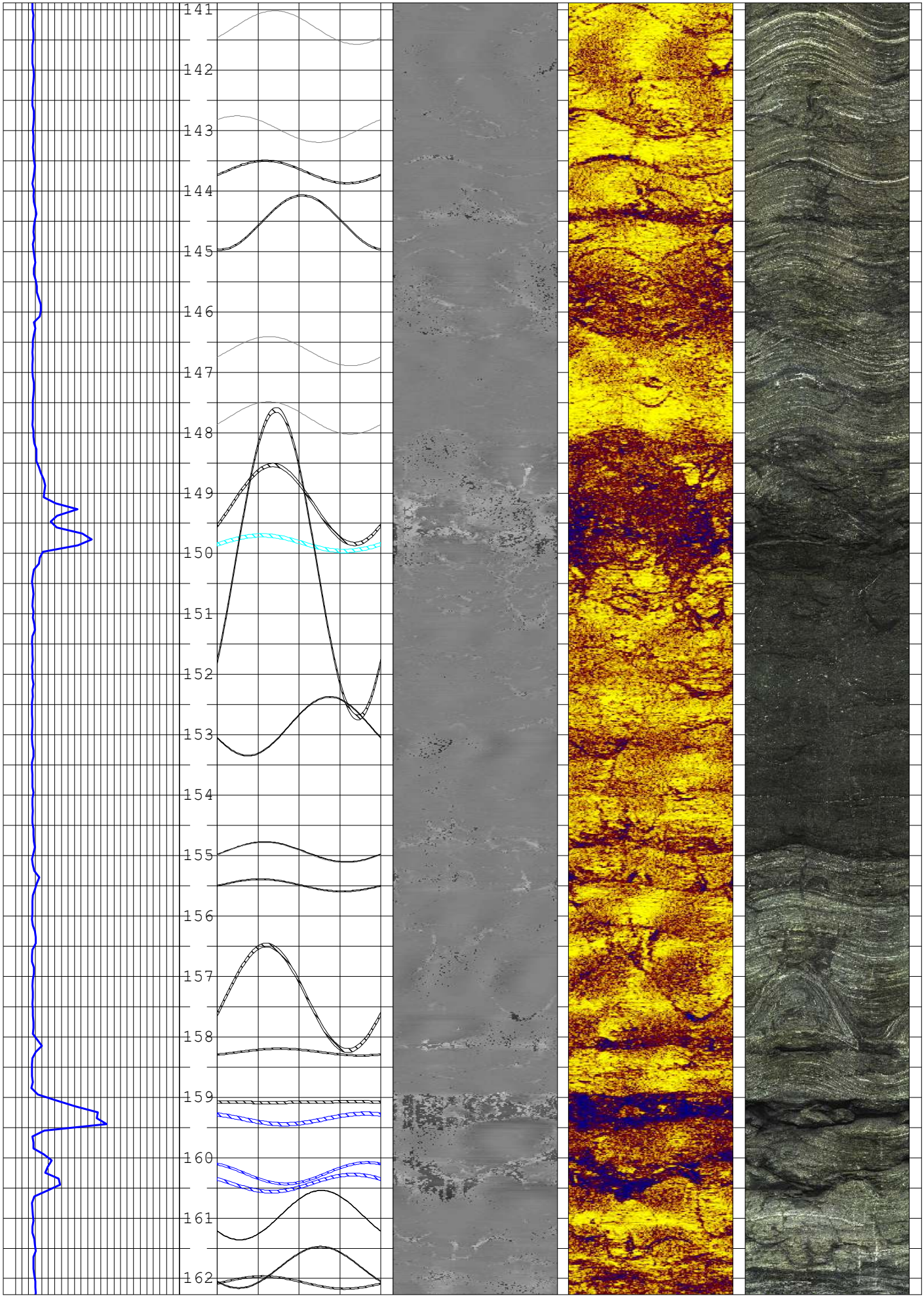
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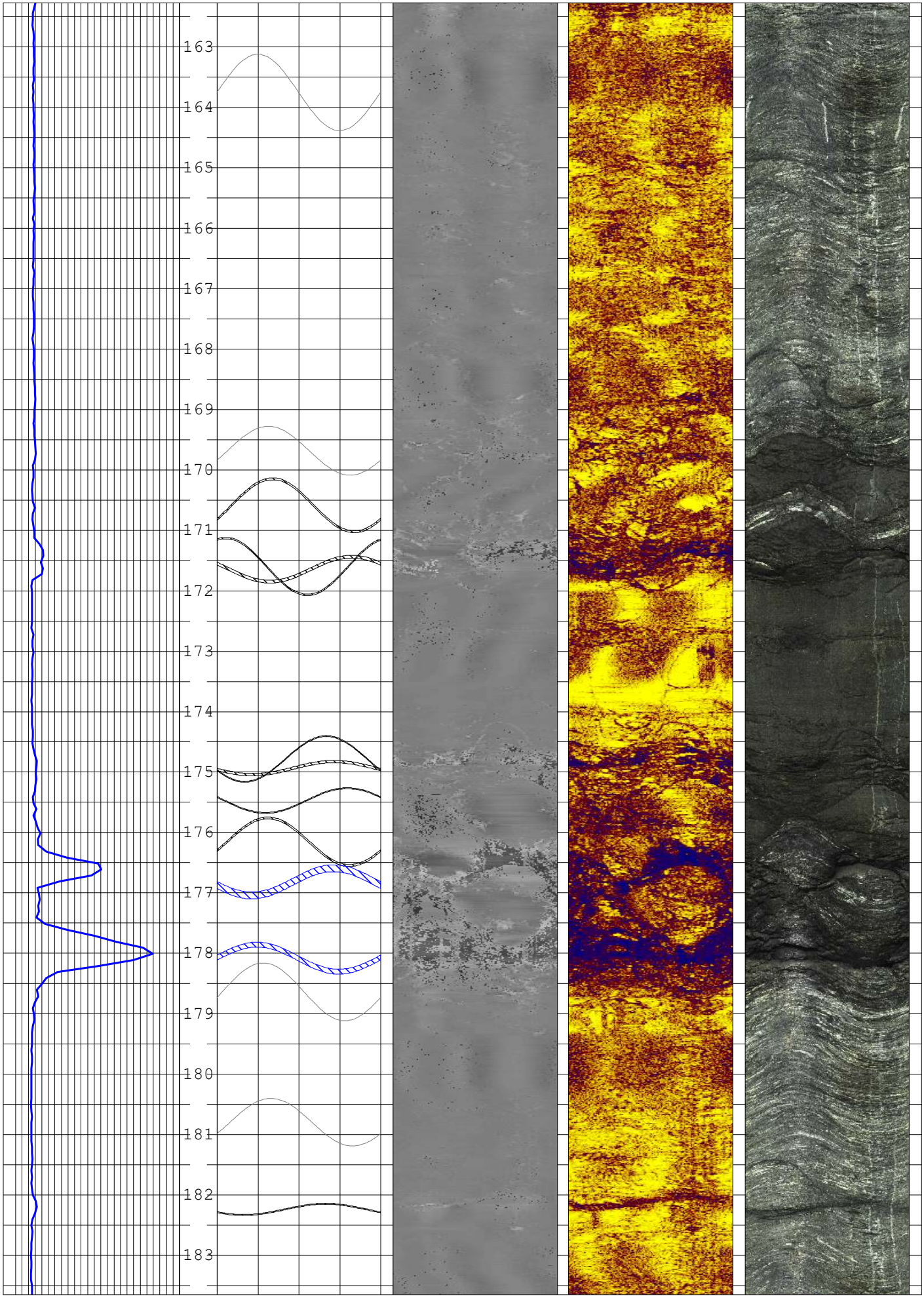
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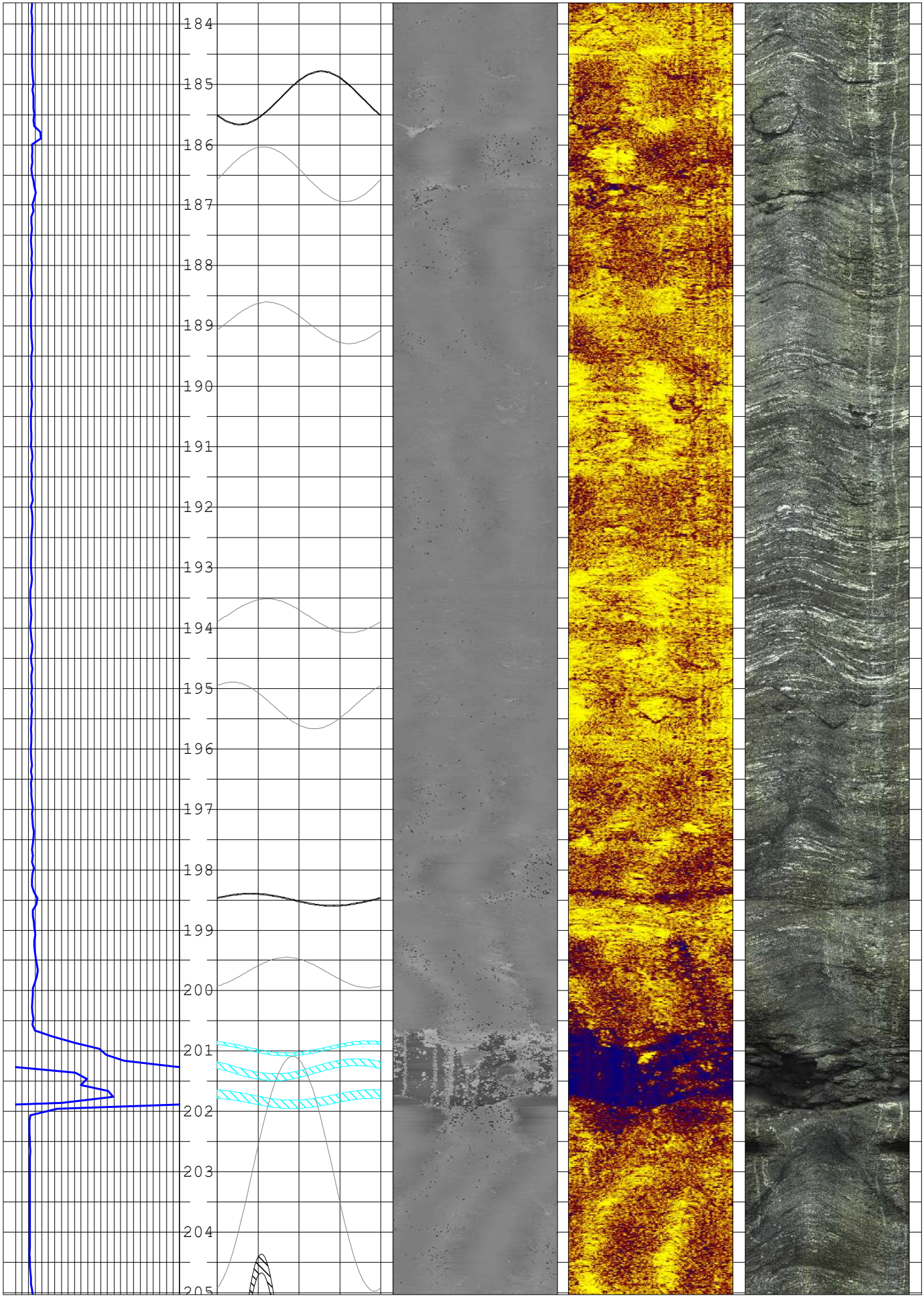
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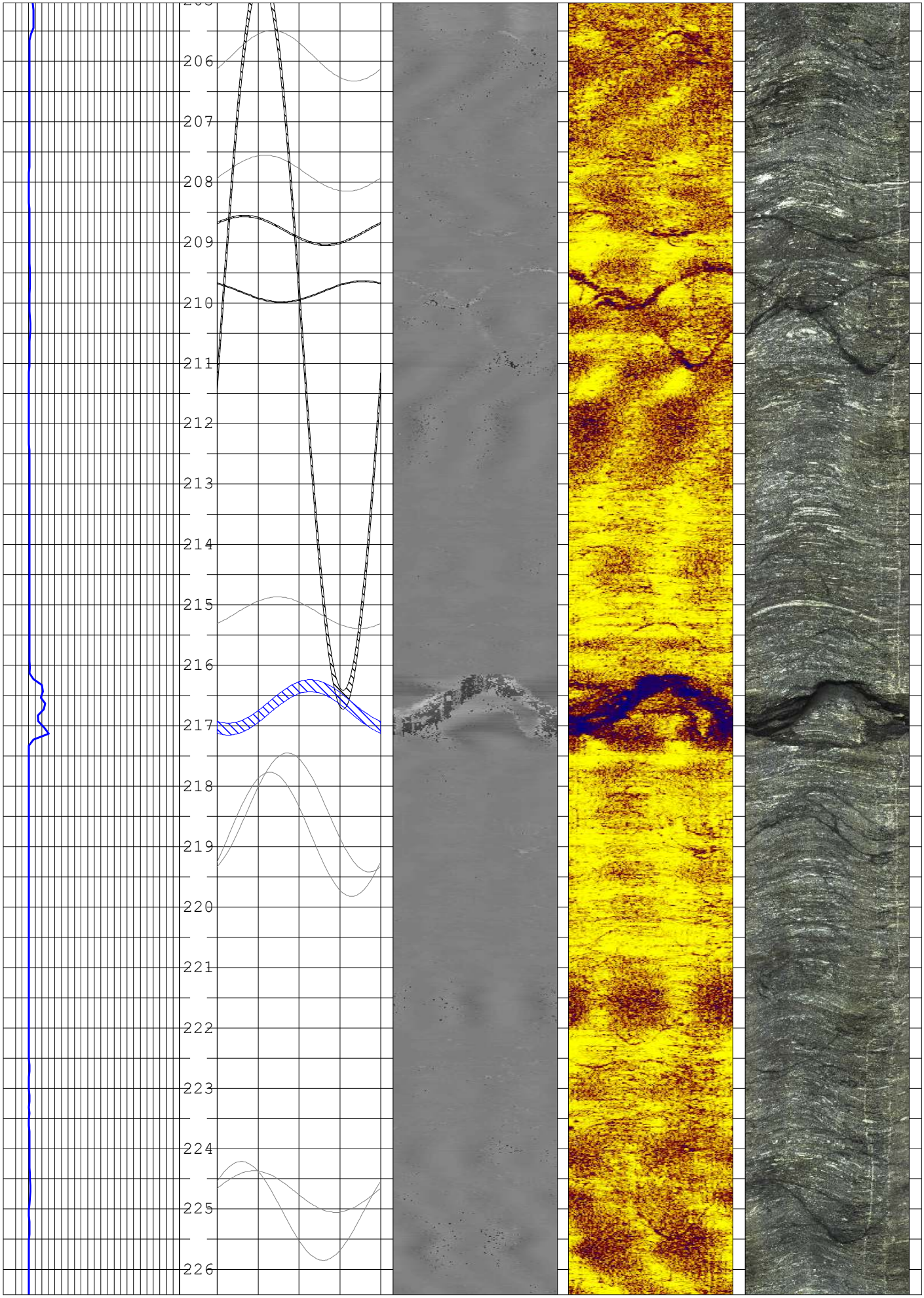
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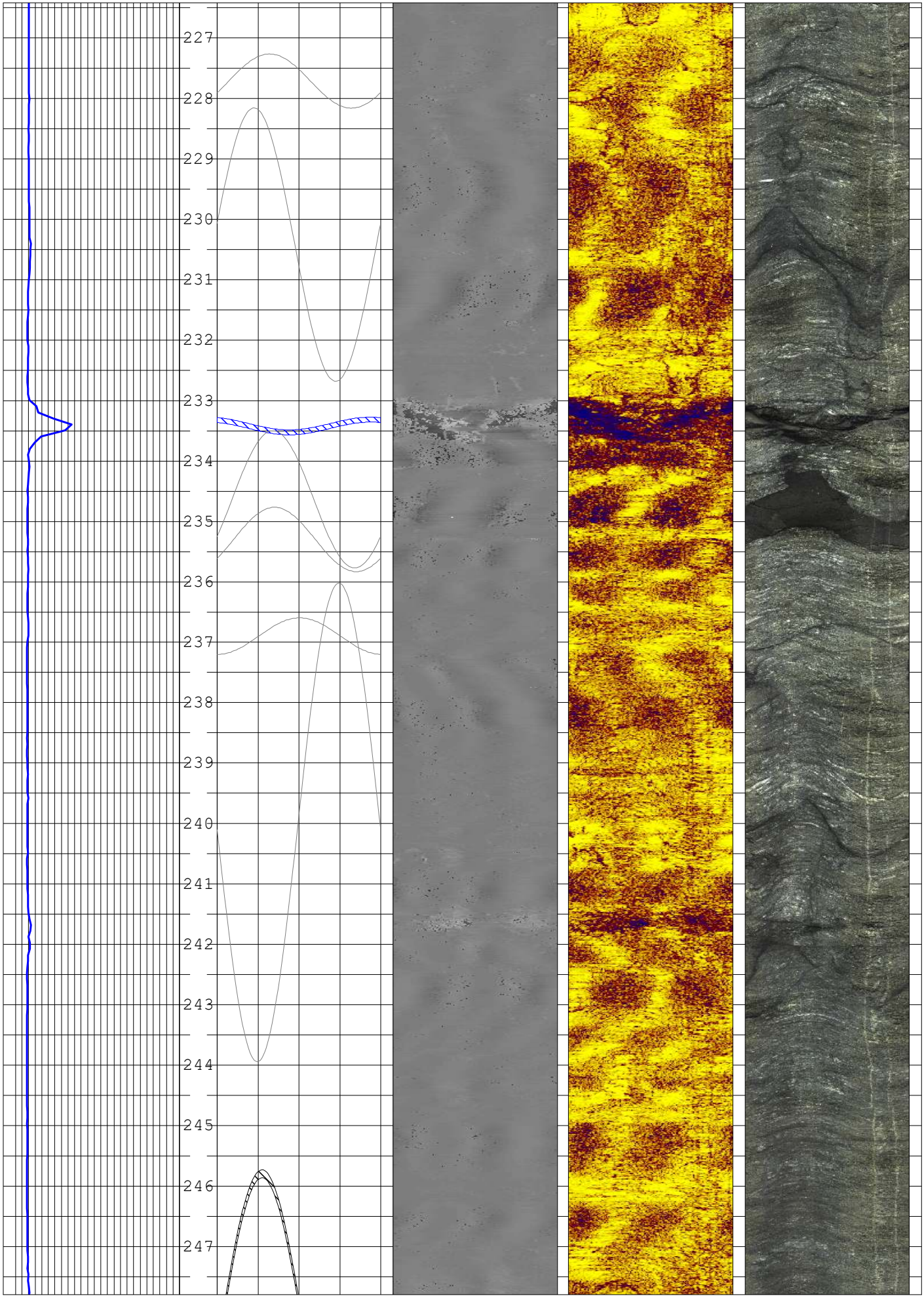
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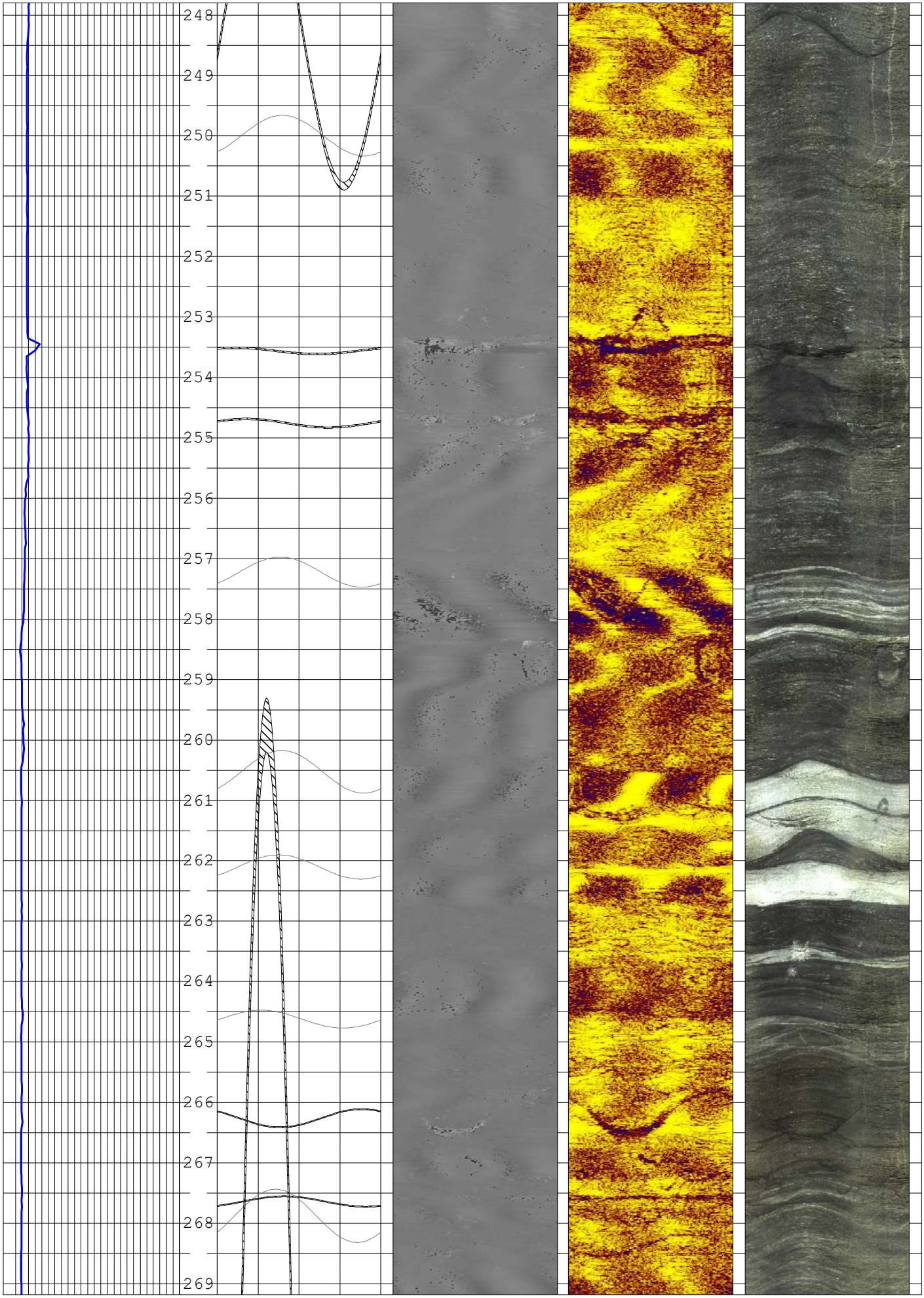
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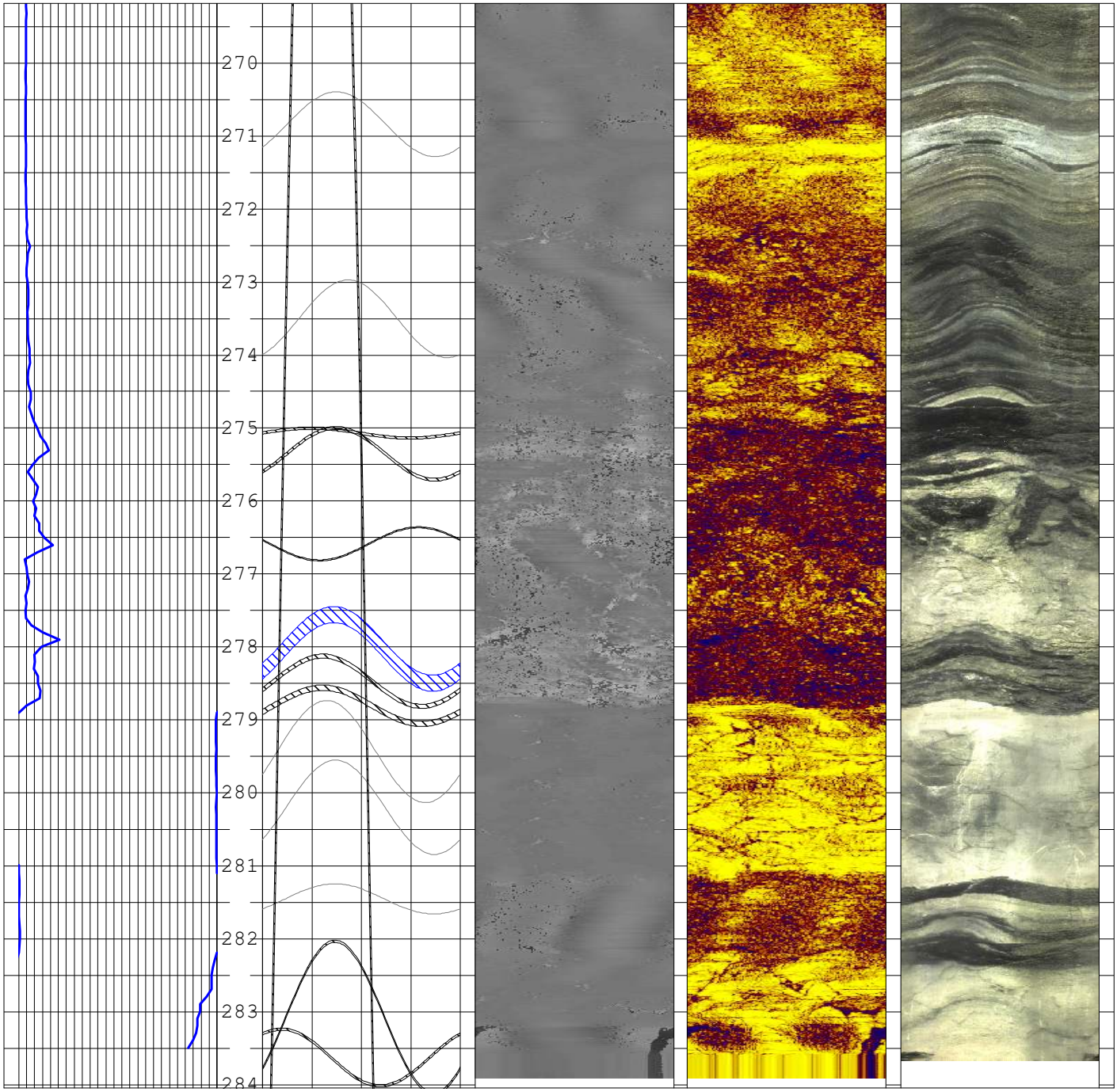
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Northeast Geophysical Services

MW-25
Coakley Landfill Superfund Site
Greenland, NH

PLATE O-2
Strike and Dip Direction of all features

Based on 169 measurements in MW-25 borehole

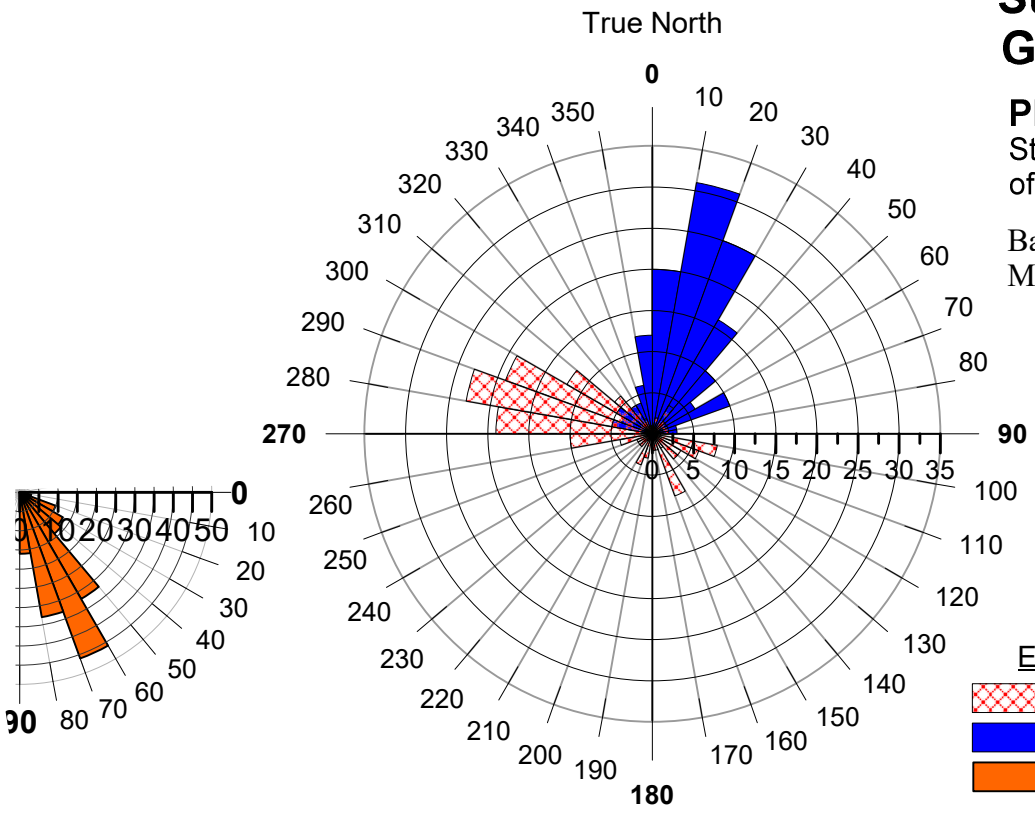
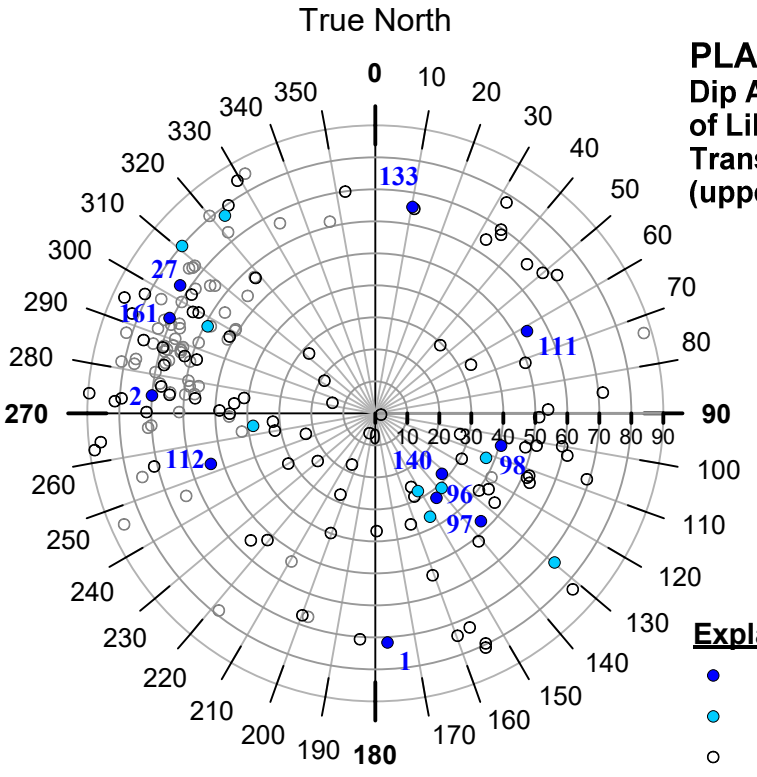


PLATE O-3
Dip Amount and Dip Azimuth of Likely and Possibly Transmissive Fractures (upper hemisphere plot)



Declination: 14.9 degrees west

TABLE O-1 Planar features interpreted from acoustical and optical televiewers
Coakley Landfill Superfund Site - Greenland, NH **February, 2021**
Declination: 14.9 degrees west

Borehole	Feature # Number	Feature depth Feet	Dip Degrees	Dip Azimuth magnetic	Strike magnetic	Dip Azimuth True	Strike True	Aperture mm	Category Type
MW-25	1	44.9	72	192	102	177	87	38	107
MW-25	2	47.1	70	289	199	275	185	7	107
MW-25	3	48.8	66	348	258	333	243	<1 mm	100
MW-25	4	51.3	78	338	248	323	233	2	108
MW-25	5	52.1	37	167	77	152	62	22	108
MW-25	6	54.1	51	316	226	301	211	<1 mm	100
MW-25	7	55.5	69	303	213	288	198	<1 mm	100
MW-25	8	56.1	59	312	222	297	207	4	108
MW-25	9	56.2	73	145	55	130	40	9	108
MW-25	10	58.4	68	320	230	305	215	<1 mm	100
MW-25	11	61.5	73	323	233	309	219	<1 mm	100
MW-25	12	65.6	67	309	219	295	205	<1 mm	100
MW-25	13	67.8	74	323	233	308	218	<1 mm	100
MW-25	14	68.0	29	170	80	155	65	4	101
MW-25	15	69.1	26	169	79	154	64	7	101
MW-25	16	69.9	79	340	250	325	235	8	101
MW-25	17	70.6	71	100	10	85	355	3	101
MW-25	18	72.0	40	215	125	200	110	6	101
MW-25	19	72.6	69	122	32	107	17	3	101
MW-25	20	74.6	37	177	87	162	72	8	101
MW-25	21	75.5	78	47	317	32	302	2	101
MW-25	22	76.1	68	65	335	50	320	3	101
MW-25	23	76.4	7	210	120	195	105	3	101
MW-25	24	77.0	41	291	201	277	187	9	101
MW-25	25	78.8	28	218	128	203	113	4	101
MW-25	26	80.2	80	326	236	311	221	7	108
MW-25	27	80.7	73	318	228	303	213	7	107
MW-25	28	81.7	62	302	212	287	197	6	101
MW-25	29	82.7	63	304	214	289	199	<1 mm	100
MW-25	30	86.2	80	169	79	154	64	2	101
MW-25	31	86.7	83	147	57	132	42	1	101
MW-25	32	89.8	56	333	243	318	228	2	101
MW-25	33	90.8	51	313	223	298	208	3	101
MW-25	34	91.5	64	303	213	288	198	<1 mm	100
MW-25	35	93.1	58	302	212	287	197	5	101
MW-25	36	93.4	85	344	254	329	239	2	101
MW-25	37	94.7	14	298	208	284	194	3	101
MW-25	38	94.8	81	288	198	273	183	1	101
MW-25	39	96.2	82	307	217	292	202	2	101
MW-25	40	96.9	54	328	238	313	223	<1 mm	100
MW-25	41	98.6	68	318	228	303	213	3	101
MW-25	42	101.5	68	302	212	287	197	<1 mm	100
MW-25	43	103.6	40	141	51	127	37	2	101
MW-25	44	106.6	71	285	195	270	180	2	101
MW-25	45	107.5	42	134	44	119	29	<1 mm	100
MW-25	46	107.6	73	302	212	287	197	<1 mm	100
MW-25	47	109.1	73	171	81	156	66	2	101
MW-25	48	109.4	67	308	218	294	204	<1 mm	100
MW-25	49	111.8	62	117	27	102	12	3	101
MW-25	50	112.0	52	128	38	113	23	8	101
MW-25	51	112.3	48	118	28	103	13	5	101
MW-25	52	112.8	59	115	25	100	10	2	101
MW-25	53	114.2	73	324	234	309	219	<1 mm	100
MW-25	54	114.8	54	175	85	161	71	3	101
MW-25	55	115.1	63	315	225	300	210	1	101
MW-25	56	117.6	72	309	219	294	204	<1 mm	100
MW-25	57	118.3	65	26	296	11	281	2	101
MW-25	58	118.4	68	298	208	283	193	2	101
MW-25	59	118.7	31	133	43	118	28	4	101
MW-25	60	120.4	52	127	37	112	22	3	101

TABLE O-1 Planar features interpreted from acoustical and optical televiewers
Coakley Landfill Superfund Site - Greenland, NH **February, 2021**
Declination: 14.9 degrees west

Borehole	Feature # Number	Feature depth Feet	Dip Degrees	Dip Azimuth magnetic	Strike magnetic	Dip Azimuth True	Strike True	Aperture mm	Category Type
MW-25	61	121.8	67	305	215	290	200	<1 mm	100
MW-25	62	123.2	53	129	39	114	24	2	101
MW-25	63	123.5	59	295	205	280	190	<1 mm	100
MW-25	64	125.6	51	156	66	141	51	4	101
MW-25	65	126.2	64	303	213	288	198	<1 mm	100
MW-25	66	127.4	67	303	213	289	199	<1 mm	100
MW-25	67	128.4	44	289	199	274	184	4	101
MW-25	68	128.4	27	119	29	104	14	6	101
MW-25	69	128.8	50	86	356	71	341	4	101
MW-25	70	128.9	64	302	212	287	197	<1 mm	100
MW-25	71	131.0	77	298	208	283	193	<1 mm	100
MW-25	72	132.1	37	194	104	179	89	6	101
MW-25	73	132.2	71	271	181	256	166	2	101
MW-25	74	134.9	57	291	201	276	186	<1 mm	100
MW-25	75	136.6	74	175	85	160	70	2	101
MW-25	76	137.5	67	299	209	284	194	<1 mm	100
MW-25	77	138.2	81	170	80	155	65	1	101
MW-25	78	139.0	52	235	145	220	130	3	101
MW-25	79	140.1	60	300	210	286	196	<1 mm	100
MW-25	80	141.3	59	307	217	292	202	<1 mm	100
MW-25	81	143.0	53	224	134	209	119	<1 mm	100
MW-25	82	143.7	49	286	196	271	181	5	101
MW-25	83	144.5	70	7	277	352	262	2	101
MW-25	84	146.7	56	294	204	279	189	<1 mm	100
MW-25	85	147.8	59	293	203	278	188	<1 mm	100
MW-25	86	149.2	76	302	212	288	198	5	101
MW-25	87	149.8	38	279	189	264	174	13	108
MW-25	88	150.2	86	310	220	295	205	2	101
MW-25	89	152.9	71	68	338	53	323	2	101
MW-25	90	154.9	45	285	195	270	180	3	101
MW-25	91	155.0	46	284	194	269	179	<1 mm	100
MW-25	92	155.5	32	275	185	260	170	4	101
MW-25	93	157.4	79	288	198	273	183	4	101
MW-25	94	158.3	19	318	228	303	213	7	101
MW-25	95	159.1	2	117	27	102	12	11	101
MW-25	96	159.4	28	147	57	132	42	15	107
MW-25	97	160.3	47	151	61	136	46	8	107
MW-25	98	160.4	41	119	29	104	14	12	107
MW-25	99	161.0	68	50	320	35	305	2	101
MW-25	100	161.8	64	47	317	33	303	2	101
MW-25	101	162.1	32	280	190	265	175	8	101
MW-25	102	163.8	75	270	180	255	165	<1 mm	100
MW-25	103	169.7	68	293	203	278	188	<1 mm	100
MW-25	104	170.6	69	302	212	287	197	4	101
MW-25	105	171.6	71	199	109	184	94	2	101
MW-25	106	171.6	51	116	26	101	11	9	101
MW-25	107	174.8	67	60	330	46	316	2	101
MW-25	108	174.9	34	78	348	63	333	9	101
MW-25	109	175.5	51	106	16	91	1	3	101
MW-25	110	176.2	67	292	202	277	187	3	101
MW-25	111	176.8	54	76	346	62	332	21	107
MW-25	112	178.1	54	268	178	253	163	15	107
MW-25	113	178.6	71	281	191	266	176	<1 mm	100
MW-25	114	180.8	67	298	208	284	194	<1 mm	100
MW-25	115	182.2	29	59	329	44	314	6	101
MW-25	116	185.2	70	49	319	34	304	2	101
MW-25	117	186.5	70	282	192	267	177	<1 mm	100
MW-25	118	189.0	64	291	201	276	186	<1 mm	100
MW-25	119	193.8	60	291	201	276	186	<1 mm	100
MW-25	120	195.3	67	213	123	198	108	<1 mm	100

TABLE O-1 Planar features interpreted from acoustical and optical televiewers
Coakley Landfill Superfund Site - Greenland, NH **February, 2021**

Declination: 14.9 degrees west

Borehole	Feature # Number	Feature depth Feet	Dip Degrees	Dip Azimuth magnetic	Strike magnetic	Dip Azimuth True	Strike True	Aperture mm	Category Type
MW-25	121	198.5	31	255	165	240	150	5	101
MW-25	122	199.7	57	333	243	318	228	<1 mm	100
MW-25	123	201.0	31	153	63	138	48	13	108
MW-25	124	201.3	37	127	37	112	22	26	108
MW-25	125	201.8	28	166	76	151	61	38	108
MW-25	126	203.0	85	346	256	332	242	<1 mm	100
MW-25	127	205.9	69	301	211	286	196	<1 mm	100
MW-25	128	207.9	61	285	195	270	180	<1 mm	100
MW-25	129	208.8	56	239	149	224	134	5	101
MW-25	130	209.8	47	142	52	127	37	3	101
MW-25	131	210.5	88	277	187	263	173	3	101
MW-25	132	215.1	58	313	223	298	208	<1 mm	100
MW-25	133	216.7	65	25	295	10	280	25	107
MW-25	134	218.4	81	335	245	320	230	<1 mm	100
MW-25	135	218.8	81	296	206	282	192	<1 mm	100
MW-25	136	224.7	64	261	171	246	156	<1 mm	100
MW-25	137	225.0	79	233	143	218	128	<1 mm	100
MW-25	138	227.7	70	296	206	281	191	<1 mm	100
MW-25	139	230.4	86	261	171	246	156	<1 mm	100
MW-25	140	233.4	33	159	69	144	54	20	107
MW-25	141	234.6	82	303	213	288	198	<1 mm	100
MW-25	142	235.3	73	306	216	291	201	<1 mm	100
MW-25	143	236.9	61	2	272	347	257	<1 mm	100
MW-25	144	240.0	88	88	358	73	343	<1 mm	100
MW-25	145	248.3	86	279	189	264	174	3	101
MW-25	146	250.0	64	323	233	309	219	<1 mm	100
MW-25	147	253.6	18	219	129	204	114	8	101
MW-25	148	254.8	23	245	155	230	140	6	101