REPORT

Hydrogeology and Hydrology Level 1 and 2 Study

Proposed Thomas Street Quarry Expansion, 4608 Perth Line 5, Perth South, ON

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was engaged by St. Marys Cement Inc. (Canada) (SMC) to complete a Hydrogeology and Hydrology Level 1 and 2 Study technical report in support of a licence application under the Aggregate Resources Act for a proposed Category 2, Class A Quarry Below Water Table. This Study was completed for the property located at 4608 Line 5, Perth South, Ontario, approximately two kilometres southwest of the Town of St. Marys (the “Site” – Figure 1.1). The Site is planned as an expansion of the adjacent Thomas St. Quarry.

The ultimate objectives of the Study were to: 1) characterize the baseline hydrogeological and hydrological conditions in the vicinity of the Site (“Existing Scenario”); and 2) assess the potential incremental effects on groundwater and surface water, if any, of the quarry expansion on the previously approved Operations and Rehabilitated Scenarios. The Study scope of work included the following tasks:

- Background information review;
- Site reconnaissance;
- Borehole drilling and logging;
- Hydraulic testing;
- Water level monitoring;
- Water quality sampling;
- Water well survey;
- Site water balance;
- Groundwater modelling;
- Impact assessment; and
- Reporting.

This report describes regional setting, field investigations, Site water balance, groundwater modelling, impact assessment, conclusions and recommendations.

1.1 Site Development

1.1.1 Existing Scenario

The Site area is approximately 46 hectares (ha) and rectangular in shape (Figure 1.1). Current land use is agricultural, with farm buildings and a residence in the southern portion of the property. The Site is surrounded by agricultural fields to the north and west, Perth Road Line 5 and the Thames River to the south, and the Thomas St. Quarry to the east.

Nearby SMC operations include the aforementioned Thomas St. Quarry (or North Quarry) on the north side of the Thames River and the South Quarry on the south side of the River. The Thomas St. Quarry has been actively mined since 1968. The South Quarry is no longer mined and currently serves as the location of the SMC cement plant.

The existing Thomas St. Quarry has a licensed extraction area of 210 ha with an annual tonnage limit of 3.25 million tonnes per year. To-date, quarrying has occurred within the approximate southern half of the extraction area with future quarrying progressing northward. The current quarry sits at an elevation of approximately 274 metres above sea level (masl) (Figure 1.1). The Quarry is licensed to extract to a floor elevation of 267 masl; however, the final quarry floor is expected to remain, for the foreseeable future, close to the base of a limestone / dolostone contact, at an elevation of approximately 271 masl or greater (Figure 1.2).

The Thomas St. Quarry is a below-water operation and requires dewatering of surface water and groundwater that accumulates within the quarry through direct precipitation on the quarry footprint or seepage through the quarry walls. This dewatering allows for safe and efficient mining operations. Water ingress is conveyed to the North Quarry Sump and thereafter pumped and discharged into the nearby Thames River via a pipe underneath Thomas St.

1.1.2 Operations Scenario

The Site Operations Scenario is planned as an expansion of the adjacent Thomas St. Quarry (Figure 1.2). The tonnage limit for the combined Site and Thomas St. Quarry operations will remain at 3.25 million tonnes per year. The proposed extraction area of the Site lands is approximately 43 ha. The eastern to northeastern flank will be contiguous with the Thomas St. Quarry property, the northwest and western flanks of the property will have 15 m setbacks, whereas the southern flank of the property will have a 30 m setback. Quarrying will begin within the southern half of the extraction area and proceed northwards. Based on SMC mining plans the final floor elevation of the Site will range from 271 masl to 279 masl and be contiguous with the Thomas St. Quarry floor (Figure 1.2).

Dewatering will be accomplished in a similar manner as Thomas St. Quarry with surface water and groundwater inputs passively drained over the pit floor to a sump(s) and eventually pumped to the Thames River.

Some portable processing equipment will be present within the Site during Operations; however, the majority of processing will continue at the Thomas St. location. Required fuel and chemicals will be stored at the Thomas St. location.

The impact assessment described herein considers the Operations Scenario at “full build-out” as depicted in Figure 1.2.

1.1.3 Rehabilitated Scenario

The approved Rehabilitated Scenario site plan for the Thomas St. Quarry involves the creation of a quarry lake at water elevation +/- 282 masl with 2:1 till slide slopes along the west, north and east side slopes of the extraction area and a large till backfill berm along the south perimeter. With the inclusion of the expansion lands, the joint Rehabilitated Scenario for the Site and Thomas St. Quarry is now envisioned as follows (as depicted on Figure 1.3):

- Previously stockpiled till will be backfilled atop the quarry floor, thus creating a mounded “peninsula” of till material with a maximum elevation of 300 masl. Note that this till material is placed entirely within the Thomas St. Quarry area (as opposed to the Site).
- The majority of the quarry walls will be sloped with backfilled till.
- Dewatering will cease during rehabilitation, thus allowing a lake to form within the quarry.

- The lake level is expected to rise and eventually equilibrate at an elevation of approximately +/- 294 masl based on the modelling described later in this report. At this elevation, water will rise above the bedrock to within the overburden horizon.

The presence of the till slide slopes will limit the lake's hydraulic interaction with the surrounding native overburden. An exception to the till sloping is the southwest corner of the Site where the lake will be in direct contact with the native granular and will be allowed to freely drain through this natural impoundment. Under average climatic conditions, water seeping through the overburden in this area may remain below ground surface and discharge directly to the Thames River. During higher water level periods it may be possible that a portion of lake flow "daylights" as seepage along the overburden face prior to reaching the Thames River. The potential for this occurrence will be confirmed through future monitoring. Should seepage daylighting be deemed plausible, such discharge could be managed at the downstream perimeter of the Site (likely via drainage ditching) and redirected to the Thames River via culvert under Perth Road Line 5.

1.2 Previous Work

Golder has completed several prior geological and hydrogeological projects at the Site and the adjacent SMC Thomas St. Quarry operations as summarized in Table 1. In addition, annual groundwater monitoring reports and data collection in support of the Thomas St. Quarry Permit To Take Water (PTTW) are consulted as part of the Study (Amec Foster Wheeler, 2013 – 2017).

Most pertinent to the current work, and as integrated further in subsequent sections, the geology for the Site was defined in a field program completed in 2017 – 2018 in support of the hydrogeological evaluation for the licence application described herein. The work included the visual and geophysical logging of five cored boreholes and four rotary drilled boreholes, whole rock chemistry analysis of recovered core, test pitting at 19 locations, and an assessment of the estimated reserves of cement grade limestone. The nine open holes drilled as part of this resource evaluation now form the groundwater monitoring locations utilized as part of the current work.

Table 1: List of Previous Investigations by Golder

Project No.	Publication Date	Title / Description	Pertinent Data
001-1306	March 2002	"Rock Quality and Hydrogeological Assessment, Thomas St. Quarry"	Borehole logs, packer testing results, geophysical logs, hydrogeological impact assessment
03-1112-034	November 2003	"Soil and Bedrock Resource Assessment, South Quarry Expansion Area"	Borehole logs, geochemistry data, geophysical logs
04-1112-056	December 2004	"Assessment of Clay and Limestone Resources, St, Marys Quarry" - Thomas St. Quarry and South Quarry	Geochemistry and physicals data, borehole logs, test pit logs, historical data, geologic model, reserve estimates
09-1112-6039	April 2012	"Hydrogeological Assessment Proposed Quarry Deepening, St. Marys Cement, Thomas St. Quarry" attached to Permit to Take Water (PTTW) application	Geochemistry and physicals data, existing groundwater flow model, borehole logs, geophysical logs, packer test data, groundwater modelling, hydrogeological impact assessment, historical groundwater levels and pumping data, buckling analysis
13-1152-0013	May 2013 (geophysical record only)	Geophysical borehole logging, Thomas St. Quarry	Gamma and resistivity logs for the monitoring well installed by AMEC in 2013.

2.0 REGIONAL SETTING

2.1 Topography

Ground surface elevation within the study area slopes in a southerly direction, ranging from approximately 330 masl in the northwest to 295 masl at the Thames River to the south (Figure 2.1). The Site itself ranges in elevation from 322 masl along its north flank to 297 masl at its south flank. The adjacent Thomas St. Quarry floor currently resides at approximately 274 masl.

2.2 Drainage

The Site lies within the “05T North Thames / Medway River” subwatershed, which itself belongs to the larger Thames River watershed (Thames-Sydenham and Region Source Protection Committee, 2015). There are two main drainage features within the study area: 1) the North Thames River, directly south of the Site; and 2) Trout Creek, which discharges to the North Thames River northeast of the Site (Figure 2.1). The North Thames River at Town of St. Marys drains an area of over 1,080 km^2 with an average flow rate of roughly 1 million m^3/day (Environment Canada, 2019).

A series of small, intermittently flowing channels drain the lands immediately flanking the North Thames River; one such channel occurs on-Site and is discussed further below.

There are no naturally occurring wetlands mapped within the study area.

2.3 Regional Geology

2.3.1 Overburden

The Site is located within the Stratford Till Plain physiographic region (Chapman and Putnam, 1984). The till is a product of the Huron ice lobe and is described as fairly uniform silty clay. A network of glacial spillway overlies the till plain, converging in the area of the Site along the North Thames River and Trout Creek drainage corridors (Figure 2.2). More locally, surficial geology in the vicinity of the Site is mapped as silty clay till to the north, eolian sand and gravel deposits centrally within Site, and alluvial granular deposits along the North Thames River (Figure 2.2).

A pre-existing regional overburden thickness map (Golder, 2012) is adopted for this Study with local modifications in the area of the Site based on recent drilling and expanded Thomas St. Quarry footprint (Figure 2.3). Overburden thickness ranges from 50 m northwest of the Site to zero thickness in the existing quarry area and in some discrete locations around the North Thames River and Trout Creek.

2.3.2 Bedrock

Regional bedrock geology consists of Paleozoic limestone and dolostone formations overlying Precambrian crystalline rocks (Figure 2.4). The following bedrock units are of importance to the Study (listed from youngest to oldest, or from top down):

1) *Dundee Formation:* A fresh, grey to brown, fine-grained, partly crystalline, non-porous, thinly to thickly bedded limestone. The Dundee Formation limestone forms upper portion of the subject resource of the proposed Thomas St. Quarry Expansion. Regionally, the formation may reach 45 m thick (Armstrong and Carter, 2010); in the vicinity of the Site observed thicknesses range from 10 m to 18 m. The exposure of the formation within the existing Thomas St. Quarry face exhibits black, argillaceous laminations forming bedding partings of broad lateral continuity (Golder, 2012). As evidenced in the quarry walls, the sequence is

cut by orthogonal sets of widely spaced vertical fractures extending down through the sequence from rock surface. These fractures are open near the bedrock surface but appear to be comparatively tight near the base of the exposures in the quarry walls.

2) *Upper Lucas Formation:* A fresh to faintly weathered, light to medium tan brown, fine to medium grained, faintly to moderately porous to pitted, thin to medium bedded limestone. The Upper Lucas Formation forms lower portion of the subject resource of the proposed Thomas St. Quarry Expansion. Regionally, the totality of the Lucas Formation may reach over 90 m thick (Armstrong and Carter, 2010); in the vicinity of the Site drilling indicates the Lucas Formation is at least 22 m thick with the Upper Lucas forming the top 7 m to 10 m.

3) *Lower Lucas Formation.* A light to medium tan brown, fine to medium grained, faintly to highly porous or vuggy, thin to medium bedded dolostone and dolomitic limestone. In the vicinity of the Site the Lower Lucas is at least 15 m thick. The upper 7 to 10 m of the formation is characterized by comparatively low permeability dolostone underlain by a porous, highly permeable water bearing gypsiferous dolostone horizon.

A pre-existing regional bedrock surface map (Golder, 2012) is adopted for this Study with local modifications in the area of the Site based on recent drilling and expanded Thomas St. Quarry footprint (Figure 2.5). The surface reflects an irregular erosional pattern but generally slopes in a southwesterly direction, ranging in elevation from approximately 310 masl in the northeast to approximately 270 masl in the southwest. Beneath the bedrock surface the underlying Paleozoic rock formations dip to the southwest at a slope of approximately 0.2% to 0.4% (Golder, 2012 and Matrix, 2014).

2.4 Regional Hydrogeology

2.4.1 Hydrostratigraphy

The following regional hydrostratigraphic units are relevant to the Study (from ground surface downwards):

1) *Overburden:* At a regional scale (i.e. beyond the Site alone), the overburden is predominately comprised of low permeability, clayey silt to silty clay till aquitard (Stratford Till) although there are coarser deposits along the Thames River drainage corridor in the vicinity of the Site.

2) *Dundee Formation:* The Dundee Formation is considered a moderate aquifer, with the upper 3 m to 5 m of weathered subcrop constituting a particularly permeable horizon (SWS, 2011). Prior regional studies have characterized the Dundee Formation hydraulic conductivity (K) in the range of 5E-6 m/s to 2E-4 m/s (SWS, 2011 and 2013).

3) *Upper Lucas Formation:* Early regional studies conceptualized Lucas Formation in its entirety as a moderate aquifer with hydraulic conductivity in the range of 5E-5 m/s to 8E-5 m/s (SWS, 2011). More recent interpretations considered the Upper Lucas Formation limestone as a series of bedding plane aquifers (K ~ 1E-3 m/s) and aquitards (K ~ 5E-7 m/s) (SWS, 2013). In a bulk hydraulic sense, the Upper Lucas Formation could be characterized as a moderate aquifer as the high permeability of the bedding plane / fractures would dominate the overall transmissivity.

4) *Lower Lucas Formation, Upper Zone:* The upper dolostone of the Lower Lucas Formation is considered a regional aquitard with conceptual hydraulic conductivity ranging from 3E-8 m/s to 5E-7 m/s (SWS, 2013).

5) *Lower Lucas Formation, Lower Zone:* The lower dolostone of the Lower Lucas Formation is considered a highly productive regional aquifer with conceptual hydraulic conductivity ranging from 5E-6 m/s to 2E-3 m/s.

2.4.2 Groundwater Flow

Infiltration to the shallow groundwater system within North Thames watershed is relatively limited as a result of the expansive presence of low permeability surficial till. Regional estimates of recharge rates range from 152 mm/yr to 168 mm/yr (SWS, 2011). Subsequent leakage rates from overburden to underlying bedrock aquifers would be lower; as will be discussed later in the modelling section the proportion of recharge entering the bedrock system is estimated to be approximately 75 mm/yr.

Regional groundwater flow patterns within the bedrock aquifers is inferred on the basis of 267 MECP water well records and 21 Site wells (Figure 2.6). The illustrated flow mapping combines MECP static water levels from a broad timeframe and different bedrock units; as such, Figure 2.6 is considered a generalized, average depiction of regional trends. Groundwater is inferred to flow from a high of 330 masl in the east to a low of 260 masl in the west, resulting in an average gradient of 6E-3 m/m across the study area. It is notable that the Thames River does not appear to exert a significant influence on bedrock flow patterns; a further inspection of individual bedrock wells within 200 m of the Thames reveals bedrock water levels are typically much lower (10 m+) than nearby river (i.e. DEM) levels. These observations suggest that, at a regional scale, the bedrock aquifers have a poor hydraulic connection to the Thames River.

2.5 Regional Groundwater Use

2.5.1 MECP Water Wells

Based on a review of the Ontario Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (WWIS) database, there are 36 water well records within 1 km of the Site. The locations of the water well records are shown on Figure 2.7, with a summary of well information provided in Table A.1 (Appendix A). Of the 36 well records:

- Fourteen wells are listed as water supply wells. The water supply wells are identified for livestock and/or domestic use, with the exception of two wells listed for industrial (Well ID 5001485, Maple Leaf Foods Inc.) and commercial uses (Well ID 5002354, owner not specified). The water supply wells were drilled between 1955 and 2016 to depths of 4.3 to 111.3 mbgs and static water levels ranged from depth of 2.1 to 72.8 mbgs (where reported). Of the fourteen water supply wells, one was listed as an overburden well, one well did not list the type, and the remainder were listed as bedrock wells. The reported well yields for the water supply wells ranged from approximately 4 to 82 litres per minute (L/min).
- Six wells are listed as monitoring/test holes/observation wells, two of which were listed as ‘not used’.
- Two wells are listed as ‘Abandoned-Other’.
- Fourteen wells do not have a well status or use listed.

2.5.2 Permit To Take Water

Section 34 of the Ontario Water Resources Act (OWRA) requires any entity taking more than a total of 50,000 litres of water in a day to obtain a Permit To Take Water (PTTW) from the MECP. There are four active MECP PTTWs within 5 km of the Site (MECP, 2019[2]); of these, two permits are held by SMC, one is held by Town of St. Marys, and one is held by Maple Leaf Foods Inc. (Figure 2.7). The permits are discussed in the following sections.

2.5.2.1 St. Marys Cement

Water is taken from up to eight sources across the existing Thomas St. (North) Quarry and South Quarry sites and used for dewatering, aggregate washing, cooling, and communal water supply (Table 2).

Table 2: St. Marys Cement PTTW Details

Permit No.	Supply ID	Purpose	Source	Open Interval (mbgs)	Maximum Permitted Taking (m^3/day)	Average Reported Taking (m^3/day)[2]
5440-8YFHPP	North Quarry Sump	Dewatering	Dundee / Lucas Aquifers	Shallow Sump	30,240	10,757
5440-8YFHPP	South Quarry Pond	Dewatering	Dundee / Lucas Aquifers	Shallow Pond	10,000	4,461
7810-ARSLPG	Pond	Aggregate Washing	Unknown	Shallow Pond	10,902	Unknown
5440-8YFHPP	Deep Well 3	Cooling Water	Dundee / Lucas Aquifers[1]	Unknown	4,355	1,184
5440-8YFHPP	Deep Well 4	Cooling Water	Dundee / Lucas Aquifers[1]	Unknown	3,892	2,444
5440-8YFHPP	Deep Well 5 (5002282)	Cooling Water	Dundee / Lucas Aquifers	4.6 to 50.3	4,091	0
5440-8YFHPP	Garage Well	Communal	Bedrock[2]	Unknown	10	0.75
5440-8YFHPP	Crusher Well	Communal	Bedrock[2]	Unknown	2	0.125

1. Assumed based on Deep Well 5 information.
2. 2017 average as reported in Wood, 2018.

The Thomas St. Quarry is a below-water operation and requires dewatering of surface water and groundwater that accumulates within the quarry through direct precipitation on the quarry footprint or seepage into the quarry through the quarry walls. This dewatering allows for safe and efficient mining operations. Water ingress is conveyed to the North Quarry Sump (“Source 6”) and thereafter discharged into the nearby Thames River. As indicated in Table 2, the average withdrawal of 10,757 m^3/d from the North Quarry Sump is the largest water taking at the SMC operation.

Similarly, the South Quarry is dewatered by maintaining desired water levels in the South Quarry Pond (Source 7). Whereas the South Quarry Pond receives groundwater and surface water influx, it also takes excess water from the kiln plant.

Three groundwater sources support operation of the kiln plant, which requires a steady supply of water for cooling and clinker production. Water for the kiln plant is taken from two onsite bedrock wells near the plant, namely Deep

Well 3 and Deep Well 4. In addition, Deep Well 5, located south of the plant, is maintained as a backup and fire suppression well. These sources draw water from the deeper bedrock aquifers in the area. After use, the excess water from the kiln plant is then discharged to the South Quarry Pond.

2.5.2.2 Town of St. Marys

The Town of St. Marys is serviced by three municipal supply wells (Table 3). The closest well to the Site, Well 3, lies approximately 2.2 km to the east-northeast (Figure 2.7). The wells are inferred to draw from the Dundee and Lucas Formation unit aquifers based on open hole interval depth.

Table 3: Town of St. Marys PTTW Details

Permit No.	Supply ID	Purpose	Source	Open Interval (mbgs)	Maximum Permitted Taking (m³/day)	Average Reported Taking (m³/day)[1]
5303-AASQEC	Well 1 (5001709)	Municipal	Dundee / Lucas Aquifers	12.3 to 45.7	5,184	1,099
5303-AASQEC	Well 2A (5005984)	Municipal	Dundee / Lucas Aquifers	18 to 46	5,184	1,120
5303-AASQEC	Well 3 (5003118)	Municipal	Dundee / Lucas Aquifers	12.3 to 47.6	5,184	495

[1] Average water use in 2017 as per Ontario Clean Water Agency, 2018.

2.5.2.3 Maple Leaf Foods

The Maple Leaf Foods food processing operation is serviced by two industrial supply wells (Table 4). The closest well to the Site, MECP Well ID 5001485, lies approximately 450 m to the northwest whereas the second well, MECP Well ID 5002264, is located approximately 780 m to the west of the Site (Figure 2.7). The wells are inferred to span Dundee and Upper / Lower Lucas geologic formations based on open hole interval depth. However, prior assessment has inferred that the main water bearing unit supplying these wells is likely the Lower Lucas Formation (Lower Zone) based on examination of water levels (Golder, 2012).

Table 4: Maple Leaf Foods PTTW Details

Permit No.	Supply ID	Purpose	Source	Open Interval (mbgs)	Maximum Permitted Taking (m³/day)	Average Reported Taking (m³/d)[1]
2834-9XKR9R	5001485	Industrial	Lower Lucas Aquifer	41.8 to 111.2	3,864[2]	950
2834-9XKR9R	5002264	Industrial	Lower Lucas Aquifer	45.7 to 102.1	3,864[2]	357

[1] 2009 estimated water use per Matrix, 2014.

[2] Combined taking from both sources not to exceed 3,864 m³/day.

2.6 Source Water Protection Considerations

The Site is located within the Upper Thames River Source Protection Area. Source water protection planning for the Region is governed by the Thames-Sydenham Region Source Protection Plan (SPP). Technical aspects of the SPP are documented in the *Upper Thames River Source Protection Area Assessment Report* (Thames-Sydenham Source Protection Committee, 2015), which is designed to meet the requirements of the *Technical Rules: Assessment Report (*Ministry of Environment and Climate Change, 2009). The SPP and Assessment Report may be accessed via the website: https://www.sourcewaterprotection.on.ca/approved-source-protection-plan.

The Technical Rules define three types of groundwater "vulnerable areas" wherein special source water protection considerations apply: 1) Significant Groundwater Recharge Areas (SGRAs); 2) High Vulnerability Aquifers (HVAs); and 3) Wellhead Protection Areas (WHPAs).

- **SGRAs:** According to the Technical Rules, an SGRA is an area that annually recharges water to the underlying aquifer at a rate that is greater than the rate of recharge across the whole of the related groundwater recharge area by a factor of 1.15 or more; or, the area that annually recharges a volume of water to the underlying aquifer that is 55% or more of available surplus. Whereas most of the northern half of Upper Thames watershed is not SGRA, a portion of the Site – that roughly corresponding to the sand and gravel deposits within the southern half of the Site– is classified as SGRA (see Map 4-2-1 of the SPP). As will be discussed in later sections, the water table is inferred to exist below the overburden in this area. As such, the recharge would ultimately report to the bedrock aquifer and either be captured by the Thomas St. quarry dewatering (and eventually discharged to the Thames River) or flow downgradient (westerly) within the regional system.
- **HVAs:** According to the Technical Rules, the vulnerability of an aquifer may be assessed using a quantitative analysis such as the calculation of intrinsic susceptibility index, aquifer vulnerability index, surface to aquifer advection time, or surface to well advection time. Each approach is in some way related to groundwater time of travel; in other words, vulnerability increases as the time for a surficial contaminant to reach the water table (or shallowest significant aquifer) decreases. HVA mapping bears some similarity to the aforementioned SGRA distribution at a regional scale, although only the extreme southeast corner of the Site is classified as HVA (See Map 4-3-2 of the SPP). However, as the water table is inferred to be below the overburden in this area, the sand and gravel deposit is not considered an "aquifer" and any HVA designation is likely not warranted on-Site.
- **WHPA-Q1/Q2:** According to the *Technical Rules,* WHPA-Q1 is the combined area that is the drawdown cone of influence of a municipal well plus the whole of the cones of influence of all other wells that intersect that area and any surface water drainage area upstream of, and including, a losing reach of a stream that contributes a significant portion of surface water to the wells. WHPA-Q2 is the area defined in WHPA-Q1 and any area outside the WHPA-Q1 where a future reduction in recharge would have a measurable impact on the municipal wells. Note that WHPA-Q1/Q2 are not related to time of travel capture zone-based WHPA-A,B,C,D (see below).

  WHPA-Q1/Q2 are intended to be protective of water quantity. In other words, an increase in water taking or decrease in recharge within these WHPAs may cause a heightened risk to maintaining water supply at the associated well(s). According to mapping in the *Tier Three Water Budget and Local Area Risk Assessment*

Town of St. Marys (Matrix, 2014) both the Thomas St. Quarry and the Site lie within the St. Marys municipal well's WHPA-Q1/Q2.

It is our understanding that the Tier Three groundwater model calibration considered the Thomas St. quarry layout circa 2009 with a floor elevation of 277 masl (Matrix, 2014). This resulted in a reported simulated quarry inflow of 4,110 m^3/d. For the predictive scenario analysis used to develop the WHPA Q1/Q2, the quarry footprint appeared to remain the same but the floor was deepened to 270 masl. The quarry inflow rate was not explicitly reported under this scenario.

- **WHPA-A,B,C,D:** WHPA-A, B, C, and D are based on water supply well time-of-travel capture zones as follows:
  - WHPA-A: 100 metre radius around well;
  - WHPA-B: less than or equal to 2-year time of travel;
  - WHPA-C: between 2-year and 5-year time of travel;
  - WHPA-D: between 5-year and 25-year time of travel.

These WHPAs are intended to be protective of well water quality. In other words, a chemical or pathogen that enters the groundwater system within these WHPAs has a heightened probability to be captured by the associated water supply well. The closest WHPA-A,B,C or D to the Site lies over 2 km to the northeast at the Town of St. Marys wellfields as shown on Map 4-1-21 of the SPP.

3.0 FIELD INVESTIGATIONS

The hydrogeological and hydrological conditions at the Site were evaluated through a series of field investigations carried out between 2017 and 2019. The overall field program included test pitting and grain size analysis, drilling, borehole logging, geophysical logging, hydraulic (packer) testing, water level monitoring, water quality sampling, private water well survey and hydrologic site reconnaissance. The subsequent sections describe field methodology and results.

3.1 Overburden Test Pitting and Grain Size Analysis

3.1.1 Methodology

An overburden test pitting program was conducted as part of the original resource evaluation on the southern half of the Site to outline the potential gravel resource. Nineteen test pits (TP17-01 to TP17-18 and TP17-20) were excavated in November 2017 by a track mounted excavator supplied and operated by SMC. The test pits ranged in depth from approximately 3.8 to 5.1 mbgs. . . Test pit locations were recorded in the field with a handheld GPS. The test pits were photographed and logged in the field by a Golder Technician. Upon completion the pits were backfilled, and the topsoil was replaced. A total of 35 representative granular samples were collected from the test pits and stored on the SMC site for submission to the SMC internal laboratory.

3.1.2 Results

Test pit locations, logs and grain size distribution curves are provided in Appendix B. It should be noted that the test pitting was restricted to the southern portion of the property, which exhibits a different surficial geology than the northern half (predominantly till). During test pitting, the shallow stratigraphy was noted as sandy silt to silty sand in the first metre with the subsurface material becoming progressively coarser (gravelly) with depth. . .

The hydraulic conductivity of coarser-grained material, such as that found on-Site, may be estimated from the laboratory derived grain size distribution curves using the commonly employed Hazen Method as follows (Fetter, 2001):

$$K = C\,(d_{10})^2$$

Where:

- K is hydraulic conductivity in m/s;
- C is an empirical coefficient, which takes a value between 0.8 and 1.2 for medium to coarse sands (1.0 is used herein); and
- d_{10} is the diameter of the 10th percentile grain size of the material (effective grain size) in mm.

The 35 grain size distribution curves were assessed in order to provide an understanding of the saturated hydraulic conductivity of the granular overburden at the south of the Site. In summary, the Hazen Method calculations yielded hydraulic conductivities ranging from 6E-5 m/s to 5E-3 m/s with a geometric mean of 2E-3 m/s.

3.2 Borehole Drilling and Logging

3.2.1 Methodology

Nine Site boreholes (Figure 3.1) were advanced in 2017 as part of the geologic characterization of the site (see Appendix B). Of the nine boreholes, five were advanced using coring (“BH”-series) whereas the remaining four (“MW”-series) were advanced using mud/air rotary drilling methods. The boreholes were designed to assess geologic conditions within the Overburden, Dundee, Upper Lucas and Lower Lucas Formations. These holes are now implemented as bedrock groundwater monitors, providing Site-wide inference of both geologic and groundwater conditions in support of this Level 1 /2 Hydrogeology and Hydrology Study.

3.2.1.1 Cored Boreholes

Five cored boreholes (BH17-01, BH17-02, BH17-03, BH17-04 and BH17-05) were advanced between October 30, 2017 and November 30, 2017. Drilling was undertaken by Orbit Garant Drilling Services Inc. (Orbit Garant) using a track mounted Acker Soil-Max rig. Drilling was supervised in the field by a Golder technician who was responsible for documentation of drilling procedures and events such as rod drops or flush water loss, sequential placement of core and accurate meterage in the core trays on a per run basis, geotechnical logging of core indices (e.g., Total Core Recovery, Solid Core Recovery, Rock Quality Designation, fracture frequency) and providing a preliminary lithological log of the boreholes as they were advanced, including identifying limestone and dolostone based on a 10% hydrochloric acid (HCl) response as the core was recovered.

Soil sampling was carried out in overburden materials from BH17-01 to BH17-03, where possible, using a 0.61 m long, 50 mm diameter stainless steel split spoon sampling system. In many cases, the sampling spoon could not advance due to presence of gravel and cobbles. A steel HW casing with a cutting shoe was advanced through the overburden at each of the boreholes. At BH17-01 to BH17-04, the HW casing was set approximately 1 m into bedrock and cement grouted to ground surface. The overburden at BH17-05 was drilled with a tri-cone bit by McLeod Water Wells using mud rotary techniques, and a 0.2 m outer diameter steel casing was set at bedrock and cement grouted to ground surface. Therefore, at BH17-05 the HW casing (required for HQ coring) was later advanced by Orbit approximately 1 m into bedrock, without being cemented. The five cored boreholes were advanced through the HW casing into the limestone bedrock using an HQ wireline coring system in 1.5 m runs to the targeted depths. The wells were completed as open holes in bedrock with locked above ground protective casings.

Upon completion of each borehole, the core was lithologically logged in detail by R. Blair Geoscience Consulting Inc. (RBGC) in the SMC Thomas St. Quarry vehicle bay.

3.2.1.2 Rotary Drilled Holes

The four rotary holes (MW17-01, MW17-02, MW17-03, MW17-04) were advanced between November 21 and 24, 2017. Drilling was undertaken by McLeod Water Wells Ltd. using a mud/air rotary rig. Drilling was supervised in the field by a Golder technician who was responsible for documentation of drilling procedures and collection of chip samples at 0.9 m intervals for field screening with 10% HCl to identify the base of the limestone. Air lifted groundwater strikes and yields were also noted.

Mud rotary drilling techniques were used to tri-cone through the overburden and advance a 6-inch steel casing approximately 1 m into bedrock. Air rotary drilling techniques were used to tri-cone into rock between 53.4 and 85.5 mbgs to the target depth of 5 m below the first karst gypsum aquifer horizon. The wells were completed as open boreholes with locked above ground protective casings. Upon completion, wells were air lifted for approximately one hour to gauge the yield and develop the well.

3.2.1.3 Geophysics

To assist with stratigraphic correlation and assessing the fracture network, Golder ran downhole geophysics in the nine boreholes during January 2018. The logging included natural gamma, apparent conductivity, optical televiewer and caliper techniques.

The geophysical interpretation was carried out by R. Blair Geoscience Consulting Inc (RBGC). The interpretation also took into consideration one cored borehole (BH-3) drilled in 2010 on the west boundary of the Thomas St. Quarry directly adjacent to the Site and a rotary drilled monitoring well (MW13-01) drilled in 2013 on the Thomas St. Property, adjacent to the north boundary of the Site (Figure 1.1). The geophysical signatures were correlated with the detailed lithological logging of the cored boreholes which was then used to interpret the stratigraphic sequence encountered in the monitoring wells.

3.2.2 Results

Detailed borehole logs are provided in Appendix B with a summary of completion details listed below in Table 5. Geological and geophysical results are plotted on cross-sections Figure 3.2 and Figure 3.3. The results of the natural gamma, apparent conductivity, optical televiewer and caliper logs are provided in Appendix C.

Table 5: Borehole Summary

ID	Drilling Method	Hole Diameter (m)	Easting	Northing	Ground Elevation (masl)	Depth (mbgs)	Depth to Bedrock (mbgs)	Formations Encountered
BH17-01	Coring	0.096	485,898	4,787,643	299.58	35.18	7.52	Overburden, Dundee, Upper and Lower Lucas (Upper Zone)
BH17-02	Coring	0.096	485,674	4,787,714	300.57	42.70	9.85	Overburden, Dundee, Upper and Lower Lucas (Upper Zone)
BH17-03	Coring	0.096	485,704	4,788,206	320.69	57.58	26.38	Overburden, Dundee, Upper and Lower Lucas (Upper Zone)
BH17-04	Coring	0.096	485,884	4,788,423	321.76	50.09	25.73	Overburden, Dundee, Upper and Lower Lucas (Upper Zone)
BH17-05	Coring	0.096	485,747	4,787,931	304.36	50.19	12.19	Overburden, Dundee, Upper and Lower Lucas (Upper Zone)
MW17-01	Rotary	0.156	485,483	4,788,470	322.49	85.50	26.5	Overburden, Dundee, Upper and Lower Lucas (Upper+Lower Zone)
MW17-02	Rotary	0.156	485,540	4,787,990	305.65	61.00	14.6	Overburden, Dundee, Upper and Lower Lucas (Upper+Lower Zone)
MW17-03	Rotary	0.156	485,617	4,787,503	297.93	65.50	9.5	Overburden, Dundee, Upper and Lower Lucas (Upper+Lower Zone)
MW17-04	Rotary	0.156	485,853	4,787,404	296.73	53.40	4.6	Overburden, Dundee, Upper and Lower Lucas (Upper+Lower Zone)

Notes:

[1.] Top of pipe and ground surface elevations surveyed by Archibald, Gray and McKay Ltd. (AGM) on December 19, 2017.

[2.] Elevations provided in metres above sea level (masl) and depths provided in metres below ground surface (mbgs).

3.2.2.1 Overburden

The composition of the overburden varies from sand and gravel beneath portions of the southern half of the property to clayey silt/silty clay till beneath the northern half; this is consistent with the previously described regional surficial geology mapping (Figure 2.2). The surface topography of the southern half of the Site varies in elevation from approximately 298 masl to 306 masl then rises comparatively steeply to 320 masl to 322 masl. This rise in elevation beneath the north half of the Site aligns with an increase in overburden thickness from approximately 4.5 m to 12 m in the southern half of the site to approximately 26 m beneath the northern half (Figure 2.3).

3.2.2.2 Dundee Formation

The Dundee Formation forms the top of the bedrock surface, declining approximately 12 m across the site from 296 masl in the northeast corner to 284 masl in the southwest corner of the property (Figure 2.5). Thickness varies between 13.5 m to 18.0 m with an average of 16.8 m; the observed variations in thickness are attributed to the ancient erosional actions at the bedrock surface. The Dundee Formation is comprised of limestone that is light brownish grey, fine to medium grained crystalline, non-porous to faintly porous, thinly to thickly bedded fossiliferous limestone with weakly to moderately developed stylolites, fine argillaceous partings (0.05 mm) and scattered pelecypod, crinoid ossicle and rugosa coral fossils.

3.2.2.3 Upper Lucas Formation

The Upper Lucas Formation underlies the Dundee Formation. Thickness varies between 8.3 m and 9.5 m with an average of 9.1 m; these findings are consistent with the thickness encountered at the adjacent Thomas St. Quarry. The rock sequence is comprised of limestone that is light to medium tan brown, very fine to medium grained, faintly to moderately porous to pitted, faintly petroliferous, very thinly to medium bedded varying in texture from laminar stromatolitic, oolitic, slump brecciated to massive bedded. Some sections are friable, notably the oolitic limestone.

3.2.2.4 *Lower Lucas Formation*

The Lower Lucas Formation underlies the Upper Lucas Formation. The contact between the Upper and Lower is taken at the first occurrence of the semi-continuous dolostone sequence (Figure 3.1). The Lower Lucas Formation is dolostone that is predominately light brown to brownish grey, porous, thinly to medium bedded with interbeds of calcareous dolostone and limestone.

A weathered karst gypsum and dolostone layer approximately 0.5 to 0.75 m thick occurs approximately 9 to 10 m beneath the Upper/Lower Lucas Formation contact (i.e. Lower Lucas “Lower Zone”) (Figure 3.1). The layer is evident in the optical televiewer logs as a weathered horizon. This specific karst gypsum horizon forms a laterally continuous aquifer beneath the area from which the Town of St. Marys pumps much of its water supply from.

3.3 Hydraulic (Packer) Testing

3.3.1 Methodology

Hydraulic (packer) testing was conducted in the five cored boreholes to measure hydraulic conductivity of the saturated bedrock formations encountered. The packer testing was supervised by Golder and conducted by drilling contractor Orbit Garant between May and June 2018.

Testing was undertaken using pneumatic packers (Wireline Packer Type II) lowered through HQ rods. The packers were inflated with nitrogen gas through an inflation line. The locations for the packer seats were selected after reviewing the core photos and optical televiewer imagery. For the double packer array, a 5 m test interval was chosen. The bottom of each borehole was tested with a single packer array, and as such the bottom packer interval length varied between 3.3 and 6.2 m, based on where the single packer was inflated in relation to the bottom of the hole. For each subsequent test interval, a double packer array was used.

A Level Troll data logger was placed within the test interval to measure the water level and an RST vibrating wire data logger was lowered inside the rods above the packer array to obtain real-time water level measurements within the test interval. A Diver data logger was placed below the test interval to check for lower packer bypass. The condition of the rods (including threads) were inspected and the length of the rods and packer tool was measured. An initial rod leakage test was conducted and the same rods were used for each subsequent hole.

The packer testing procedure was as follows:

- **Pressure Static Recovery -** After packer inflation, the pressure recovery to hydrostatic level was monitored for at least 30 minutes. If the water level did not reach steady state conditions after 30 minutes, the period was extended for up to 60 minutes. A casing seal test was performed prior to commencing each injection by adding water in the annulus between the HW casing and the HQ rods and monitoring the pressure, to look for packer bypass.
- **Diagnostic Phase (Slug Injection) –** An initial slug injection test (at least 10 m head change within approximately 30 seconds) was performed within each test interval to determine the magnitude of transmissivity. If the recovery was incomplete after 30 minutes, monitoring continued for a total of 60 minutes. If full recovery was achieved within 30 minutes (relatively high transmissivity) then additional testing was conducted at this interval.

- **Additional Testing Phase for High Transmissivity Test Intervals -** If full recovery from the slug injection was achieved within 30 minutes, a constant rate injection (CRI) test was conducted over a 30 minute period. An injection head was attached to the top of rods and the pressure and flow rate were monitored using a flow meter totalizer. Following the CRI, the recovery was monitored.

Hydraulic conductivity of each test interval was estimated using standard steady-state analysis methods. The slug injection results were analyzed using the Hvorslev method (Hvorslev, 1951) and the CRI results were analyzed using the Thiem steady-state equation (Thiem, 1906; Kruseman and de Ridder, 1994).

3.3.2 Results

The hydraulic conductivity (K) estimates obtained from packer testing in saturated bedrock encountered in BH17-01 to BH17-05 are provided in Table 6, and the analysis sheets are included in Appendix D.

Table 6: Packer Testing Results

Borehole No.	Ground Surface Elevation (masl)	Test #	Test Date	Test Interval (masl)	Bedrock Formation	Interval Static Water Level (masl)	Test Type	K (m/s)
BH17-01	299.58	1	01-Jun-2018	269.42 - 264.38	Upper Lucas, Lower Lucas	279.41	CRI	1E-5
		2	04-Jun-2018	274.27 - 269.16	Upper Lucas	280.41	FHT	4E-8
		3	04-Jun-2018	279.32 - 274.22	Dundee, Upper Lucas	280.48	FHT	7E-7
BH17-02	300.57	1	04-Jun-2018	263.31 - 258.15	Lower Lucas	279.84	CRI	1E-5
		2	05-Jun-2018	267.76 - 262.66	Upper Lucas, Lower Lucas	280.62	CRI	1E-6
		3	05-Jun-2018	272.81 - 267.71	Upper Lucas	***285.73***	FHT	3E-7
		4	05-Jun-2018	277.86 - 272.76	Dundee, Upper Lucas	283.10	CRI	5E-6
		5	06-Jun-2018	282.91 - 277.81	Dundee	284.93	FHT	2E-8
BH17-03	320.69	1	29-May-2018	266.4 - 263.09	Lower Lucas	277.19	FHT	7E-6
		2	29-May-2018	272.37 - 267.27	Upper Lucas, Lower Lucas	277.34	CRI	5E-6
		3	30-May-2018	278.13 - 273.03	Dundee, Upper Lucas	279.81	CRI	2E-6
BH17-04	321.76	1	30-May-2018	277.9 – 274.16	Upper Lucas	***294.19***	FHT	1E-7
		2	31-May-2018	283.7 - 278.6	Dundee/ Upper Lucas	***291.77***	FHT	1E-7

Borehole No.	Ground Surface Elevation (masl)	Test #	Test Date	Test Interval (masl)	Bedrock Formation	Interval Static Water Level (masl)	Test Type	K (m/s)
		3	31-May-2018	288.7 - 283.6	Dundee	***292.36***	FHT	3E-7
BH17-05	304.36	1	24-May-2018	260.54 - 255.46	Lower Lucas	277.93	CRI	8E-6
		2	25-May-2018	264.97 - 259.87	Lower Lucas	279.45	CRI	9E-6
		3	25-May-2018	270.01 - 264.91	Upper Lucas, Lower Lucas	279.26	CRI	9E-6
		4	28-May-2018	275.12 - 270.02	Upper Lucas	280.54	FHT	2E-6
		5	28-May-2018	278.28 - 273.18	Dundee, Upper Lucas	280.00	CRI	8E-6

Notes:
###.## (bold, italics) - indicates water level was still dropping or recovering after 60 minutes.

Based on the above results:

- The hydraulic conductivity estimates for test intervals within the Lower Lucas formation ranged from 1E-5 m/s to 1E-6 m/s, with a geometric mean of 7E-6 m/s.
- The hydraulic conductivity estimates for test intervals within the Upper Lucas formation ranged from 1E-5 m/s to 4E-8 m/s, with a geometric mean of 1E-6 m/s.
- The hydraulic conductivity estimates for test intervals within the Dundee formation ranged from 8E-6 m/s to 2E-8 m/s, with a geometric mean of 6E-7 m/s.

Prior testing at the Thomas St. Quarry (Golder, 2012) exhibited similar results to the above, although it is noted that the maximum hydraulic conductivity measured in Lower Lucas (8E-4 m/s), Upper Lucas (1E-4 m/s) and Dundee (1E-5 m/s) formations were all significantly greater than the upper limits measured during the current work. These prior upper ranges are considered in the model calibration (Section 5).

3.4 Groundwater Level Monitoring

3.4.1 Methodology

Groundwater monitoring is conducted in all nine boreholes to establish groundwater levels across the Site. Manual water level probe measurements were taken in December 2017 upon completion of the drilling program. Dataloggers were later installed in each borehole in July 2018. The loggers are set to record pressure (effectively hydraulic head after post-processing) and temperature every 30 minutes. Quarterly monitoring events have proceeded since July 2018 with both manual groundwater levels and datalogger downloads collected during each event. Subsequent to download, datalogger water levels (head readings) from the past quarter are adjusted in accordance with manual water level readings and post-processed to account for changes in atmospheric pressure as indicated by an on-Site barometric datalogger.

Water level monitoring within the open boreholes is expected to provide a quasi "averaging" of the hydraulic head within the combined saturated hydrostratigraphic sequence. The characterization of the *saturated* bedrock system is a primary focus in this Study as this is where any significant groundwater impacts as a result of quarry dewatering would be expected to occur. However, boreholes BH17-01, BH17-02, BH17-03, BH17-05, MW17-02, MW17-03 and MW17-04 appear to intersect both unsaturated and saturated flow systems as cascading flow was audibly observed within their annulus. In other words, a relatively shallow, "perched" fracture(s) was inferred to be discharging water into the borehole above the underlying saturated system. Under these conditions the water level probe would often signal two water level readings – the first being the perched fracture, the second being the underlying saturated system. A clear separation between the two readings was occasionally difficult to demarcate given the sensitivity of the probe and thus the true depth to saturated conditions could not be exactly determined. It followed that datalogger hydrographs were only adjusted to manual readings where the saturated system was established with confidence.

3.4.2 Results

Measured groundwater elevations are summarized in Table 7 and datalogger hydrographs are provided on Figure 3.4. In addition, seasonal high (April 2019) and low (July 2019) manual water levels are plotted for each borehole in plan view on Figure 3.5.

Table 7: Measured Groundwater Elevations

Well ID	Top of Pipe Elevation (masl)[1,2]	Ground Surface Elevation (masl)[1]	Groundwater Elevation (masl)					
			19-Dec-2017	19-Jul-2018	10-Oct-2018	14-Jan-2019	09-Apr-2019	15-Jul-2019
BH17-01	300.65	299.58	279.72	279.45	279.18	280.66	281.64	280.89
BH17-02	301.47	300.57	284.09	284.86	289.41	289.48	289.48	286.76
BH17-03	321.79	320.69	276.92	276.78	277.28	277.52	278.44	278.60
BH17-04	322.87	321.76	293.12	294.02	294.89	294.71	290.70	288.90
BH17-05	305.04	304.36	279.44	283.68	285.26	285.39	288.09	285.45
MW17-01	323.15	322.49	274.84	274.76	275.34	275.34	275.69	275.87
MW17-02	306.26	305.65	276.41	276.69	277.41	276.97	277.67	277.87
MW17-03	298.58	297.93	281.48	281.71	283.18	285.50	285.68	286.05
MW17-04	297.39	296.73	281.00	281.21	281.09	282.57	283.03	282.66

Notes:

1. Top of pipe and ground surface elevations surveyed by AGM on December 19, 2017.
2. "masl" = meters above mean sea level.

These data and illustrations allow for the following commentary:

- Based on manual water levels, bedrock groundwater elevation ranges from a high of approximately 290.7 masl at BH17-04 during April 2019 to a low of 274.8 masl at MW17-01 during July 2018 (Figure 3.4). As a result of the Site's considerable change in topographic relief, measured depth to water ranges from as shallow as 11.1 m at BH17-02 to as deep as 47.4 m at MW17-01. All of the water levels reside beneath the overburden / rock contact.
- During the period of record, water levels range with approximately +/- 2 m at most boreholes (Figure 3.4).

- The highest groundwater elevations occur within April to June 2019, likely in response to the spring freshet, with subsequent water level decline into summer (Figure 3.4). Notably, the BH-series holes generally reach their water level apex in the early spring whereas the MW-series holes peak towards late spring / early summer. A primary differentiator between these two borehole groupings is their depth: the BH-series holes terminate within the upper zone of the Lower Lucas Formation (aquitard) whereas the MW-series holes terminate within the lower zone of the Lower Lucas Formation (aquifer). It may be that the overall hydraulic head in the MW-series holes is dictated by the deep aquifer such that responses to gradual infiltration of snowmelt are relatively delayed.
- A significant water level rise is uniquely observed at BH17-01, BH17-02, MW17-03 and MW17-04 after two large storm events on October 31 and November 1, 2018 (Figure 3.4). Thereafter, the water levels at these wells begin to slowly decline until another large precipitation event occurred in late November, whereupon the water levels are seen to rise again. These four wells are all located within the sandy southern portion of the property, downhill from the till mound to the north. It is speculated that Site-wide surplus generated from larger precipitation events is at least partially being infiltrated within the southern portion of the property where ground conditions are more amenable to facilitating recharge, thus causing water levels to rise more pronouncedly at this location.
- Groundwater sampling occurred during January 16 – 24, 2019. The well purging appears to have had a significant effect on water levels at some boreholes, with post-sampling recovery taking on the order of a month (Figure 3.4). In the case of BH17-04, water levels appear to have not recovered after five months, perhaps suggesting the pre-sampling water level may not have been indicative of true static.
- It is inferred that regional bedrock groundwater flow patterns are generally westerly in direction (see Figure 2.6 and also AquaResource, 2012); however, a similar trend could not be entirely established on-Site based on the borehole water levels (Figure 3.5). Whereas there does appear to be a component of Site flow that is westerly, there also appears to be a northerly component to flow, particularly in the MWs-series holes along the western flank where over 6 m of water level decline occurs from the south to north property limits. It may be that these deep MW-series wells, which intersect the Lower Lucas lower zone aquifer, are within the zone of influence of the Maple Leaf Foods wells to the northwest.
- The Thomas St. Quarry, which is dewatered to an elevation of approximately 274 masl, does not appear to exert a strong influence on water levels at the Site as boreholes on the eastern flank of the Site have water levels 5 m or more greater than that of the quarry floor. It is notable that long-term monitoring at the Thomas St. Quarry (Amec Foster Wheeler, 2017) has shown bedrock wells within the quarry setback with water levels 8 m greater than the quarry floor.
- The Thames River water level adjacent to the Site ranges in elevation from approximately 296 masl (upstream) to 292 masl (downstream) based on a survey done in summer 2019 (Delph and Jenkins, 2019). The closest borehole to the River, MW17-04, exhibits water levels at least 10 m lower than River water level. It is thus speculated that the Thames River has little influence on Site water levels and the saturated groundwater system lies within the bedrock and below the Thames River in this area. Note that such observations are not exclusive to the Site area; as mentioned in Section 2.4.2 a regional inspection of individual bedrock wells within 200 m of the Thames reveals bedrock water levels are lower (10 m+) than nearby river (i.e. DEM) levels. These observations suggest that, at a regional scale, the bedrock aquifer has a poor hydraulic connection to the Thames River.

The effect of the aforementioned perched fracture discharge on water levels in BH17-01, BH17-02, BH17-03, BH17-05, MW17-02, MW17-03 and MW17-04 should be considered in interpreting any results. As mentioned previously, the transmissivity of the saturated system within the borehole is sufficient to maintain some separation between the perched fracture(s); however, this does not mean that the water level in the borehole is not in some way affected. There is the potential that the measured saturated water levels in these holes are potentially greater than what would be measured had the perched fracture not existed. Relatedly, it could be expected that the hydrograph of these perched fracture holes would be more sensitive to recharge events and thus lead to a more “erratic” water level pattern or trend deviation. . .

3.5 Groundwater Quality Sampling

3.5.1 Methodology

Groundwater samples were collected from eight monitoring locations to characterize baseline groundwater quality at the Site. Samples were collected from BH17-01, BH17-02, BH17-04 and BH17-05 using a Grundfos Redi-Flo2 submersible pump with 5/8-inch LDPE polyethylene tubing. For the larger diameter wells (MW17-01 to MW17-04), a Grundfos Redi-Flo3 submersible pump with 1-inch HDPE polyethylene tubing was used. Sampling at BH17-03 was attempted but due to a downhole obstruction (inferred to be loose rock) the sampling equipment could not be sufficiently lowered into the hole.

Three well volumes were purged from each monitoring location prior to sampling. At BH17-04, the well went dry after purging one well volume and therefore samples were collected without additional purging, once the well began to recover. Conductivity, pH and temperature parameters were measured during purging.

The samples were submitted under chain of custody procedure to Maxxam Analytics (now Bureau Veritas Canada) for analysis of a suite of water quality parameters including general chemistry, nutrients, metals, inorganics and petroleum hydrocarbons. Monitoring locations MW17-01 to MW17-04 were also sampled for *E. Coli* and total coliforms. A blind duplicate sample was collected for all parameters at MW17-02.

3.5.2 Results

Groundwater quality results are presented in Table E.1 to E.3 (Appendix E) and the laboratory certificates of analysis are also included in Appendix E.

The analytical results were compared to the O. Reg 169/03 Ontario Drinking Water Quality Standards (ODWS), amended December 2016. Results were also compared to the ‘Table 2’ groundwater standards from the MECP “Soil, Groundwater and Sediment Standards for Use under Part XV.1 of the Environmental Protection Act”, dated April 2011 (MECP Table 2 Standards).

Hardness values ranged between 73 and 300 milligrams per litre (mg/L) as calcium carbonate ($CaCO_3$) and were all outside the corresponding ODWS operational guideline of 80 to 100 mg/L as $CaCO_3$. Hardness is often found to be naturally elevated in groundwater in the region, relative to the ODWS criteria (Singer, 2003).

Total coliforms measured in samples collected from MW17-01, MW17-02 and MW17-03 were reported as 0, 5 and 27 colony forming units per 100 millilitres (CFU/100mL), respectively; and, *E. Coli* concentrations were reported as 0 CFU/100mL for MW17-01 to MW17-03. A “NDOGT” qualifier was reported for MW17-04 indicating “no data due to overgrowth, total coliforms and/or *E. Coli* detected”. The ODWS standard for Total Coliforms and *E.Coli* is “not detectable”. The presence of coliforms in is likely related to the application of manure on farm fields.

Nitrate concentrations in groundwater samples collected from BH17-01 (11.7 mg/L) and BH17-02 (10.7 mg/L) were above the ODWS maximum acceptable concentration of 10.0 mg/L. Elevated nitrate concentrations are likely related to the application of fertilizer on farm fields.

None of the other groundwater parameters analyzed were detected at concentrations greater than the applicable MECP Table 2 Standards or ODWS criteria.

3.6 Water Well Inventory (Domestic Well Survey)

3.6.1 Methodology

A door-to-door survey of residential properties within one kilometer of the Site was conducted to document the approximate location and construction of existing water wells and establish baseline groundwater conditions at the wells.

Prior to the survey, a review of the MECP Water Well Information System database (WWIS) was conducted to obtain documented water well records within one kilometre of the Site (Figure 3.6). Information such as well depth, water depth, and well yield are considered in this assessment.

Next, a list of municipal addresses of properties within one kilometer of the Site was compiled from the Perth County interactive mapping website. A total of 48 residential addresses were found; however, upon ground-truthing it was found that the 48 addresses corresponded to 46 active properties. . .

On April 2, 2019, a notification letter from SMC with attached survey was hand delivered by Golder to each accessible residence in the study area to request their participation in the well survey and to provide details on the date and time that a follow-up visit was scheduled. A copy of the survey package is included in Appendix F. The survey included questions regarding well completion/construction, water usage, adequacy of supply, and previous or existing water quality issues. The option was also provided to submit the responses by mail (pre-paid postage provided). A follow-up visit was carried out on April 9, 2019.

3.6.2 Results

Ultimately, of the 46 properties visited, a response was received from 23 properties and an additional 8 properties were observed to have wells where no survey response was received. Field identified wells are shown on Figure 3.6. The survey results are summarized in Table F.1 (Appendix F) with the following noted:

- The survey identified 18 active wells and one inactive well within one kilometre of the Site. All wells were used for domestic purposes and in some instances were also used for farming/livestock/barn. An additional 8 properties were observed to have wells where no survey response was received.
- The active wells were drilled to depths ranging between approximately 24 mbgs and 116 mbgs.
- Three active wells were identified as dug wells, all of which were located at 1930 Perth Road 139, installed between 6 and 11 mbgs and have an associated dug pond for increased capacity. Three additional wells (status unknown) were visually identified at 1738 Perth Road 123, 1760 Perth Road 123 and 1801 Perth Road 139; however, survey responses were not received.
- Multiple well owners indicated the well on their property was previously replaced/deepened due to water quantity issues.
- No well owners indicated issues related to water quality.

- In addition to the 17 active domestic wells identified in the vicinity of the Site, there is also an existing domestic well location on-site. During a Site visit, a damaged water well (concrete casing) was observed adjacent to the barn. In addition, a well in a metal casing was noted adjacent to the southeast corner of the house and was observed to be connected to the water pump in the basement of the house.

Lastly, it is our understanding that no well interference complaints have been received by SMC during 2019.

3.7 Surface Water Reconnaissance

A Site visit was completed to confirm the catchment divides, surface water features, land uses and general site conditions. The site visit occurred June 29, 2018 and was completed by two Golder employees. This visit followed a period of significant precipitation events and provided an enhanced opportunity to observe wet or saturated conditions.

There were two locations on the Site where standing or flowing water was observed. These included a small pond at the northern edge of the Site and a flowing channel within the wooded area at the centre of the Site. The water within the wooded area was flowing from north to south, however there was no standing or flowing water upstream or downstream of the wooded area. The water appeared to report from subsurface pathways and then returned back to subsurface after flowing across the surface. Subsequent visits during routine monitoring suggest that this feature likely only flows during or shortly after precipitation or melt events. . .

No other portions of the Site contained surface water. There was no discharge of surface water from the Site and no culverts or channels were identified.

4.0 SITE HYDROLOGY

4.1 Water Balances

This section discusses the surface water balance of the Site for Existing, Operations and Rehabilitated Scenarios.

4.1.1 Methodology

The water balance assessment was based on meteorological data from the Stratford Wastewater Treatment Plant (WWTP) Meteorological Station approximately 20 km northeast of the Site from 1960 to 2016.

Water balance calculations are based on the following equation:

$$P = S + ET + R + I$$

Where:

P = precipitation;

S = change in soil water storage;

ET = evapotranspiration;

R = surface runoff; and

I = infiltration (groundwater recharge).

Precipitation data collected at the Stratford WWTP station indicate a mean annual precipitation (P) of 1,034 mm/yr.

Short-term or seasonal changes in soil water storage (S) occur as demonstrated by the dry conditions in the summer months and the wet conditions in the winter and spring. Long-term changes (e.g., year to year) in soil water storage are considered negligible.

Evapotranspiration (ET) refers to water lost to the atmosphere from vegetated surfaces. The term combines evaporation (i.e. water lost from soil or water surfaces) and transpiration (i.e. water lost from plants and trees) because of the difficulties in measuring these two processes separately. Potential ET refers to the loss of water from a vegetated surface to the atmosphere under conditions of an unlimited water supply. The actual rate of ET is typically less than the potential rate under dry conditions (e.g., during the summer months when there is a moisture deficit). The mean annual potential ET for the study area is approximately 608 mm/yr based on data provided by Environment Canada (EC).

Annual water surplus is the difference between P and the actual ET. The water surplus represents the total amount of water available for either surface runoff (R) or groundwater infiltration (I) on an annual basis. On a monthly basis, surplus water remains after actual evapotranspiration has been removed from the sum of rainfall and snowmelt, and maximum soil or snow pack storage is exceeded. Maximum soil storage is quantified using a water holding capacity (WHC) specific to the soil type and land use.

Infiltration and runoff factors are based on Site-specific topography, surficial soil type, and vegetative cover.

4.1.2 Water Balance Scenarios

Under the Existing Scenario, the catchment is composed of agricultural lands, wooded lands, undifferentiated land (upland thicket), and a few built-up areas, including roads and buildings (Figure 4.1).

Under the Operations Scenario, most of the Site and Thomas St. Quarry lands will be mined to form a contiguous quarry, leaving a narrow border of open pasture (earth berm) defined by the setback boundary (Figure 4.2).

Under the Rehabilitated Scenario, the mined Site will fill with water to become a quarry lake (contiguous with Thomas St quarry lake). Additionally, a narrow border of open pasture (earth berm) defined by the setback boundary will surround the ponded area (Figure 4.3). A minor adjustment was made to the overburden sloping along the north face in the Rehabilitation Scenario (Figure 1.3) after the water budget analysis described herein was completed. The adjustment resulted in a slight decrease in lake area and an associated slight increase in above-water overburden sloping. These updates would incur such a small change to the Rehabilitated Scenario water budget (<5% change in surplus) that the analysis was not revisited.

4.1.3 Water Holding Capacities and Infiltration Factors

Table 3.1 from the MOE Stormwater Management Planning and Design Manual (MOE, 2003) is used to determine the water holding capacity (WHC) values for the various soil types and land uses used in the water balance. Annual evapotranspiration values are based on the WHC of each land use area. The existing Site is divided into five land uses: wooded, undifferentiated (upland thicket) agricultural (pasture and shrubs), gravel (roadways/driveways), and buildings (roofs). Water holding capacities and infiltration factors are identified for all five land uses (Table 8). Additional water holding capacities and infiltration factors are determined for the quarry, berm, and quarry pond that will be constructed during the operational and rehabilitation phases.

Table 8: Summary of Catchment Areas, WHCs, Soil Types, and Infiltration Factors

Existing Scenario					
Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m^2)**
Wooded	300 mm	Mixed Trees	Sandy Loam	0.3	10,431
Undifferentiated	300 mm	Upland Thicket	Sandy Loam	0.3	24,189
Agricultural	150 mm	Tilled	Silt Loam	0.3	428,427
Gravel	100 mm	Gravel Driveways/ Roadways	Gravelly Sand	0.3	442
Buildings	Precip - PE	Roofs	N/A	0	1,140
Total					**464,629**
Operations Scenario					
Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m^2)**
Open Pasture	100 mm	Berm	Silt Loam	0.3	61,085
Quarry	10 mm	Quarry Excavation	Gravelly Sand	0.0	403,544
Total					**464,629**
Rehabilitated Scenario					
Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m^2)**
Open Pasture	100 mm	Berm	Gravelly Sand	0.3	78,949
Pond	0 mm	Open Water	Bedrock	0.0	385,679
Total					**464,629**

4.2 Results

A summary of water balance results from each quarry scenario are described below with detailed analysis provided in Appendix G.

4.2.1 Existing Scenario

Table 9 lists the results of the average annual water balance for the Site under the Existing Scenario.

Table 9: Existing Scenario Water Balance Results

Land Use	Area	Precipitation		ET		Surplus		Infiltration		Runoff	
	Ha	mm/yr	m^3/yr	mm/yr	m^3/yr	mm/yr	m^3/yr	mm/yr	m^3/yr	mm/yr	m^3/yr
Wooded	10,431	1,035	10,796	601	6,300	434	4,527	130	1,358	304	3,169
Upland Thicket	24,189	1,035	25035	470	11,369	563	13,618	169	4,085	394	9,533
Agricultural	428,427	1,035	443422	575	246,346	460	197,076	138	59,123	322	137,954
Gravel	442	1,035	457	470	208	563	249	169	75	394	174
Buildings	1,140	1,035	1180	608	693	427	487	0	0	427	487
TOTAL	**464,629**	**1,035**	**480,890**	**570**	**264,916**	**465**	**215,957**	**139**	**64,641**	**326**	**151,317**

The total annual surplus is estimated to be 465 mm or 215,957 m^3/yr and the estimated infiltration is approximately 139 mm or 64,641 m^3/yr. Runoff is calculated as the difference between surplus and infiltration and is estimated to be 326 mm or 151,317 m^3/yr. Thus, approximately 30% of the annual surplus infiltrates while the remaining 70% is surface runoff.

4.2.1.1 Thomas St. Quarry Inflows

The proportions of groundwater versus surface water inflows to the Thomas St. Quarry are also evaluated for subsequent use in the model calibration (Section 5). For this analysis the estimated surface water runoff contributing to the quarry is subtracted from the actual measured quarry pumping rates to “back out” the groundwater contribution. Based on the water balance analysis the estimated runoff into the quarry footprint during 2017 is 2,922 m^3/d (Appendix G). The recorded average annual daily pumping rate from the quarry during 2017 is 10,757 m^3/d (Wood, 2018). As such, the expected groundwater contribution would be 10,757 – 2,922 = 7,835 m^3/d. However, this estimate is confounded by several issues. Firstly, quarry inflows are occasionally allowed to form large ponds in certain areas which are then dewatered several months later. As a result, water that entered the quarry in a certain year may not actually be pumped out until the next year. The effect of such water storage and delayed withdrawal may ultimately result in an over-estimation of actual inflows during a calendar year, which may have happened during 2017. Secondly, previous PTTW reporting suggested that the pumping meters may have been over-estimating inflows as a result of calibration issues (Amec Foster Wheeler, 2017). As such, the actual groundwater contributions to the quarry during may be significantly less than the calculated 7,835 m^3/d.

4.2.2 Operations Scenario

Table 10 lists the results of the average annual water balance for the Site under the Operations Scenario.

Table 10: Operations Scenario Water Balance Results

Land Use	Area	Precipitation		ET		Surplus		Infiltration		Runoff	
	Ha	mm/yr	m^3/yr	mm/yr	m^3/yr	mm/yr	m^3/yr	mm/yr	m^3/yr	mm/yr	m^3/yr
Open Pasture	61,085	1,035	63,223	550	33,597	485	29,626	146	8,888	340	20,738
Quarry	403,544	1,035	417,668	470	189,666	563	227,195	0	0	563	227,195
TOTAL	**464,629**	**1,035**	**480,891**	**481**	**223,263**	**553**	**256,821**	**19**	**8,888**	**534**	**247,933**

The total annual surplus for the Site is estimated to be 256,821 m^3/yr. This represents an increase of approximately 40,864 m^3/year (+19%) as a result of land use changes resulting from quarrying activities (due to the lower water holding capacity, there is less opportunity for evapotranspiration of water). The total Site infiltration is expected to be reduced by 55,753 m^3/year (86%). The total Site runoff is expected to increase by 96,616 m^3/year (+64%).

4.2.3 Rehabilitated Scenario

Table 11 lists the results of the average annual water balance for the Site under the Rehabilitated Scenario.

Table 11: Rehabilitated Scenario Water Balance Results

Land Use	Area	Precipitation		ET		Surplus		Infiltration		Runoff	
	Ha	mm/yr	m^3/yr	mm/yr	m^3/yr	mm/yr	m^3/yr	mm/yr	m^3/yr	mm/yr	m^3/yr
Open Pasture	78,949	1,035	81,712	550	43,422	485	38,290	146	11,488	340	26,803
Pond	385,679	1,035	399,178	608	234,493	427	164,685	0	0	427	164,685
TOTAL	**464,629**	**1,035**	**480,890**	**598**	**277,915**	**437**	**202,975**	**25**	**11,488**	**412**	**191,488**

The total annual surplus for the entire property is estimated to be 202,975 m^3/yr. This represents a decrease of approximately 12,982 m^3/yr compared to Existing Scenario (-6%). The infiltration is reduced by approximately 53,153 m^3/yr (-82%). The total runoff would increase by approximately 40,171 m^3/yr (+27%).

5.0 GROUNDWATER FLOW MODELLING

Computer-based groundwater flow modelling is conducted as part of this Study to simulate Existing Scenario conditions and predict potential groundwater impacts as a result of Operations and Rehabilitated Scenarios.

The model described herein is based on a pre-existing 2012 MODFLOW model first utilized in support of the Thomas St. Quarry PTTW amendment (Golder, 2012). The conceptual basis for the current modelling is described in Section 2 and Section 3; in particular, with updates to the prior model undertaken as a result of new field data as described in Section 3. In order to provide a thorough understanding of the entire model, both the pre-existing (unmodified) and updated model details are jointly reported on herein.

5.1 Model Construction

5.1.1 Assumptions

The following general assumptions, retained from previous work (Golder, 2012), are employed in the current model analysis:

- The model considers steady-state flow and reflects average annual conditions. Actual water levels and/or flow rates may fluctuate as a result of seasonal variation and/or significantly wet or dry years.
- Groundwater flow is three-dimensional (3D). The model construct allows for both lateral and vertical flow paths between adjacent hydrostratigraphic units.
- Only the saturated bedrock system is directly modelled under the Existing and Operations Scenarios. Similar to previous work (Golder, 2012), the native overburden is “inactivated” as it is inferred to be unsaturated in the vicinity of the Site on the basis of measured Site water levels residing below the overburden / bedrock contact. It follows that surface water features which flow upon overburden, such as the Thames River, are disconnected from the underlying bedrock system in the area of the Site and are thus not explicitly considered. However, under the Rehabilitated Scenario, the flooded pit has water levels that rise to within the overburden at the perimeter of the pit; under this condition the overburden and Thames River are activated and connectivity between the saturated overburden and bedrock systems is established in the area of the Site.
- Groundwater flow within the bedrock system may be simulated as an equivalent porous medium (EPM). In this setting, groundwater flow is a function of the hydraulic gradient and the hydraulic conductivity of the medium. An EPM assumption is deemed sufficient for characterizing groundwater flow at the scale of this analysis.

5.1.2 Code

The MODFLOW-2005 code (Harbaugh, 2005) is used to simulate groundwater flow at the site. MODFLOW is a multi-purpose 3D groundwater flow code developed by the United States Geological Survey. It is modular in nature and uses the finite difference formulation of the groundwater flow equation in its solution. MODFLOW is recognized as an industry standard for general purpose groundwater flow modelling and has gained wide acceptance from academia, consultants and regulatory agencies worldwide.

Visual MODFLOW Classic is used as the pre and post-processor for the simulations presented in this report.

The Algebraic Multigrid Methods for Systems Solver (SAMG) is used to solve the groundwater flow equations.

5.1.3 Domain and Grid

The model domain encapsulates the Site and regional surrounds, covering an area of approximately 144 km^2 (Figure 5.1). The model domain retains the same extents as the prior 2012 model and is delineated based on hydrogeologic boundaries as described further below.

The top of the model construct follows topography (Figure 5.1). Under Existing and Operations Scenarios the overburden is inactive, thus the active top of the model is bedrock surface (Figure 5.2). The bottom of the model is truncated within the Lower Lucas Formation Lower Zone aquifer (see model cross-sections in Figure 5.3 and Figure 5.4). . . Within this vertical construct the model consists of eight numerical layers. Horizontally, the model domain is discretized into 50 m x 50 m cells. In total the model is comprised of approximately 404,000 active cells.

5.1.4 Hydrostratigraphy and Material Properties

The modelled hydrostratigraphy and material properties are summarized in Table 12 and illustrated in cross-section on Figure 5.3 and Figure 5.4. In summary, the modelled hydrostratigraphic units are, from ground surface down:

1) Overburden (where active):
    a) Backfilled Till (In Pit)
    b) Native Granular
    c) Native Till
2) Dundee / Upper Lucas; and
3) Lower Lucas (Upper)
4) Lower Lucas (Lower)

Similar to previous modelling, the Dundee and Upper Lucas Formation units are combined into one bulk unit given their similar hydraulic properties (Section 3). However, the Dundee / Upper Lucas Formation thickness has been updated relative to prior work (Golder, 2012) as a result of recent borehole drilling which refined the bedrock surface at the Site (Section 3). Otherwise, the recent geologic picks for the Site generally remain within 4 m of previously modelled formation surfaces and therefore the remainder of the model surfaces are left unaltered.

The hydraulic conductivity of each bedrock unit is slightly adjusted relative to prior work (with a half order of magnitude) in lieu of new hydraulic testing data (Section 3) and calibration targets (Section 5.2). The originally applied anisotropy of K_H:K_V = 100:1 is maintained within the Lower Lucas (Upper) Aquitard (Golder, 2012); however, the remaining aquifer units are made isotropic as this is found to be favourable to the calibration result.

Table 12: Modelled Hydrostratigraphy and Material Properties

Model Layer	Unit	Modelled Thickness (m)	Horizontal Hydraulic Conductivity, K_H (m/s)	Vertical Hydraulic Conductivity, K_z (m/s)
1	Native Till[1]	Up to 50 m	1E-6	1E-6
1	Native Granular[1]	Up to 12 m	2E-3	2E-3
1	Flooded Quarry Lake[1]	Up to 27 m	1	1
1 / 2	Backfilled Till (In Pit)	Up to 30 m	1E-6	1E-6
2	Dundee / Upper Lucas	<5 to 30	5E-5	5E-5
3	Lower Lucas (Upper)	1	1E-7	1E-9
4	Lower Lucas (Upper)	4	1E-7	1E-9
5	Lower Lucas (Lower)	5	1E-4	1E-4
6	Lower Lucas (Lower)	6	1E-4	1E-4
7	Lower Lucas (Lower)	10	1E-4	1E-4
8	Lower Lucas (Lower)	24	1E-4	1E-4

[1] Where active in the Rehabilitated Scenario model.

5.1.5 Recharge

The regional recharge rate is slightly increased from 50 mm/yr to 75 mm/yr over prior work (Golder, 2012) as this adjustment is found improve the calibration results. This "recharge" input actually represents the estimated regional leakage rate from the (inactive) overburden into the underlying Dundee Formation rather than the recharge infiltrating the overburden at surface.

During Operations a recharge rate of zero is applied over the quarried areas as any surplus water is assumed to be collected at the sump and removed from the quarry via pumping.

During the Rehabilitated Scenario, when the overburden (Layer 1) is activated in the vicinity of the Thomas St. Quarry and Expansion lands, a recharge rate of 200 mm/yr is applied over the coarse-grained alluvium deposit following the Thames River. Based on the water budget (Appendix G) a recharge rate of 92 mm/yr is applied over the backfilled till within the quarry. As further inferred from the water budget, runoff from the berms and till into the lake as well as surplus directly input to the lake results in a total "recharge rate" of 757 mm/yr. This relatively large water input results in the creation of a quarry lake as described further below.

5.1.6 Boundary Conditions

The modelled boundary conditions are as follows (with reference to Figure 5.5):

- The northern and southern flanks of the model domain are approximately perpendicular to the direction of regional flow (west to east) and are thus assigned as "no flow" boundaries in all model layers.
- The Dundee / Upper Lucas inflows and outflows are implemented using constant heads in Layer 2 along the western (assigned head = 325 masl) and eastern (assigned head = 270 masl) flanks of the model, respectively.
- The Lower Lucas (Lower) inflows and outflows are implemented using constant heads in Layer 8 along the western (assigned head = 315 masl) and eastern (assigned head = 260 masl) flanks of the model, respectively.
- Locally, the existing and future quarry is implemented via drain cells filling the quarry volume in Layer 2 (i.e. the Dundee / Upper Lucas limestone resource) with drainage heads set at the approximate quarry floor elevation (see Figure 1.1 for Existing Scenario and Figure 1.2 for Operations Scenario). The drain cells are assigned a conductance of 100 m^2/day. During the Rehabilitated Scenario the drain cells are removed and the quarry volume is allowed to fill with water.
- During the Rehabilitated Scenario, when the overburden (Layer 1) in the vicinity of the Site is activated, the Thames River is implemented as constant head cells ranging in elevation from 298 masl immediately upstream of the Thomas St. Quarry to 294 masl immediately downstream of the Thomas St. Quarry Expansion lands.

5.2 Pumping Wells

There are four modelled PTTW groundwater users (Figure 5.5). The modelled sources and associated well pumping rates are summarized in Table 13 and are based on the average annual taking as described previously (Section 2.5). The pumping rates are held constant through Existing, Operations and Rehabilitated Scenarios in order to isolate the effects of the Site dewatering on groundwater conditions. Note that the quarry pumping is not included in Table 13 as the quarries are modelled not as pumping wells but as drain cells within the quarry volume

(Section 5.1); based on this approach the model calculates the dewatering rate at the quarries and this is compared to reported takings during the calibration process (described below).

Table 13: Modelled Pumping Wells

Permit Holder / Number	Well ID	Purpose	Screened Unit	Modelled Rate (m^3/d)
SMC / 5440-8YFHPP	Deep Well 3	Cooling Water	Dundee / Upper Lucas / Lower Lucas	1,148
SMC / 5440-8YFHPP	Deep Well 4	Colling Water	Dundee / Upper Lucas / Lower Lucas	2,444
Town of St. Marys / 5303-AASQEC	Well 1	Municipal	Dundee / Upper Lucas / Lower Lucas	1,099
Town of St. Marys / 5303-AASQEC	Well 2A	Municipal	Dundee / Upper Lucas / Lower Lucas	1,120
Town of St. Marys / 5303-AASQEC	Well 3	Municipal	Dundee / Upper Lucas / Lower Lucas	495
Maple Leaf Foods / 2834-9XKR9R	5001485	Industrial	Lower Lucas	950
Maple Leaf Foods / 2834-9XKR9R	5002264	Industrial	Lower Lucas	357

5.3 Existing Scenario Calibration

5.3.1 Approach

Calibration involves the iterative adjustment of model inputs to achieve simulated groundwater flow conditions reasonably consistent with measured site-specific data (“targets”) under existing conditions. The prior model calibration (Golder, 2012) provided a foundational set of input parameters; the focus of this current work is refining these prior inputs to better match the current dataset as described in Section 3.

There are four main calibration targets:

1) Average measured groundwater levels at the Site (the four MW-series holes) and Thomas St. Quarry and area (21 wells) monitoring networks (see Section 3.4).

2) MECP WWIS well groundwater levels at 267 bedrock wells (see Section 2.4.2);

3) Groundwater elevation mapping (see Figure 2.6); and

4) Existing Thomas St. Quarry groundwater inflows. The average measured inflow to Thomas St. Quarry during 2017 was 10,757 m^3/d (Wood, 2018). Subtracting the runoff calculated via the Site water balance results in an estimated average groundwater inflow of 7,835 m^3/d – in theory, this would be the quarry inflow calibration target. However, there is some indication that this number may be an overestimation as described previously in Section 4. In attempt to provide a more accurate calibration target we examine Thomas St. Quarry daily pumping rates during 2017 (Figure 2.3 of Wood, 2018) and find that there is a significant decrease in overall pumping between the first and second half of the year, where average rates drop from

fluctuating around 15,000 m^3/d to 5,000 m^3/d. We speculate that the first part of the year involved pumping stored water and runoff whereas the second part of the year was more indicative of "real time" groundwater inflows. Thus, for the purposes of the steady-state model calibration, we adopt a groundwater inflow target of 5,000 m^3/d.

Goodness-of-fit for each calibration iteration is assessed via statistical and other quantitative or qualitative means including:

- *Calibration Plot*: Simulated versus observed head values are compared on a plot with a central 45 degree line. In an idealized result, each point will lie along the 45-degree line. However, this seldom occurs in practice. Instead, the calibration plot is used as a visual inspection tool to determine goodness-of-fit and to detect any simulation bias (too high or too low relative to measured data) in the output.
- *Mean Residual:* This term indicates the average difference between observed and simulated water levels. The mean residual may suggest the degree to which the model is, on average, predicting heads above or below the observed dataset. A mean residual approaching zero is usually desired.
- *Mean Absolute Residual:* This indicator represents the average absolute value of the difference between observed and simulated water levels. At the Site, a mean absolute residual of less than 3 m or less is considered reasonable given the previously described challenge of obtaining precise water levels as a result of "perched" fracture flow into the borehole annulus (Section 3.4). Globally, a somewhat larger mean absolute residual of 5 m or less is considered acceptable given the data uncertainties associated with the MECP Water Well Information System.
- *NRMS*: This indicator, expressed in percentage, is the root mean square error divided by (or normalized by) the range of observed values for the dataset multiplied by 100%. A satisfactory NRMS value can be subjective and, aside from the expectation of a decreasing NRMS with a calibration improvement, there is not a set target value that may be consistently ascribed in every scenario. For example, a model calibration of well water levels at a relatively small site with subdued gradient may show very little residual error at each well but have a relatively high NRMS as result of the tight range of observed heads. Nonetheless, based on Golder's experience, a NRMS target of 10% or less is frequently employed as a target in Ontario.
- *Comparison to Water Level Maps*: The model output is visually compared to inferred groundwater elevation maps for both overburden and bedrock.
- *Comparison to Measured Flows*: Simulated quarry inflows are compared to measured inflows.

5.3.1 Calibration Adjustments

As described in Section 5.1, the current model largely retained the layer structure and boundary condition assignments of the prior model (Golder, 2012), with some adjustments local to the Site as a result of the newly acquired field data (Section 3). As such, calibration adjustments focused on hydraulic conductivity and recharge inputs as follows:

1) **Dundee / Upper Lucas**. The Dundee / Upper Lucas aquifer hydraulic conductivity was increased from 1E-5 m/s to 5E-5 m/s; this adjustment had a generally beneficial effect on both water level and quarry inflow target matching.

2) **Lower Lucas (Upper Zone)**: The Lower Lucas (Upper Zone) aquitard hydraulic conductivity was decreased from 5E-6 m/s to 1E-7 m/s in order to provide greater separation in hydraulic head between the Upper Lucas and Lower Lucas aquifers; this adjustment had a generally beneficial effect on water level target matching.

3) **Lower Lucas (Lower Zone)**: The Lower Lucas Lower Zone aquifer hydraulic conductivity was increased from 7E-5 m/s to 1E-4 m/s; this adjustment had a generally beneficial effect on both water level and quarry inflow target matching.

4) **Vertical Anisotropy**: The originally applied anisotropy of K_H:K_V = 100:1 is maintained within the Lower Lucas (Upper Zone) aquitard; however, the remaining aquifer units are made isotropic as this is found to be particularly favourable to quarry inflow target matching.

5) **Recharge**: The recharge rate is increased from 50 mm/yr to 75 mm/yr; this adjustment had a generally beneficial effect on both water level and quarry inflow target matching.

5.3.2 Calibration Results

Site / Thomas St. Quarry and MECP well water level calibration statistics, including calibration plots and goodness-of-fit indicators, are shown on Figure 5.6. The following is noted:

- The Site / Thomas St. Quarry water levels show a reasonable scatter about the 45-degree line with no undue bias in Site trends. Globally, the simulated water levels also show a reasonable scatter about the 45-degree line with no large bias in Site trends. There is a slight trend towards underestimating water levels in the Dundee / Upper Lucas within the downgradient half of the model domain. One potential explanation for this occurrence is that some older wells in proximity to the Thomas St. Quarry are now simulating a minor amount of drawdown as a result of the Thomas St. Quarry expanding relative to the historic conditions present during their construction.
- The Site / Thomas St. simulated water level residual mean (0.35 m) is close to zero and the absolute residual mean (2.8 m) is within the target of 3 m. Globally, the residual mean (0.46 m) is reasonable and the absolute residual mean (3.8 m) is within the target of 5 m.
- The Site / Thomas St. normalized RMS (27.5%) is beyond the target of less than 10%; however, the large nRMS in this case is primarily related to the relatively tight range of observed water levels (12 m). Globally, the normalized RMS (6.8%) meets the target of less than 10%.

The simulated groundwater levels in the Dundee / Lucas Formation aquifer are shown on Figure 5.7 and compared to the inferred groundwater patterns based on measured data (Figure 2.6). Regionally, both simulated and inferred patterns share a trend of east to west flow and exhibit a similar uniform gradient of approximately 0.5%. In addition, both patterns show a local perturbation around the Thomas St. Quarry. This occurrence is more prominent in the simulated pattern; however, the inferred pattern relies in part on historic water levels which may not be fully reflective of current water levels around the quarry as are modelled in this analysis. Based on the simulated groundwater levels an Existing Scenario quarry dewatering zone of influence of approximately 2 km is inferred.

The simulated groundwater inflow to Thomas St. Quarry is 3,900 m^3/d. This result is considered somewhat of an underestimation given the target of 5,000 m^3/d, although this comparison must again be tempered with the uncertainty of the quarry pumping measurements (Section 4). In any case, the simulated inflow of 3,900 m^3/d is still well within the range of measured quarry pumping during the latter half of 2017 and is thus considered an acceptable result.

Through the calibration process it is found that recharge rates, the hydraulic conductivities of the geologic units, and the simulated flow patterns are in good agreement with available field data. The calibrated model values are therefore considered to represent reasonable estimates for use in estimating future groundwater conditions for the proposed Thomas St. Quarry Expansion impact assessment.

5.4 Operations Scenario

5.4.1 Approach

The Operations Scenario is modelled by taking the calibrated Existing Scenario model (described above) and extending the future Site to full build-out as shown on Figure 5.8 (similar to the layout in Figure 1.2). As with the Existing Scenario, the Operations Scenario models the dewatered quarry using drain cells along the quarry walls and pit floors with head assignments corresponding to quarry topography. No other variables are changed in this modelled scenario.

5.4.2 Results

The simulated groundwater inflow to the combined quarries is 5,500 m^3/day with the Site contributing 1,400 m^3/day, or approximately 25%, of this total. Almost all of the quarry inflows (>90%) are derived from the aforementioned leakage (recharge) from the overburden to the rock within the model domain (see Section 5.1.5). The remaining quarry inflow is sourced from regional inflows as characterized by the constant head boundary condition along the eastern flank of the model (see Section 5.1.6).

Regionally, the Operations Scenario simulated flow pattern (Figure 5.9) is comparable to Existing Scenario (Figure 5.7) in that groundwater continues to flow from east to west at a fairly uniform gradient.

The incremental drawdown imposed by Site dewatering within the Dundee / Upper Lucas is shown on Figure 5.10. The maximum amount of drawdown is 4 m and occurs along the west-central flank of the Site. Off-site, the zone of influence (as defined by the 1 m drawdown contour) reaches approximately 1 km west of the expansion lands. With respect to the Lower Lucas (Lower Zone) aquifer, the drawdown is less than 0.2 m as a result of this aquifer being separated from the quarry by an aquitard.

The impact of quarry dewatering and associated drawdown on surrounding receptors is discussed in Section 6.

5.5 Rehabilitated Scenario

5.5.1 Approach

The Rehabilitated Scenario begins with the Operations Scenario as its basis and then applies two major alterations as shown on Figure 5.11: 1) the backfilling of till within the quarry, including the formation of a large till peninsula and till sloping applied along the majority of the formerly exposed quarry walls; and 2) the cessation of dewatering such that a quarry lake is, over time, allowed to form around the backfilled till with the final lake level residing within the native overburden. In order to realize this conceptualization in the model the following adjustments are made:

- Layer 1 is activated within the quarry footprint and south to the Thames River. This layer activation allows the lake level to rise to within the overburden. By extension, the lake is therefore in contact with the now-activated granular material within the setback and, further downgradient, the Thames River. Notably, the entirety of Layer 1 (i.e. west, north and east of the quarry) is not activated because groundwater interaction between the lake and native overburden will be limited as a result of the application of till along the west, north and east slopes of the lake.

- The Thames River is implemented in Layer 1 as constant head cells with assigned heads of 297 masl and 293 masl immediately upstream and downstream of the Site. These water levels are approximately 1 m greater than the surveyed low water levels in summer of 2019 and are intended to reflect an average annual condition.
- High hydraulic conductivity “lake” cells (K = 1 m/s) are applied within the quarry lake volume in Layers 1 and 2. These cells produce a “flattening” of the hydraulic head within the lake, resulting in a de facto simulated lake level.
- Backfilled till (K = 1E-6 m/s) is applied within the peninsula and slope volumes in Layers 1 and 2. Notably, the quarry slopes remain exposed in the southwest corner of the Site; this is to allow the lake to drain passively through the native granular within the setback, eventually discharging towards the Thames River.
- Native granular (K= 2E-3 m/s) is applied within the setback in Layers 1 and 2.
- A recharge rate of 100 mm/yr is assumed to occur over the backfilled till; larger recharge values cause mounding above ground surface within the till peninsula.
- The lake will receive “recharge” in the form of direct precipitation minus evaporation over the lake plus runoff from the till. Based on the Site water balance (Section 4) a total recharge rate of 711 mm/yr is applied.
- A recharge rate of 300 mm/yr is assumed to occur over the native granular material.

5.5.2 Results

Regionally, the Rehabilitated Scenario simulated flow pattern (Figure 5.12) is comparable to Existing Scenario (Figure 5.7) in that groundwater continues to flow from east to west at a fairly uniform gradient. The quarry lake is estimated to rise to an elevation of 294 masl which, in turn, results in an increase in water levels to the north, west and east of the Site.

The water table is expected to rise to within the overburden horizon for the majority of Site perimeter. As mentioned previously, the lake level is, in part, maintained by allowing passive subsurface drainage from the quarry lake through the native overburden in the southwest corner with eventual discharge to the Thames River. The average flow rate from the lake through the overburden at the southwest corner is simulated as approximately 2,900 m^3/d. Meanwhile, simulated lake discharge to the surrounding groundwater system outside of the southwest area (i.e. into the till slopes and bedrock) is 2,700 m^3/d.

The impact of the Rehabilitated Scenario on surrounding receptors is discussed in Section 6.

6.0 IMPACT ASSESSMENT

The following subsections summarize the incremental impacts of the Site development on groundwater and surface water resources.

6.1 Operations Scenario

6.1.1 Groundwater

6.1.1.1 Effects

The following potential Operations Scenario groundwater effects are identified as part of this assessment:

- The average simulated groundwater inflow at the Site is 1,400 m^3/d, or 25% of the combined Site and Thomas St. Quarry simulated inflow of 5,500 m^3/day. Almost all of the quarry inflow (>90%) is derived from leakage (recharge) from the overburden to the rock within the model domain (see Section 5.1.5).
- Site quarry dewatering is estimated to produce a zone of influence reaching a maximum of 1 km from the perimeter of the Site (as defined by the 1 m drawdown contour) (Figure 5.10). The maximum drawdown is approximately 4 m which occurs along the west-central flank of the Site.
- As a result of the confining effects of the low-permeability Lower Lucas (Upper Zone) aquitard, which underlies the quarry, the maximum drawdown in the Lower Lucas (Lower Zone) aquifer is less than 0.2 m emanating from the Site and is thus considered negligible.
- Site water quality (Section 3.5) will likely improve under Operations as sources of bacteria loadings (for e.g. manure application) will cease. In addition, provided SMCs Spill Prevention and Contingency Plan is followed (Appendix H), the risk of groundwater contamination related to equipment re-fuelling and fuel storage is low.

6.1.1.2 Impacts to Receptors

The above groundwater effects may impact key groundwater receptors as follows:

Town of St. Marys Municipal Wells

The three St. Marys municipal wells range in depth from approximately 46 mbgs to 48 mbgs and are inferred to draw water from the Dundee and Lucas aquifer units based on their open hole depth (see Table 3 in Section 2.5). According to the Tier 3 Water Budget and Local Area Risk Assessment, the Safe Additional Available Drawdown (SAAD) at Well 1, Well 2A, and Well 3 is 10.2 m, 12.8 m and 16.6 m, respectively (Matrix, 2014). Simulated drawdown at these wells as a result of Site dewatering is nil and will thus have no impact on municipal well yield or SAAD.

Maple Leaf Foods Wells

The two Maple Leaf Foods wells range in depth from approximately 102 mbgs to 111 mbgs and are inferred to draw water from the Lower Lucas Aquifer (see Table 4 in Section 2.5). Simulated future drawdown at these wells within the Lower Lucas Aquifer as a result of Operations dewatering is practically negligible (less than 0.2 m) and will not pose an adverse impact to well operation.

Private Wells

There are only two private wells in the MECP water well database that lie within the Site zone of influence with one being on-Site (Figure 5.10). The simulated incremental drawdown from Site dewatering is compared to the available water column in these two wells. In this analysis the water column is calculated as the static water level height above the bottom of the well in the MECP WWIS database. It is found that that neither well experiences greater than a 10% reduction in available water column; as such, adverse effects to well operation are considered unlikely as a result of Site dewatering. Nonetheless, a groundwater monitoring and response program, including a complaint response program, has been developed with potential mitigation measures as described in Section 8 below.

Thames River

As mentioned previously, the Thames River is considered hydraulically disconnected from the underlying bedrock aquifer in the area of the Site and is thus not expected to be adversely affected by drawdown. Instead, groundwater inflow that is pumped from the quarry will ultimately be discharged to the adjacent Thames River, providing a minor supplement to existing flows (5,500 m^3/day is <0.5% of existing Thames River flow adjacent to the Site).

6.1.2 Surface Water

6.1.2.1 Effects

The following potential Operations Scenario surface water effects are identified as part of this assessment:

- Under Operations Scenario average annual surplus will be increasing by 40,864 m^3, compared to Existing Scenario.
- With the changes in land use under Operations Scenario, rate of infiltration will decrease on Site, with the majority of Site surplus occurring as runoff collecting the in the quarry sump(s).
- Site runoff under Operations Scenario will be largely controlled by quarry dewatering and will not flow naturally to off-Site receptors.

6.1.2.2 Impacts to Receptors

The Ministry of Natural Resources and Forestry Ontario Flow Assessment Tool (OFAT) was used to determine that the North Thames River watershed at the potential expansion quarry discharge is approximately 107,700 ha. The expansion area accounts for approximately 0.04% of this catchment (i.e. 46 ha). The estimated average flow in the North Thames River at this point is approximately 14,460 L/s. The increase in annual runoff from the Site is expected to be 96,616 m^3/yr (i.e. 3.1 L/s), which is an increase of approximately 0.02% to the North Thames River average annual flow. This increase in discharge under Operations Scenario to the North Thames River is not expected to have a significant impact on the North Thames River flow regime or channel stability.

Although the Operations Scenario results in an increase in annual surplus and Site runoff, the receiving system is not expected to see an increase in peak flows or channel erosion as a result of the Site. The majority of the Site discharge will be controlled by the quarry dewatering and will be discharged at a controlled rate. This will effectively mitigate natural peak flows since rainfall or melt events will be stored in the quarry sump(s) until it can be pumped out.

6.2 Rehabilitated Scenario

6.2.1 Groundwater

6.2.1.1 Effects

The following potential Rehabilitated Scenario groundwater effects are identified as part of this assessment:

- During rehabilitation, groundwater levels will slowly recover as a lake is formed. The final expected lake elevation – approximately +/- 294 masl – may result in surrounding groundwater levels being greater than those pre-quarry, with the Site portion of the lake influencing water levels north, west, and east of the expansion lands.

- Based on available topographic data it appears likely that, under average climatic conditions, the lake level of 294 masl may be maintained by passive subsurface drainage southwards from the Site lake through the overburden to directly discharge to the Thames River.
- The average flow rate from the lake through the overburden at the southwest corner is simulated as approximately 2,900 m^3/d. This flow rate could vary considerably as a result of seasonal variation and/or significantly wet or dry years. During higher water level periods it may be possible that a portion of lake flow “daylights” as seepage along the overburden face prior to reaching the Thames River. The potential for this occurrence will be confirmed through future monitoring. Should seepage daylighting be deemed plausible, such discharge could be managed at the downstream perimeter of the Site (likely via drainage ditching) and redirected to the Thames River via culvert under Perth Road Line 5.
- It is further noted that the simulated lake discharge to the surrounding groundwater system outside of the southwest area (i.e. into the till slopes and bedrock) is 2,700 m^3/d.
- Site water quality (Section 3.5) will likely improve relative to the Existing Scenario as sources of mass bacteria loadings (for e.g. manure application) will have ceased.

6.2.1.2 Impacts to Receptors

The above groundwater effects may impact key groundwater receptors as follows:

Water Wells

Local wells may experience an increase in capacity as water levels rebound.

Thames River

Under the Rehabilitated Scenario the Thames River will become hydraulically connected to the quarry lake as water levels rise to within the overburden and discharge from the lake to the river. The average flow rate from the lake to the Thames River is estimated to be approximately 2,900 m^3/d, thus providing a minor supplement (<0.3%) to existing flows.

6.2.2 Surface Water

6.2.2.1 Effects

The following potential Rehabilitated Scenario surface water effects are identified as part of this assessment:

- Under Rehabilitated Scenario average annual surplus is estimated to decrease by 12,982 m^3/yr compared to the Existing Scenario.
- With the changes in land use under Rehabilitated Scenario, the rate of infiltration will decrease, while the runoff will slightly increase on Site compared to the Existing Scenario.
- Site runoff under Rehabilitated Scenario will be largely controlled by the storage in the flooded quarry and the flow-through design and therefore high discharge flows will be attenuated.

6.2.2.2 Impacts to Receptors

The increase in annual runoff from the Site is expected to be 40,171 m^3/yr (i.e. 1.27 L/s), which is a increase of approximately 0.009% to the North Thames River average annual flow. This increase in discharge under Rehabilitated Scenario to the North Thames River is not expected to have a significant impact on the North Thames River flow regime or channel stability.

The Rehabilitated Scenario results in a decrease in annual surplus and Site runoff. Similar to the Operations Scenario, the receiving system is expected to see a decrease in peak flows or channel erosion as a result of the Site. This is a result of the flow response attenuation in the flooded quarry and the controlled discharge through the flow-through system.

The Rehabilitated Scenario considers the overburden within the setback as a semi permeable impoundment for the eventual quarry lake. Future monitoring, after the completion of quarrying, will determine the likelihood of the quarry lake actually rising to the level of the overburden. If the quarry lake water level will rise to the level of the overburden, then a future geotechnical study would be considered at that time to confirm the suitability of the overburden to impound the lake. This would include the evaluation and design of any required seepage collection and control measures.

6.3 Source Water Protection Impacts

Site development may result in some alteration to the source water protection vulnerable area mapping as previously defined in Section 2.6. Ultimately, any updates to the Source Protection Plan are directed by the Upper Thames River Conservation Authority and would likely call for the use of the associated “Tier Three” model that was used to develop the original vulnerable areas and are thus outside of this current scope of work. However, in concept, we envision the following potential changes:

- **SGRAs and HVAs:** The SGRA and HVA mapping may expand in the area of future quarrying to reflect the removal of the overburden and exposure of the water table. However, it is noted that during the Operations Scenario very little recharge is expected to take place within the quarry because a) the dewatered quarry will create a hydraulic barrier to downward leakage; and 2) any surplus will be directed towards the sump and pumped out of the quarry.

- **WHPA-Q1/Q2:** The WHPA-Q1/Q2 extents for the Town of St. Marys municipal wells encompasses, and is influenced by, quarry dewatering. The Tier Three model used to develop the WHPA Q1/Q2 considered a 2009 quarry footprint that was smaller than the combined Site and Thomas St. Quarry areas but significantly deeper (270 masl) (Matrix, 2014). Although the Tier Three quarry inflow was not reported, it is reasoned that, because of its deeper floor (but smaller footprint) the Tier Three quarry groundwater taking is likely similar to that predicted herein. It follows that the Operations Scenario water taking would have little effect on the currently mapped WHPA-Q1/Q2. During the Rehabilitated Scenario, quarry dewatering will cease and, all other factors remaining equal, will result in a much smaller WHPA-Q1/Q2 (an overall positive effect). . .

- **WHPA-B,C,D:** As noted in Section 5, regional groundwater flow patterns through the Town of St. Marys will maintain the pre-existing east to west direction throughout all stages of the project. The incremental effect of Site dewatering during Operations and subsequent water level rise during Rehabilitation is limited to west of the Thomas St. Quarry and therefore will not have any direct impact on the Town of St. Marys WHPA-B,C,D.

7.0 MONITORING PROGRAM

Groundwater level monitoring will be conducted to evaluate quarry-related drawdown during Operations. The monitoring will include the following eight locations:

- MW17-01
- MW17-02
- MW17-03
- MW17-04
- BH17-01
- BH17-02
- BH17-03
- BH17-04
- BH17-05

Monitoring of the BH-series boreholes will continue until they are mined out as part of quarry extraction activities.

Dataloggers will be maintained in each borehole to provide a continuous record. Monitoring events will occur quarterly and will include manual measurements and data uploads.

Groundwater level monitoring shall be conducted for two years following the cessation of Operations activities and the subsequent commencement of quarry lake filling during Rehabilitation. The rationale for the two-year monitoring period is that if water wells have not been impacted as a result of groundwater decline during Operations then they will not be impacted during quarry flooding. The two-year period will further confirm that the drawdown has stabilized following completion of quarrying.

Groundwater sampling shall be conducted to evaluate potential changes in groundwater quality during Operations. Boreholes MW17-01, MW17-02, MW17-03 and MW17-04 will be sampled annually; these wells are situated along the quarry perimeter and will not be mined out. The analytical suite will include general chemistry, metals, petroleum hydrocarbons, BTEX, and bacteria. Groundwater sampling shall continue for two years following the cessation of Operations activities and the subsequent commencement of quarry lake filling during Rehabilitation.

No on-Site surface water features will be maintained and therefore no monitoring of surface water features is required.

Dewatering rates will be monitored and documented under the future Permit To Take Water. Discharge management and monitoring will be managed and documented under the current or future amended Environmental Compliance Approval.

The annual monitoring that is currently taking place for the existing quarry will be amended to include the wells on the Site.

8.0 WATER WELL COMPLAINT AND RESPONSE ACTION PLAN

The overall objective of the water well complaint action plan is to promptly remedy potential water supply impacts to private water wells users should their water supply be affected by the future development of the quarry. As mentioned previously, the potential for adverse effects to private well operation as a result of Site dewatering are unlikely. However, the phasing of planned extraction allows for a gradual progression of the quarry face towards potential receptors within the zone of influence and will thus allow for on-going monitoring and mitigation (if needed) to be implemented in advance of potential impacts to water wells.

It should be noted that a Site monitoring program (Section 7) will be implemented throughout the Operations Scenario. The data collected through the monitoring program will allow the quarry operator to identify potential impacts to neighbouring private water wells before they occur. This will provide the quarry operator with sufficient time to proactively address any potential interference of neighbouring water supplies before any impacts actually occur. It is further noted that the degree of hydraulic interconnection with the quarry or areas of groundwater recharge via fracture networks may vary. As such, it is not recommended to proactively deepen wells that may be affected.

Well complaints in the area will be evaluated on a case by case basis and the appropriate actions will be undertaken to address the issue as is the current practice. Although it is not expected that there will be impacts on wells related to the proposed expansion, SMC will respond to well complaints in accordance with the procedures for the existing Thomas St. Quarry.

If a water well complaint is received by SMC for private wells located within the estimated zone of influence the following actions will be taken:

- A representative from SMC will meet with the landowner and discuss the complaint. If warranted, SMC will contact local well contractors in the event of a well malfunction and those within this zone will be immediately supplied a temporary water supply if the issue cannot be easily determined and rectified (see steps below).
- The available contractor will then respond to the resident with the supply issue and rectify the problem as expediently as possible provided the landowner authorizes the work.
- If the issue raised by the landowner is related to loss of water supply, SMC will have a consultant/contractor determine the likely causes of the loss of water supply, which can result from a number of factors, including pump failure (owner’s expense), extended overuse of the well (owner’s expense) or lowering of the water level in the well from potential quarry interference (quarry expense). This assessment process would be carried out at the expense of the quarry operator and the results provided to the homeowner.
- The consultant/contractor will be able to readily determine if pump failure is the problem and, should the landowner choose to have the pump repaired or replaced at their expense, the contractor would correct the situation for the landowner.
- If, however, the well interference is determined to be caused by SMC quarry activities then water well supply mitigation will be considered. If the water level in the well is lowered to a point where it has interfered with pumping, there are a few initial steps that the consultant/contractor will determine the feasibility of, including adjusting the pump pressure or lowering the pump level in the well. In the event that the well is incapable of providing water (i.e., the water level is too low in comparison to the depth of the well), or the repair to the pumping system will be more than a day, the consultant/contractor will continue to supply a potable water

source for the residence (until restoration of the well is complete). These actions would be carried out at the expense of the quarry operator. In extreme cases where the water level in the well has been lowered significantly, the well may have to be deepened, widened or relocated.

- In summary, mitigation for affected wells could include the following measures: lowering of the pump to take advantage of existing storage within the well; deepening of the well to increase the available water column; widening of the well to increase the available storage of water; relocation of the well to another area on the property; drilling of multiple low yield wells; installing a cistern at the request of the property owner; and implementation of additional storage that can be filled with water from the existing well on a low yield setting.

8.1 Mitigation Strategies

There are several mitigation strategies that could be implemented to affect the supply of surrounding water wells, to counteract the effect of quarry-related groundwater level drawdown, if required, based on the results of the monitoring program.

- Well Deepening: This would be effective, for example, for shallow bedrock wells that no longer have a sufficient water column due to quarry-related groundwater level drawdown. The results of the hydrogeological program indicate that well deepening is feasible, since water supply is obtained from duplicate private water wells and municipal wells. The results of drilling and testing of the deep boreholes and monitoring wells indicate a source of deeper water supply.
- Well Replacement: This measure could be introduced for wells where well deepening was not sufficient and could also be positioned further from the quarry.
- Additional Wells: Additional wells could be installed a connected by plumbing into the residence by piping as such that there is a common feed of water from multiple wells.
- Trickle Wells: Wells that have had the water column lowered and the supply reduced by groundwater level drawdown. This would involve the pumping of the well into a storage system such as a subsurface system.

The requirement for any of these mitigation measures would be determined based on the results of the groundwater monitoring program.

9.0 CONCLUSIONS

The impacts of Site Operations and Rehabilitated Scenarios on groundwater and surface water resources relative to the Existing Scenario have been evaluated through field investigations, desktop analysis and computer modelling. .The following conclusions are provided based on this study:

Existing Scenario

- The Site ranges in elevation from 322 masl along its north flank to 297 masl at its south flank. The adjacent Thomas St. Quarry floor currently resides at approximately 274 masl.
- The Site lies within the “05T North Thames / Medway River” subwatershed, which itself belongs to the larger Thames River watershed. The North Thames River at Town of St. Marys drains an area of over 1,080 km^2 with an average flow rate of roughly 1 million m^3/day.

- There are locations on the Site where standing or flowing water is occasionally observed. These include a small pond at the northern edge of the Site and a flowing channel within the wooded area at the centre of the Site. It is likely that this latter feature only flows in relation to precipitation or melt events.
- Surficial geology in the vicinity of the Site is mapped as silty clay till to the north, eolian sand and gravel deposits centrally within Site, and alluvial granular deposits along the North Thames River. Site overburden thickness ranges from less than 5 m (south) to over 26 m (north). According to grain size analysis, the hydraulic conductivity of the sand and gravel deposits ranges from 6E-5 m/s to 5E-3 m/s with a geometric mean of 2E-3 m/s.
- Bedrock geology / hydrostratigraphy consists of the following units (top down):
    - Dundee Formation Limestone Aquifer, 13.5 m – 18 m thick, estimated K = 1E-5 m/s to 2E-8 m/s.
    - Upper Lucas Formation Limestone Aquifer, 8.3 m – 9.5 m thick, estimated K = 1E-4 m/s to 4E-8 m/s.
    - Lower Lucas Formation (Upper Zone) Dolostone Aquitard, 9 m – 10 m thick, estimated K = 1E-7 m/s or less.
    - Lower Lucas Formation (Lower Zone) Dolostone Aquifer, estimated K = 8E-4 m/s to 1E-6 m/s.
- Infiltration to the shallow groundwater system within North Thames watershed is relatively limited as a result of the expansive presence of low permeability surficial till. Regional estimates of recharge rates range from 152 mm/yr to 168 mm/yr (SWS, 2011). The subsequent leakage rate from overburden to underlying bedrock aquifers is estimated to be approximately 75 mm/yr.
- Regional bedrock groundwater mapping indicates flow from east to west at an average gradient of 6E-3 m/m. Site groundwater levels range from a high of approximately 290.7 masl at BH17-04 during April 2019 to a low of 274.8 masl at MW17-01 during July 2018. As a result of the Site's considerable change in topographic relief, measured depth to water ranges from as shallow as 11.1 m at BH17-02 to as deep as 47.4 m at MW17-01. Water levels range with approximately +/- 2 m at most boreholes. All of the water levels reside beneath the overburden / rock contact. Definitive measurements of water table depth are challenging at some boreholes owing to the presence of perched fractures discharging water into the hole.
- The Thomas St. Quarry, which is dewatered to an elevation of approximately 274 masl, does not appear to exert a strong influence on water levels at the Site as boreholes on the eastern flank of the Site have water levels 5 m or more greater than that of the quarry floor. In fact, the lowest water levels on-Site are those furthest from the quarry (MW17-01).
- The Thames River water levels are significantly greater than Site bedrock water levels. In addition, regional groundwater flow mapping suggests that the River does not exert a significant influence on flow patterns. As such, the Thames River is considered hydraulically isolated from the underlying bedrock aquifer.
- Notable groundwater quality findings include elevated hardness and the presence of bacteria and elevated nitrates, these latter two parameters suggesting impacts from surficial contaminants (for example, manure application).
- According to a desktop query of the MECP WWIS there are 36 water well records within 1 km of (and on) the Site. Of the 36 well records, 14 are listed as water supply wells, six are monitoring wells, two are abandoned,

and fourteen do not have status or use listed. A follow-up well survey found 18 active private wells within 1 km of the Site. The majority of these wells are completed within the bedrock aquifer(s).

- According to the MECP PTTW database there are four active MECP PTTWs within 5 km of the Site. Of these, two permits are held by SMC (dewatering and industrial supply), one is held by Town of St. Marys (three municipal wells), and one is held by Maple Leaf Foods Inc (two industrial wells).
- Total annual surplus is estimated to be 465 mm or 215,957 m^3/yr and the estimated infiltration is approximately 139 mm or 64,641 m^3/yr. Runoff is calculated as the difference between surplus and infiltration and is estimated to be 326 mm or 151,317 m^3/yr. Thus, approximately 30% of the annual surplus infiltrates while the remaining 70% is surface runoff.
- Based on the water balance analysis the estimated daily average runoff into the quarry footprint during 2017 is 2,922 m^3/d. The recorded average annual daily pumping rate from the quarry during 2017 is 10,757 m^3/d (Wood, 2018). As such, the expected groundwater contribution would be 10,757 – 2,922 = 7,835 m^3/d. However, this estimate is confounded by several issues including the presence of pond storage (delayed pumping) and potential inaccuracies in pumping meters.
- The Site is located within the Upper Thames River Source Protection Area. Under the Source Protection Plan mapping:
  - A southern portion of the Site is mapped as Significant Groundwater Recharge Area and Highly Vulnerable Aquifer; these designations appear to be related to the sand and gravel surficial deposits in the area. SGRA and HVA.
  - The Site lies within the St. Marys municipal well's WHPA-Q1/Q2.
  - The closest WHPA-A,B,C or D to the Site lies over 2 km to the northeast at the Town of St. Marys wellfields.

Operations Scenario

- The simulated groundwater inflow to the combined quarries is 5,500 m3/day with the Site contributing 1,400 m3/day, or approximately 25%, of this total.
- Site quarry dewatering is estimated to produce a zone of influence reaching a maximum of 1 km from the perimeter of the Site (as defined by the 1 m drawdown contour) (Figure 5.10). The maximum drawdown is approximately 4 m which occurs along the west-central flank of the Site.
- The Lower Lucas (Lower Zone) aquifer experiences negligible drawdown.
- The Town of St. Marys municipal wells and Maple Leaf Foods wells will not experience adverse effects as a result of quarry-induced drawdown.
- Only two private wells lie within the Site dewatering zone of influence (Figure 5.10). Based on their depth and static water level, neither well is expected to experience any adverse effects to well operation as a result of the minor drawdown imposed by the Site.
- Nonetheless, a groundwater monitoring and response program, including a complaint response program, will be utilized in accordance with the Thomas St. Quarry practices in the event of unanticipated impacts on

water wells. Potential mitigation measures are available and can be used to protect well owner's water supply if required.

- The Thames River is considered hydraulically disconnected from the underlying bedrock aquifer in the area of the Site and is thus not expected to be adversely affected by drawdown. Instead, groundwater inflow that is pumped from the quarry will ultimately be discharged to the adjacent Thames River, providing a minor supplement to existing flows (5,500 m^3/day is <0.5% of existing Thames River flow adjacent to the Site).
- Site groundwater quality will likely improve under Operations as sources of bacteria loadings (for e.g. manure application) will cease. In addition, provided SMCs Spill Prevention and Contingency Plan is followed, the risk of groundwater contamination related to equipment re-fuelling and fuel storage will be minimized.
- Under Operations Scenario average annual surplus is estimate to increase by 40,864 m^3/yr compared to the Existing Scenario. With the changes in land use under Operations Scenario, the rate of infiltration will decrease on Site, with the majority of Site surplus occurring as runoff collecting the in the quarry sump(s). Site runoff under Operations Scenario will be largely controlled by quarry dewatering and will not flow naturally to off-Site receptors.
- The increase in annual runoff from the Site results in an approximately 0.02% increase to the North Thames River average annual flow. This increase in discharge under Operations Scenario to the North Thames River is not expected to have a significant impact on the river flow regime or channel stability.

Rehabilitated Scenario

- During rehabilitation, groundwater levels will slowly recover to pre-quarry conditions as a lake is formed. The final expected lake elevation – approximately +/- 294 masl – may result in surrounding groundwater levels being greater than those pre-quarry.
- The lake level will be maintained by allowing passive subsurface drainage from the quarry lake through the native overburden in the southwest corner of the Site with eventual discharge to the Thames River. The average flow rate from the lake through the overburden is simulated as approximately 2,900 m^3/d. During higher water level periods it may be possible that a portion of lake flow "daylights" as seepage along the overburden face prior to reaching the Thames River. The potential for this occurrence will be confirmed through future monitoring. Should seepage daylighting be deemed plausible, such discharge could be managed at the downstream perimeter of the Site (likely via drainage ditching) and redirected to the Thames River via culvert under Perth Road Line 5.
- Site groundwater quality (Section 3.5) will likely improve relative to the Existing Scenario as sources of mass bacteria loadings (for e.g. manure application) will have ceased.
- Local wells may experience a significant increase in capacity as water levels return to pre-quarry conditions.
- Under the Rehabilitated Scenario the Thames River will become hydraulically connected to the quarry lake as water levels rise to within the overburden and discharge from the lake to the river will occur via a future culvert. The average flow rate from the lake to the Thames River will provide a minor supplement (<0.3%) to existing flows.
- Under Rehabilitated Scenario average annual surplus will decrease by an estimated 12,982 m^3/yr compared to the Existing Scenario. With the changes in land use under Rehabilitated Scenario, the rate of infiltration

will slightly decrease, while the runoff will slightly increase on Site compared to Existing Scenario. Site runoff under Rehabilitated Scenario will be largely controlled by the storage in the flooded quarry and the flow-through design and therefore high discharge flows will be attenuated.

- The increase in annual runoff from the Site is expected to be approximately 0.009% to the North Thames River average annual flow. This increase in discharge under Rehabilitated Scenario to the North Thames River is not expected to have a significant impact on the North Thames River flow regime or channel stability.

10.0 RECOMMENDATIONS

It is recommended that the following notes be put on the Site Plans:

- The Site and Thomas St. Quarry water monitoring activities shall be merged into one program with a singular annual report.
- The most current Spill Prevention and Contingency Plan for Thomas St. Quarry shall be adopted.
- Quarry dewatering rates shall be monitored and documented under the future Permit To Take Water. Discharge management and monitoring shall be managed and documented under the current or future amended Environmental Compliance Approval.
- Site water level and water quality monitoring shall be conducted during Operations and for two years following the cessation of Operations.
- Site groundwater level monitoring shall occur at: MW17-01, MW17-02, MW17-03, MW17-04, BH17-01, BH17-02, BH17-03, BH17-04 and BH17-05. Dataloggers shall be maintained in each borehole to provide a continuous record. Monitoring events shall occur quarterly and will include manual measurements and data uploads. Monitoring of the BH-series boreholes shall continue until they are mined out.
- Site water quality monitoring shall occur annually at MW17-01, MW17-02, MW17-03 and MW17-04. The analytical suite shall include general chemistry, metals, petroleum hydrocarbons, BTEX, and bacteria.
- A Water Well Complaint and Response Action Plan shall be adopted as outlined in the Hydrogeology and Hydrology Level 1 and 2 Study report (Golder, 2020). The Licensee shall restore water supplies to affected wells if the quarry is determined to have caused a loss of supply.

11.0 LIMITATIONS

11.1 Use of This Report

This report has been prepared by Golder Associates Ltd. (Golder) for use by St. Marys Cement Inc. (SMC) and its authorized agents. The factual information, descriptions, interpretations, comments, results, conclusions and electronic files contained herein are specific to the project described in this report. Information used in this report should be restricted to that specified in the scope of work unless otherwise mutually agreed upon by Golder and SMC. This report should be read in its entirety as some sections could be falsely interpreted when taken individually or out-of-context. Golder is not responsible for any use of this report and its content by a third party, and/or for its use for purposes other than those intended.

Golder is not responsible for any damages that may result from unpredictable or unknown underground conditions, from erroneous information provided by and/or obtained from sources other than Golder, and from ulterior changes in the site conditions unless Golder has been notified of any occurrence, activity, information or discovery, past or future, susceptible of modifying the underground conditions described herein, and have had the opportunity of revising its interpretations. In addition, Golder is not responsible for any decrease of a property's value or any failure to complete a transaction as a consequence of this report.

11.2 Groundwater Modelling General Limitations

Hydrogeological investigations and groundwater modelling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time and the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that field data provides a fraction of information for the site or model domain; as such a truly complete, comprehensive characterization of the groundwater system is not possible. Therefore, every groundwater model is, by necessity, a simplification of a reality.

The professional groundwater modelling services described in this report are conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions. The results of previous or simultaneous work provided by sources other than Golder and quoted and/or used herein are considered as having been obtained according to recognized and accepted professional rules and practices, and therefore deemed valid.

The model presented herein provides a predictive scientific tool to evaluate the impacts of specified hydrological stressors on a real groundwater system and to compare various scenarios in support of a decision-making process. The model's accuracy is bound to the normal uncertainty associated to groundwater modelling and no warranty, express or implied, is made.

12.0 REFERENCES

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Signature Page

We trust this report meets your current requirements. Should you have any further questions please do not hesitate to contact the undersigned. Curricula Vitae of the signatory authors are provided in Appendix I.

Golder Associates Ltd.

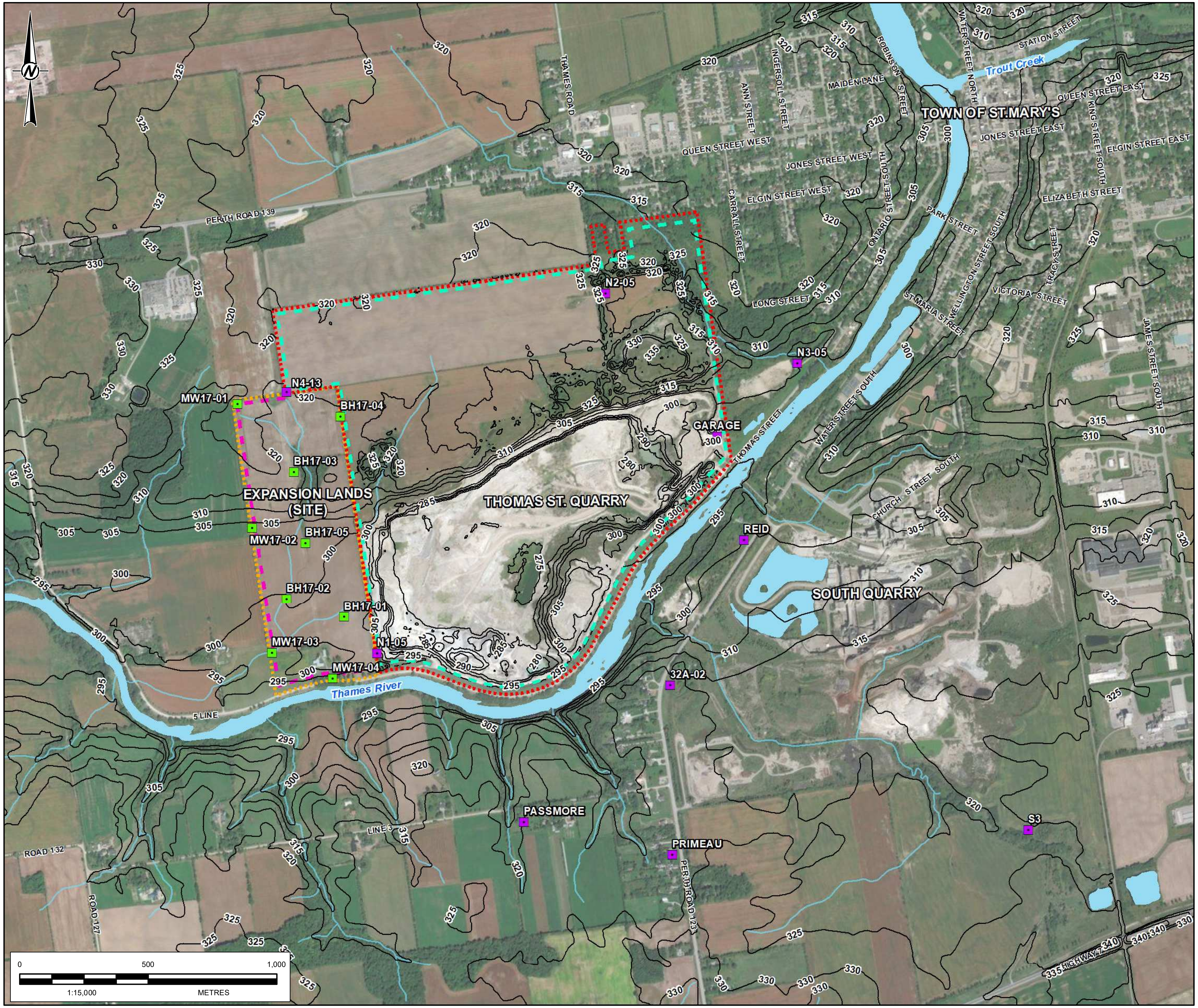
Craig DeVito, P.Eng.
Water Resources Engineer

Devin Hannan, P.Eng.
Associate, Environmental Engineer

Sean McFarland, P.Geo.
Principal, Senior Hydrogeologist

DH/AS/CD/SMMC/sy/mp

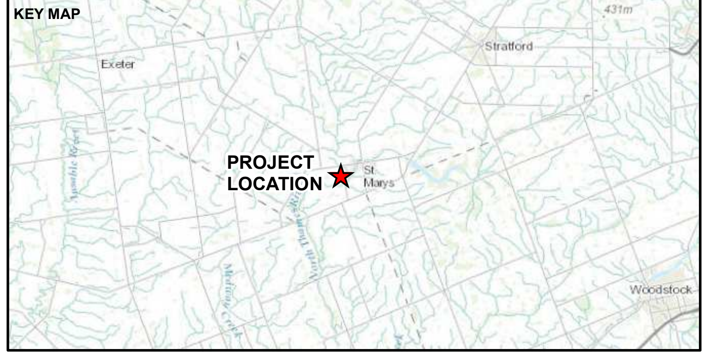
FIGURES



LEGEND

- 🟩 Site Groundwater Monitor Location
- 🟪 Thomas St. Groundwater Monitor Location
- — Ground Surface Elevation (masl)
- — Watercourse
- Existing License Boundary (Thomas St. Quarry)
- Existing Limit of Extraction (Thomas St. Quarry)
- Proposed License Boundary
- Proposed Limit of Extraction
- 🟦 Waterbody

KEY MAP



Group	Monitor ID	Easting	Northing
Site	BH17-01	485898	4787643
Site	BH17-02	485674	4787714
Site	BH17-03	485704	4788206
Site	BH17-04	485884	4788423
Site	BH17-05	485747	4787931
Site	MW17-01	485483	4788470
Site	MW17-02	485540	4787990
Site	MW17-03	485617	4787503
Site	MW17-04	485853	4787404
Thomas St.	N1-05	486027	4787502
Thomas St.	N2-05	486915	4788903
Thomas St.	N3-05	487659	4788629
Thomas St.	N4-13	485675	4788518
Thomas St.	32A-02	487166	4787379
Thomas St.	GARAGE	487348	4788345
Thomas St.	PASSMORE	486597	4786846
Thomas St.	PRIMEAU	487173	4786718
Thomas St.	REID	487452	4787943
Thomas St.	S3	488558	4786814

REFERENCE(S)
1. BASE DATA: MNR LIO, OBTAINED 2018
2. TOPOGRAPHIC MAPPING WITHIN THOMAS ST. QUARRY DERIVED FROM DRONE SURVEY PROVIDED BY SMC TO GOLDER IN DECEMBER 2018
3. BASE MAP: © 2020 MICROSOFT CORPORATION © 2020 DIGITALGLOBE ©CNES (2020) DISTRIBUTION AIRBUS DS
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
SITE PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	ST/SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
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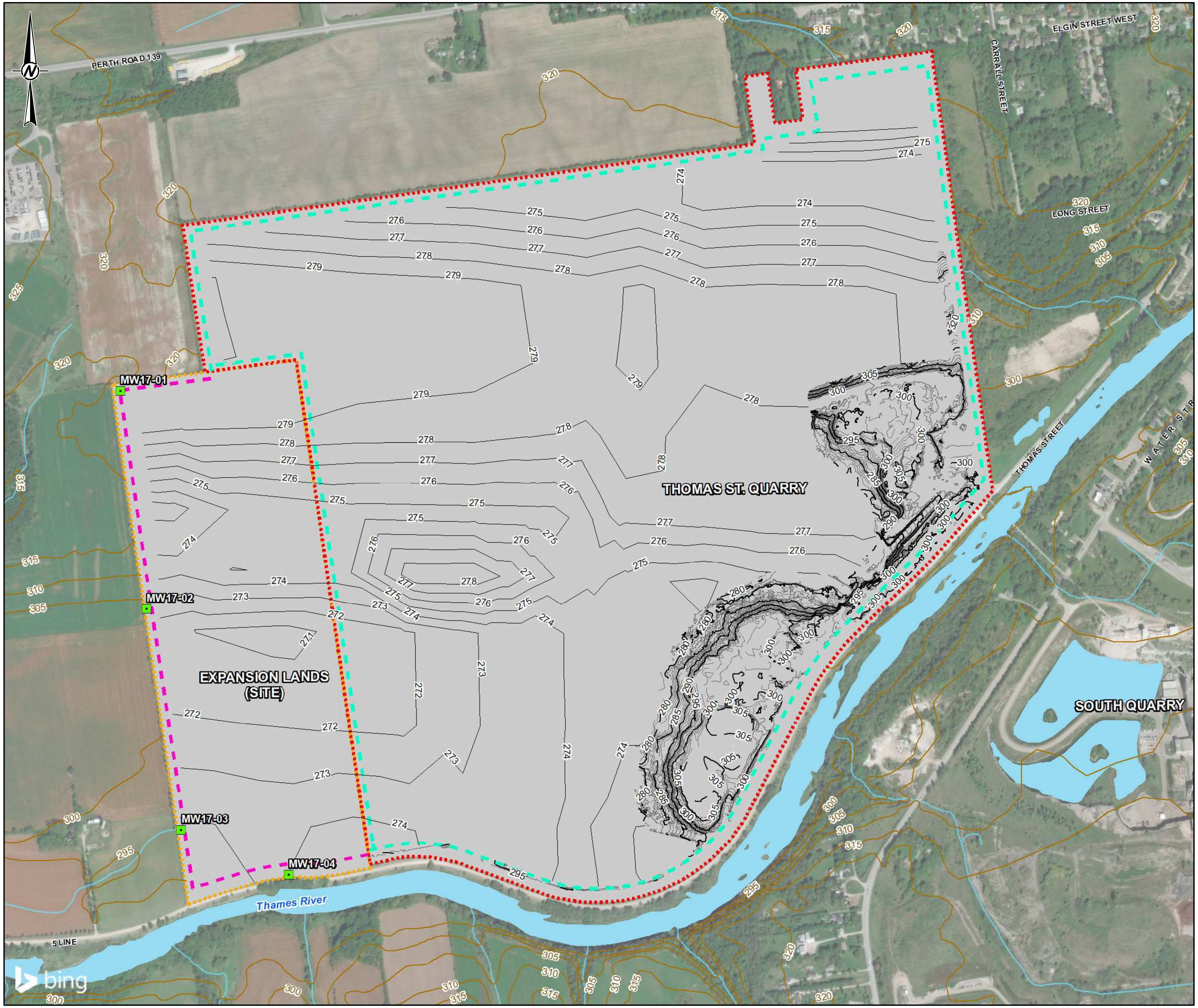

LEGEND

🟩	Site Groundwater Monitor Location
—	Ground Surface Elevation (masl)
—	Site Topography (5 m Interval)
—	Site Topography (1 m Interval)
—	Watercourse
▨	Waterbody
⬚	Existing License Boundary (Thomas St. Quarry)
⬚	Existing Limit of Extraction (Thomas St. Quarry)
⬚	Proposed License Boundary
⬚	Proposed Limit of Extraction

0 250 500

1:8,500 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. OPERATIONS AT FULL BUILD-OUT TOPOGRAPHY TAKEN FROM MINING PLANNING FINAL PIT.DWG, PETRUS, FEBRUARY 4, 2019."
3. BASE MAP: © 2020 MICROSOFT CORPORATION © 2020 DIGITALGLOBE ©CNES (2020) DISTRIBUTION AIRBUS DS
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4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
OPERATIONS SCENARIO (FULL BUILD-OUT)

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
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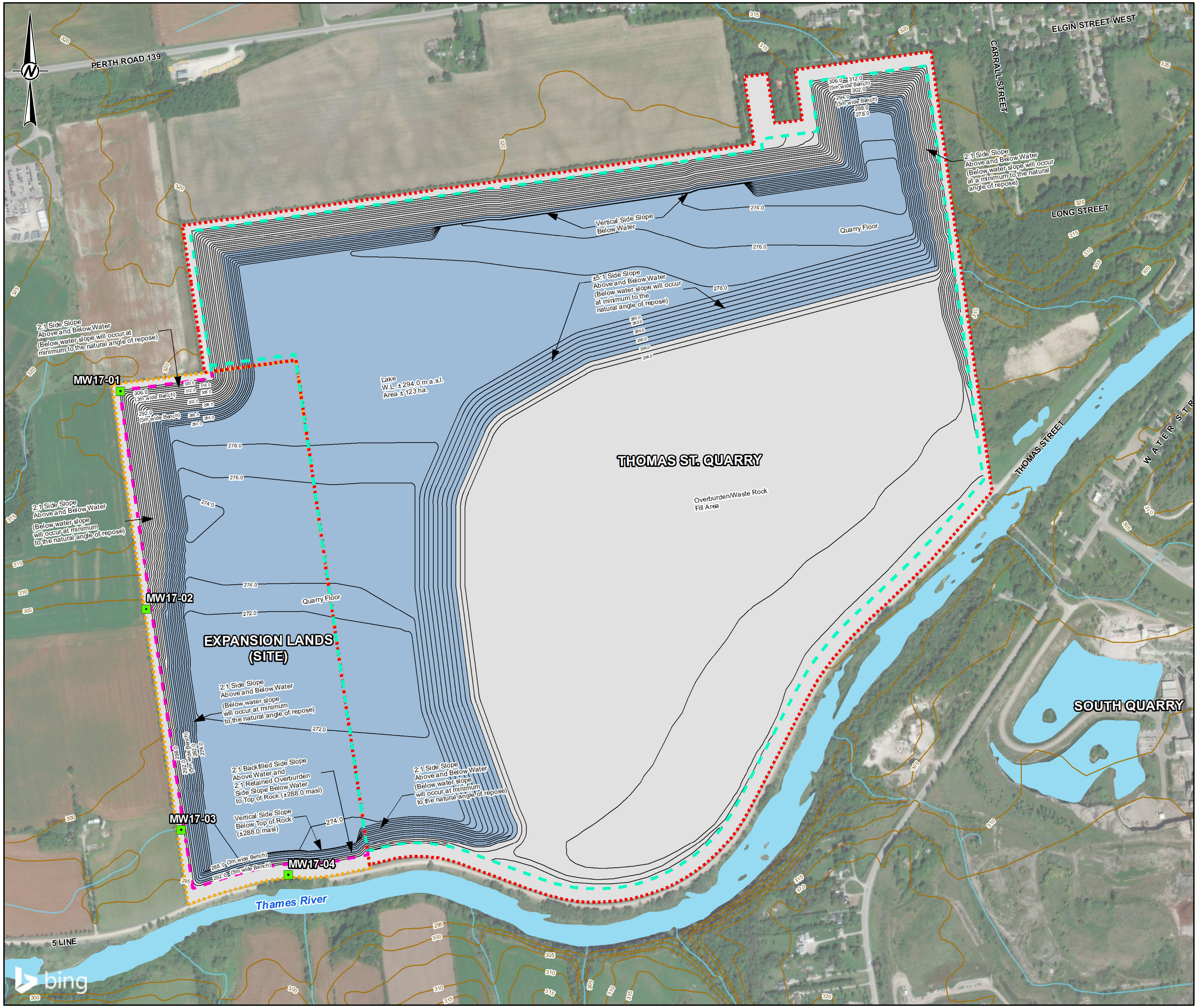

LEGEND

🟩	Site Groundwater Monitor Location
—	Ground Surface Elevation (masl)
—	Site Topography (2 m Interval)
—	Watercourse
🟦	Waterbody
▨	Existing License Boundary (Thomas St. Quarry)
▨	Existing Limit of Extraction (Thomas St. Quarry)
▨	Proposed License Boundary
▨	Proposed Limit of Extraction
🟦	Pit Lake

0 250 500

1:8,500 METRES

REFERENCE(S)

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4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
REHABILITATED SCENARIO

CONSULTANT
GOLDER

YYYY-MM-DD	2020-06-03
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

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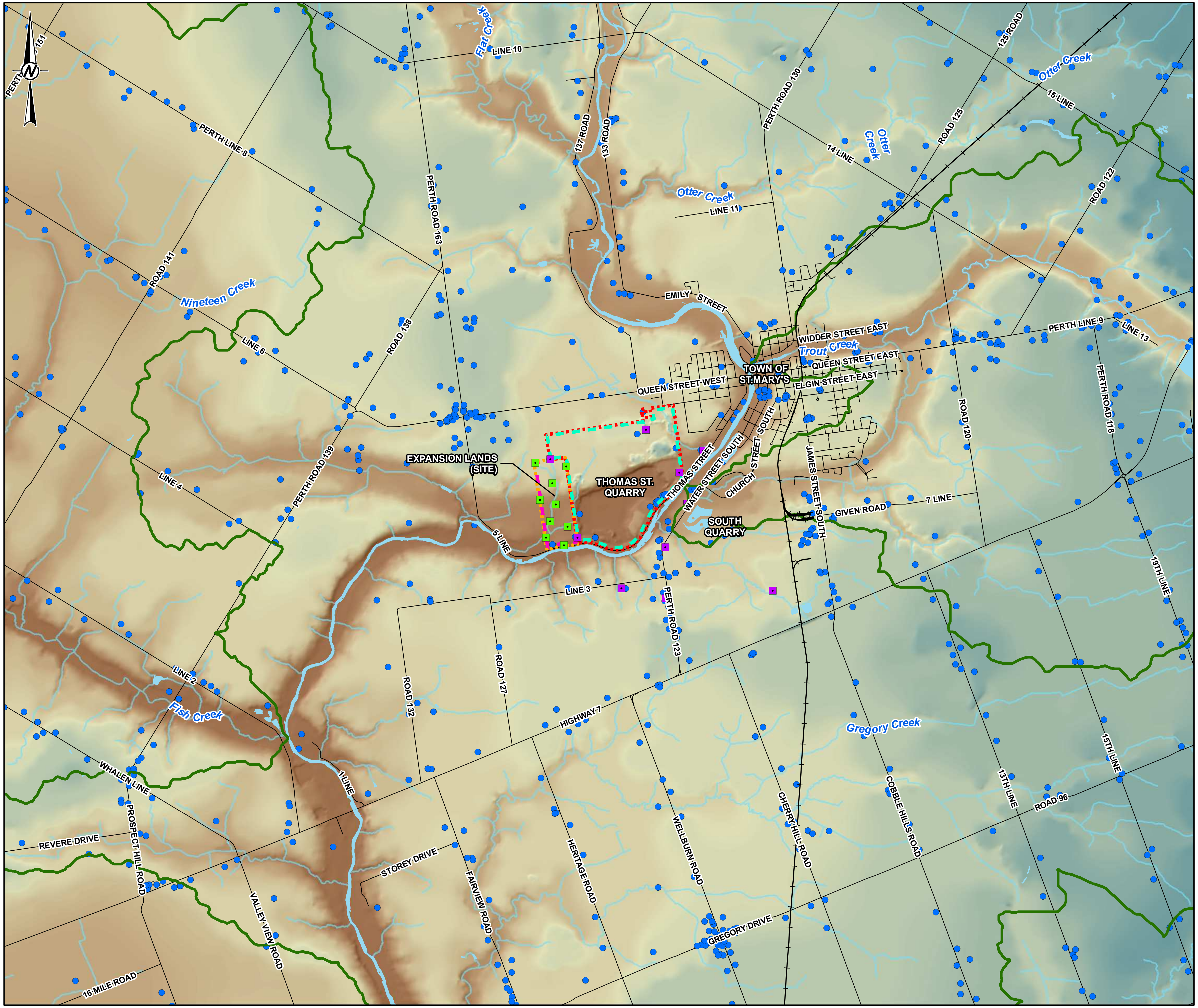

LEGEND

- ● MECP Water Well Record
- 🟩 Site Groundwater Monitor Location
- ■ Thomas St. Groundwater Monitor Location
- ┼ Railway
- — Watercourse
- ▨ Waterbody
- ▭ Existing License Boundary (Thomas St. Quarry)
- ▭ Existing Limit of Extraction (Thomas St. Quarry)
- ▭ Proposed License Boundary
- ▭ Proposed Limit of Extraction
- ▭ Watershed Boundary

Ground Surface Elvation (mas)

High: 350

Low: 270

0 1,000 2,000

1:50,000 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
REGIONAL TOPOGRAPHY AND DRAINAGE

CONSULTANT

GOLDER

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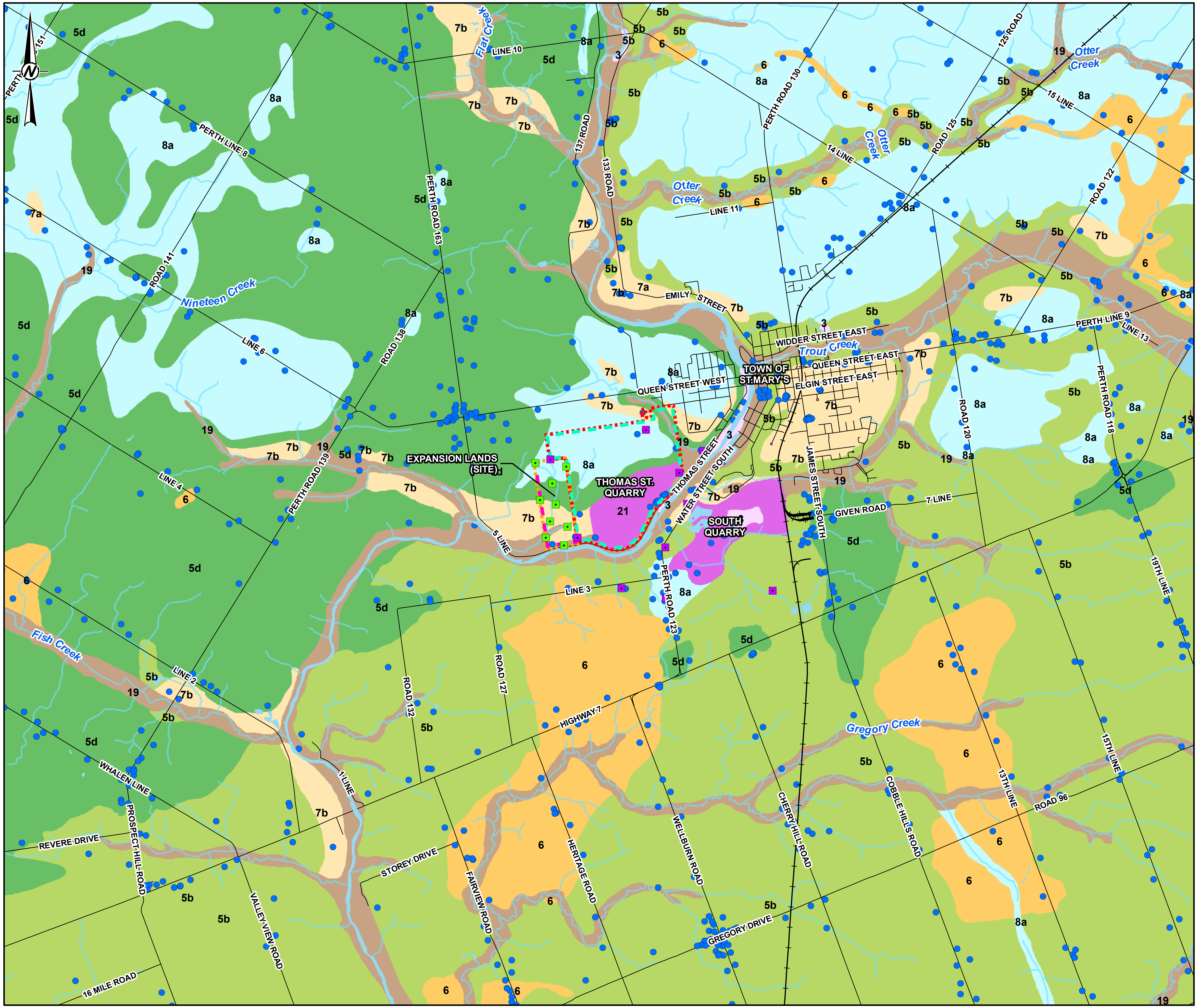

LEGEND

● MECP Water Well Record

▪ Site Groundwater Monitor Location

▪ Thomas St. Groundwater Monitor Location

Railway

Watercourse

Waterbody

Existing License Boundary (Thomas St. Quarry)

Existing Limit of Extraction (Thomas St. Quarry)

Proposed License Boundary

Proposed Limit of Extraction

Surficial Geology

3: Paleozoic bedrock

5b: Stone-poor, carbonate-derived silty to sandy till

5d: Glaciolacustrine-derived silty to clayey till

6: Ice-contact stratified deposits

7a: Sandy deposits

7b: Gravelly deposits

8a: Massive-well laminated

19: Modern alluvial deposits

21: Man-made deposits

0 1,000 2,000

1:50,000 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. SURFICIAL GEOLOGY: ONTARIO GEOLOGICAL SURVEY 2006: MRD128-SURFICIAL GEOLOGY OF SOUTHERN ONTARIO, (MNDM)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
SURFICIAL GEOLOGY

CONSULTANT
GOLDER

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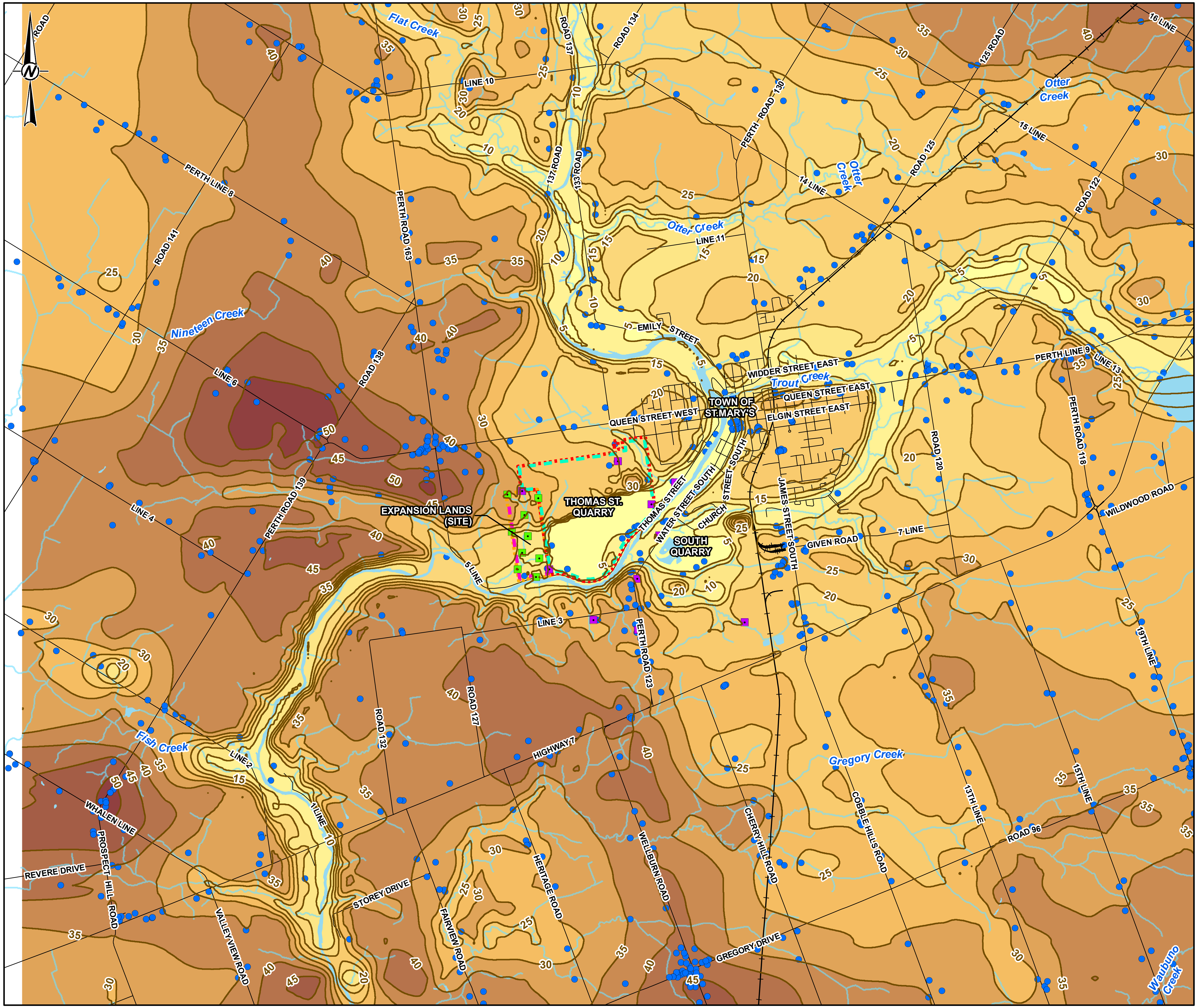

LEGEND

- ● MECP Water Well Record
- 🟩 Site Groundwater Monitor Location
- 🟪 Thomas St. Groundwater Monitor Location
- — Overburden Thickness Contour (5m Interval)
- ┼ Railway
- — Watercourse
- ▨ Waterbody
- ▭ Existing License Boundary (Thomas St. Quarry)
- ▭ Existing Limit of Extraction (Thomas St. Quarry)
- ▭ Proposed License Boundary
- ▭ Proposed Limit of Extraction

Overburden Thickness (m)

- ▨ 0 - 5
- ▨ 5 - 10
- ▨ 10 - 15
- ▨ 15 - 20
- ▨ 20 - 25
- ▨ 25 - 30
- ▨ 30 - 35
- ▨ 35 - 40
- ▨ 40 - 45
- ▨ 45 - 50
- ▨ 50 - 55

0 1,000 2,000
1:50,000 METRES

REFERENCE(S)
1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
INFERRED OVERBURDEN THICKNESS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
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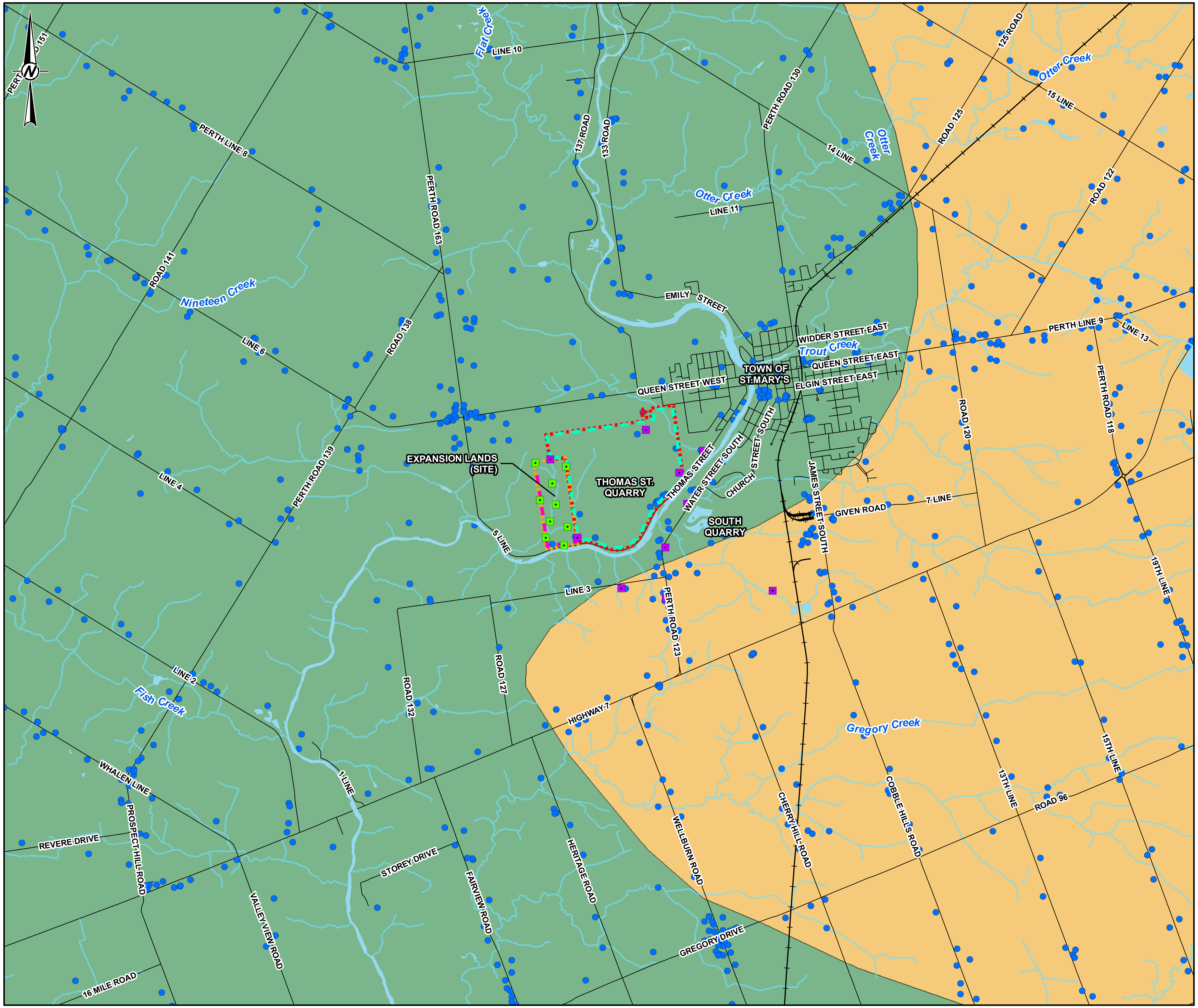

LEGEND

● MECP Water Well Record

🟩 Site Groundwater Monitor Location

🟪 Thomas St. Groundwater Monitor Location

┼ Railway

— Watercourse

▭ Waterbody

⬚ Existing License Boundary (Thomas St. Quarry)

⬚ Existing Limit of Extraction (Thomas St. Quarry)

⬚ Proposed License Boundary

⬚ Proposed Limit of Extraction

Bedrock Geology

🟩 59c Dundee Fm.

🟧 59d Detroit River Gp.; Onondaga Fm.

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. BEDROCK GEOLOGY: ONTARIO GEOLOGICAL SURVEY 2006: MRD126-REV1 BEDROCK GEOLOGY OF ONTARIO, (MNDM)
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CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
BEDROCK GEOLOGY

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-11
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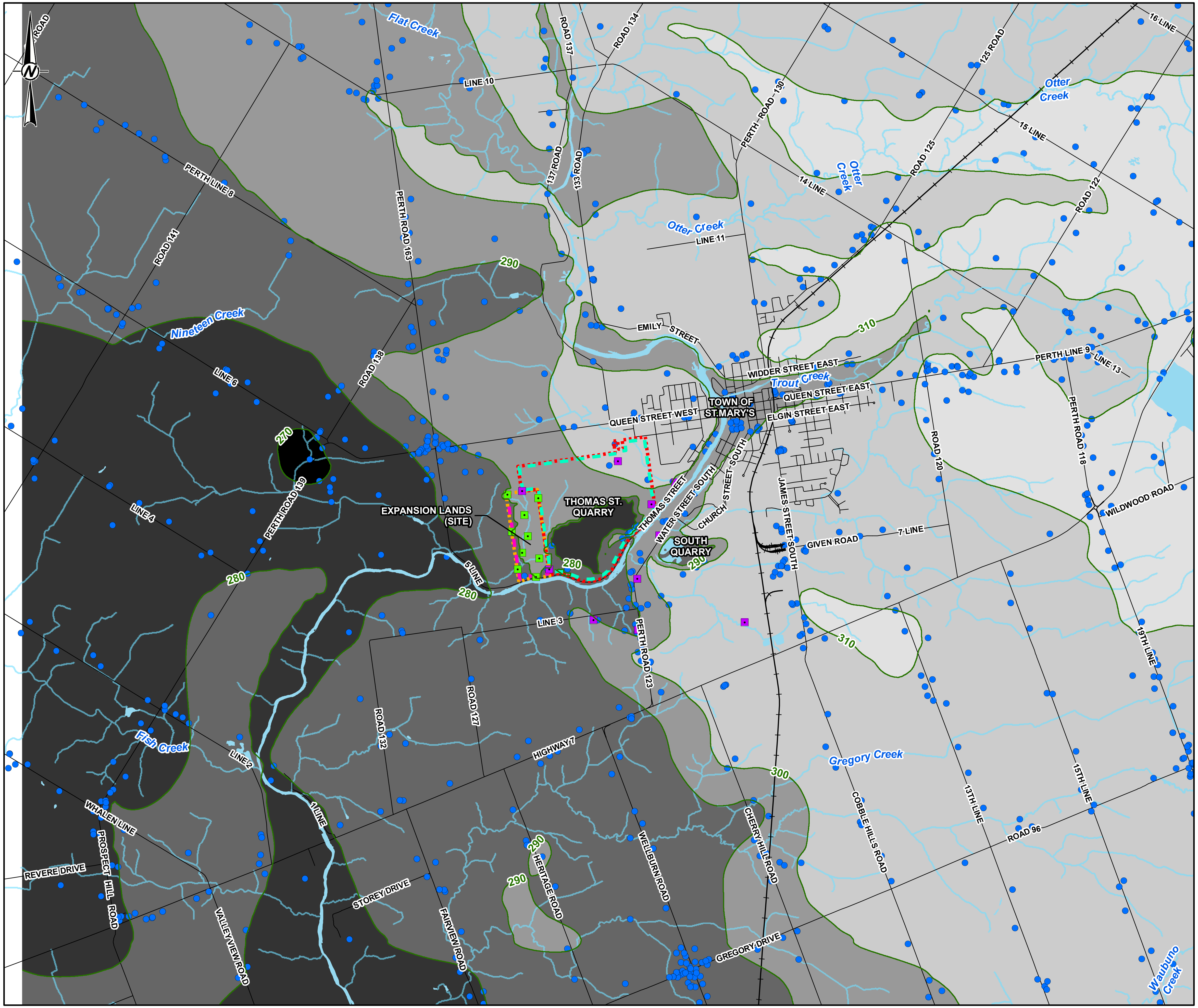

LEGEND

- ● MECP Water Well Record
- 🟩 Site Groundwater Monitor Location
- ■ Thomas St. Groundwater Monitor Location
- — Bedrock Contour (10m Interval)
- ┼ Railway
- — Watercourse
- ▬ Waterbody
- ⬚ Existing License Boundary (Thomas St. Quarry)
- ⬚ Existing Limit of Extraction (Thomas St. Quarry)
- ⬚ Proposed License Boundary
- ⬚ Proposed Limit of Extraction

Bedrock Elevation (masl)

- ■ < 270
- ■ 270 - 280
- ■ 280 - 290
- ■ 290 - 300
- ■ 310 - 310
- □ 310 - 320

0 1,000 2,000

1:50,000 METRES

REFERENCE(S)
1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXTENSION

TITLE
BEDROCK SURFACE

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-11
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PROJECT NO.	CONTROL	REV.	MAP
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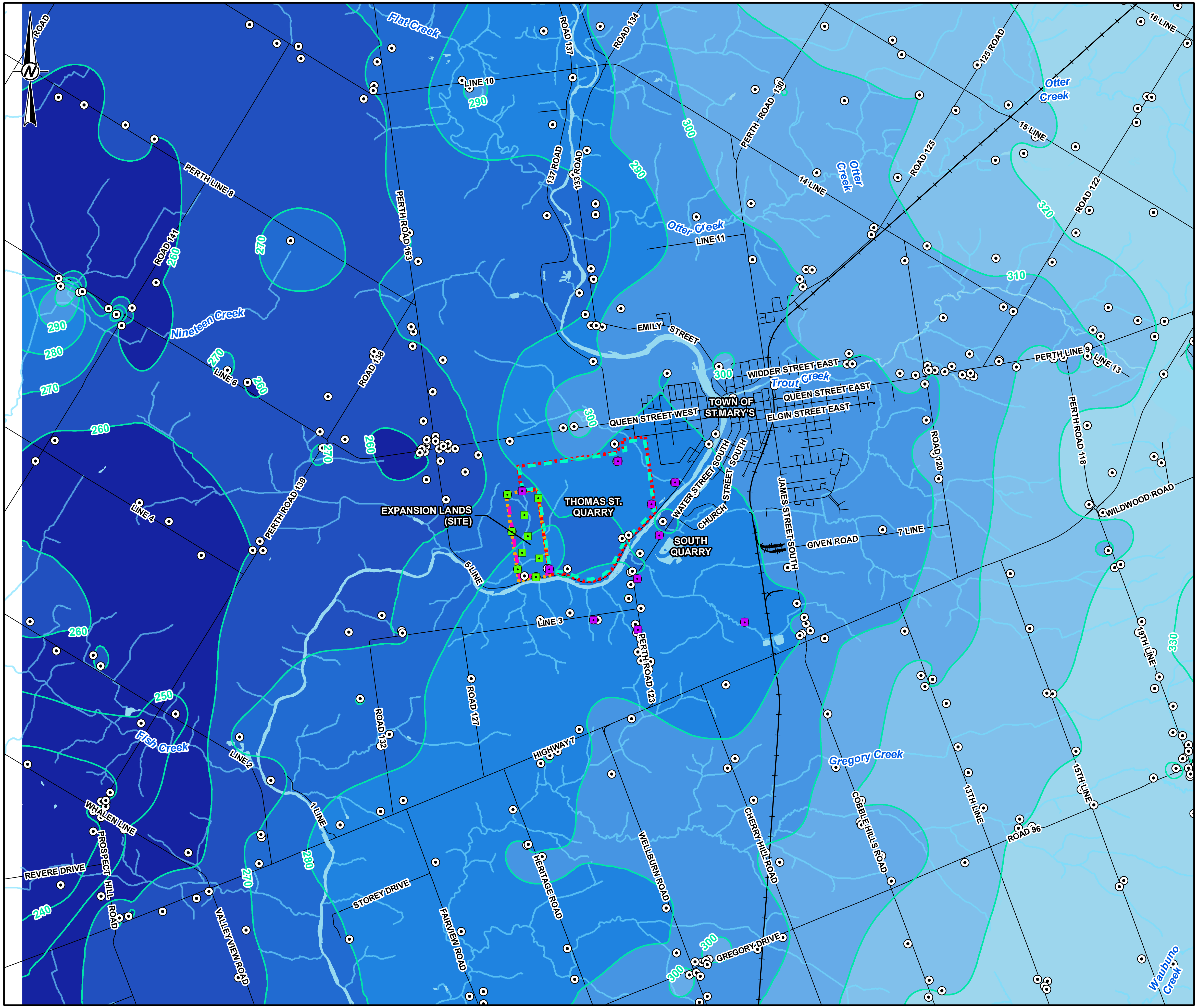


LEGEND

- ⊙ MECP Bedrock Well
- 🟩 Site Groundwater Monitor Location
- 🟪 Thomas St. Groundwater Monitor Location
- — Inferred Bedrock Water Level Contour (10m Interval)
- ┼ Railway
- — Watercourse
- ▨ Waterbody
- ⬚ Existing License Boundary (Thomas St. Quarry)
- ⬚ Existing Limit of Extraction (Thomas St. Quarry)
- ⬚ Proposed License Boundary
- ⬚ Proposed Limit of Extraction

Inferred Bedrock Water Level (masl)

- ▨ 230 - 260
- ▨ 260 - 270
- ▨ 270 - 280
- ▨ 280 - 290
- ▨ 290 - 300
- ▨ 300 - 310
- ▨ 310 - 320
- ▨ 320 - 330

0 1,000 2,000
1:50,000 METRES

REFERENCE(S)
1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
INFERRED BEDROCK WATER LEVELS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

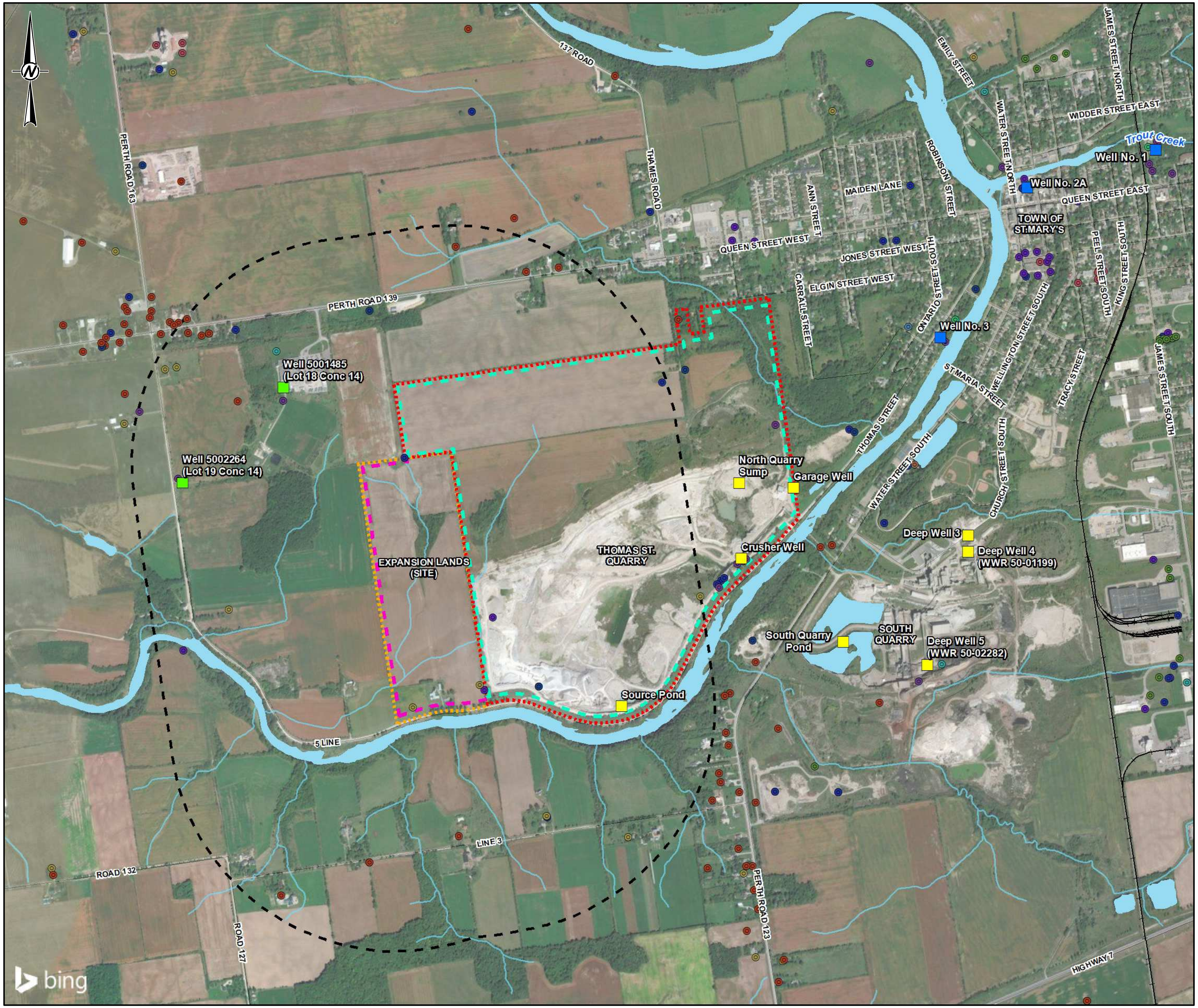
PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	2.6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

PATH: S:\Clients\Votorantim_Cimentos\Bonis_Quarry\99_PROJ\1781508\40_PROD\0008_Hydrogeology\1781508-0008-CH-0008.mxd PRINTED ON: 2020-03-12 AT: 5:58:21 PM



LEGEND

Permit to take Water

- 🟩 Maple Leaf Foods
- 🟨 St. Marys Cement
- 🟦 Town of St. Marys

MECP Water Well Record (Primary Use)

- ● Commerical
- ● Domestic
- ● Industrial
- ● Livestock
- ● Monitoring
- ● Monitoring and Test Hole
- ● Municipal
- ● Not Used
- ● Other
- ● Public
- ● Test Hole
- ● Unclassified
- ┼ Railway
- — Watercourse
- ▨ Waterbody
- ▭ Existing License Boundary (Thomas St. Quarry)
- ▭ Existing Limit of Extraction (Thomas St. Quarry)
- ▭ Proposed License Boundary
- ▭ Proposed Limit of Extraction
- ▭ Thomas Street Quarry Site 1 km Buffer

0 500 1,000

1:17,000 METRES

REFERENCE(S)
1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
REGIONAL GROUNDWATER USE

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	2.7

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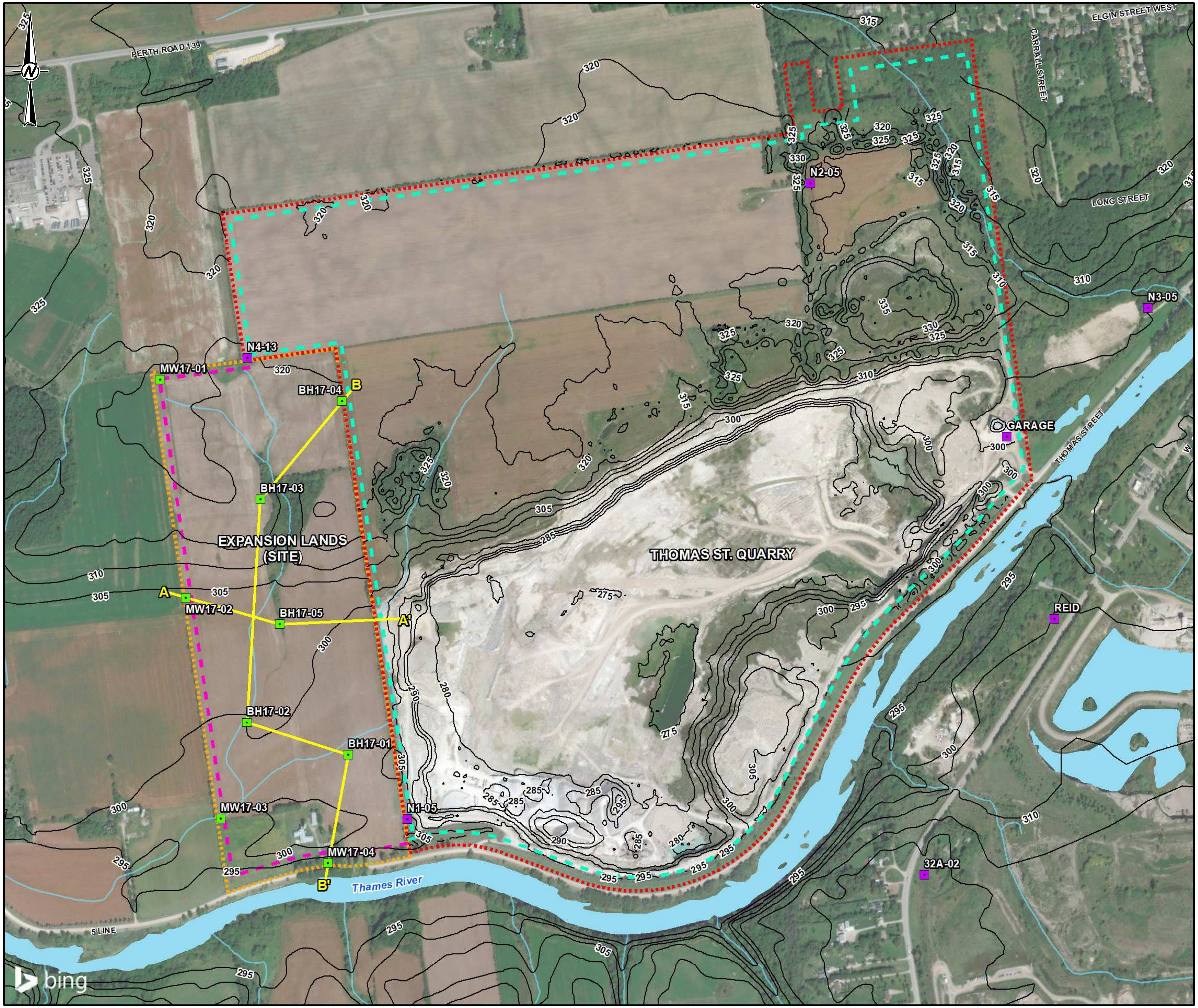

LEGEND

- 🟩 Site Groundwater Monitor Location
- 🟪 Thomas St. Groundwater Monitor Location
- Hydrostratigraphic Profile Lines
- Ground Surface Elevation (masl)
- Watercourse
- Existing License Boundary (Thomas St. Quarry)
- Existing Limit of Extraction (Thomas St. Quarry)
- Proposed License Boundary
- Proposed Limit of Extraction
- Waterbody

0 250 500

1:8,500 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2018
2. TOPOGRAPHIC MAPPING WITHIN THOMAS ST. QUARRY DERIVED FROM DRONE SURVEY PROVIDED BY SMC TO GOLDER IN DECEMBER 2018
3. BASE MAP: © 2020 MICROSOFT CORPORATION © 2020 DIGITALGLOBE ©CNES (2020) DISTRIBUTION AIRBUS DS
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
SITE MONITORS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	ST/SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	3.1

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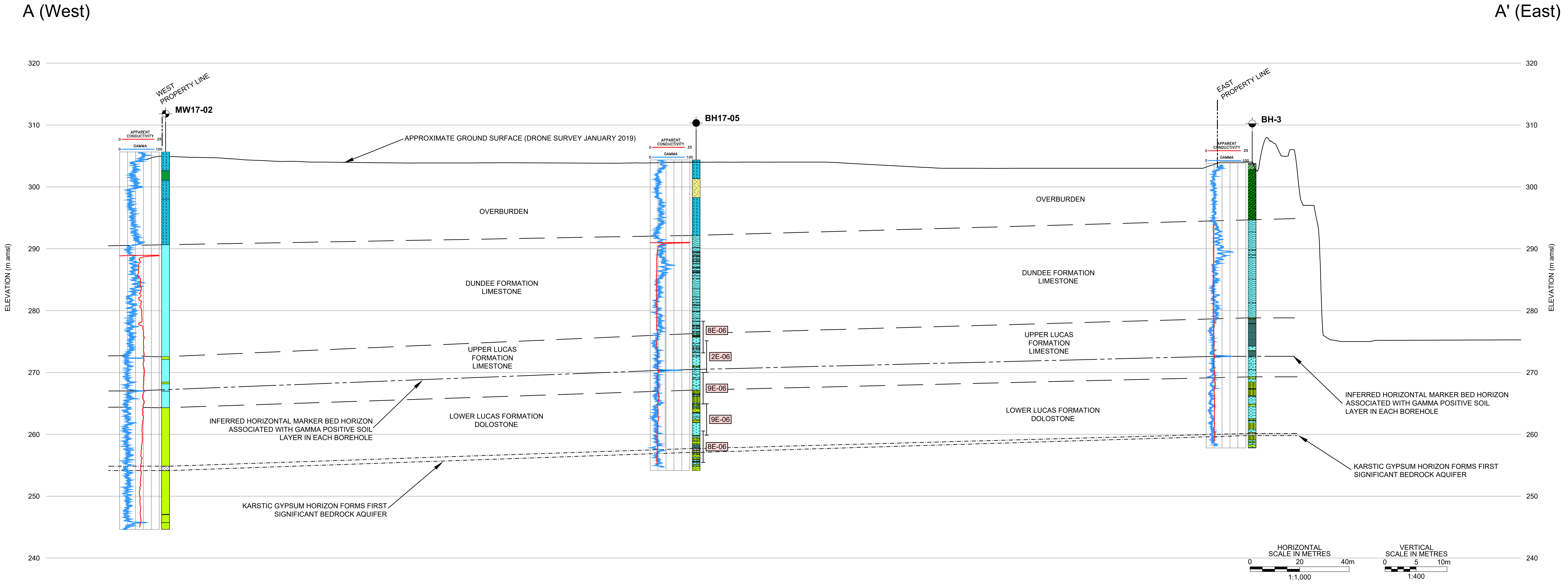
25mm



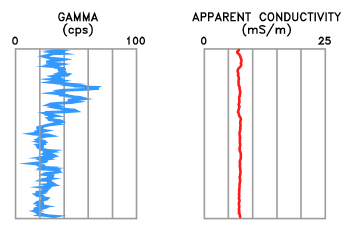
LEGEND

● CORED BOREHOLE

◑ ROTARY DRILLED HOLE

◒ BOREHOLE/MONITORING WELL
(GOLDER REPORT 09-1112-6039)

1E-05 HYDRAULIC CONDUCTIVITY (K)
VALUE IN (m/s) FROM PACKER
TESTING



— — FORMATION LINE

— - - — INFERRED HORIZONTAL MARKER BED HORIZON
ASSOCIATED WITH GAMMA POSITIVE SOIL
LAYER IN EACH BOREHOLE

—·—·—·— KARSTIC GYPSUM HORIZON FORMS FIRST
SIGNIFICANT BEDROCK AQUIFER

SIMPLIFIED STRATIGRAPHY:

- 🟪 TOPSOIL
- 🟨 SAND
- 🟦 SAND & GRAVEL
- 🟩 CLAY
- ▨ CLAYEY SILT
- ▨ CLAYEY SILT TILL
- 🟦 LIMESTONE
- 🟩 DOLOSTONE

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

FOR PROFILE LOCATION, REFER TO FIGURE 3.1.

ALL LOCATIONS ARE APPROXIMATE.

PROJECT

THOMAS ST. QUARRY EXPANSION

TITLE

WEST TO EAST PROFILE
(A-A')

GOLDER

PROJECT No.		1781508	FILE No. 1781508-8000-R0103-2
			SCALE AS SHOWN REV.
CADD	DCH/ZJB	Mar 11/20	
CHECK			**FIGURE 3.2**

Client: Votorantim Cimentos

Original Format is Tabloid 279mm x 783mm

0 25mm

Drawing file: 1781508-8000-R0103-2.dwg Mar 11, 2020 - 9:07am

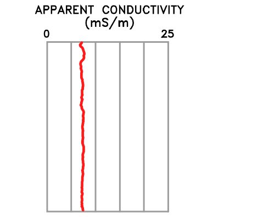
Client: Votorantim Cimentos

Original Format is Tabloid 279mm x 1434mm

Drawing file: 1781508-8000-R0103-2.dwg Mar 11, 2020 – 9:07am

LEGEND

- CORED BOREHOLE
- ROTARY DRILLED HOLE
- 1E-05 HYDRAULIC CONDUCTIVITY (K) VALUE IN (m/s) FROM PACKER TESTING



- FORMATION LINE
- INFERRED HORIZONTAL MARKER BED HORIZON ASSOCIATED WITH GAMMA POSITIVE SOIL LAYER IN EACH BOREHOLE
- KARSTIC GYPSUM HORIZON FORMS FIRST SIGNIFICANT BEDROCK AQUIFER

SIMPLIFIED STRATIGRAPHY:

🟪	TOPSOIL	🟦	SAND & GRAVEL
🟨	SAND	🟩	SILTY CLAY TILL
🟨	SILTY SAND TILL	🟩	CLAY
🟧	SILT	🟩	CLAYEY SILT TILL
🟧	SILT TILL	🟦	LIMESTONE
▨	GRAVEL	🟩	DOLOSTONE

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

FOR PROFILE LOCATION, REFER TO FIGURE 3.1.

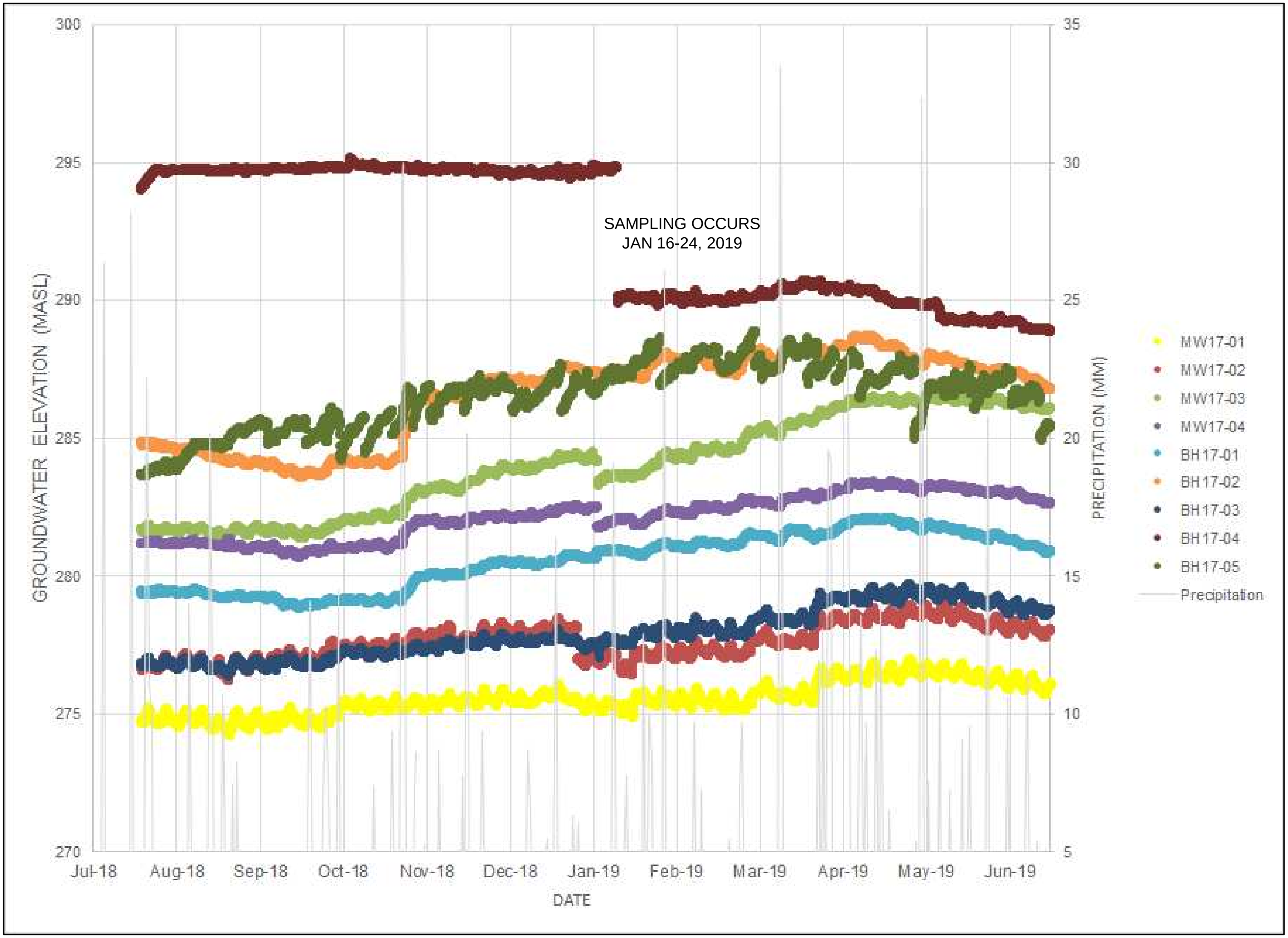
ALL LOCATIONS ARE APPROXIMATE.

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
NORTH TO SOUTH PROFILE
(B-B')

GOLDER

PROJECT No.		1781508	FILE No. 1781508-8000-R0103-2	
			SCALE AS SHOWN	REV.
CADD	DCH/ZJB	Mar 11/20	**FIGURE 3.3**	
CHECK				



NOTES

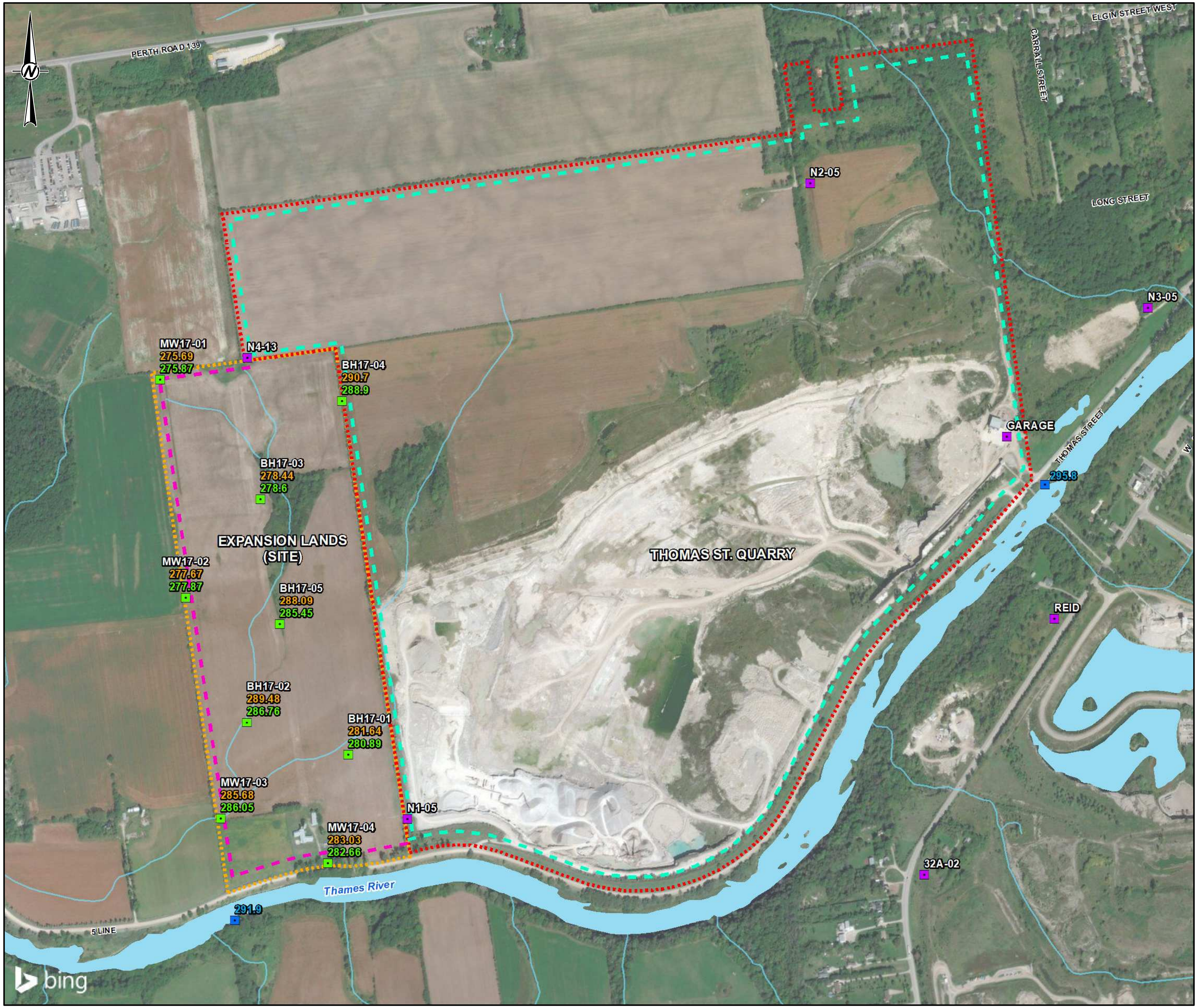
ST. MARYS CEMENT INC. (CANADA): THOMAS ST. QUARRY EXPANSION

GOLDER

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

SITE GROUNDWATER HYDROGRAPHS

MARCH 2020	PROJECT: 1781508	FIGURE: 3.4



LEGEND

281.64	April 9 2019 Measured Water Level (masl)
281.64	July 15 2019 Measured Water Level (masl)
281.64	Thames River water level surveyed by Delph and Jenkins on July 26 2019
🟩	Site Groundwater Monitor Location
🟪	Thames St. Groundwater Monitor Location
🟦	Thames River Water Elevation Location
—	Ground Surface Elevation (masl)
—	Watercourse
⬚	Existing License Boundary (Thomas St. Quarry)
⬚	Existing Limit of Extraction (Thomas St. Quarry)
⬚	Proposed License Boundary
⬚	Proposed Limit of Extraction
🟦	Waterbody

0 250 500

1:8,500 METRES

NOTE(S)

1. THOMAS ST. QUARRY 2019 MONITOR WATER LEVELS, COLLECTED BY WOOD, NOT AVAILABLE AT TIME OF FIGURE PRODUCTION.

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2018
2. TOPOGRAPHIC MAPPING WITHIN THOMAS ST. QUARRY DERIVED FROM DRONE SURVEY PROVIDED BY SMC TO GOLDER IN DECEMBER 2018
3. BASE MAP: © 2020 MICROSOFT CORPORATION © 2020 DIGITALGLOBE ©CNES (2020) DISTRIBUTION AIRBUS DS
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
SITE GROUNDWATER ELEVATIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	ST/SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	3.5

LEGEND

① Field Identified Well

MECP Water Well Record (Final Status)

🔴 Abandoned
🟣 Alteration
🟢 Observation
🟠 Test Hole
🔵 Water Supply
⚫ Unclassified
┼ Railway
— Watercourse
🟦 Waterbody
┅ Existing License Boundary (Thomas St. Quarry)
┅ Existing Limit of Extraction (Thomas St. Quarry)
┅ Proposed License Boundary
┅ Proposed Limit of Extraction
┅ Proposed License Boundary 1 km Buffer

0 500 1,000
1:16,000 METRES

REFERENCE(S)
1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
MECP WATER WELL RECORDS AND PRIVATE WELL SURVEY

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	3.6

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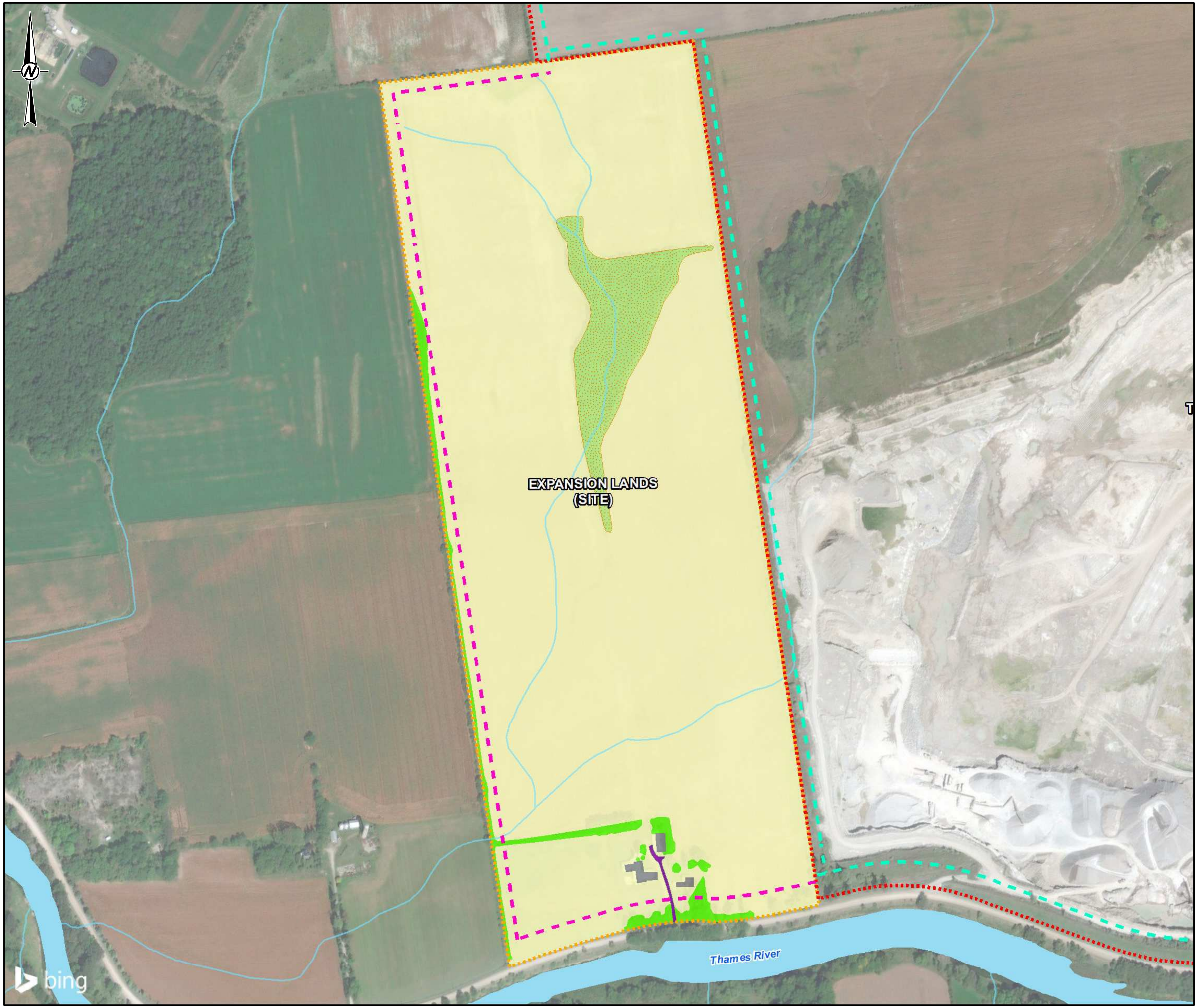

LEGEND

- Watercourse
- Waterbody
- Existing License Boundary (Thomas St. Quarry)
- Existing Limit of Extraction (Thomas St. Quarry)
- Proposed License Boundary
- Proposed Limit of Extraction

Land Use

- Tilled
- Building
- Road
- Wooded (Mixed Trees)
- Undifferentiated (Upland Thicket)

LAND USE TYPE	AREA (ha)
Tilled	42.84
Building	0.11
Road	0.04
Undifferentiated (Upland Thicket)	2.42
Wooded (Mixed Trees)	1.04

0 100 200 300

1:5,000 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. LAND USE INFOMATION OBTATAINED FROM MNRF LIO SOUTHERN ONTARIO LAND RESOURCE INFORMATION SYSTEMT (SOLRIS) V2.0 (2015).
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
LAND USE UNDER EXISTING SCENARIO

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	4.1

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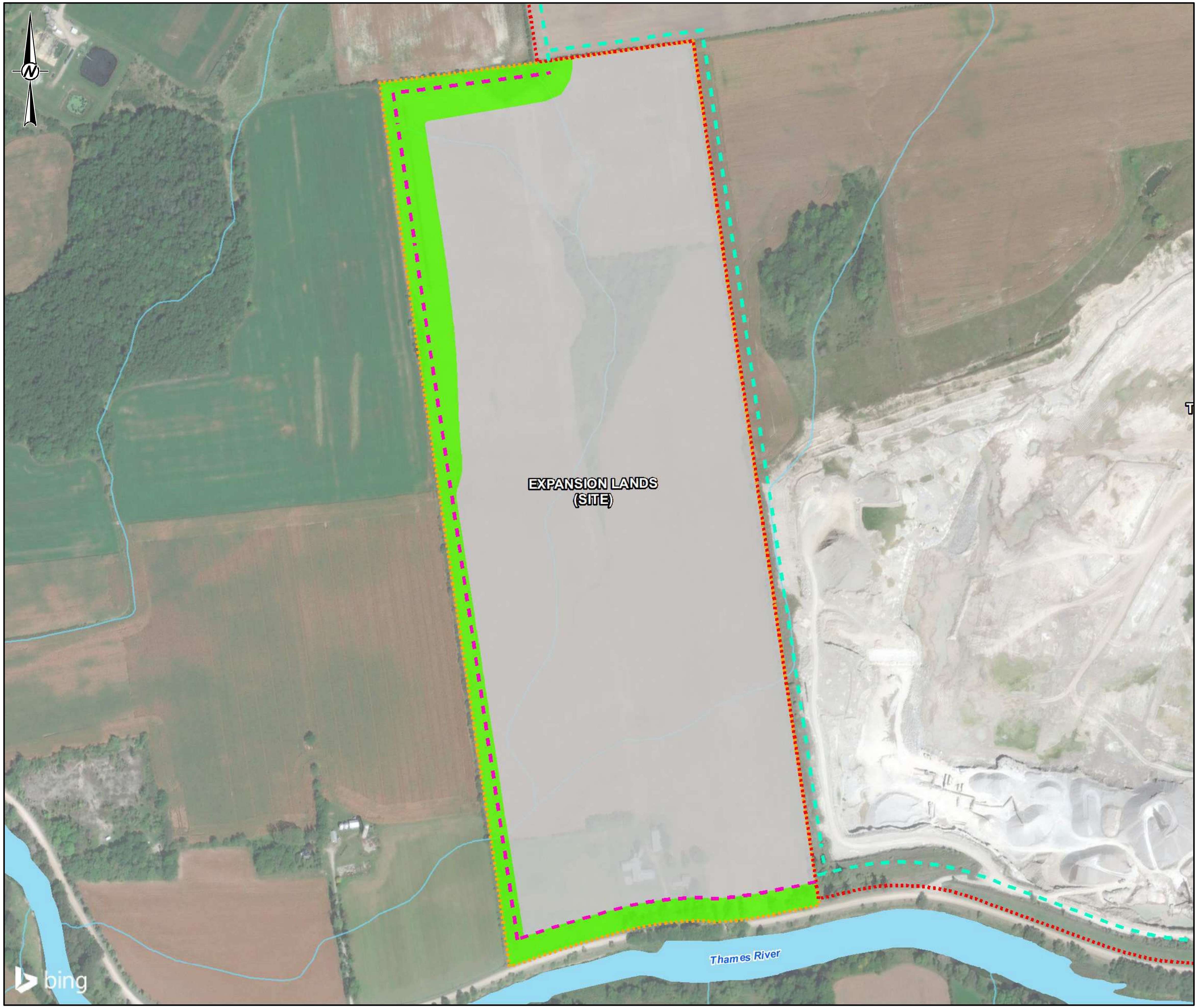
25mm



LEGEND

━	Watercourse
▇	Waterbody
⬚	Existing License Boundary (Thomas St. Quarry)
⬚	Existing Limit of Extraction (Thomas St. Quarry)
⬚	Proposed License Boundary
⬚	Proposed Limit of Extraction

Land Use

🟩	Grass Berm
▇	Quarry Extraction

Land Use Type	Area (ha)
Grass Berm	6.11
Quarry Extraction	40.354681

0 100 200 300

1:5,000 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. LAND USE INFOMATION OBTATAINED FROM MNRF LIO SOUTHERN ONTARIO LAND RESOURCE INFORMATION SYSTEMT (SOLRIS) V2.0 (2015).
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
LAND USE UNDER OPERATIONS SCENARIO

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	4.2

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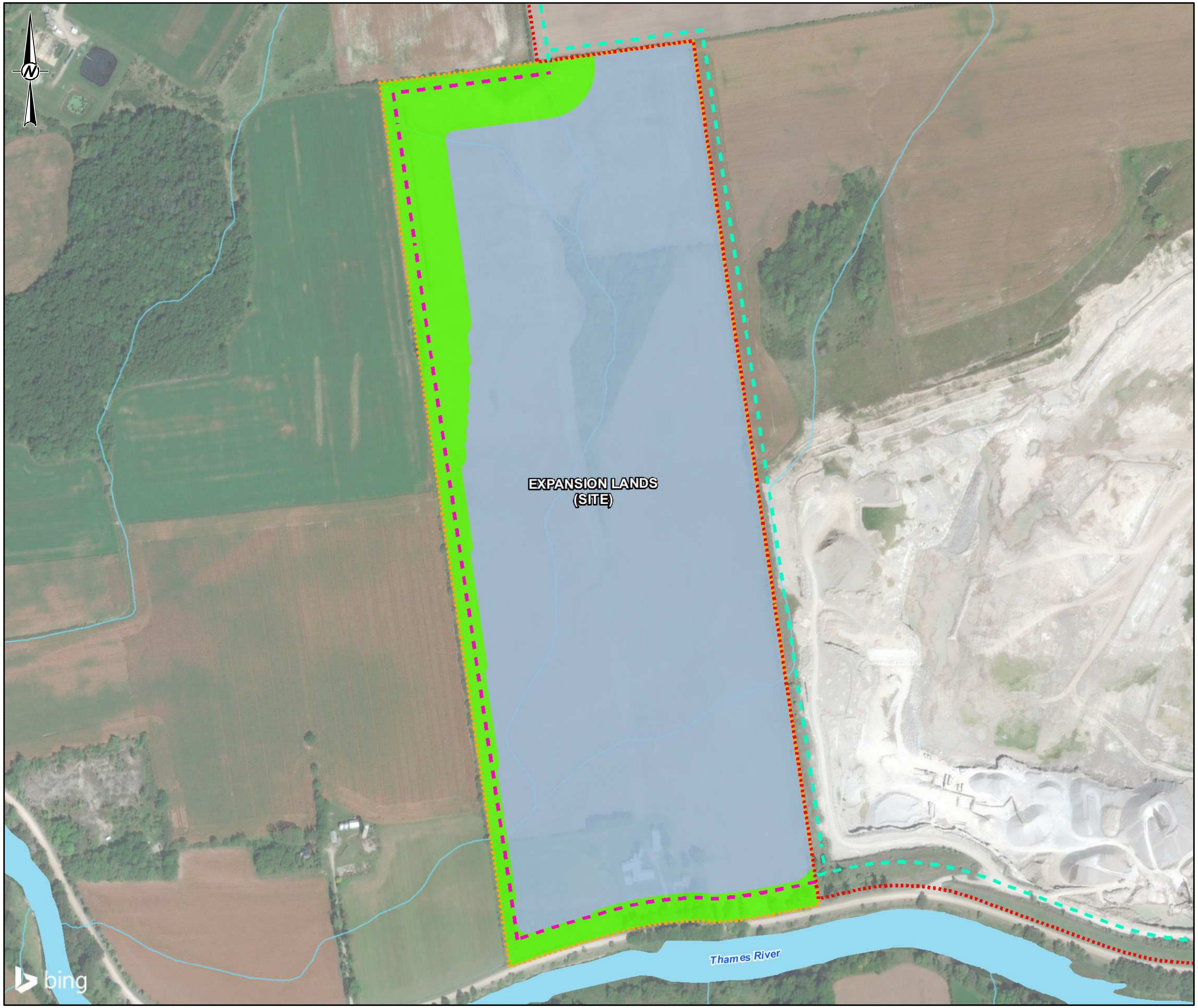

LEGEND

- Watercourse
- Waterbody
- Existing License Boundary (Thomas St. Quarry)
- Existing Limit of Extraction (Thomas St. Quarry)
- Proposed License Boundary
- Proposed Limit of Extraction

Land Use

- 🟩 Fully Vegetated Berm
- Pit Lake

Land Use Type	Area (ha)
Fully Vegetated Berm	7.89
Pit Lake	38.57

0 100 200 300

1:5,000 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. LAND USE INFOMATION OBTATAINED FROM MNRF LIO SOUTHERN ONTARIO LAND RESOURCE INFORMATION SYSTEMT (SOLRIS) V2.0 (2015).
3. PROJECTION: TRANSVERSE MERCATOR   DATUM: NAD 83   COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
LAND USE UNDER REHABILITATED SCENARIO

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	4.3

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25mm

0

LEGEND

●	Modelled Pumping Well
●	MECP Water Well Record
🟩	Site Groundwater Monitor Location
🟪	Thomas St. Groundwater Monitor Location
- - -	Model Cross-Sections
┼	Railway
—	Watercourse
▨	Waterbody
⬚	Existing License Boundary (Thomas St. Quarry)
⬚	Existing Limit of Extraction (Thomas St. Quarry)
⬚	Proposed License Boundary
⬚	Proposed Limit of Extraction
⬚	Model Domain

Ground Surface Elevation (masl)

High: 350

Low: 270

0 1,000 2,000

1:50,000 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

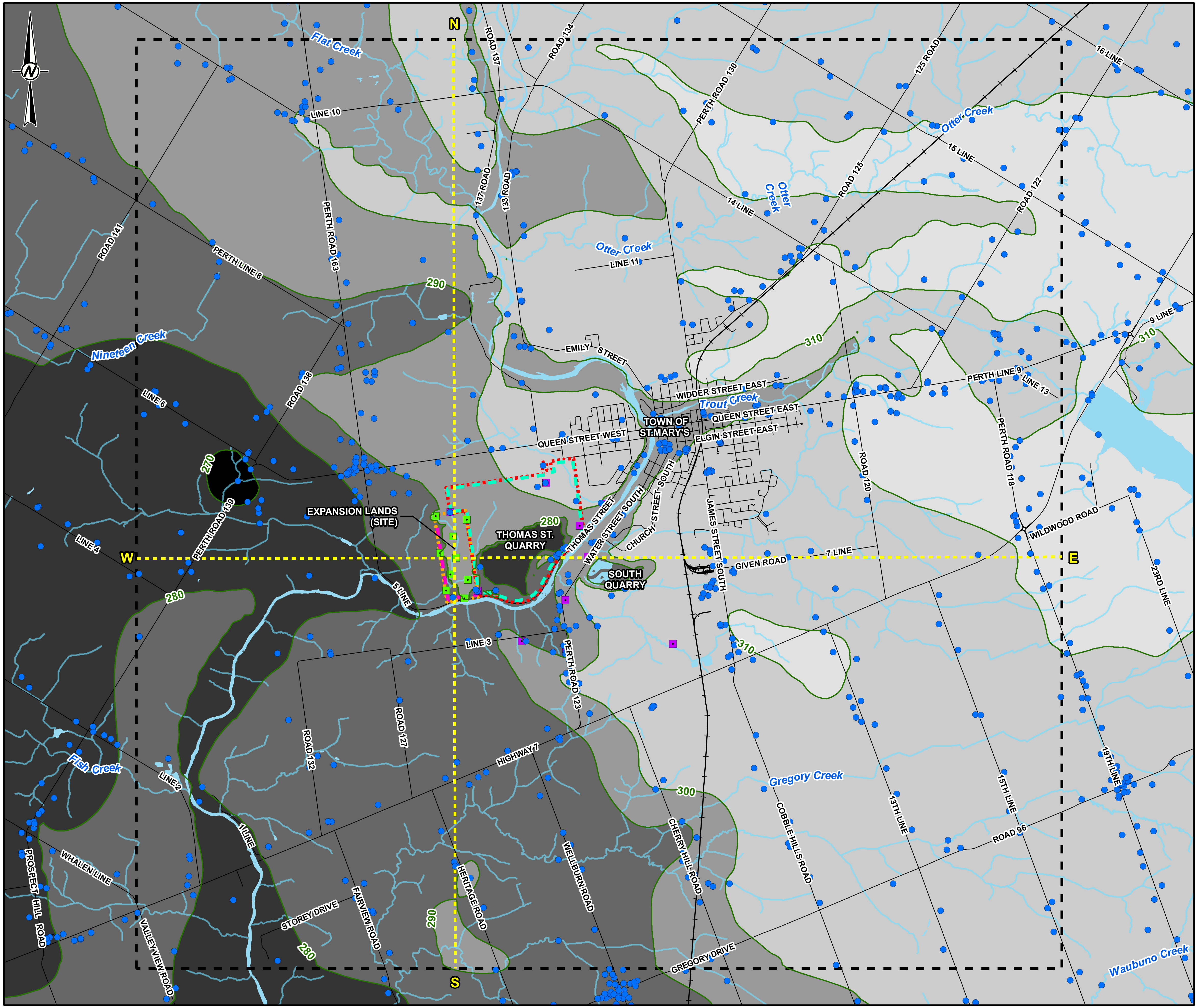
TITLE
MODEL DOMAIN

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	5.1



LEGEND

- ● MECP Water Well Record
- 🟩 Site Groundwater Monitor Location
- ■ Thomas St. Groundwater Monitor Location
- Model Cross-Sections
- Bedrock Contour (10m Interval)
- Railway
- Watercourse
- Waterbody
- Existing License Boundary (Thomas St. Quarry)
- Existing Limit of Extraction (Thomas St. Quarry)
- Proposed License Boundary
- Proposed Limit of Extraction
- Model Domain

Bedrock Elevation (m)

- ■ < 270
- ■ 270 - 280
- ■ 280 - 290
- ■ 290 - 300
- ■ 300 - 310
- ■ 310 - 320

0 1,000 2,000

1:50,000 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
MODELLED BEDROCK SURFACE

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	5.2

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25mm

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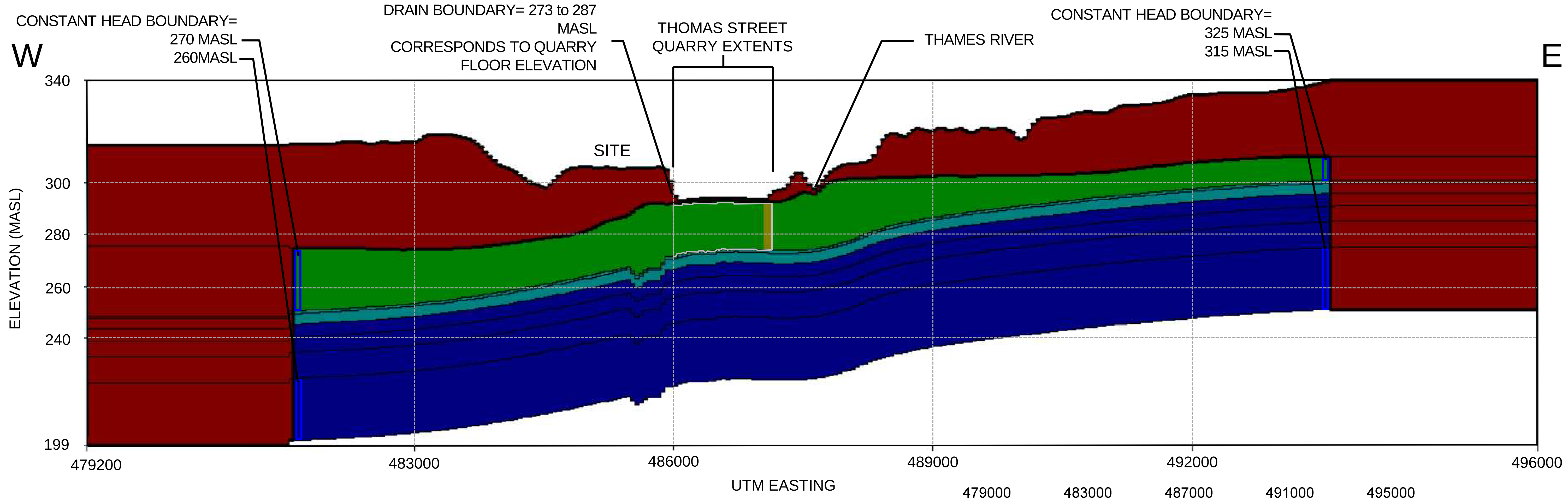


LEGEND

🟩 DUNDEE/ UPPER LUCAS FORMATION (K= 5E-5 M/S)

🟫 NATIVE TILL (K= 1E-6 M/S)

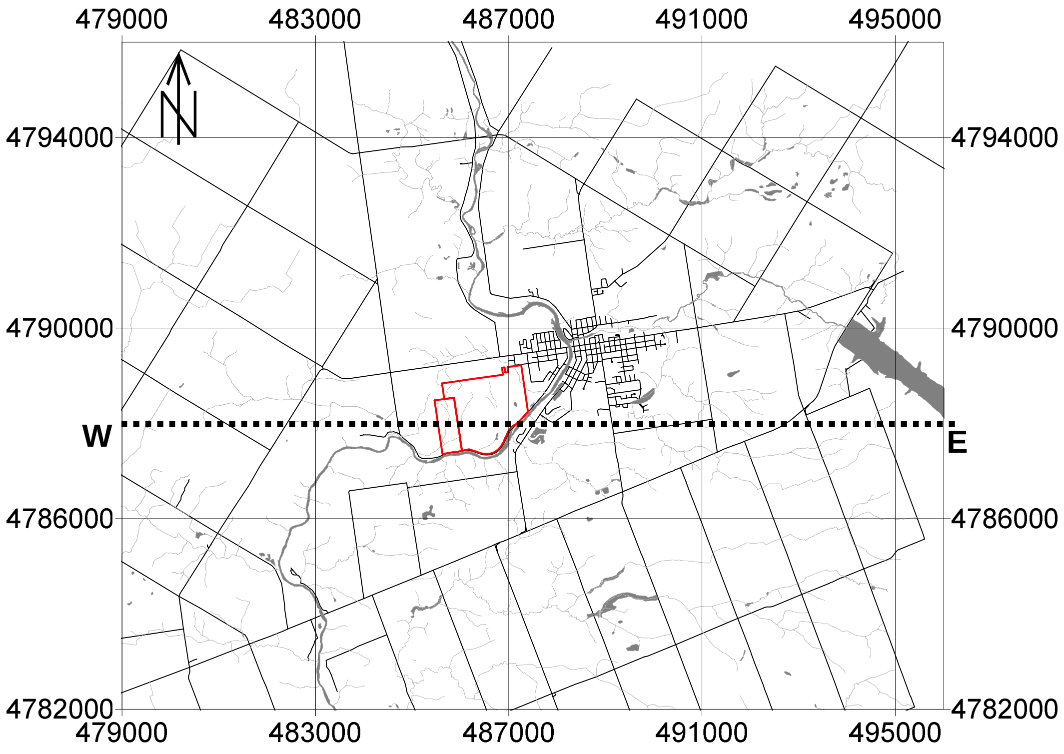
🟦 LOWER LUCAS FORMATION UPPER (K= 1E-7 M/S)

🟦 LOWER LUCAS FORMATION LOWER (K= 1E-4 M/S)

🟥 INACTIVE FLOW BOUNDARY

⬜ DRAIN BOUNDARY

▭ CONSTANT HEAD BOUNDARY



NOTES

1. Vertical exaggeration is 30x.
2. Horizontal hydraulic conductivity listed.
3. Horizontal to vertical hydraulic conductivity for each model layer = 1:1 with the exception of the Lower Lucas Formation (Upper) where K_v= 1E-9 m/s.

CLIENT
ST. MARY'S CEMENT INC. (CANADA)

PROJECT
THOMAS STREET QUARRY EXPANSION

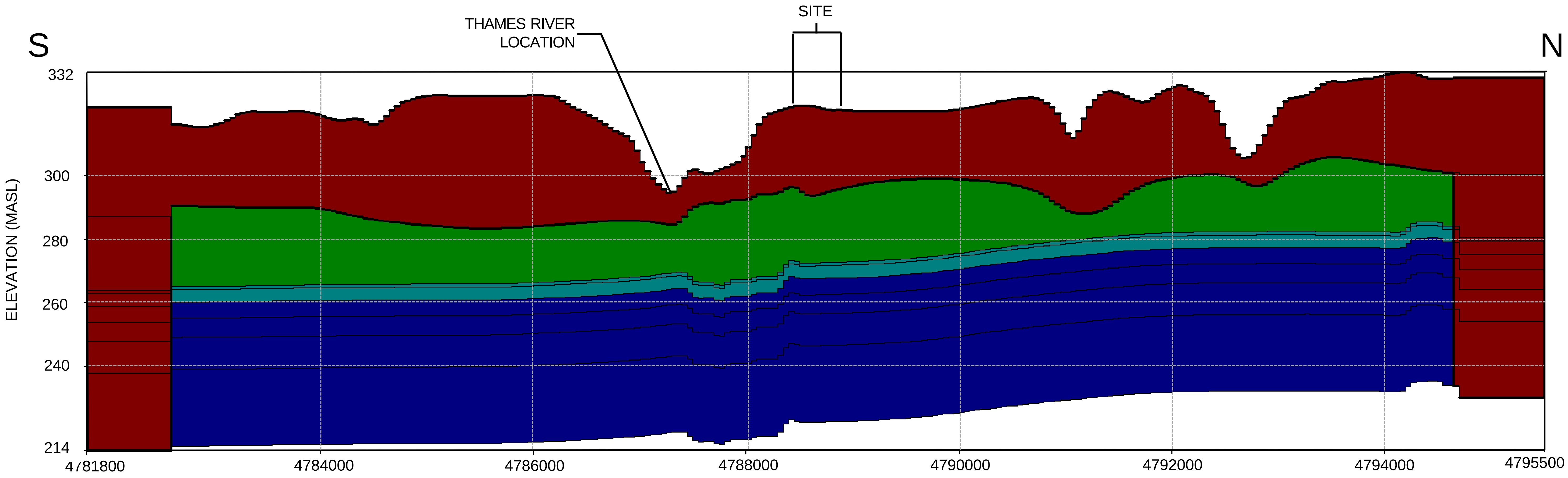
CONSULTANT

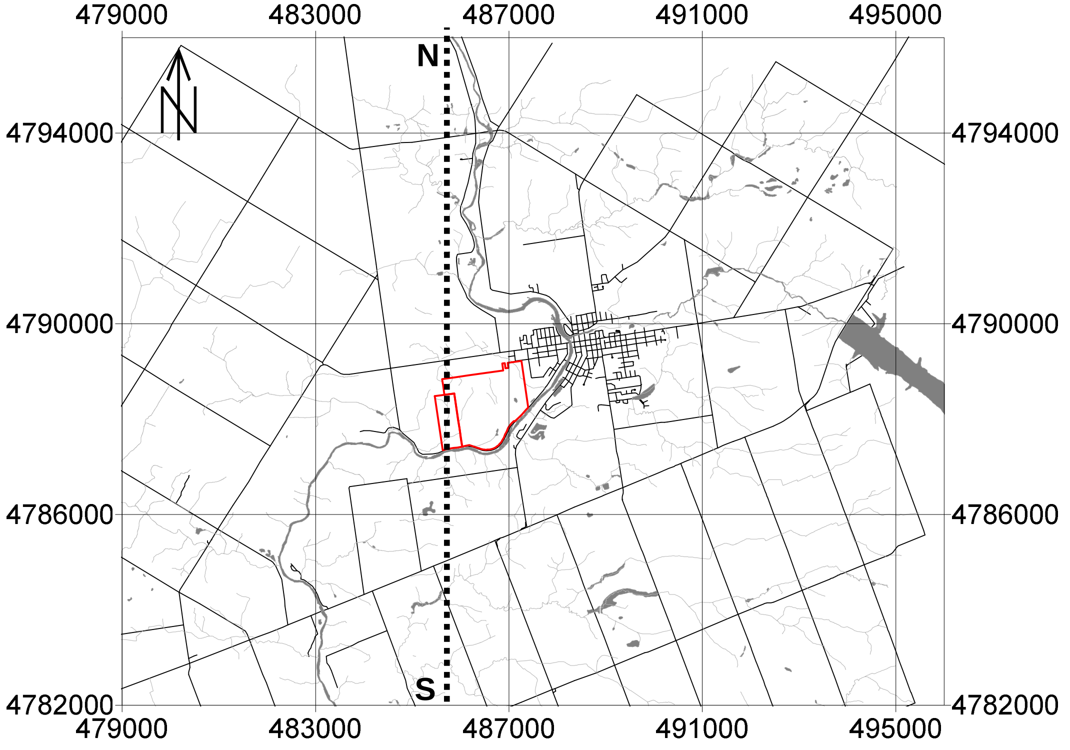
GOLDER

YYYY-MM-DD	2020-03-11
PREPARED	HW
DESIGN	HW
REVIEW	DAH
APPROVED	DAH

TITLE
MODEL SECTION WEST-EAST

PROJECT No. 1781508
Rev. A
FIGURE 5.3





LEGEND

🟩 DUNDEE/ UPPER LUCAS FORMATION (K= 5E-5 M/S)

🟦 LOWER LUCAS FORMATION UPPER (K= 1E-7 M/S)

🟦 LOWER LUCAS FORMATION LOWER (K= 1E-4 M/S)

🟥 INACTIVE FLOW BOUNDARY

NOTES

1. Vertical exaggeration is 30x.
2. Horizontal hydraulic conductivity listed.
3. Horizontal to vertical hydraulic conductivity for each model layer = 1:1 with the exception of the Lower Lucas Formation (Upper) where K_v= 1E-9 m/s.

CLIENT
ST. MARY'S CEMENT INC. (CANADA)

PROJECT
THOMAS STREET QUARRY EXPANSION

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
PREPARED	HW
DESIGN	HW
REVIEW	DAH
APPROVED	DAH

TITLE
MODEL SECTION SOUTH-NORTH

PROJECT No. 1781508
Rev. A
FIGURE 5.4

LEGEND

- ● Modelled Pumping Well and Pumping Rate
- Model Cross-Sections
- Railway
- Watercourse
- Waterbody
- Existing License Boundary (Thomas St. Quarry)
- Existing Limit of Extraction (Thomas St. Quarry)
- Proposed License Boundary
- Proposed Limit of Extraction
- Model Domain
- Constant Head Boundary Condition

Drain Boundary Conditions

- ▨ Thomas St. Drains – Layer 2 = Quarry Floor Elev.
- ▨ Site Drains (Operations) – Layer 2 = Quarry Floor Elev.

0 1,000 2,000
1:50,000 METRES

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
BOUNDARY CONDITIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
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PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	5.5

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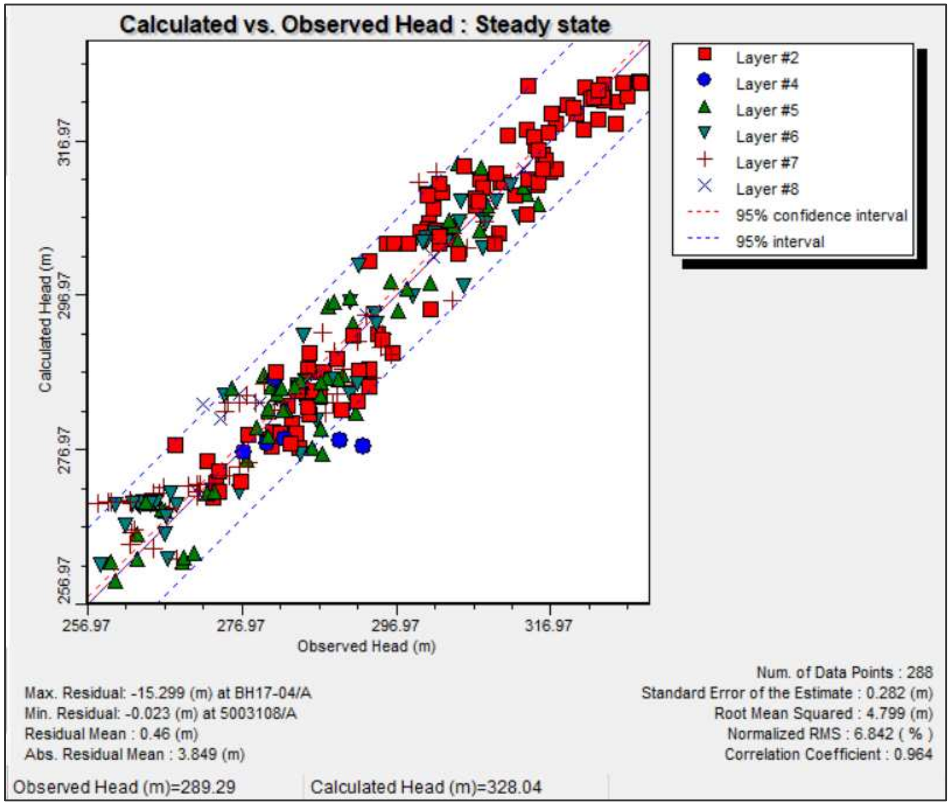
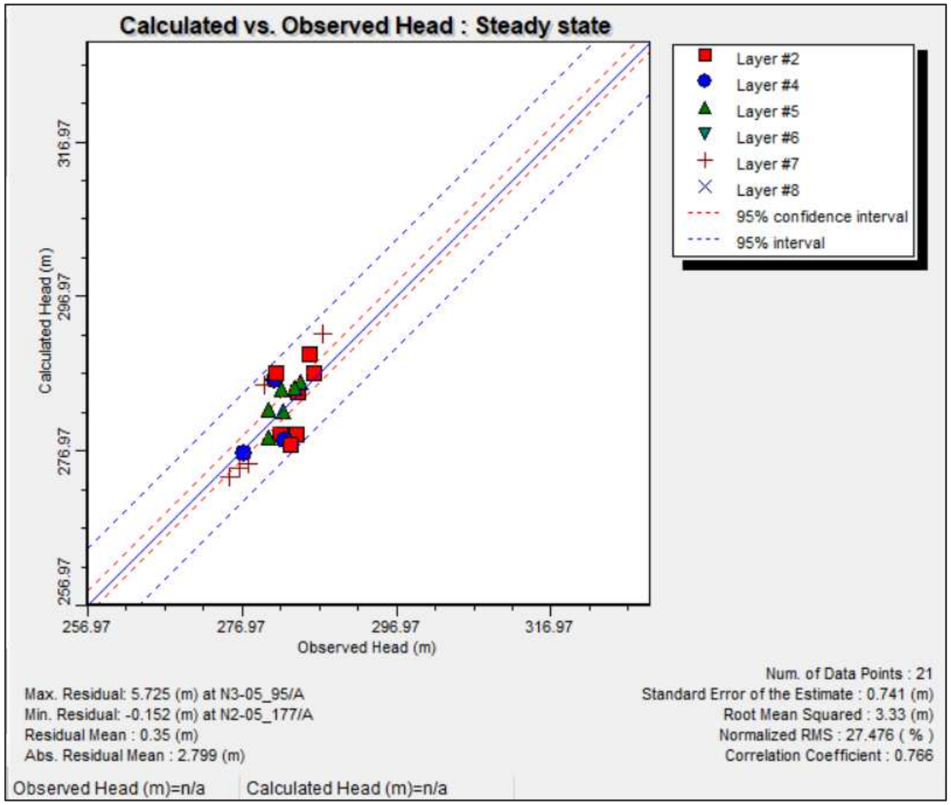


Num. of Data Points : 288
Standard Error of the Estimate : 0.282 (m)
Root Mean Squared : 4.799 (m)
Normalized RMS : 6.842 (%)
Correlation Coefficient : 0.964

Max. Residual: -15.299 (m) at BH17-04/A
Min. Residual: -0.023 (m) at 5003108/A
Residual Mean : 0.46 (m)
Abs. Residual Mean : 3.849 (m)

Observed Head (m)=289.29
Calculated Head (m)=328.04

GLOBAL



Num. of Data Points : 21
Standard Error of the Estimate : 0.741 (m)
Root Mean Squared : 3.33 (m)
Normalized RMS : 27.476 (%)
Correlation Coefficient : 0.766

Max. Residual: 5.725 (m) at N3-05_95/A
Min. Residual: -0.152 (m) at N2-05_177/A
Residual Mean : 0.35 (m)
Abs. Residual Mean : 2.799 (m)

Observed Head (m)=n/a
Calculated Head (m)=n/a

SITE / THOMAS ST.

NOTES

.

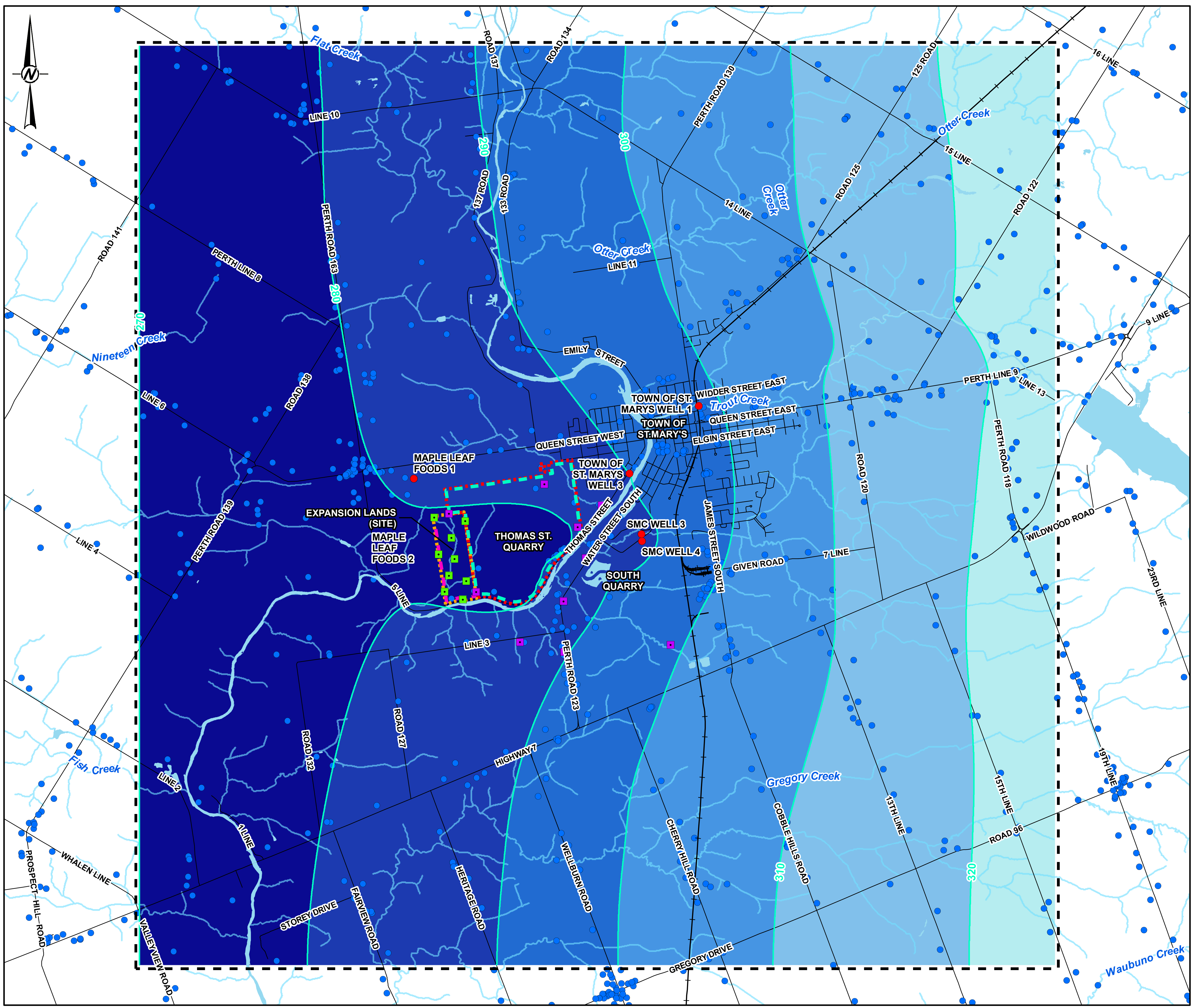
ST. MARYS CEMENT INC. (CANADA): THOMAS ST. QUARRY EXPANSION

GOLDER

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

CALIBRATION STATISTICS

MARCH 2020	PROJECT: 1781508	FIGURE: 5.6



LEGEND

● Modelled Pumping Well
● MECP Water Well Record
▣ Site Groundwater Monitor Location
▣ Thomas St. Groundwater Monitor Location
— Simulated Groundwater Level Contour (10 m Interval)
—+— Railway
— Watercourse
▨ Waterbody
▭ Existing License Boundary (Thomas St. Quarry)
▭ Existing Limit of Extraction (Thomas St. Quarry)
▭ Proposed License Boundary
▭ Proposed Limit of Extraction
▭ Model Domain

Simulated Groundwater Level (m)

▨ 270 - 280
▨ 280 - 290
▨ 290 - 300
▨ 300 - 310
▨ 310 - 320
▨ 320 - 330

0 1,000 2,000
1:50,000 METRES

NOTE(S)

1. SIMULATED GROUNDWATER LEVELS ARE TAKEN FROM LAYER 2 DUNDEE / UPPER LUCAS FORMATION AQUIFER MODELLED HEAD OUTPUT.

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
SIMULATED GROUNDWATER LEVELS (EXISTING SCENARIO)

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	5.7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
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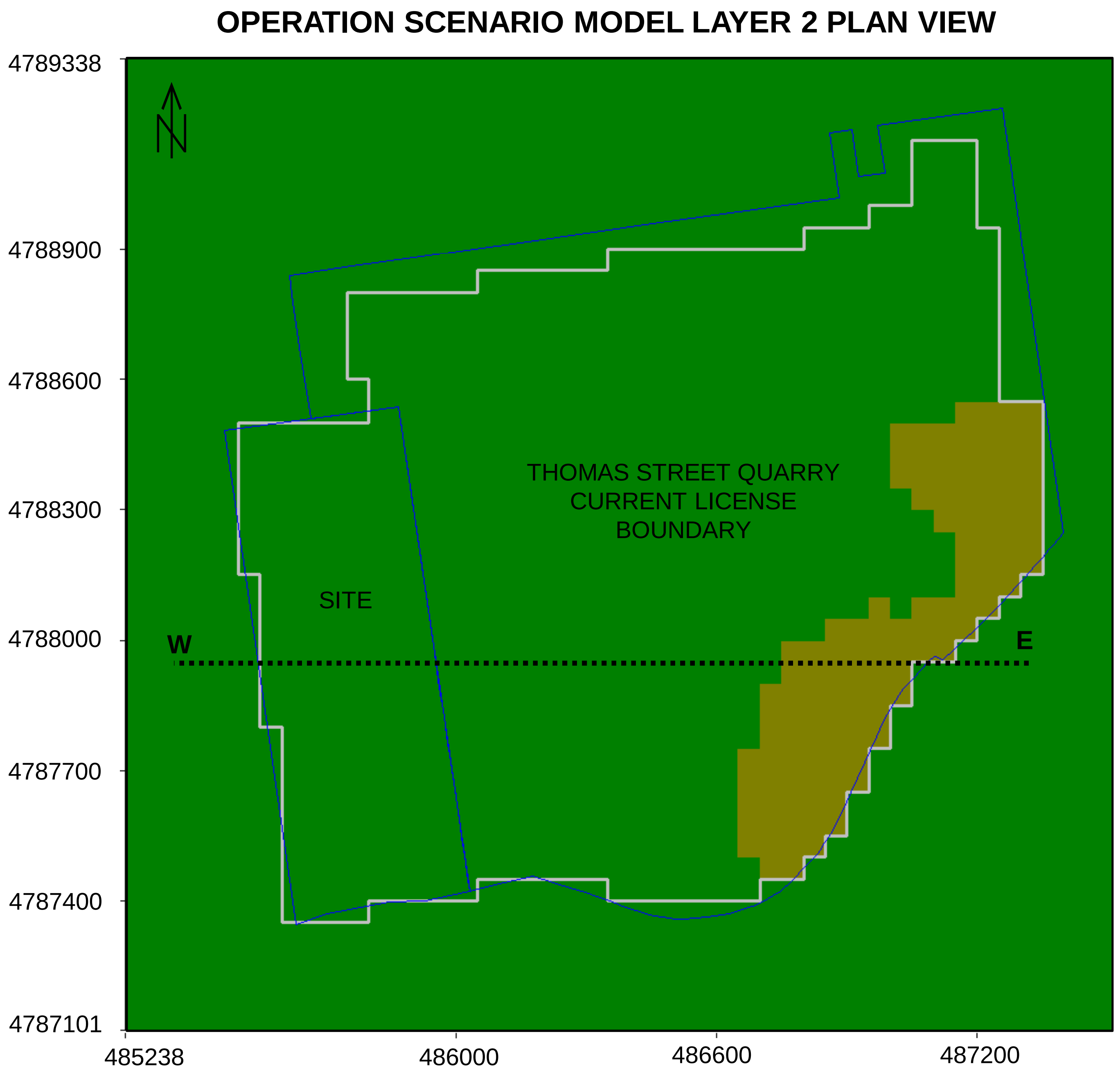
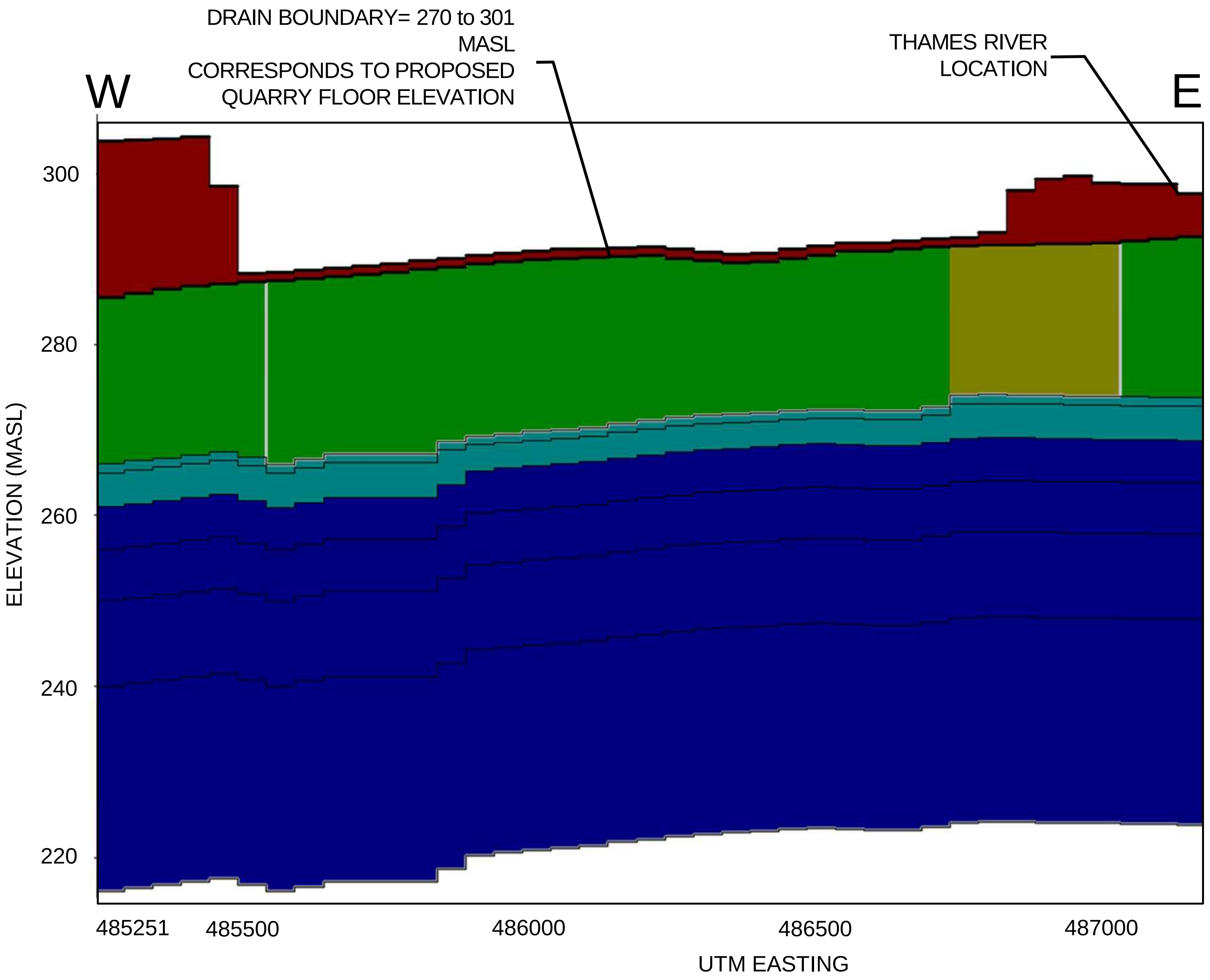
PATH: S:\Clients\Votorantim_Cimentos\Bonis_Quarry\99_PROJ\1781508\40_PROD\0008_Hydrogeology\1781508-0008-CH-0017.mxd PRINTED ON: 2020-03-12 AT: 6:01:16 PM


OPERATION SCENARIO MODEL LAYER 2 PLAN VIEW



LEGEND

🟩 DUNDEE/ UPPER LUCAS FORMATION (K= 5E-5 M/S)	🟥 INACTIVE FLOW BOUNDARY
🟫 BACKFILLED TILL (K= 1E-6 M/S)	⬜ DRAIN BOUNDARY
🟦 LOWER LUCAS FORMATION UPPER (K= 1E-7 M/S)	
🟦 LOWER LUCAS FORMATION LOWER (K= 1E-4 M/S)	

NOTES

1. Vertical exaggeration is 15x.
2. Horizontal hydraulic conductivity listed.
3. Horizontal to vertical hydraulic conductivity for each model layer = 1:1 with the exception of the Lower Lucas Formation (Upper) where K_v= 1E-9 m/s.

CLIENT
ST. MARYS CEMENT INC. (CANADA)

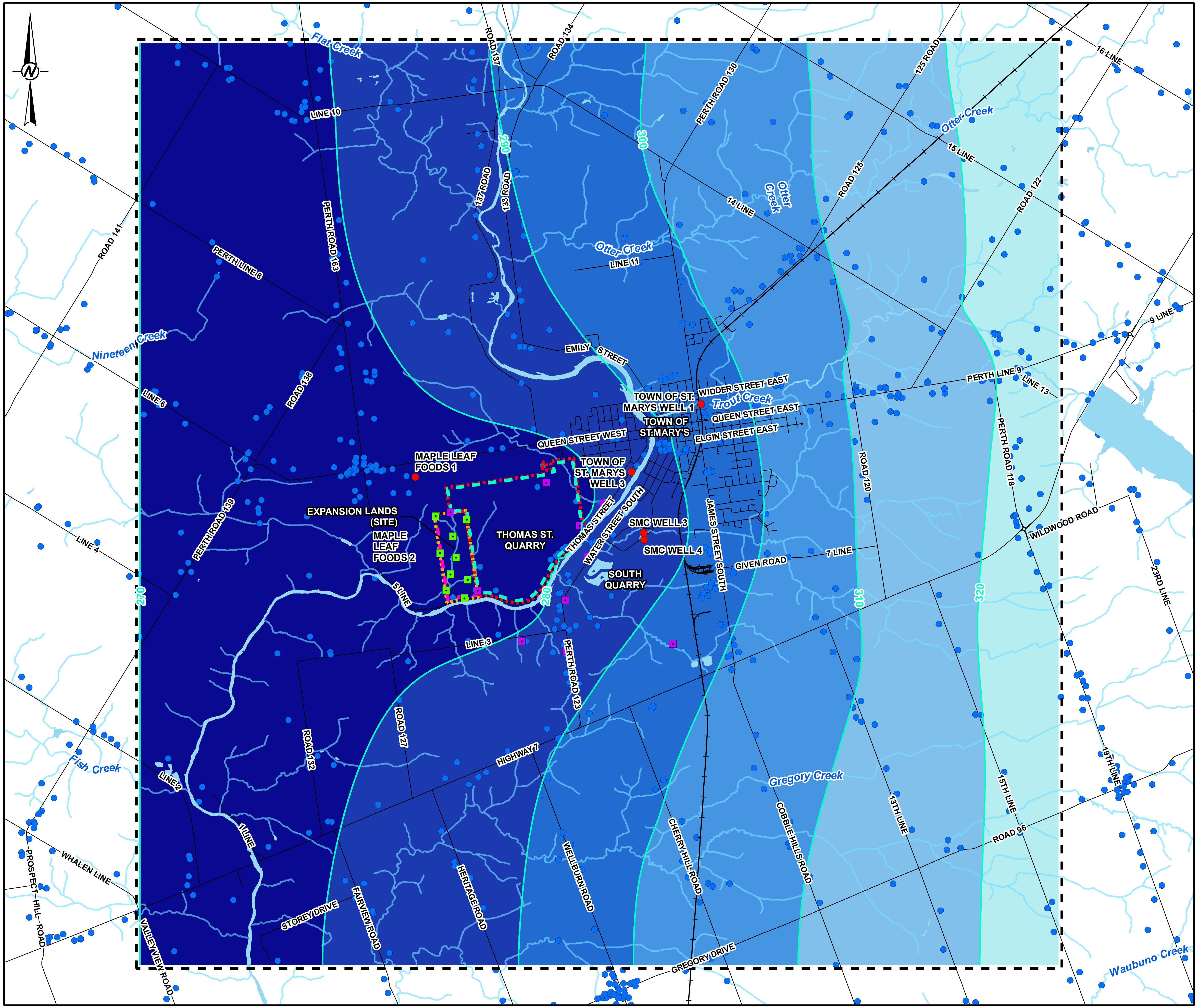
PROJECT
THOMAS STREET QUARRY EXPANSION

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
PREPARED	HW
DESIGN	HW
REVIEW	DAH
APPROVED	DAH

TITLE
OPERATIONS SCENARIO MODEL SET UP

PROJECT No.	Rev.	FIGURE
1781508	A	5.8



LEGEND

● Modelled Pumping Well
● MECP Water Well Record
▣ Site Groundwater Monitor Location
▣ Thomas St. Groundwater Monitor Location
— Simulated Groundwater Level Contour (10 m Interval)
┼ Railway
— Watercourse
▆ Waterbody
⬚ Existing License Boundary (Thomas St. Quarry)
⬚ Existing Limit of Extraction (Thomas St. Quarry)
⬚ Proposed License Boundary
⬚ Proposed Limit of Extraction
⬚ Model Domain

Simulated Groundwater Level (Operations)

▆ 270 - 280
▆ 280 - 290
▆ 290 - 300
▆ 300 - 310
▆ 310 - 320
▆ 320 - 330

0 1,000 2,000
1:50,000 METRES

NOTE(S)

1. SIMULATED GROUNDWATER LEVELS ARE TAKEN FROM LAYER 2 DUNDEE / UPPER LUCAS FORMATION AQUIFER MODELLED HEAD OUTPUT.

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
OPERATIONS (FULL BUILD-OUT) SIMULATED GROUNDWATER LEVELS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	5.9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
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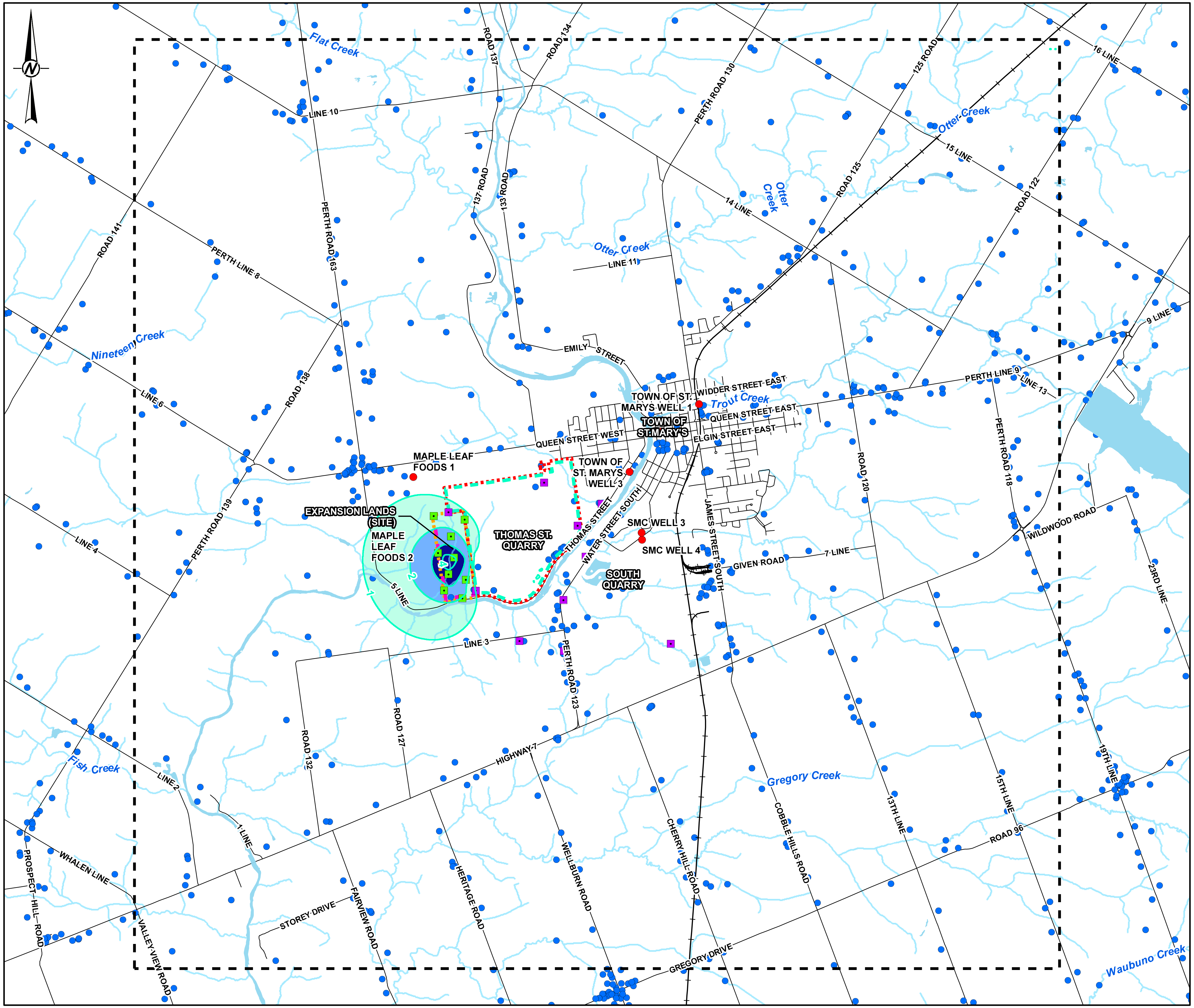

LEGEND

●	Modelled Pumping Well
●	MECP Water Well Record
▪	Site Groundwater Monitor Location
▪	Thomas St. Groundwater Monitor Location
—	Drawdown Contour (1m Interval)
┼	Railway
—	Watercourse
▬	Waterbody
▭	Existing License Boundary (Thomas St. Quarry)
▭	Existing Limit of Extraction (Thomas St. Quarry)
▭	Proposed License Boundary
▭	Proposed Limit of Extraction
▭	Model Domain

Drawdown (m)

▭	1 m - 2 m
▭	2 m - 3 m
■	3 m - 4 m

0 1,000 2,000

1:50,000 METRES

NOTE(S)

1. DRAWDOWN SHOWN IS INCREMENTAL WATER LEVEL DECREASE AS A RESULT OF SITE DEWATERING

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
OPERATIONS (FULL BUILD OUT) SIMULATED DRAWDOWN – DUNDEE / UPPER LUCAS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-11
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PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	5.10

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25mm
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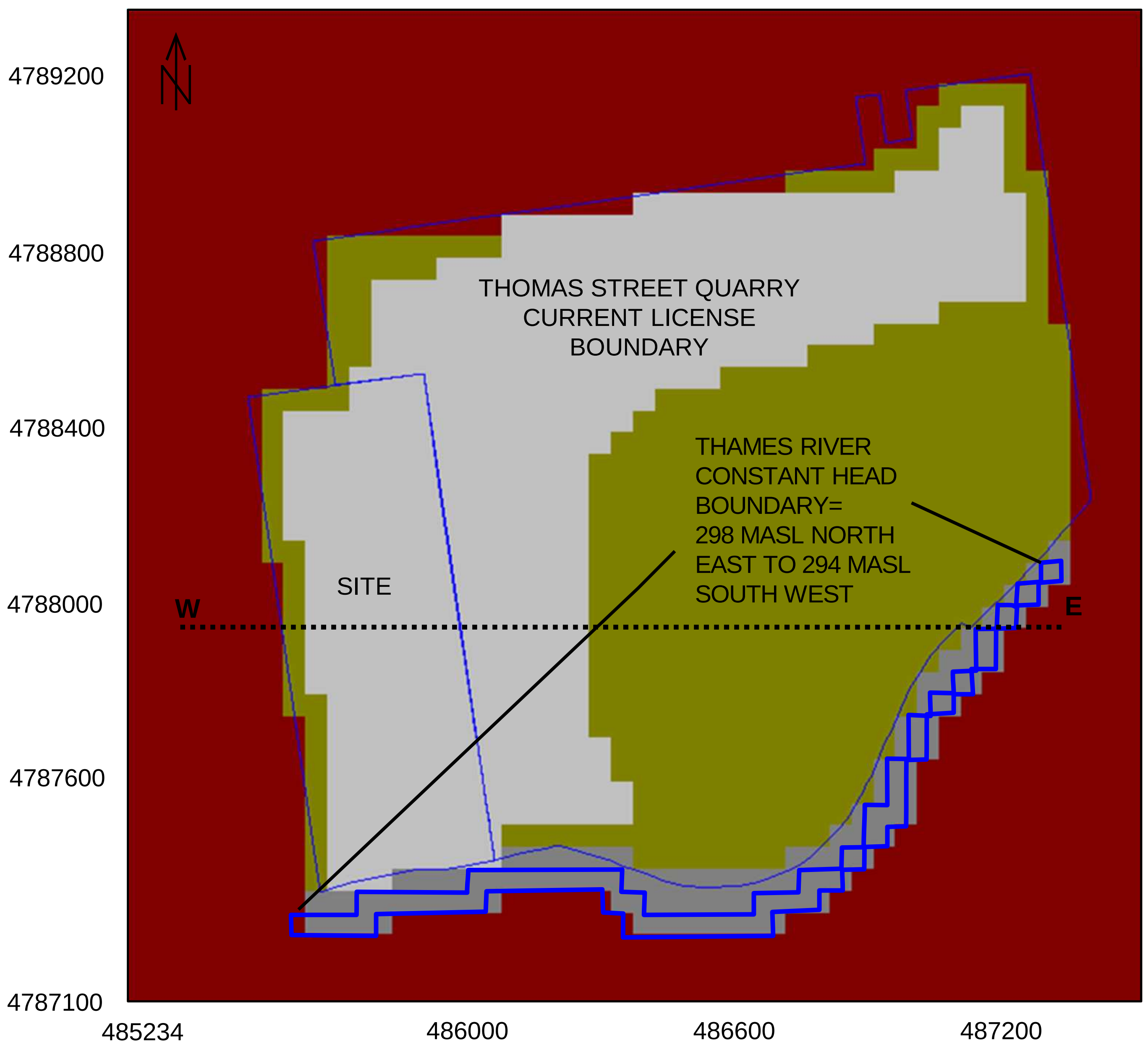
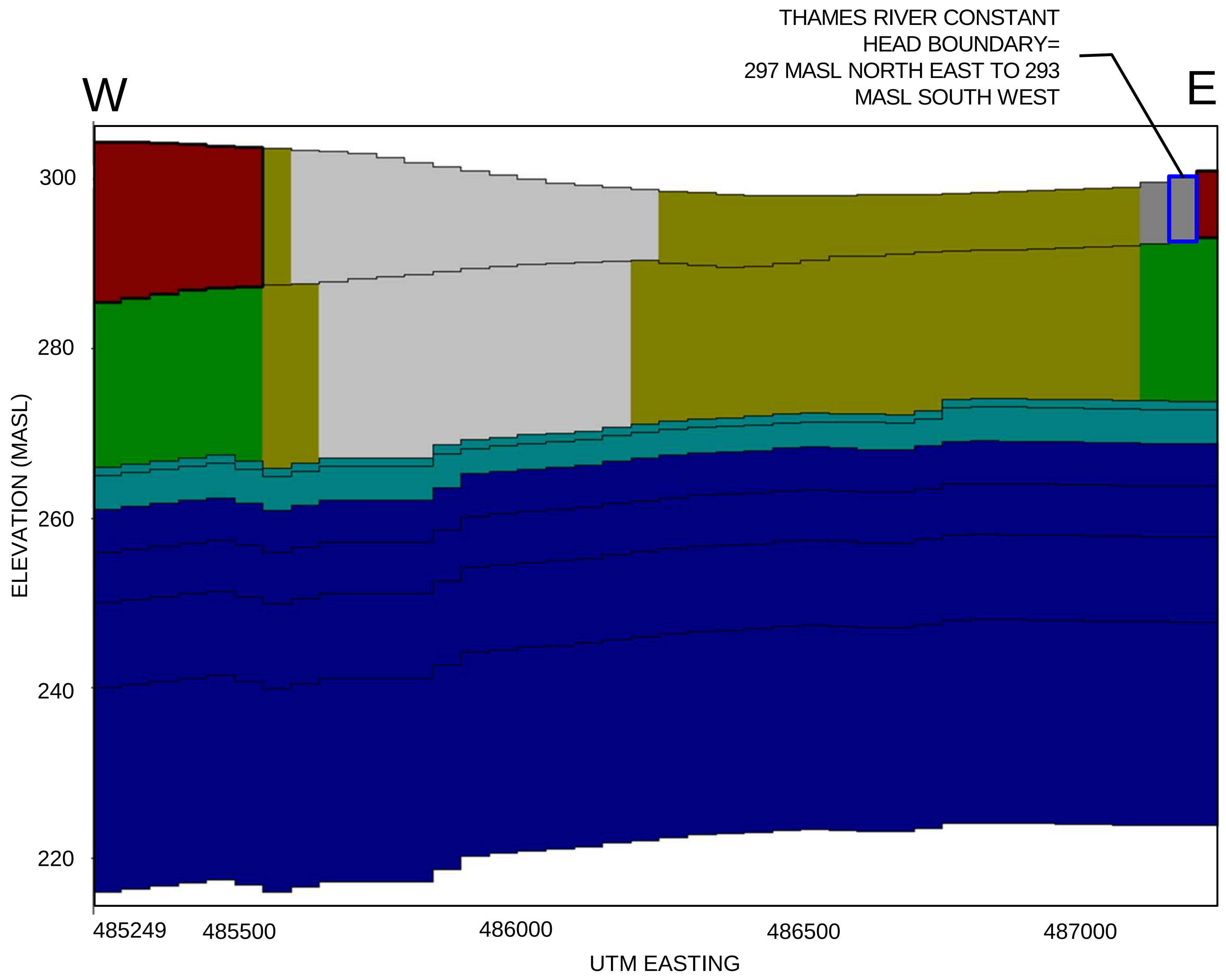
REHABILITATED SCENARIO MODEL LAYER 1 PLAN VIEW





LEGEND

🟩 DUNDEE/ UPPER LUCAS FORMATION (K=5E-5 M/S)

🟫 BACKFILLED TILL (K=1E-6 M/S)

🟦 LOWER LUCAS FORMATION UPPER (K=1E-7 M/S)

🟦 LOWER LUCAS FORMATION (K=1E-4 M/S)

⬜ FLOODED QUARRY LAKE (K=1 M/S)

⬛ NATIVE GRANULAR (K=2E-3 M/S)

🟥 INACTIVE FLOW BOUNDARY

☐ CONSTANT HEAD BOUNDARY

NOTES

1. Vertical exaggeration is 15x.
2. Horizontal hydraulic conductivity listed.
3. Horizontal to vertical hydraulic conductivity for each model layer = 1:1 with the exception of the Lower Lucas Formation (Upper) where K_v= 1E-9 m/s.

CLIENT
ST. MARYS CEMENT INC. (CANADA)

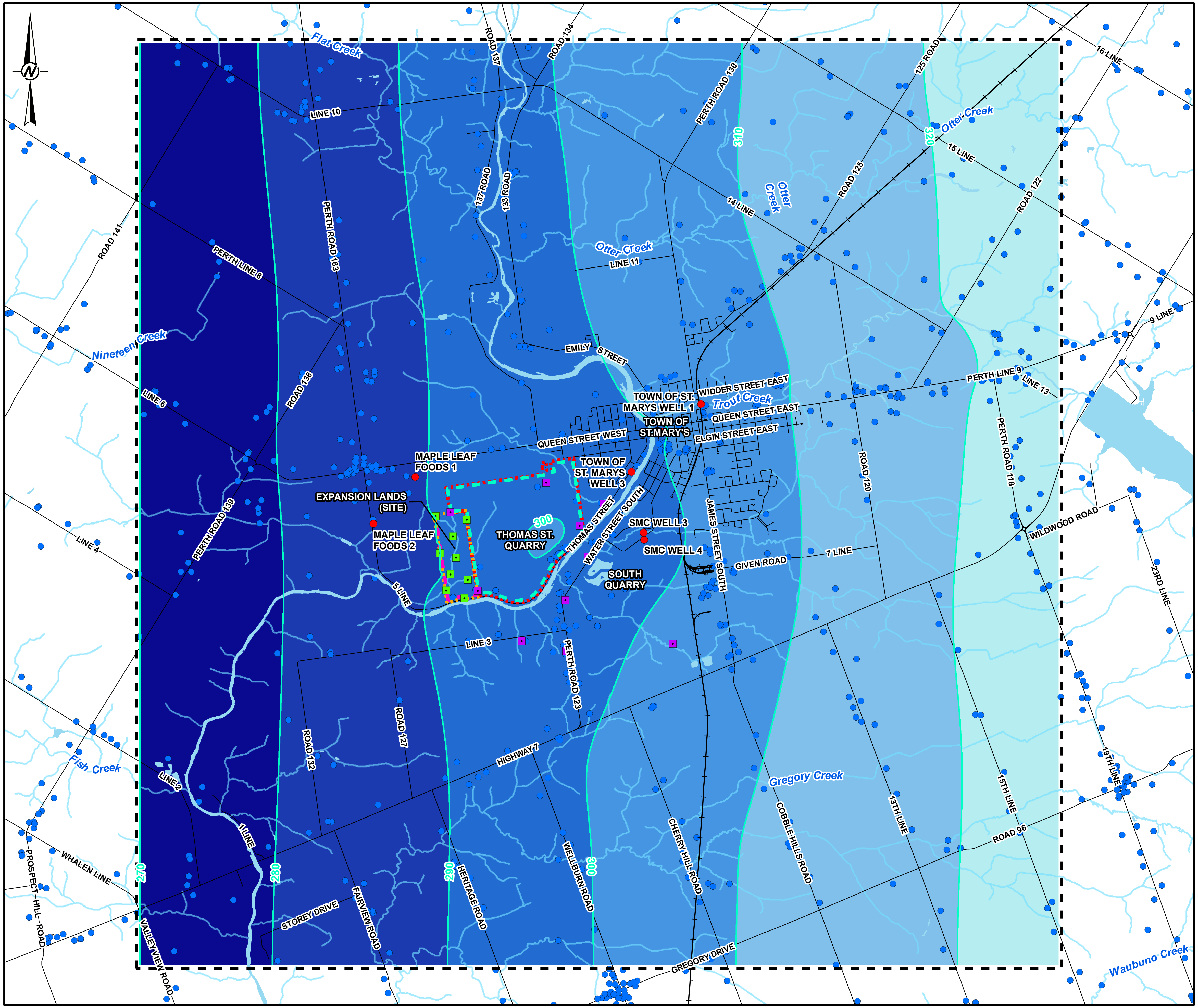
PROJECT
THOMAS STREET QUARRY EXPANSION

CONSULTANT
GOLDER

YYYY-MM-DD 2020-03-11
PREPARED HW
DESIGN HW
REVIEW DAH
APPROVED DAH

TITLE
REHABILITATED SCENARIO MODEL SET UP

PROJECT No. 1781508
Rev. A
FIGURE 5.11



LEGEND

- ● Modelled Pumping Well
- ● MECP Water Well Record
- ▪ Site Groundwater Monitor Location
- ▪ Thomas St. Groundwater Monitor Location
- — Simulated Groundwater Level Contour (10 m Interval)
- ┼ Railway
- — Watercourse
- ▬ Waterbody
- ⬚ Existing License Boundary (Thomas St. Quarry)
- ⬚ Existing Limit of Extraction (Thomas St. Quarry)
- ⬚ Proposed License Boundary
- ⬚ Proposed Limit of Extraction
- ⬚ Model Domain

Simulated Groundwater Level (Rehabilitation)

- ▬ 270 - 280
- ▬ 280 - 290
- ▬ 290 - 300
- ▬ 300 - 310
- ▬ 310 - 320
- ▬ 320 - 330

0 1,000 2,000
1:50,000 METRES

NOTE(S)

1. SIMULATED GROUNDWATER LEVELS ARE TAKEN FROM LAYER 2 DUNDEE / UPPER LUCAS FORMATION AQUIFER MODELLED HEAD OUTPUT.

REFERENCE(S)

1. BASE DATA: MNR LIO, OBTAINED 2019
2. MECP WATER WELL RECORDS OBTAINED OCTOBER 2019
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
THOMAS ST. QUARRY EXPANSION

TITLE
REHABILITATED SCENARIO SIMULATED GROUNDWATER LEVELS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-11
DESIGNED	ST
PREPARED	SO
REVIEWED	DH
APPROVED	SM

PROJECT NO.	CONTROL	REV.	MAP
1781508	-	-	5.12

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm 0

APPENDIX A

MECP Water Well Records

Table A.1

SUMMARY OF MECP WATER WELL RECORDS

Hydrogeology and Hydrology Level 1 and 2 Study

Proposed Thomas Street Quarry Expansion

									DEPTH			TEST PUMPING			STRATIGRAPHY			
WELL ID	EASTING	NORTHING	YEAR DRILLED	CASING DIAMETER (MM)	DRILLING METHOD	WELL TYPE	WELL STATUS	WATER USE	TOTAL WELL DEPTH (M)	WATER FOUND (M)	STATIC WATER LEVEL (M)	WATER LEVEL AFTER PUMPING (M)	RATE (L/MIN)	DURATION (HRS:MIN)	DEPTH TO UNIT BASE (M)	MATERIAL 1	MATERIAL 2	MATERIAL 3
5000188	484663	4788911	1955	101.6	Cable Tool	Bedrock	Water Supply	Livestock and Domestic	65.2	49.7	31.1	32.6	68.2	4:00	1.8	CLAY		
															11.9	MEDIUM SAND		
															13.1	CLAY		
															44.2	MEDIUM SAND		
															65.2	LIMESTONE		
5000228	485999	4787513	1965	127.0	Cable Tool	Bedrock	Water Supply	Livestock and Domestic	35.7	34.1	8.5	14.0	68.2	3:00	1.5	CLAY	MEDIUM SAND	
															9.1	GRAVEL	BOULDERS	
															15.2	LIMESTONE		
															23.2	LIMESTONE		
															35.7	LIMESTONE		
5000229	484894	4787843	1956	101.6	Cable Tool	Bedrock	Water Supply	Livestock and Domestic	42.7	39.6	18.3	18.3	22.7	1:00	6.4	GRAVEL	STONES	
															12.2	CLAY	STONES	
															18.3	MEDIUM SAND	STONES	
															21.3	CLAY		
															21.9	FINE SAND		
															42.7	LIMESTONE		
5000230	486972	4787903		101.6					55.8		24.4	25.3	45.5	3:00				
5001485	485104	4788983	1968	304.8	Cable Tool	Bedrock	Water Supply	Industrial	111.3	68.6	59.7	72.8	1818.4	24:00	5.2	CLAY	GRAVEL	
															21.3	CLAY	GRAVEL	
															41.5	CLAY	MEDIUM SAND	GRAVEL
															44.5	LIMESTONE		
															53.3	LIMESTONE		
															80.8	LIMESTONE		
															82.6	LIMESTONE		
															105.2	LIMESTONE		
															108.2	LIMESTONE		
															111.3	LIMESTONE		
5001486	485894	4789443	1968	914.4	Boring	Overburden	Water Supply	Domestic	4.3	2.4	2.1	4.0	9.1	1:00	2.4	CLAY		
															4.3	GRAVEL	CLAY	
5001487	485704	4787413	1968	76.2	Cable Tool	Bedrock	Water Supply	Livestock and Domestic	35.7	33.5	12.2	25.9	136.4	4:00	33.5	PREV. DRILLED		
															35.7	LIMESTONE		
5001571	486294	4786933		101.6					63.1		34.1	34.7	54.6	1:30				
5001716	484614	4788903	1970	101.6	Rotary (Convent.)	Bedrock	Water Supply	Livestock and Domestic	80.8	64.6	61.3	62.2	22.7	2:00	64.6	PREV. DRILLED		
															80.8	LIMESTONE		
5001810	486204	4789333							44.5		24.4	33.5	9.1	5:00				
5002023	484806	4789062	1973	127.0	Rotary (Convent.)	Bedrock	Water Supply	Domestic	71.6	71.6	65.2	65.8	40.9	1:00	1.8	CLAY		
															38.7	CLAY	STONES	
															71.6	LIMESTONE		
5002165	486348	4789351		127.0					47.5		7.9	44.2	18.2	1:30				
5002250	484714	4789063	1975		Rotary (Convent.)	Bedrock	Water Supply	Domestic	77.7	71.6	65.5	66.4	31.8	2:00	1.2	TOPSOIL	FILL	SOFT
															4.6	CLAY	SOFT	
															35.1	CLAY	DENSE	
															40.5	CLAY	STONES	
															41.8	LIMESTONE	MARL	FRACTURED
															77.7	LIMESTONE		
5002354	485514	4789163	1975	101.6	Rotary (Air)	Bedrock	Water Supply	Commerical	76.2	76.2	34.1	36.0	40.9	2:00	0.6	TOPSOIL		
															3.0	CLAY	SANDY	
															12.8	CLAY	STONES	
															16.8	HARDPAN	STONES	
															23.5	CLAY		
															67.1	LIMESTONE		
															76.2	LIMESTONE		
5002412	484806	4789062	1976	127.0	Rotary (Convent.)	Bedrock	Water Supply	Domestic	79.6		66.8		27.3	0:15	71.6	PREV. DRILLED		
															79.6	LIMESTONE		
5002543	484934	4788763	1977	127.0	Rotary (Convent.)	Bedrock	Water Supply	Domestic	96.6	83.8	66.1		54.6	0:40	0.6	TOPSOIL		
															5.5	SAND	GRAVEL	BOULDERS
															38.1	CLAY		
															43.0	CLAY	ROCK	
															83.8	LIMESTONE		
															96.6	LIMESTONE		
															0.6	TOPSOIL		
															5.5	SAND	GRAVEL	BOULDERS

Table A.1

SUMMARY OF MECP WATER WELL RECORDS

Hydrogeology and Hydrology Level 1 and 2 Study
Proposed Thomas Street Quarry Expansion

									DEPTH			TEST PUMPING			STRATIGRAPHY			
WELL ID	EASTING	NORTHING	YEAR DRILLED	CASING DIAMETER (MM)	DRILLING METHOD	WELL TYPE	WELL STATUS	WATER USE	TOTAL WELL DEPTH (M)	WATER FOUND (M)	STATIC WATER LEVEL (M)	WATER LEVEL AFTER PUMPING (M)	RATE (L/MIN)	DURATION (HRS:MIN)	DEPTH TO UNIT BASE (M)	MATERIAL 1	MATERIAL 2	MATERIAL 3
															38.1	CLAY		
															43.0	CLAY	ROCK	
															83.8	LIMESTONE		
															96.6	LIMESTONE		
5002878	486654	4786843		127.0					52.1		36.6	45.7	36.4	1:00				
5003468	485907	4786846		152.4					56.1		34.4	35.7	45.5	1:30				
5003499	484711	4789127	1988	127.0	Rotary (Convent.)	Bedrock	Water Supply	Domestic	91.4	85.3	70.7	76.2	36.4	2:00	0.3	TOPSOIL		
															3.4	CLAY		
															15.5	CLAY		
															21.3	HARDPAN		
															32.3	CLAY		
															42.4	HARDPAN		
															43.6	LIMESTONE		
															54.9	LIMESTONE		
															91.4	LIMESTONE		
5005088	485513	4786730		152.4					67.1		35.1	39.0	90.9	1:30				
5005149	485513	4786730																
5005372	484501	4788717	2002	101.6	Not Known	Overburden	Abandoned-Other	Not Used	62.5		61.0				62.5	PREV. DRILLED		
5005891	486260	4787504							31.1		15.8		136.4					
7105903	485134	4788764	2008	158.8	Rotary (Convent.)		Observation Wells	Not Used	114.3	76.2	71.9		90.9	1:00				
															0.6	TOPSOIL		
															4.0	CLAY	STONES	
															39.6	CLAY	STONES	
															114.3	LIMESTONE		FRACTURED
7105904	484670	4788421	2008	158.8	Rotary (Convent.)		Observation Wells	Not Used	105.2	64.0	62.8		227.3	1:00				
															0.6	TOPSOIL		
															4.0	CLAY	STONES	
															45.4	CLAY		HARD
															83.5	LIMESTONE		
															105.2	LIMESTONE		
7147858	486057	4787808	2010				Test Hole	Monitoring	15.2						0.6	TOPSOIL	SAND	
															5.2	SILT		DENSE
															9.1	CLAY	SILT	DENSE
															15.2	SAND	POROUS	
7155323	484694	4787664	2010	50.8	Rotary (Convent.)			Monitoring	5.3						0.3	TOPSOIL		LOOSE
															3.8	SAND	GRAVEL	LOOSE
															5.3	SILT	SAND	DENSE
7165439	486020	4787489	2011	31.7	Rotary (Convent.)		Observation Wells	Monitoring	37.5	33.5	20.1		136.4	1:00	1.8	CLAY		
															7.3	CLAY	STONES	
															10.7	STONES		
															29.3	LIMESTONE		
															37.5	LIMESTONE		
7165988	486260	4787504																
7200114	485124	4786583		158.8					67.1		40.8	44.8	90.9	1:30				
7204362	486803	4788846																
7204363	485668	4788514	2013	139.7	Rotary (Convent.)		Observation Wells	Monitoring	79.2						9.8	CLAY		
															24.4	CLAY	STONES	
															79.2	LIMESTONE		LAYERED
7241791	485668	4788514	2015															
7253914	486297	4786929		158.8														
7273470	484774	4789052	2016	152.4	Rotary (Convent.)		Water Supply	Domestic	85.3	79.2	72.8	82.3	45.5	2:00	2.7	CLAY		
															37.5	CLAY		
															85.3	LIMESTONE		
7274252	484924	4789078	2016				Abandoned-Other											

APPENDIX B

Site Borehole Logs and Test Pit Grain Size Results

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-01

SHEET 1 OF 4

LOCATION: N 4787643.3 ;E 485897.9

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: October 30 - November 3, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DRILLING RECORD: HW CASING (0 to 9.0 m); HQ CORING (8.1 to 10 m)

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	299.58
TOPSOIL	0.00
SILT, trace sand, trace organics; brown **NOTE,** soil sequence interpretation based on standard split spoon sample methods to elev. 298.0 m. Below elev. 298.0 m, based on limited recovery in HQ core barrel while coring through overburden with water flush.	299.33 0.25
sandy **GRAVEL**, trace to some silt, trace to some clay; brown to grey, contains cobbles and boulders	297.98 1.60
Bedrock Surface, 7.52 m **DUNDEE FORMATION, 7.52 m to 22.26 m** Fresh, faintly weathered on open argillaceous bedding partings to 8.33m, light brownish grey, fine to medium grained crystalline, non-porous with faintly porous sections, thinly to medium bedded (7.52-12.62m) becoming medium to thickly bedded (12.62-22.26m) **FOSSILIFEROUS LIMESTONE** with weakly to moderately developed stylolites below 12.62m, fine argillaceous partings (.05mm) and scattered pelecypod shells, crinoid ossicles and rugosa coral fossils.	292.06 7.52
	291.25 8.34
	290.33 9.28
	9.44
Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil debris in at	289.83 9.81

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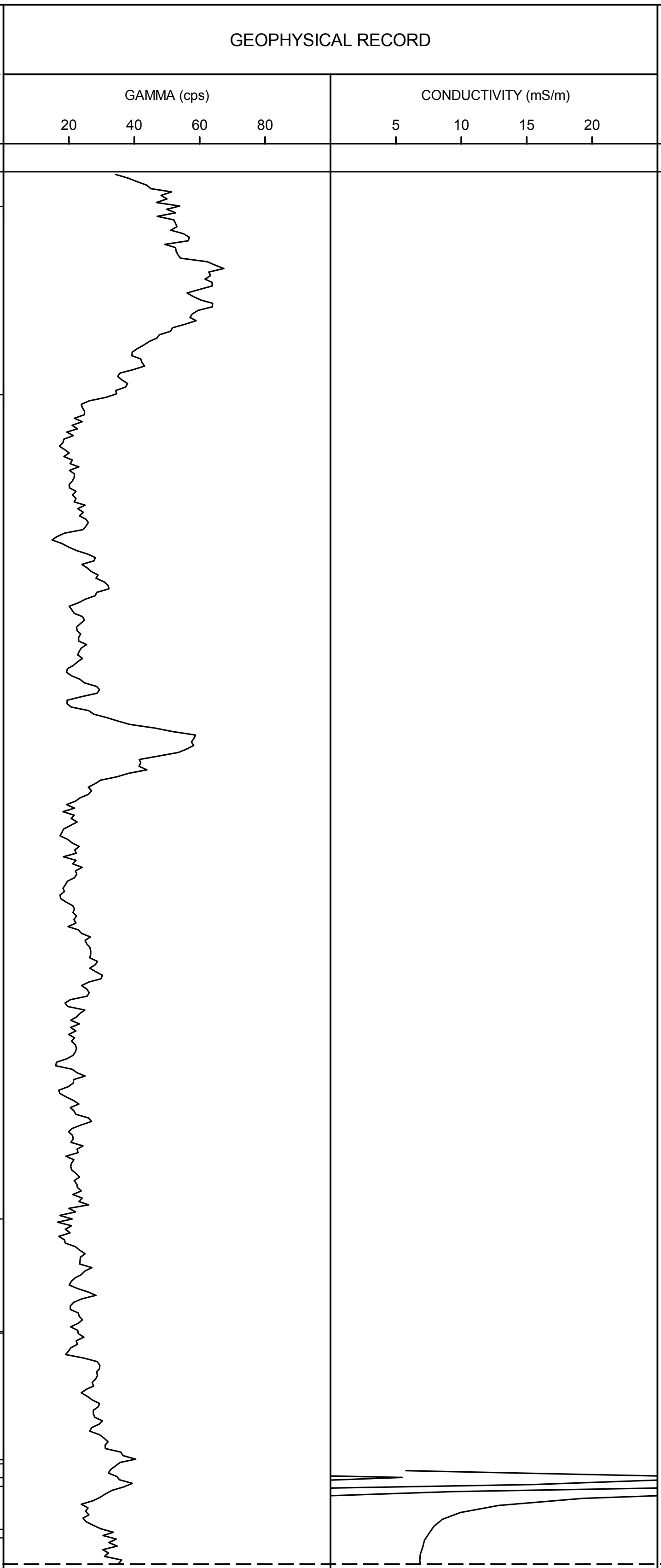


DEPTH SCALE METRES: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-01

SHEET 2 OF 4

LOCATION: N 4787643.3 ;E 485897.9

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: October 30 - November 3, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

9.25-.28m, 9.38-44m, 9.75-.81m, 10.33-.35, 10.79-.84m and 11.83-.84m (open, weathered).

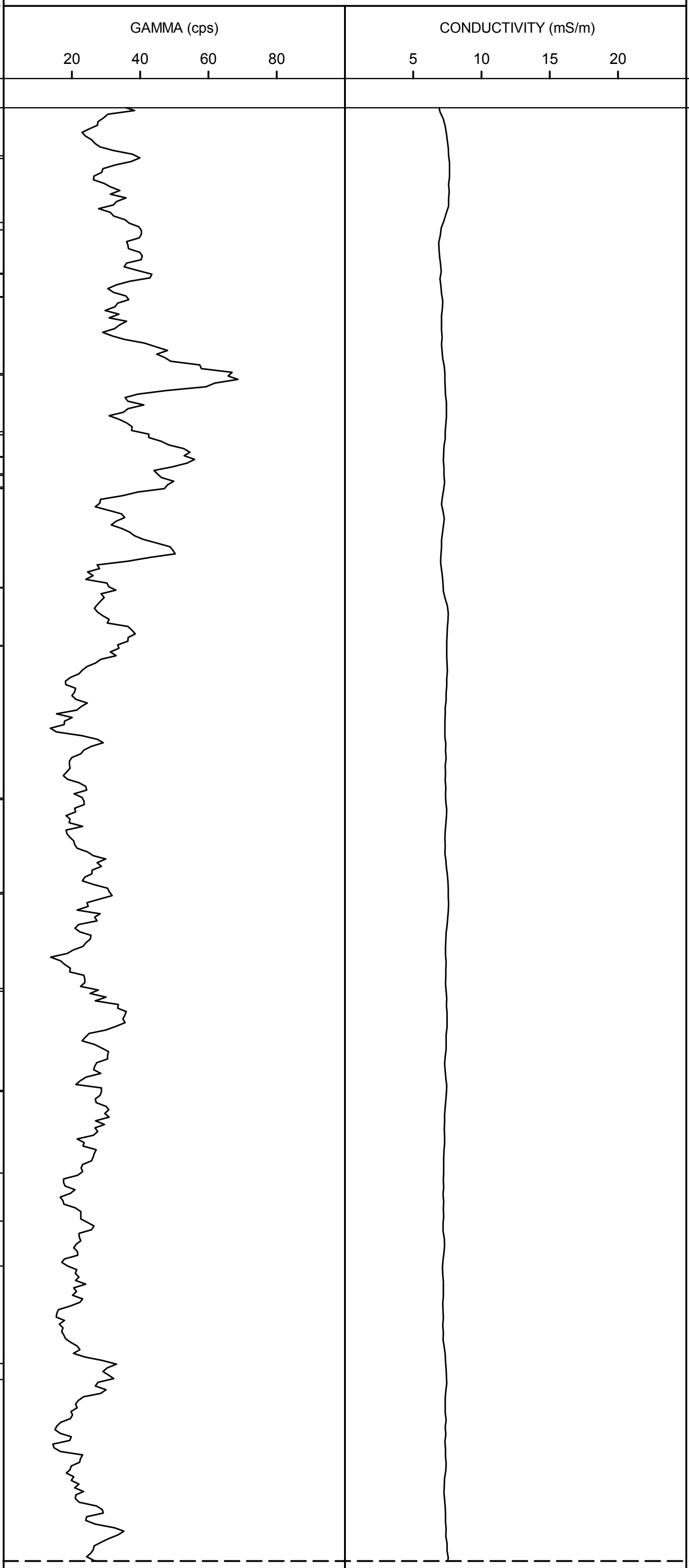
More prominent black, argillaceous to argillaceous limestone bedding partings occur at 8.33-.34m (weathered), 11.14m (weathered), 11.30-.305m (with 2mm crystalline, pinkish rhodochrosite lamination), 12.23-.25m, 12.40m, 12.52-.53m, 12.61-.62m, 13.30-.302m, 13.70-.705m, 14.75-.76m, 15.40-.41m, 16.06-.08m, 16.76-.77m, 18.64-.75m (fine argillaceous partings in limestone), 20.25-.32m (fine argillaceous partings in weakly nodular limestone) and 21.76-.83m (fine argillaceous partings in weakly nodular limestone).

Porous, pitted coral fossil limestone bed with mottled natural petroleum staining occurs at 17.33-.66m. Nodular limestone bed occurs at 17.66-.97m.

Moderately developed stylolites occur at 18.53m, 19.68m and 19.84m.
Porous, pitted limestone with coral fossil traces occurs at 20.32-.50m.
Faint to moderate, dark brown petroleum staining at 21.83-22.26 m.

DRILLING RECORD: HQ CORING

ELEV.	DEPTH (m)
289.25	10.35
288.79	10.84
288.44	11.15
	11.31
287.75	11.84
287.35	12.25
	12.41
	12.53
	12.62
286.28	13.31
285.88	13.71
284.83	14.76
284.18	15.41
283.52	16.08
282.82	16.77
282.25	17.33
281.92	17.66
281.61	17.97
280.94	18.64
	18.75



DEPTH SCALE METRES: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

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DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-01

SHEET 3 OF 4

LOCATION: N 4787643.3 ;E 485897.9

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: October 30 - November 3, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	PIEZOMETER OR STANDPIPE INSTALLATION

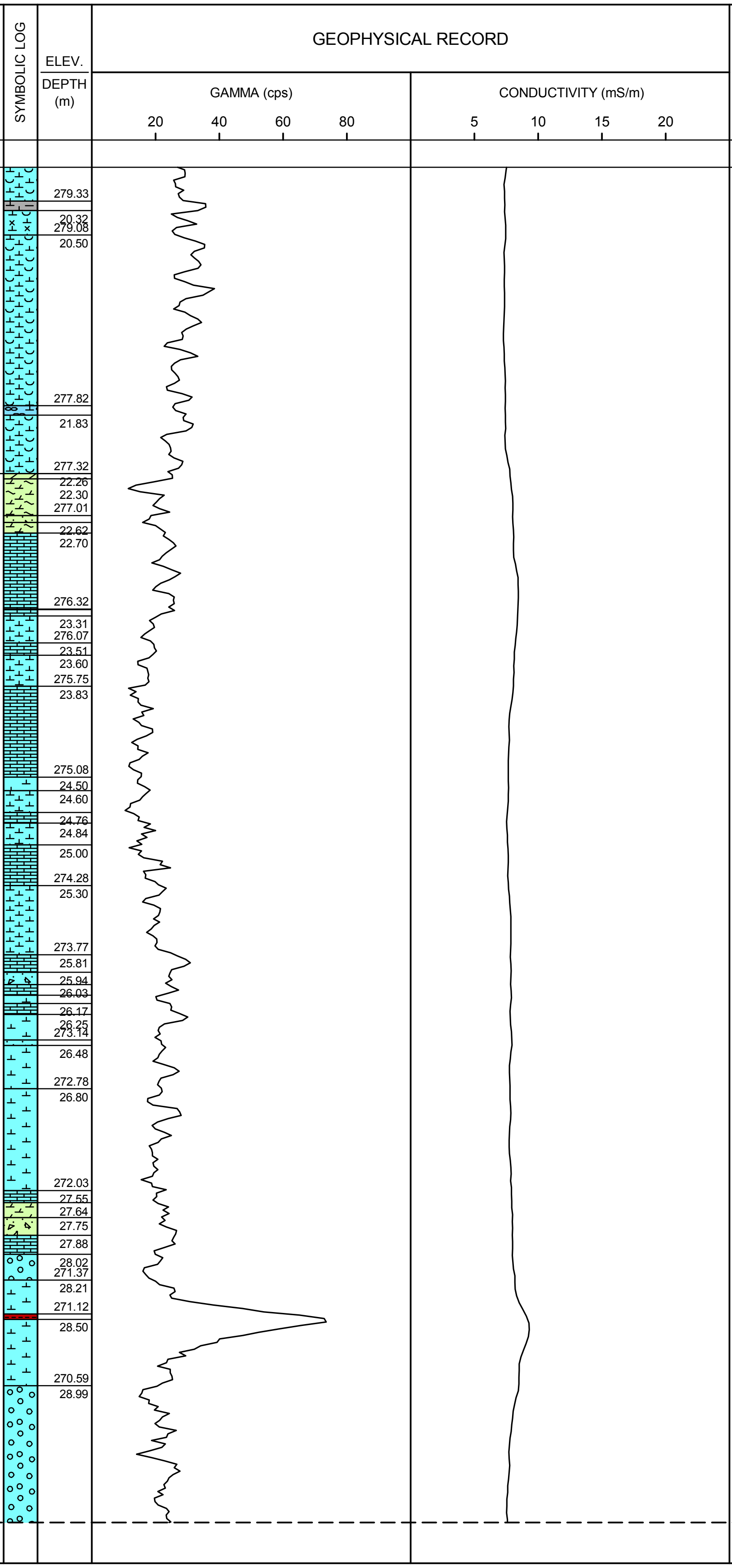
--- CONTINUED FROM PREVIOUS PAGE ---

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

HQ CORING

LUCAS FORMATION, 22.26 m to 35.18 m
UPPER LUCAS FORMATION, 22.26 m to 31.48 m

From 22.26 m to 22.70 m, Upper Lucas Dolostone Marker Bed, faintly to moderately weathered, light to medium brownish grey, fine grained crystalline, faintly to moderately porous, medium bedded, wavy laminar textured **ARGILLACEOUS DOLOSTONE** with cap of moderately to highly weathered, light to medium yellowish brown, fine grained, very porous (absorptive), pitted dolostone at 22.26-.30m. Wavy texture imparted by fine argillaceous lamination in the dolostone. Collapse breccia between 22.57-.62m. Sharp, open contact with overlying Dundee Formation is a weathered open bedding fracture, lower contact is transitional.
From 22.70 m to 27.64 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, laminar to massive textured **LIMESTONE.** Finely laminated with thin argillaceous partings, faintly petroliferous limestone at 22.70-23.26m, 23.83-24.50m, 24.76-.84m, 25.00-.30m, 25.81-26.25m (weakly pitted with slumped bedding structure), 27.55-.64m. Dark grey shaley parting at 23.26-.265m. At 23.31-.83m, faint to moderately weathered, light creamy grey, fine grained ,faintly porous, pitted easily broken Limestone. From 26.25m to 26.80m, very light tan grey, moderately porous, weakly laminated Limestone with slumped bedding structures and intraformational breccia at 26.44-.48m. Medium to thick bed of light to medium tan to creamy grey, fine grained crystalline, weakly laminated to massive textured, moderately porous Limestone at 26.80-27.55m.
From 27.64 m to 27.88 m, distinctive thin **marker bed** of medium grey **LITHOCLASTIC ARGILLACEOUS DOLOSTONE** at 27.64-.88m with well developed stylolite at 27.69m and slumped bedding structure of tan limestone in grey dolostone at 27.75-.88m.
From 27.88 m to 31.48 m, Finely laminated, faintly petroliferous limestone sections occur at 27.88-28.02m, 30.06-.59m and 31.00-.12m. Light tan brown, fine grained crystalline, moderately porous, thickly bedded **OOLITIC LIMESTONE**



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DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-01

SHEET 4 OF 4

LOCATION: N 4787643.3 ;E 485897.9

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: October 30 - November 3, 2017
DRILL RIG: Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
30–40	HQ CORING	see below	see below	see below	see below	

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beds occur at 28.02-.21m and 28.99-30.06m. Medium to thick bed of light to medium tan to creamy grey, fine grained crystalline, weakly laminated to massive textured, moderately porous **LIMESTONE** at 28.21-.99m, 30.59-31.00m, 31.12-.48m. Slumped bedding structure occurs at 31.12-.16m with 1-2mm argillaceous parting at 31.16m.
Very thin layer of dark brown, laminated calcareous **CLAYEY SILT SOIL** at 28.46-.50m.

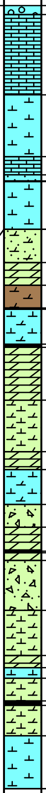
LOWER LUCAS FORMATION, 31.48 m to 35.18 m
Transitional upper contact into distinct **marker bed** of light grey, fine grained crystalline, moderately porous, pitted (1-5mm), weakly laminated **DOLOSTONE** at 31.48-.70m with disseminated pyrite veinlets. Individual beds of medium brown, laminated **DOLOSTONE** occur at 31.70-.85m (black bituminous partings at 31.77-.78m), 32.24-.61m (porous, pitted with black argillaceous partings at 32.24-.26m), 32.95-33.07m, 33.45-.67m (light tan brown with argillaceous partings at 33.61-.62m), 34.30-.45m (slump breccia), 33.45-.67m (argillite partings at 33.61-.62m) and 34.30-.38m. Second **marker bed** of medium grey, fine grained crystalline, faintly to moderately porous argillaceous dolostone at 33.67-34.00m with well developed stylolite at 33.80m and lithoclastic breccia at 33.80-34.00m (angular light tan grey calcareous dolostone lithoclasts from underlying bed in medium grey dolostone matrix) with sharp basal contact. Light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded, finely laminated **CALCAREOUS DOLOSTONE** beds occur at 32.61-.95m, and 33.30-34.30m with slump breccia at 33.30-.45m and light tan grey, massive textured calcareous dolostone beds at 34.00-.30m and 34.45-.83m (dark brown laminated with bituminous partings and black argillaceous partings at 34.60-.63m).
Medium brown, fine grained crystalline, faintly to moderately porous, thin beds of **DOLOMITIC LIMESTONE** at 32.01-32.24m (finely laminated) with black argillaceous partings at 32.24-.26m, 33.07-.30m, 34.38-.45m and 34.63-.83m (dark brown laminated with bituminous partings). Medium to dark brown, finely laminated, bituminous **LIMESTONE** beds at 31.85-32.00m (black bituminous, argillaceous partings at 32.00-.01m) and 34.83-35.18m.

End of Borehole, 35.18 m

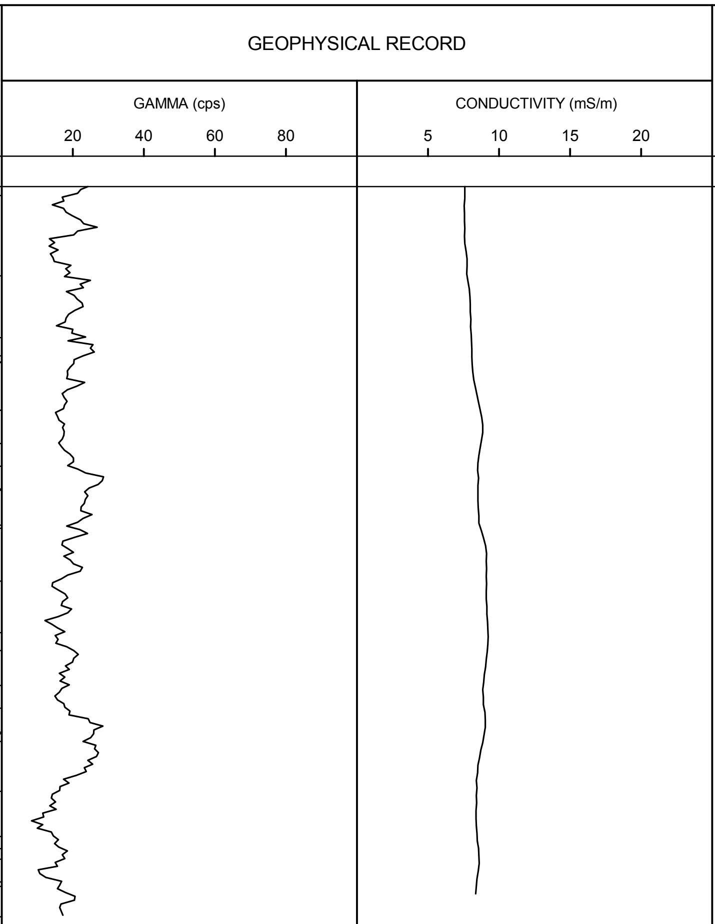
NOTES,

1. 60% loss of circulation around elev. 282.5 m (depth of 17.1 m) and complete loss of circulation at 265.6 m (depth of 34.0 m).

2. Static water level measured in open borehole at elev. 279.7 m (depth of 19.9 m), cascading water noted in borehole.



ELEV.	DEPTH (m)
269.52	30.06
268.99	30.59
268.58	31.00
	31.17
268.10	31.48
267.88	31.70
	31.85
	32.01
267.34	32.26
266.97	32.61
266.63	32.95
	33.07
266.28	33.30
	33.45
	33.67
265.58	34.00
265.28	34.30
	34.45
	34.63
264.75	34.83
264.40	35.18



DEPTH SCALE
1 : 50

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-02

SHEET 1 OF 5

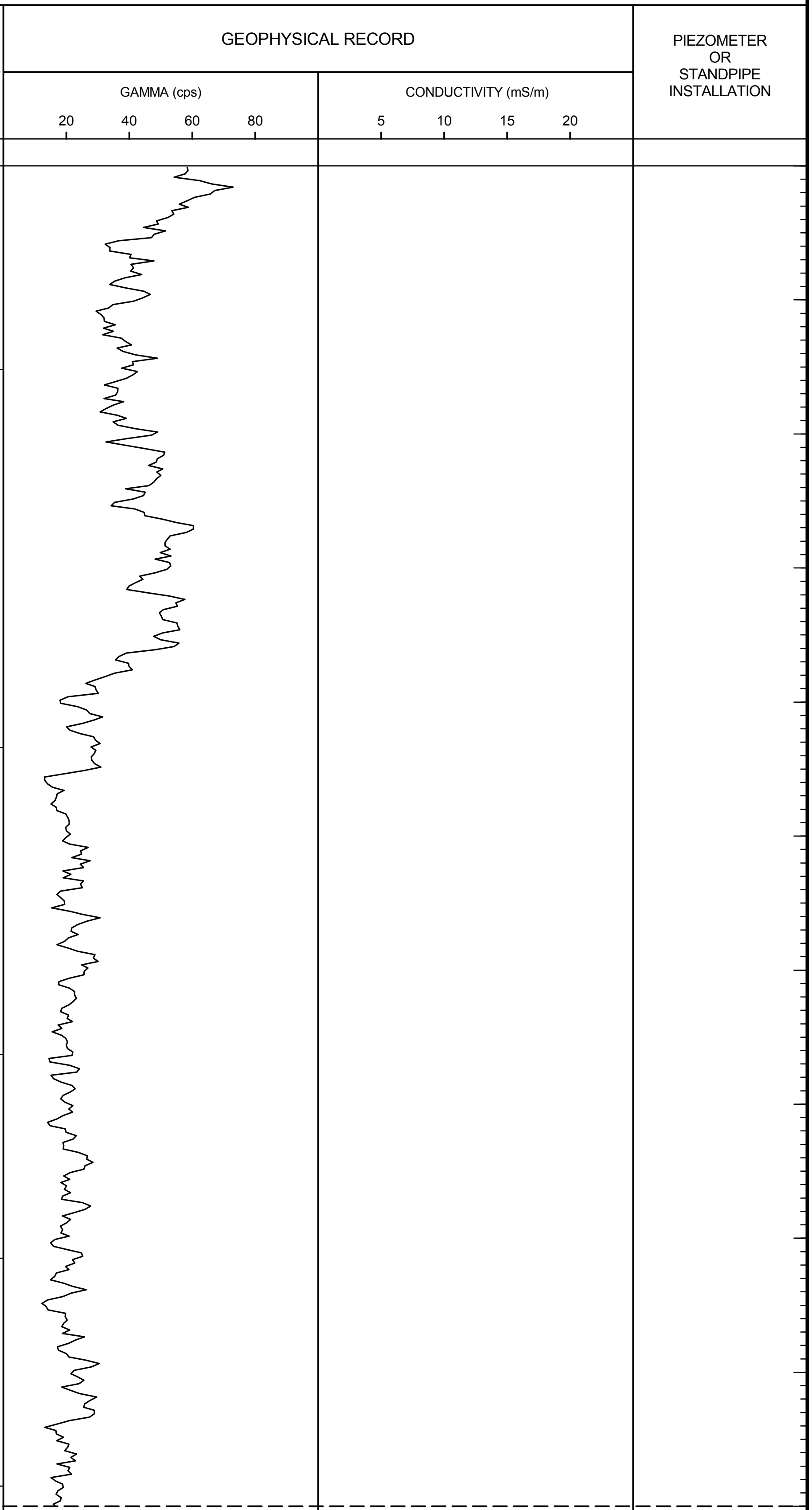
LOCATION: N 4787714.4 ;E 485673.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017
DRILL RIG: Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)
		GROUND SURFACE	300.57
0		**SILT**, some gravel, trace sand; brown **NOTE,** soil sequence interpretation based on limited recovery using standard split spoon sample methods to elev. 296.4 m. Below elev. 296.4 m, based on limited recovery in HQ core barrel while coring through overburden with water flush.	0.00
1			299.05
2		**SAND and GRAVEL**; brown	1.52
3			
4			296.23
5	HW CASING	**GRAVEL**, some sand; brown, contains cobbles and boulders	4.34
6			293.94
7		**GRAVEL**, some silt, some clay, some sand; brown, contains cobbles	6.63
8			292.42
9		**SAND and GRAVEL**; brown, contains cobbles	8.15
			290.72
10		**Bedrock Surface, 9.85 m**	9.85



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DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-02

LOCATION: N 4787714.4 ;E 485673.7
INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017
DRILL RIG: Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

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Drilling record: HW CASING (10 to 10.7 m); HQ CORING

DUNDEE FORMATION, 9.85 m to 26.00 m
Fresh, faintly weathered on open argillaceous bedding partings to 12.16m, light brownish grey, fine to medium grained crystalline, non-porous with faintly porous sections, thinly to medium bedded (9.85-16.30m) becoming medium to thickly bedded (16.30-26.00m) **FOSSILIFEROUS LIMESTONE** with weakly to moderately developed stylolites below16.30m, fine argillaceous partings (.05mm) and scattered pelecypod shells, crinoid ossicles and rugosa coral fossils.

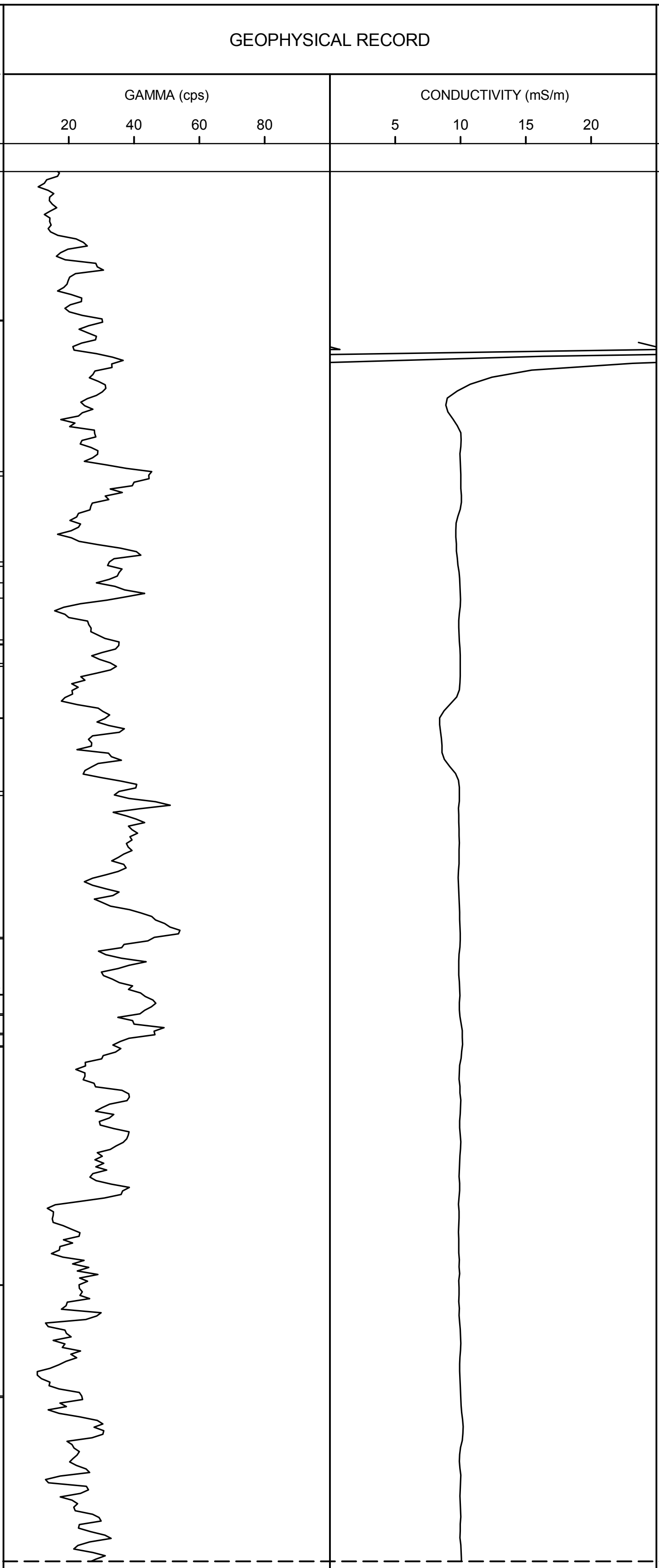
Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil debris in at 12.81-.84m, 12.96-13.07m, 13.37-.40m, 13.54-.56m, 14.46-.49m and 15.51-.52m.

More prominent black, argillaceous to argillaceous limestone bedding partings occur at 11.07-.075m, 12.16-.19m (weathered), 13.40-.405M, 13.93-.935m, 15.51-.52m, 15.92-.925m, 16.06-.07m, 16.20-.21m, 16.29-.30m (with 2-3mm crystalline, pinkish rhodochrosite lamination), 18.81-.82m and 19.73-.735m.

Weakly developed stylolite occur at 18.01m.

Porous, pitted coral fossil limestone bed with mottled natural petroleum staining occurs at 21.05-.35m.
Nodular limestone bed occurs at 21.35-.75m.
Porous, pitted limestone with coral fossil traces occurs at 25.20-.40m.
Weak, dark brown petroleum staining at 25.71-26.00 m.

ELEV.	DEPTH (m)
289.50	11.08
288.41	12.19
287.76	12.84
	12.96
	13.07
287.20	13.41
	13.56
286.64	13.94
286.11	14.49
285.06	15.52
284.65	15.93
	16.07
	16.21
	16.30
282.56	18.02
281.76	18.82



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DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB
CHECKED:

OTTAWA-GEO 1781508 ROCK.GPJ GAL-GTA.GDT 4/17/18 LMK

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-02

LOCATION: N 4787714.4 ;E 485673.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

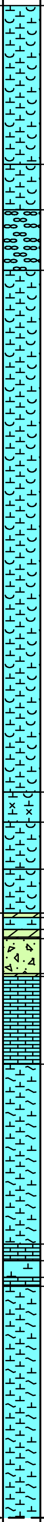
--- CONTINUED FROM PREVIOUS PAGE ---

20
21
22
23
24
25
26
27
28
29
30

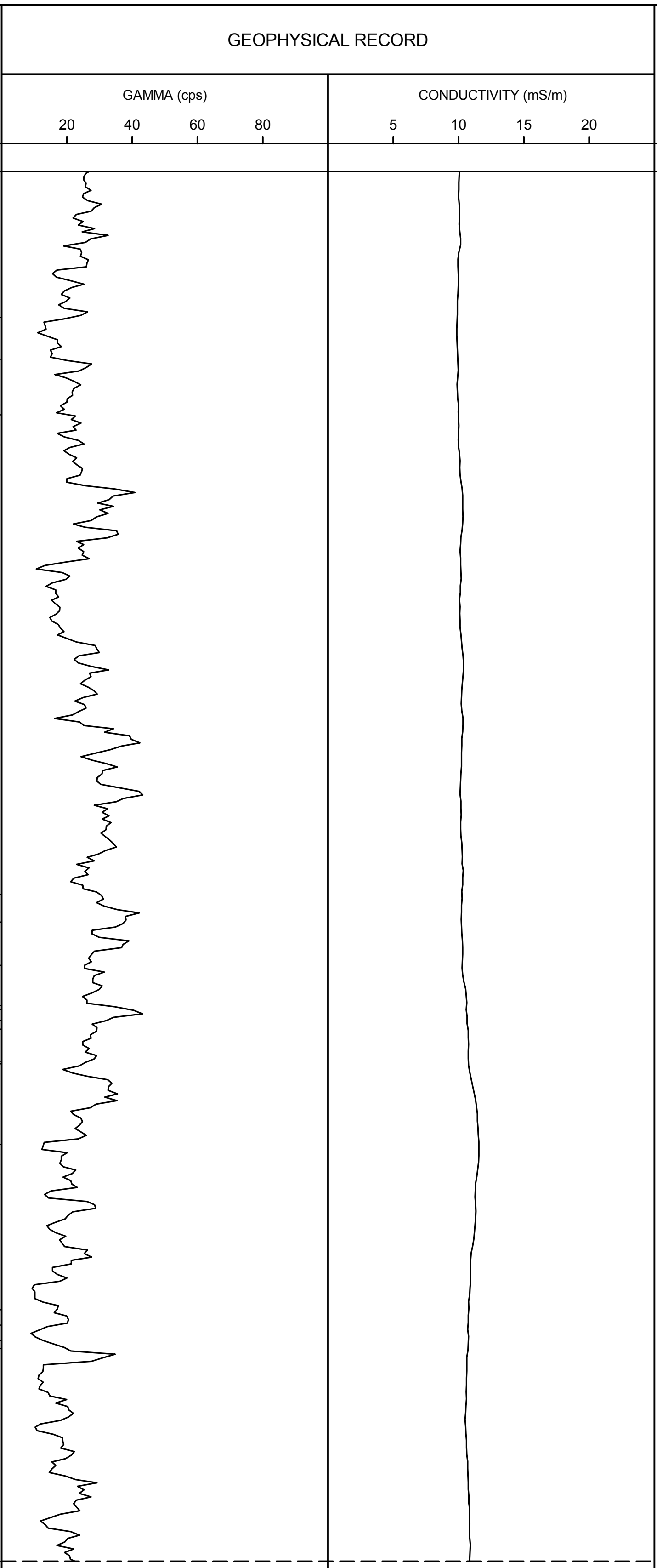
HQ CORING

LUCAS FORMATION, 26.00 m to 42.70 m
UPPER LUCAS FORMATION, 26.00 m to 35.57 m

From 26.00 m to 26.42 m, Upper Lucas Dolostone Marker Bed, faintly weathered, medium grey, fine grained crystalline, faintly porous, medium bedded, wavy laminar textured **ARGILLACEOUS DOLOSTONE** with laminar argillaceous dolostone at 26.00-.03m, 26.11-.17m and 26.40-.42m transitional into underlying limestone. Medium grey, argillaceous calcareous dolostone at 26.03-.11m. Wavy texture imparted by fine argillaceous lamination in the dolostone. Lithoclastic dolostone possibly associated with collapse breccia at 26.17-.40m. Sharp, (possibly open) contact with overlying Dundee Formation and base associated with transition to laminated limestone.
From 26.42 m to 31.43 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, laminar textured **LIMESTONE.** Medium brown, finely laminated with thin argillaceous partings, moderately porous, faintly petroliferous limestone



ELEV.	DEPTH (m)
279.52	21.05
279.22	21.35
278.82	21.75
275.37	25.20
275.17	25.40
274.86	25.71
274.57	26.00
	26.03
	26.17
274.17	26.42
273.57	27.00
272.38	28.19
	28.30
	28.47



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DEPTH SCALE
1 : 50

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-02

SHEET 4 OF 5

LOCATION: N 4787714.4 ;E 485673.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017
DRILL RIG: Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

Depth scale: 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

Drilling record: HQ CORING

sections occur at 26.42-27.00m, 28.19-.30m, 28.41-.47m, and 31.31-.43m. Intervening sections are weakly laminated. From 30.12 m to 30.60 m, very light tan grey, moderately porous, weakly laminated Limestone with thin bands of intraformational breccia at 30.12-.18m, 30.38-.40m and 30.56-.60m. Medium to thick bed of light to medium tan to creamy grey, fine grained crystalline, weakly laminated to massive textured, moderately porous Limestone at 30.60-31.31m with very thin band of intraformational breccia at 30.82-.85m.

From 31.43 m to 31.60 m, distinctive thin **marker bed** of medium grey, fine grained crystalline, faintly porous, pitted (1-2mm) **LITHOCLASTIC ARGILLACEOUS DOLOSTONE** with well developed stylolite at 31.49m.

From 31.60 m to 35.57 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, faintly laminar to massive textured **LIMESTONE.** Moderately to well developed stylolites occur at 31.62m and 31.79m.
Very thin layer of dark brown, laminated calcareous **CLAYEY SILT SOIL** at 32.56-.57m (same layer in BH17-01 at 28.46-.50m and BH17-03 at 49.62-.71m).
Slumped limestone bedding structure occurs at 32.83-.90m. Light to medium tan brown, fine grained crystalline, moderately porous, cross laminated, thickly bedded **OOLITIC LIMESTONE** bed occurs at 33.33-34.00m.
Thin dolostone layers occur at 35.26-.30m (brownish grey) and 35.30-.34m (medium grey, argillaceous).
Transitional basal contact.

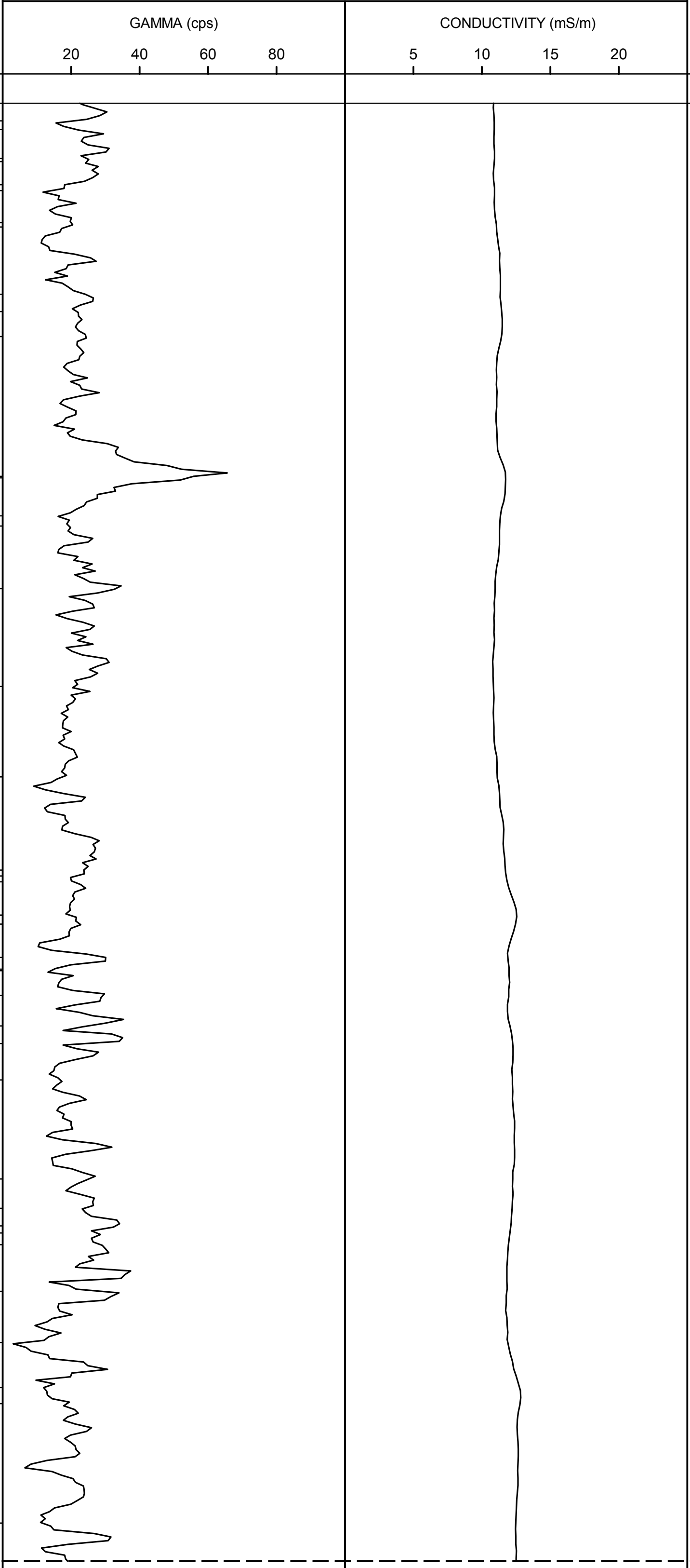
LOWER LUCAS FORMATION, 35.57 m to 42.70 m

From 35.57 m to 35.86 m, thin bed of **CALCAREOUS DOLOSTONE** at 35.57-.63m overlying distinct **marker bed** at top of sequence comprised of light grey, fine grained crystalline, moderately porous, pitted (1-5mm), weakly laminated **DOLOSTONE** with disseminated pyrite veinlets.

From 35.86 m to 38.92 m, medium brown, fine grained crystalline, faintly to moderately porous, thinly to medium bedded, laminar textured, faintly petroliferous **DOLOSTONE** at 35.86-.94m and 36.33-37.38m with weathered, porous, pitted dolostone at 36.45-.70m. Second **marker bed** of faintly to moderately weathered, medium grey, fine grained, non-porous **ARGILLACEOUS DOLOSTONE** at 37.38-.58m with moderately to highly weathered, light yellowish brown, moderately porous, laminated **DOLOSTONE** at 37.58-.70m with open bedding partings and dark grey, thin **ARGILLACEOUS DOLOSTONE** at 37.70-.75m grading at 37.75-83m to slump breccia with fragments of underlying bed. Mottled textured dolostone at 37.83-38.15m, laminar textured dolostone at 38.15-.50m, massive textured at 38.50-.81m.
Interbeds of medium to dark brown, moderately porous, thin, moderately petroliferous, bituminous **DOLOMITIC**

Elev. / Depth (m):
270.45
30.18
270.19
30.40
30.60
269.75
30.85
269.26
31.31
31.43
31.60
268.01
32.57
267.74
32.90
267.24
33.33
266.57
34.00
265.95
34.62
265.31
35.34
265.00
35.57
35.63
264.71
35.86
35.95
36.12
264.24
36.33
36.45
263.87
36.70
263.19
37.38
262.99
37.58
37.75
37.83
262.42
38.15
262.07
38.50
261.76
38.81
38.92
260.83
39.74

GEOPHYSICAL RECORD



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DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-02

SHEET 5 OF 5

LOCATION: N 4787714.4 ;E 485673.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD: HQ CORING | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

LIMESTONE at 35.94-36.12m (dark brown with black argillaceous partings at 35.94-.95m), 36.12-.33m (medium brown laminated) and 38.81-.92m with black argillaceous partings.
From 38.92 m to 42.70 m, fresh, light to medium brown, fine grained crystalline, faintly to moderately porous, medium bedded, massive to faintly laminar textured **LIMESTONE** with light tan brown laminar **DOLOMITIC LIMESTONE** with slumped bedding structure at 39.74-40.16m, medium to dark grey argillaceous dolostone bed at 40.16-.19m overlying medium brown dolostone at 40.19-.60 m transitional to medium brown **CALCAREOUS DOLOSTONE** at 40.60-.93m and medium brown, medium to thickly bedded **DOLOMITIC LIMESTONE** at 40.93-42.50m with 2mm black argillaceous parting at 41.10m. Light grey, laminated **DOLOSTONE** at 42.50-.70m.

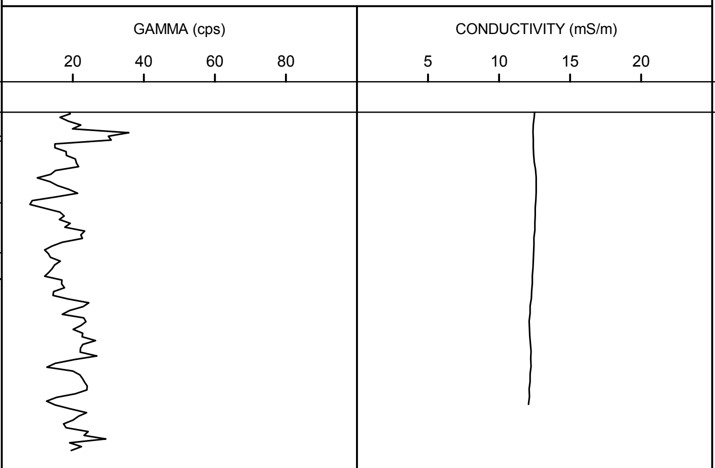
End of Borehole, 42.70 m

NOTES,

1. Complete loss of circulation around elev. 285 m (depth of 15.6 m).

2. Static water level measured in open borehole at elev. 284.1 m (depth of 16.5 m), cascading water noted in borehole.

ELEV.	DEPTH (m)
260.41	40.19
259.97	40.60
259.64	40.93
	41.11
258.07	42.50
257.87	42.70



DEPTH SCALE METRES: 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50

DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-03

SHEET 1 OF 7

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

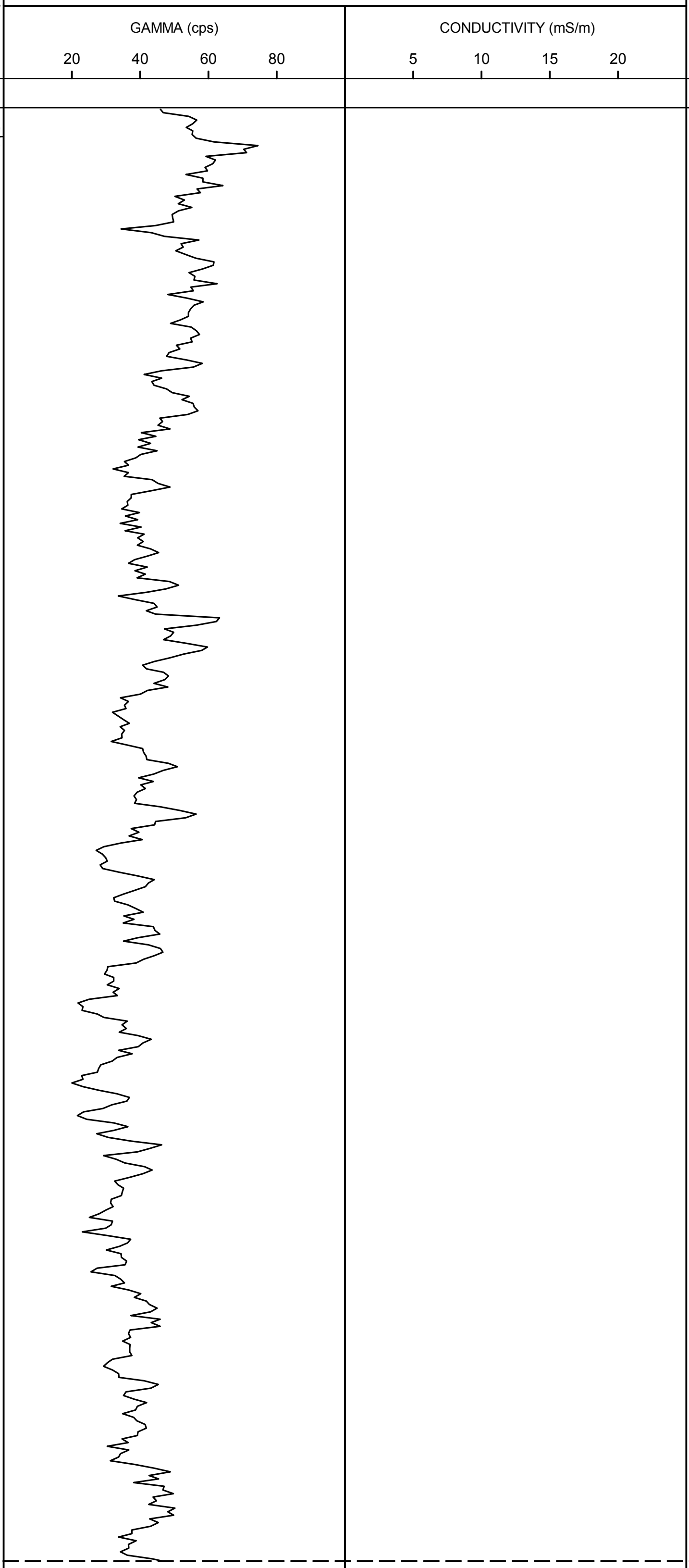
DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		320.69		
0	HW CASING	**TOPSOIL**		0.00		
		SILT, some sand, some gravel, trace to some clay; brown to brownish grey at about elev. 316.3m , **TILL** **NOTE,** soil sequence interpretation based on limited recovery using standard split spoon sample methods at intervals while triconing to elev. 299.9 m. Below elev. 299.9 m, based on limited recovery in HQ core barrel while coring through overburden with water flush.		320.49 0.20		
10		*CONTINUED NEXT PAGE*				



DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-03

SHEET 2 OF 7

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

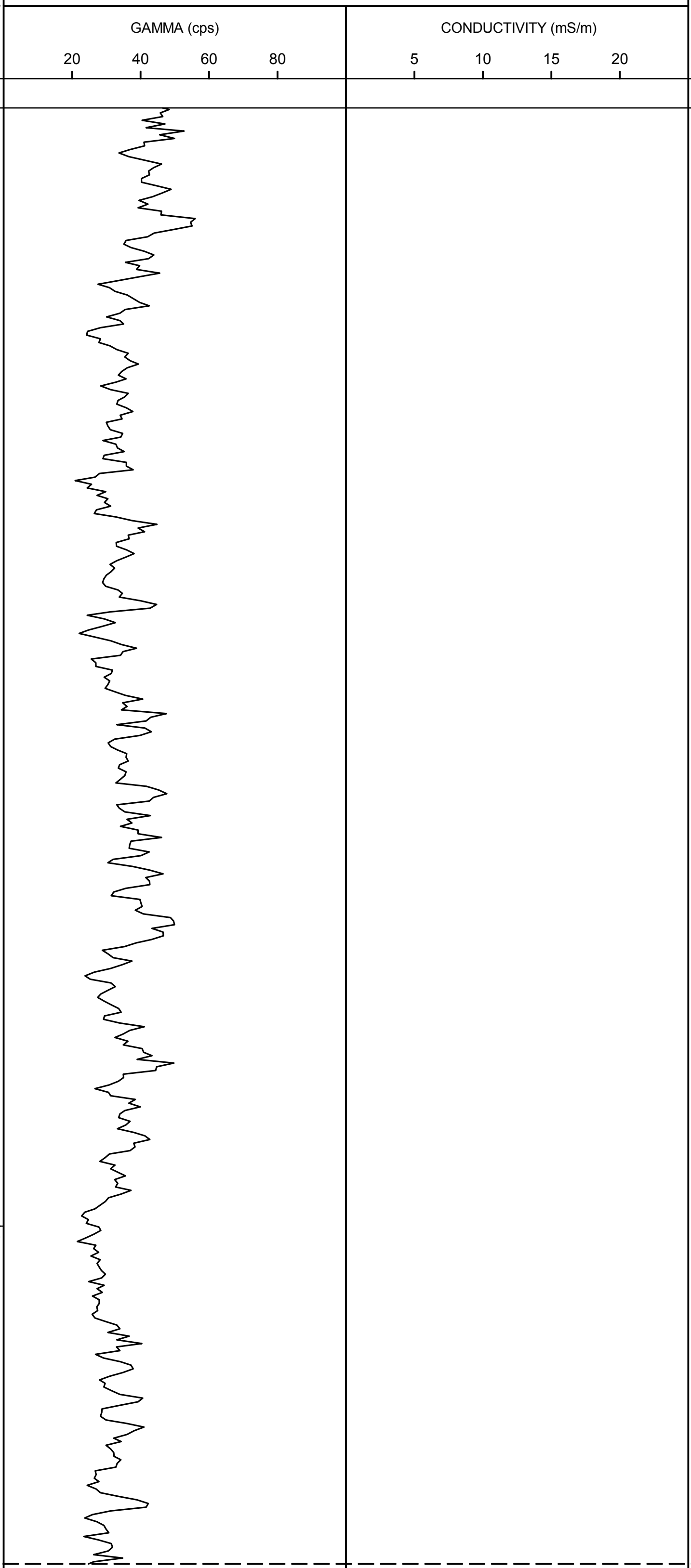
DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---				
10		**SILT**, some sand, some gravel, trace to some clay; brown to brownish grey at about elev. 316.3m , **TILL**				
11						
12						
13						
14						
15	HW CASING					
16						
17						
		sandy **CLAYEY SILT**, some gravel; brownish grey, contains cobbles **TILL**		303.01 17.68		
18						
19						
20						
		CONTINUED NEXT PAGE				



DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-03

SHEET 3 OF 7

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

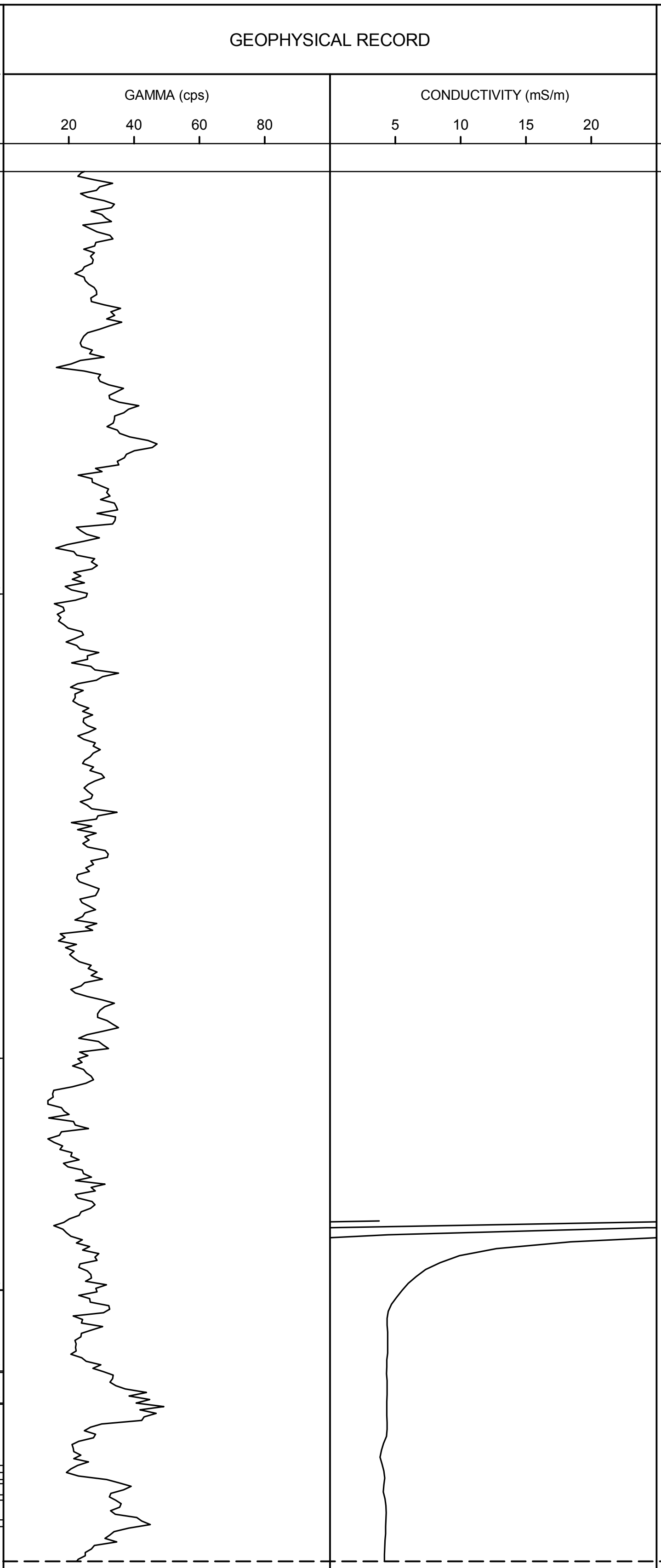
DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---		
20	HW CASING	sandy **CLAYEY SILT**, some gravel; brownish grey, contains cobbles **TILL**		
23		gravelly **SILTY SAND**, trace clay brownish grey, contains cobbles **TILL**	297.65 23.04	
26	HQ CORING	**Bedrock Surface, 26.38 m** **DUNDEE FORMATION, 26.38 m to 43.22 m** Fresh, faintly weathered on open argillaceous bedding partings to 27.80m, light brownish grey, fine to medium grained crystalline, non-porous with faintly porous fossiliferous sections, thinly to medium bedded (26.38-33.58m) becoming medium to thickly bedded (33.58-43.22m) **FOSSILIFEROUS LIMESTONE** with weakly to moderately developed stylolites below 33.58m, fine argillaceous partings (.05mm) and scattered pelecypod shells, crinoid ossicles and rugosa coral fossils.	294.31 26.38	
28			292.65 28.05	
		Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil shell debris in at 29.52-.56m, 29.70-.75m, 30.08-.15m and 31.22-.24m.	292.06 28.64	
29			291.83 28.87	
		More prominent black, argillaceous to argillaceous limestone bedding partings occur at 28.045-.050m (open with grey clay), 28.63-.64 (open with grey clay), 28.86-.87m (open with grey clay), 30.26-.27m (fine argillaceous partings in	291.38 29.44 29.56 29.75	
30		*CONTINUED NEXT PAGE*		



DEPTH SCALE

1 : 50

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-03

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

limestone), 30.84m (1-2mm parting), 31.58m (2mm parting), 31.75-.76m (argillaceous parting with 2-3mm crystalline pinkish rhodochrosite lamination), 32.28-.29m, 32.69m (2mm), 32.70m (3mm), 33.06-.07m, 33.38m (1-2mm), 33.58m (1mm), 35.95-.96m (open weathered parting with grey clay), 39.42-.43m (open weathered partings with grey clay), 39.46m (2mm), and 42.73-.77m as fine partings in argillaceous limestone.

Weakly developed stylolite occur at 33.90m.

Seams of grey calcareous clay soil occur at 29.31-.36m, 29.41-.44m, 30.67-.70m and 40.61-.64m.

Porous, pitted, medium bedded coral fossil limestone beds with mottled faint natural petroleum staining occur at 37.66-38.38m (pitted at 37.97-38.28m), 38.52-39.26m, 39.75-.95m, 39.95-40.30m (minor petroleum staining) and 40.75-41.10m.

Section from 41.10 m to 43.22 m is faintly to moderately porous, absorptive, with minor coral fossil pitting and faint petroleum staining.

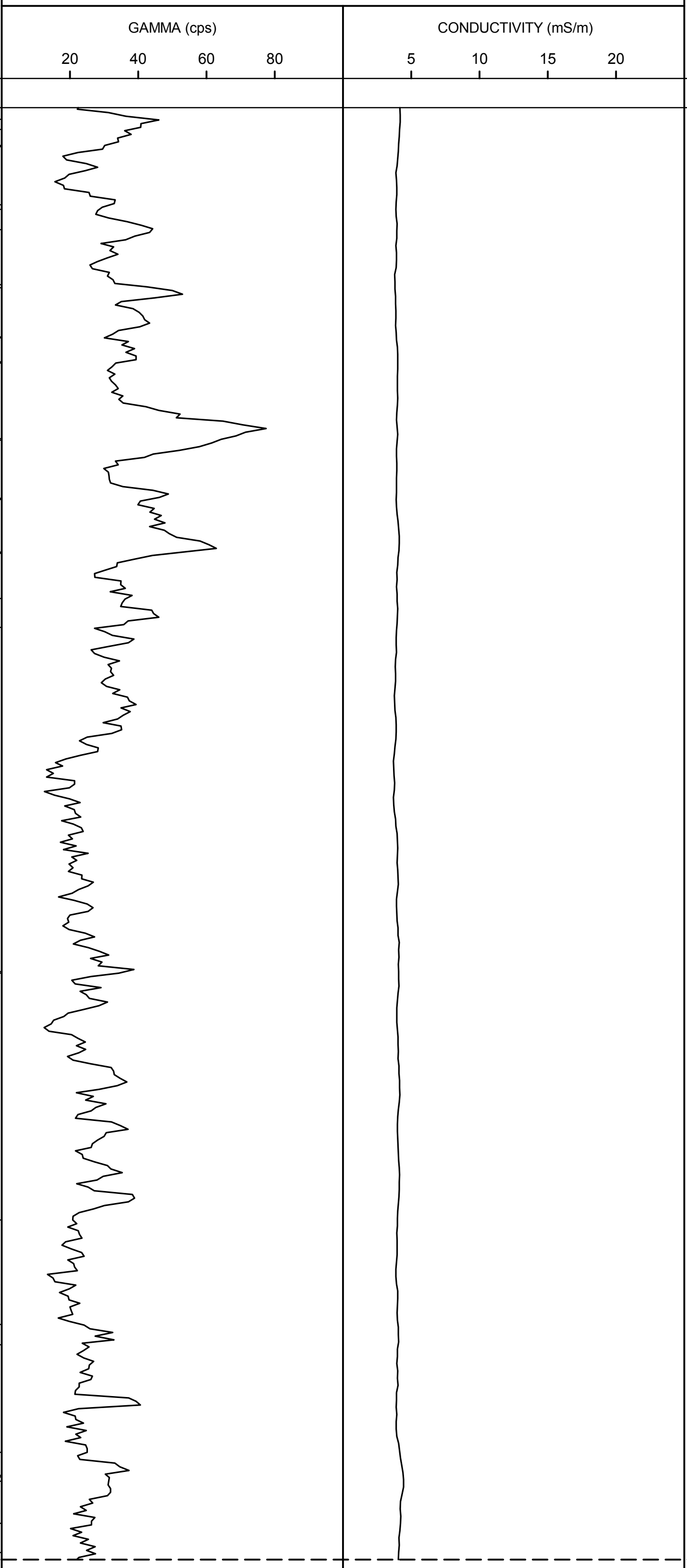
Nodular limestone beds occur at 38.30-.52m and 42.20-.38m.

Sharp basal contact with underlying Lucas Formation.

HQ CORING

ELEV. / DEPTH (m):
290.61
30.15
30.27
290.02
30.70
30.84
289.47
31.24
289.11
31.59
31.76
288.41
32.29
288.00
32.70
287.63
33.07
287.31
33.38
287.11
33.58
284.74
35.96
283.03
37.66
282.31
38.38
38.52
281.43
39.26
39.46
280.94
39.75
280.74

DEPTH SCALE METRES: 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40



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DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-03

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

DEPTH SCALE METRES: 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50

DRILLING RECORD: HQ CORING

LUCAS FORMATION, 43.22 m to 57.58 m
UPPER LUCAS FORMATION, 43.22 m to 52.45 m

From 43.22 m to 43.67 m, Upper Lucas Dolostone Marker Bed, faintly to moderately weathered, medium grey to yellowish grey, fine grained crystalline, faintly porous, medium bedded, wavy laminar textured **ARGILLACEOUS DOLOSTONE** with seam of weathered grey clay soil at 43.27-.29m. Massive textured medium grey dolostone bed at 43.40-.54m. Laminated transitional basal contact.

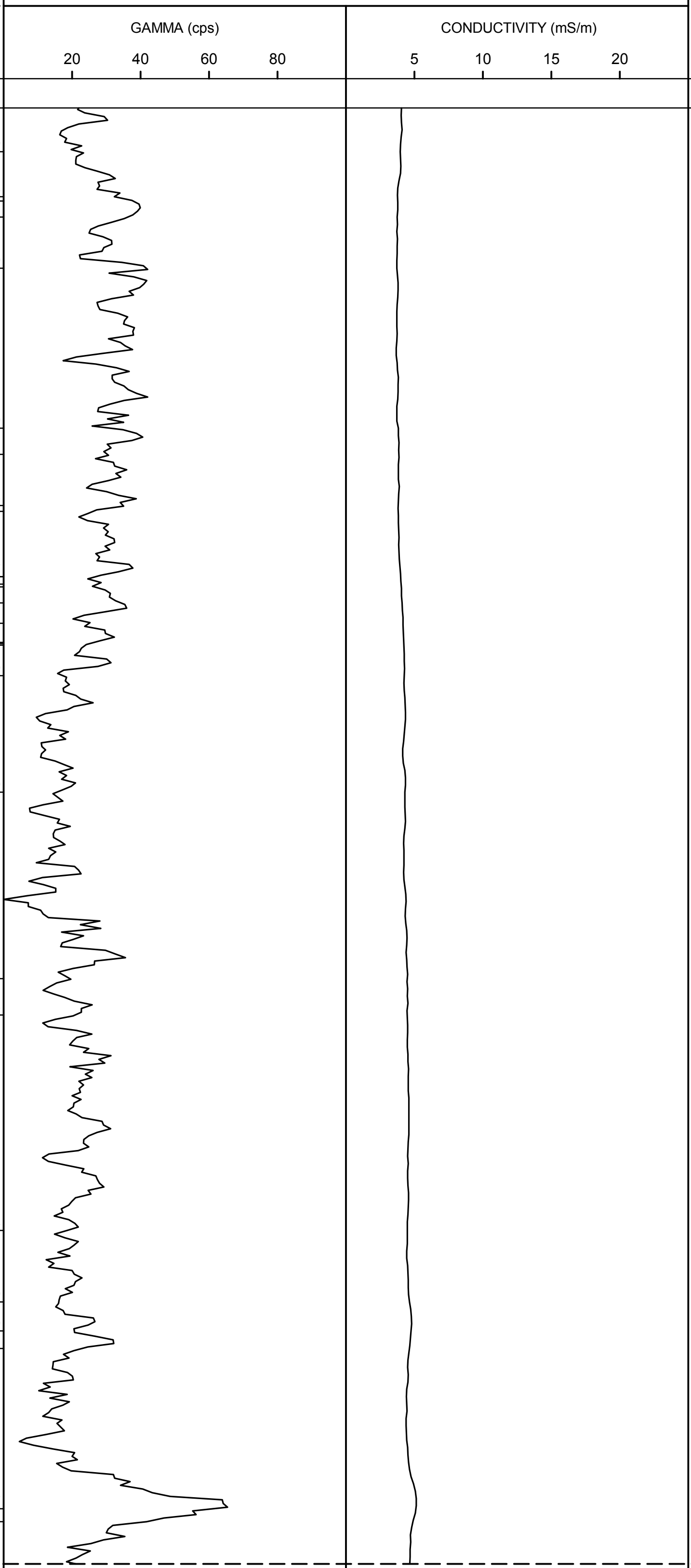
From 43.67 m to 48.40 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, laminar textured **LIMESTONE.** Medium brown, finely laminated with thin argillaceous partings, moderately porous, faintly petroliferous limestone sections occur at 43.67-.90m with prominent black bituminous shaley partings at 43.68-.69m, 45.98-46.23m with open weathered partings at 45.98-46.05m and 48.20-.40m. Medium to thick bed of light to medium tan brown to creamy grey, fine grained crystalline, weakly laminated to massive textured, moderately porous, faintly petroliferous limestone beds occur at 43.90-45.98m (open 2mm argillaceous parting at 45.70m) and 46.23-47.71m. Light tan, fine grained, thick bed of massive textured limestone at 47.71-48.20m.

From 48.40 m to 48.52 m, distinctive thin **marker bed** of medium grey, fine grained crystalline, faintly porous **ARGILLACEOUS DOLOSTONE** with open weathered top contact and well developed stylolite at bottom contact.

From 48.52 m to 52.80 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, faintly laminar to massive textured **LIMESTONE.**
Thin layer of dark brown, laminated

ELEV. / DEPTH (m):
39.95
280.39
40.30
280.08
40.64
40.75
279.59
41.10
278.49
42.20
278.31
42.38
277.96
42.77
277.47
43.22
43.29
43.40
43.54
43.69
276.79
43.90
275.99
44.70
274.71
45.98
274.46
46.23
272.98
47.71
272.49
48.20
272.29
48.40
48.52
271.07
49.62
49.71

GEOPHYSICAL RECORD



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DEPTH SCALE
1 : 50

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-03

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 10-20, 2017
DRILL RIG: Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

DRILLING RECORD: HQ CORING

--- *CONTINUED FROM PREVIOUS PAGE* ---

CLAYEY SILT SOIL at 49.62-.71m (same layer in BH17-01 at 28.46-.50m and BH17-2 at 32.56-.57m). Moderately to highly weathered, medium tan brown, fine grained crystalline, moderately porous, cross laminated, thickly bedded **OOLITIC LIMESTONE** bed occurs at 50.10-51.20m. Core is very broken into disks and friable from 50.10 m to 51.40m.
Mottled light brown limestone and medium brown porous dolomitic limestone bed at 51.20-.50m reflecting partial dolomatization of individual bed. Friable light tan, thickly bedded massive textured limestone at 51.50-52.45m associated with very broken up core.

LOWER LUCAS FORMATION, 52.45 m to 57.58 m

From 52.45 m to 53.00 m, faintly to moderately weathered, medium tan brown (52.45-.56m) to light yellowish tan brown (52.56-.80m , fine grained crystalline, moderately porous, thinly bedded, laminar textured, faintly petroliferous **DOLOSTONE** overlying distinct **marker bed** at 52.80-53.00m comprised of faintly weathered, light yellowish grey, fine grained crystalline, moderately porous, pitted (1-5mm), weakly laminated **DOLOSTONE** with disseminated pyrite veinlets.
From 53.00 m to 56.10 m, medium brown, fine grained crystalline, faintly to moderately porous, thinly to medium bedded, laminar textured, faintly petroliferous **DOLOSTONE** with interbed of dark brown, faintly petroliferous laminated bituminous **LIMESTONE** at 53.00-.13m (black argillaceous-bituminous partings at 53.04-.05m) and 53.30-.63m (moderately porous). Medium brown, moderately porous, thin, moderately petroliferous laminated **DOLOMITIC LIMESTONE** at 53.13-.30m, 54.25-.58m, 54.75-.82m and 54.82-.92m (intraformational breccia) and 54.92-55.03m. Second **marker bed** of faintly to moderately weathered, light to medium grey, fine grained, moderately porous, slump textured **DOLOSTONE** at 54.58-.75m. Porous pitted dolostone at 55.90-56.00m and laminated calcareous dolostone at 56.00-.10m.
From 56.10 m to 57.58 m, medium tan brown, fine grained crystalline, faintly laminated to massive textured, thickly bedded <<B>LIMESTONE **at 56.10-.80 overlying medium be of DOLOMITIC LIMESTONE** at 56.80-57.00m and light to medium tan brown, thinly bedded, laminar textured **CALCAREOUS DOLOSTONE** at 57.00-.32m (light grey, slump structured at 57.12-.32m with stylolite at base) overlying medium brown, moderately porous **DOLOSTONE** at 57.32-.58m.

End of Borehole, 57.58 m

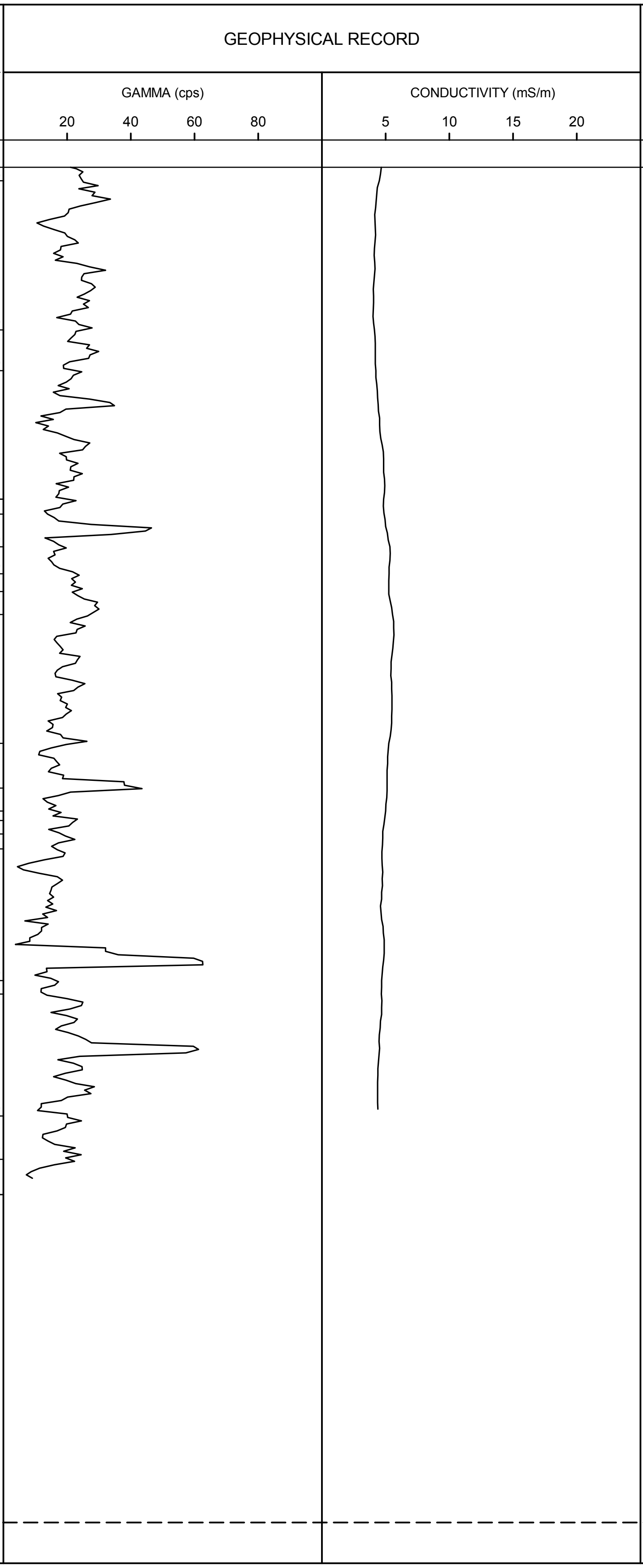
NOTES,

1. Complete loss of circulation upon commencing coring within upper rock.

2. Static water level measured in open

CONTINUED NEXT PAGE

ELEV.	DEPTH (m)
270.59	50.10
269.49	51.20
269.19	51.50
268.24	52.45
	52.56
267.89	
267.69	53.00
	53.13
	53.30
266.44	54.25
266.11	54.58
	54.82
	54.92
	55.03
264.69	56.00
	56.10
263.69	57.00
263.37	57.32
263.11	57.58



DEPTH SCALE METRES: 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60

DEPTH SCALE
1 : 50

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-03

SHEET 7 OF 7

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD GAMMA (cps) 20 40 60 80	GEOPHYSICAL RECORD CONDUCTIVITY (mS/m) 5 10 15 20	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---					
60		borehole at elev. 276.9 m (depth of 43.8 m), cascading water noted in borehole.					
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

OTTAWA-GEO 1781508 ROCK.GPJ GAL-GTA.GDT 4/17/18 LMK

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-04

SHEET 1 OF 6

LOCATION: N 4788423.2 ;E 485883.8

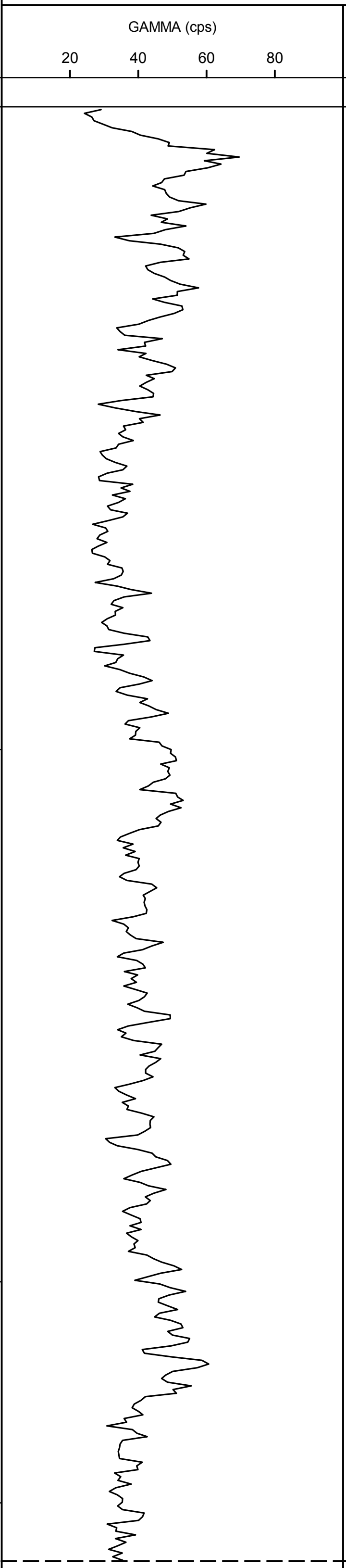
INCLINATION: -90°   AZIMUTH: ---

DRILLING DATE: November 21-27, 2017
DRILL RIG: Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)
		GROUND SURFACE	321.76
0	HW CASING	**CLAY**, some gravel, trace sand, trace silt; brown, contains cobbles **NOTE,** soil sequence interpretation based on variable recovery in HQ core barrel while coring through overburden with water flush.	0.00
4.42		**SILTY CLAY**, some sand, some gravel; brownish grey, contains cobbles **TILL**	317.34 4.42
8.08		**CLAYEY SILT**, some sand, some gravel; brownish grey, contains cobbles **TILL**	313.68 8.08
9.60		**SILTY CLAY**, some sand, some gravel; brownish grey, contains cobbles **TILL**	312.16 9.60
10			

GEOPHYSICAL RECORD



CONDUCTIVITY (mS/m): 5 10 15 20

PIEZOMETER OR STANDPIPE INSTALLATION

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-04

SHEET 2 OF 6

LOCATION: N 4788423.2 ;E 485883.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21-27, 2017

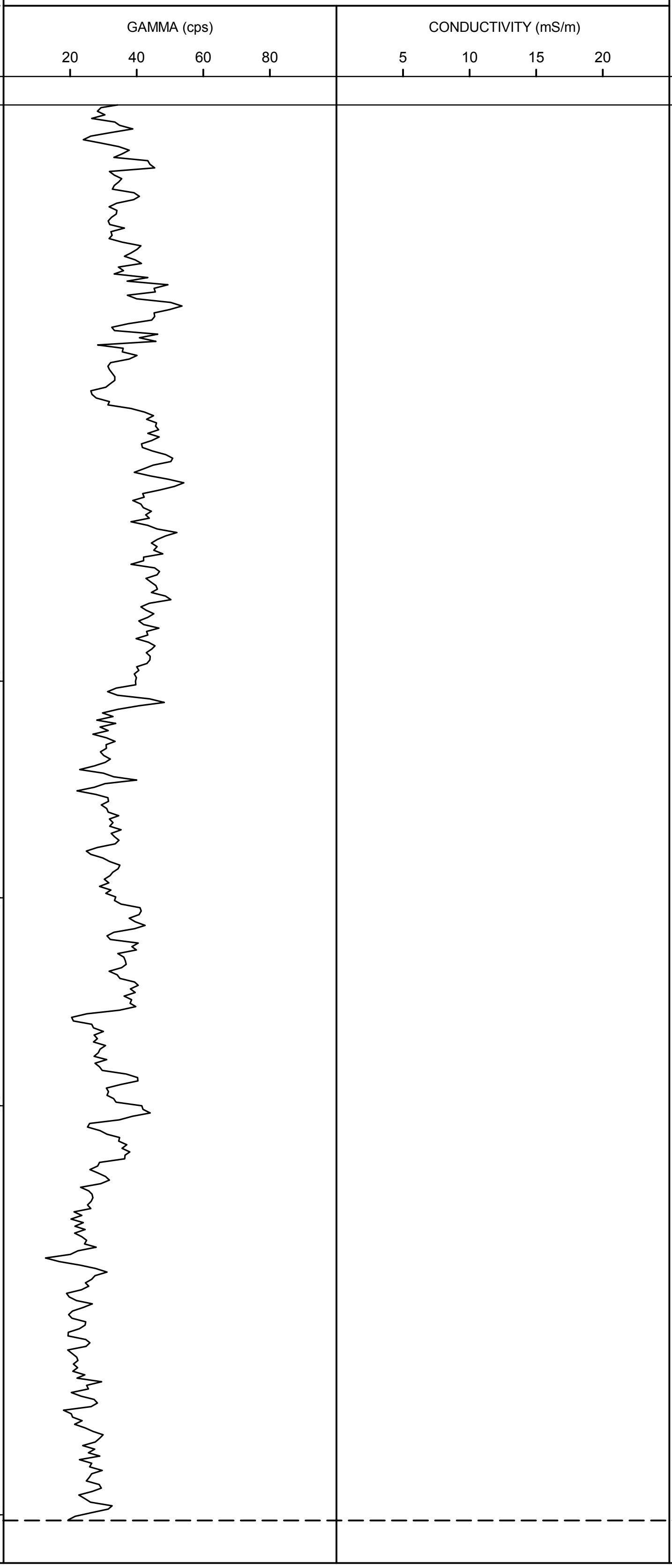
DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)
		--- CONTINUED FROM PREVIOUS PAGE ---		
10	HW CASING	**SILTY CLAY**, some sand, some gravel; brownish grey, contains cobbles **TILL** Boulder from about elev. 310.0m to 309.8m		
14		sandy **SILTY CLAY**, some gravel; brownish grey, contains cobbles **TILL**		307.69 14.07
15		sandy **CLAYEY SILT**, some gravel; brownish grey, contains cobbles **TILL**		306.16 15.60
17		**SILTY SAND**, some gravel; brownish grey, contains cobbles **TILL**		304.69 17.07
20				301.80
		CONTINUED NEXT PAGE		

GEOPHYSICAL RECORD



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-04

SHEET 3 OF 6

LOCATION: N 4788423.2 ;E 485883.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21-27, 2017

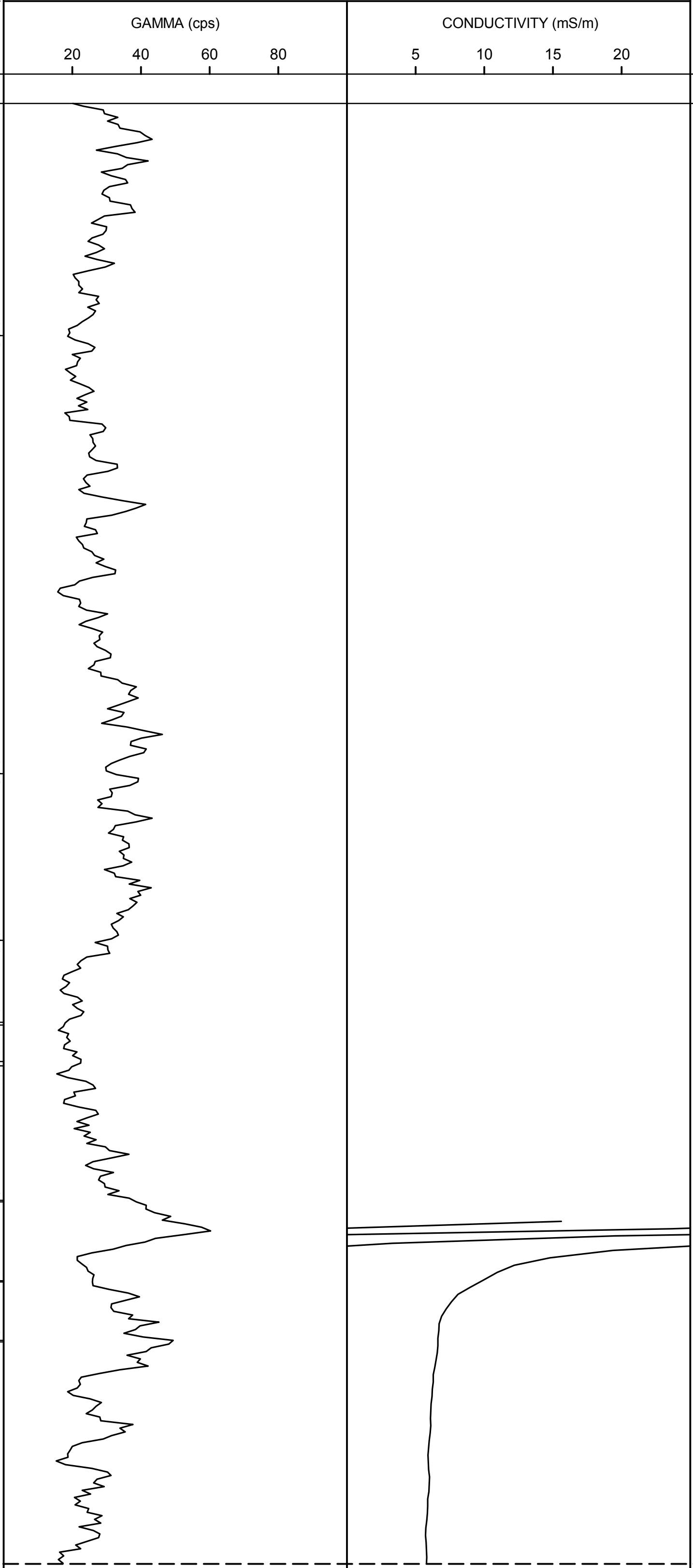
DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---		
20 21	HW CASING	sandy **CLAYEY SILT**, some gravel; brownish grey, contains cobbles **TILL**	19.96	
22 23 24		**SILTY SAND**, some gravel; brownish grey, contains cobbles **TILL**	300.17 21.59	
25		**SILTY CLAY to CLAYEY SILT**, some sand, trace gravel; brownish grey **TILL**	297.17 24.59	
26 27 28 29 30	HQ CORING	**Bedrock Surface, 25.73 m** **DUNDEE FORMATION, 25.73 m to 39.57 m** Fresh, faintly weathered on open argillaceous bedding partings to 27.52m, light brownish grey, fine grained crystalline with disseminated medium crystal grains (O.5-1.0mm), non-porous with faintly porous fossiliferous sections, thinly to medium bedded (25.73-28.48m) becoming medium to thickly bedded (28.48-39.57m) **FOSSILIFEROUS LIMESTONE** with fine argillaceous partings (.05mm) and scattered pelecypod shells, crinoid ossicles and rugosa coral fossils. Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil shell debris in shaley limestone at 26.29-.31m and 26.56-.59m. Crinoid fossil debris abundant between 29.70-31.40m. Section from 31.40m to 39.57m is faintly petroliferous with localized natural petroleum staining. Moderately developed stylolite occurs at 34.29m. Porous, pitted coral fossil limestone beds occur at 32.95-33.20m and 38.04-.23m. Nodular limestone beds occur at 33.86-34.00m and 38.25-.50m. Fine black argillaceous bedding partings	296.03 25.73 295.47 26.31 295.20 26.59 294.25 27.52 293.70 28.07 293.29 28.48	
		CONTINUED NEXT PAGE		

GEOPHYSICAL RECORD



DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-04

SHEET 4 OF 6

LOCATION: N 4788423.2 ;E 485883.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21-27, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

--- *CONTINUED FROM PREVIOUS PAGE* ---

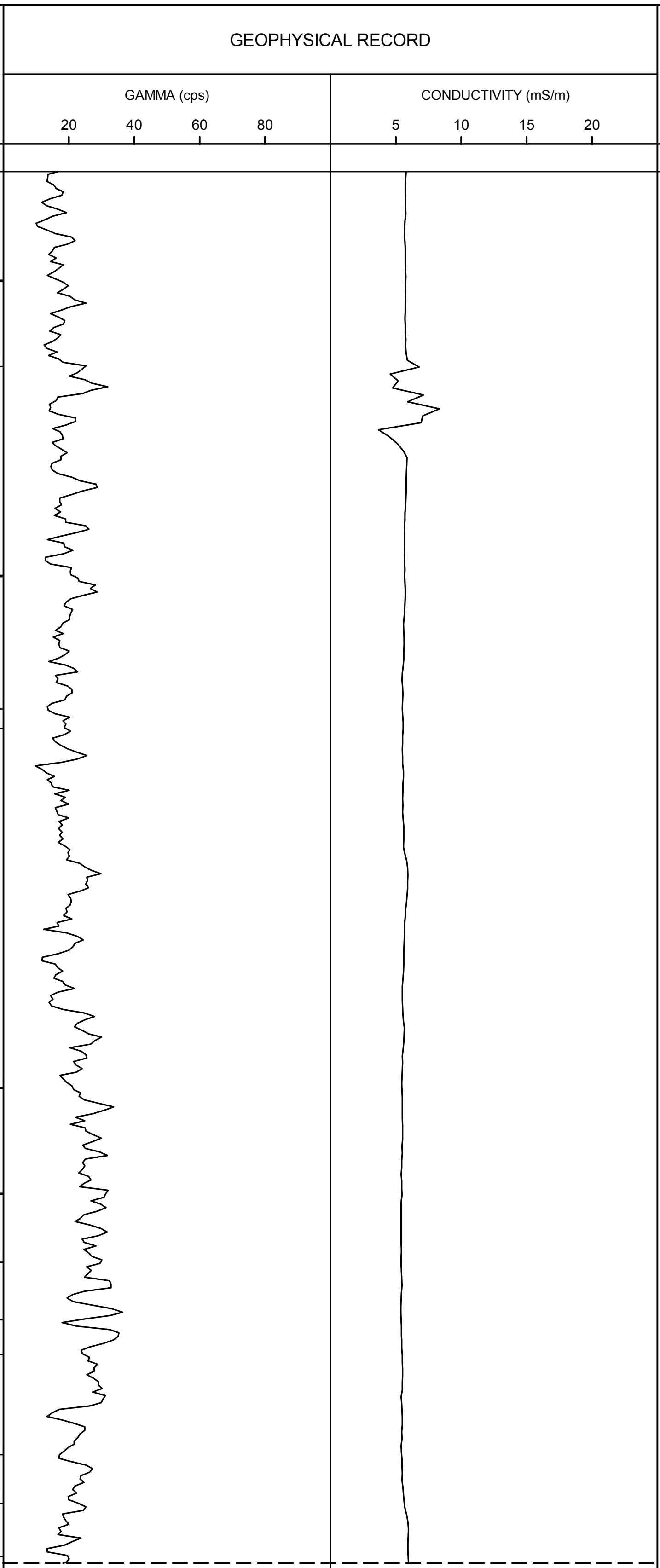
Drilling record: HQ CORING

occur at 26.06m, 26.20m, 26.74m, 26.88m, 26.91m, 28.38m, 28.77m, 31.40m, 32.17m, 32.45m, 35.00m, 35.14m and 35.95m. More prominent black 27.51-.52m, 28.06-.07m, 28.47-.48m, 30.78-.79m, 32.90-.91m, 36.58-.59m, 37.34-.35m and 37.83-.84m. Faint to moderate weathering noted by clay or brown staining occurs on majority of bedding partings.

Basal section of Dundee at 39.22-.57m comprised of faintly to moderately weathered, friable, medium brown, moderately porous, absorptive, mottled limestone with open, weathered basal contact with underlying Lucas Formation.

LUCAS FORMATION, 39.57 m to 50.09 m
UPPER LUCAS FORMATION, 39.57 m

ELEV.	DEPTH (m)
290.98	30.79
290.36	31.40
288.86	32.91
287.90	33.86
	34.00
285.18	36.59
284.42	37.35
283.93	37.84
283.51	38.25
283.26	38.50
282.54	39.22
282.19	39.57
281.81	



CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-04

SHEET 5 OF 6

LOCATION: N 4788423.2 ;E 485883.8

DRILLING DATE: November 21-27, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION

--- *CONTINUED FROM PREVIOUS PAGE* ---

Depth scale: 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50

Drilling record: HQ CORING

to 48.49 m

From 39.57 m to 40.14 m, Upper Lucas Dolostone Marker Bed, moderately weathered, light tan grey to yellowish grey, fine grained crystalline, moderately porous, medium bedded, fine wavy laminar textured **DOLOSTONE** with medium grey, weathered, weakly laminated argillaceous dolostone at 39.95-40.09m, porous, pitted at 39.85-40.00m, open weathered bedding fractures at 39.57m, 39.60m, 39.67m, 39.84m and brown weathered bedding fractures at 40.06m, 40.14m and 40.17m. Transitional basal contact.

From 40.14 m to 44.90 m, interbedded sequence of faintly to moderately weathered, light to medium tan brown, fine grained crystalline, faintly to moderately porous, faintly petroliferous, thinly to medium bedded, finely laminar textured **LIMESTONE.**

Medium brown, finely laminated with thin black argillaceous partings, moderately porous, faintly petroliferous limestone sections occur at 40.14-.45m, 42.52-.79m,43.50-.64m and 44.78-.90m. Fine argillaceous partings in limestone at 40.69-.71m. Laminated, porous fossiliferous limestone bed at 40.78-41.25m with transitional contacts. Moderately porous rugosa coral fossil bed at 42.14-.27m.

Medium to thick beds of medium tan brown, fine grained crystalline, saccharoidal textured, faintly petroliferous limestone occur at 42.79-43.50m (weakly laminated), 43.64-44.30m (weakly laminated) and 44.30-.78m (massive textured).

From 44.90 m to 44.93 m, distinctive thin **marker bed** of medium grey, fine grained crystalline, faintly porous **ARGILLACEOUS DOLOSTONE** with weathered argillaceous parting at top and well developed irregular stylolite at base. Same marker bed as in boreholes BH17-01 at 27.64-.88m, BH17-02 at 31.43-.60m and BH17-03 at 48.40-.52m. Top of bed appears to have been eroded leaving 3cm remnant compared to occurrence in the other boreholes.

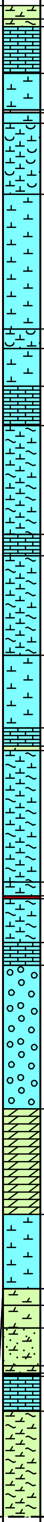
From 44.93 m to 48.75 m, interbedded sequence of faintly to moderately weathered, medium tan brown, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, faintly laminar to massive textured **LIMESTONE.**

Argillaceous bedding parting (2mm) at 45.80m. Thin layer of dark brown, laminated clayey silt soil at 49.62-.71m (same layer in BH17-01 at 28.46-.50m, BH17-2 at 32.56-.57m and BH17-03 at 49.62-.71m).

Moderately weathered, medium brown, friable, finely laminated limestone beds occur at 46.20-.35m and 47.30-48.00m (both very broken core).

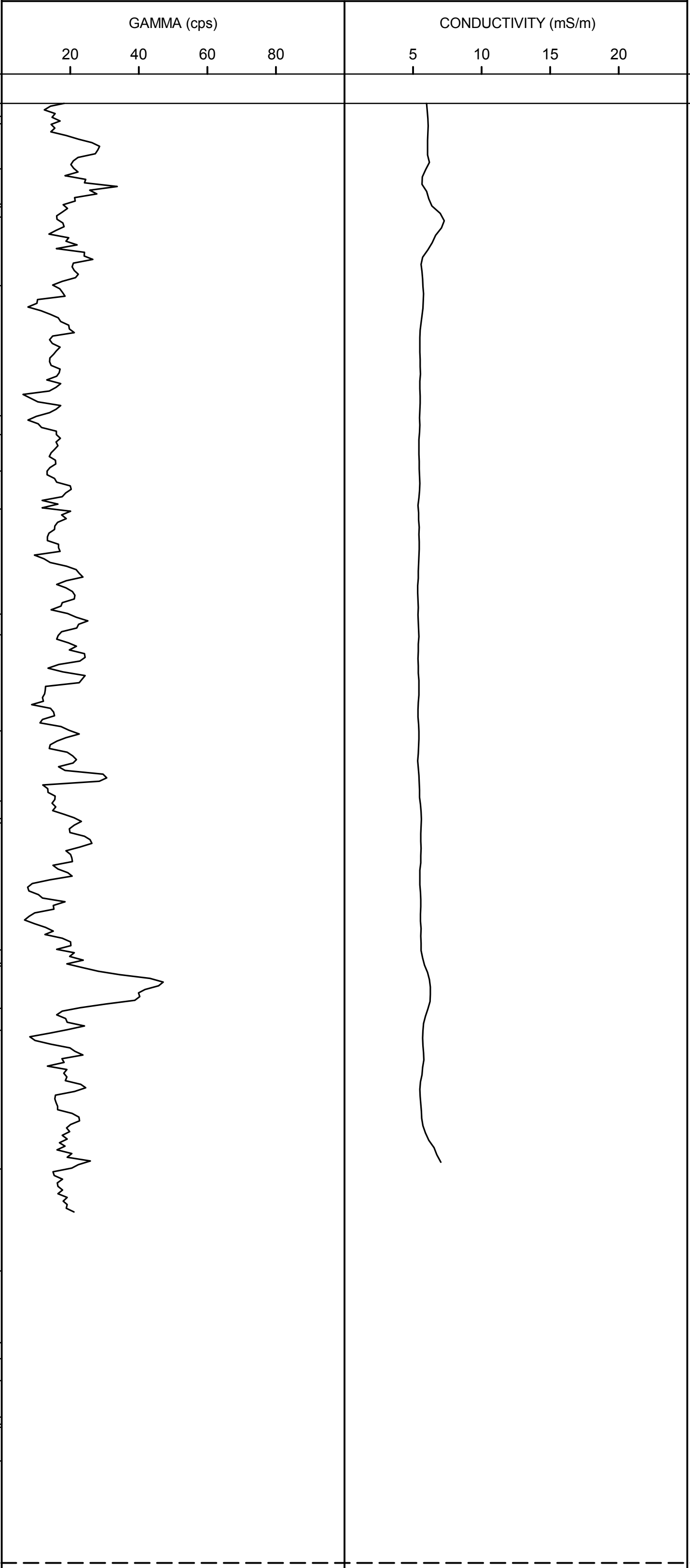
Moderately to highly weathered, medium tan brown, fine grained crystalline, moderately porous, laminated, thickly bedded **OOLITIC LIMESTONE** bed occurs at 46.35-47.30m. Core is very broken into disks and friable from 46.25 m to 48.50 m.

Friable light tan, medium bedded, massive textured saccharoidal limestone at 48.00-.49m associated with broken up core. Transitional basal contact.



ELEV. / DEPTH (m):
39.95
40.14
281.31
40.45
281.07
40.78
280.51
41.25
279.62
42.14
42.27
279.24
42.52
278.98
42.78
278.26
43.50
43.64
277.46
44.30
276.98
44.78
44.93
275.96
45.80
45.91
275.56
46.20
46.35
274.46
47.30
273.76
48.00
273.27
48.49
48.60
48.75
272.76
49.07
272.46
49.30

GEOPHYSICAL RECORD



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DEPTH SCALE

1 : 50

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-04

SHEET 6 OF 6

LOCATION: N 4788423.2 ;E 485883.8

DRILLING DATE: November 21-27, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD GAMMA (cps) 20 40 60 80	CONDUCTIVITY (mS/m) 5 10 15 20	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---					
50		**LOWER LUCAS FORMATION, 48.49 m to 50.09 m**		271.67 50.09			

From 48.49 m to 49.00 m, faintly weathered, medium tan grey, thinly bedded, massive textured **DOLOSTONE** occur at 48.49-.75m (weathered friable upper contact) with angular rip-up clasts at 48.55-.60m and weakly laminated light tan dolostone at 48.60-.75m overlying distinct **marker bed** at top of sequence comprised of faintly weathered, light yellowish grey, fine grained crystalline, moderately porous, pitted (1-5mm), weakly laminated **DOLOSTONE** with disseminated pyrite veinlets.

From 49.00 m to 50.09 m, faintly weathered, medium brown, fine grained crystalline, moderately porous, finely laminated textured, medium to thickly bedded, faintly petroliferous **DOLOSTONE** with thin bed of calcareous dolostone at 49.00-.05m, dark brown to black, finely laminated bituminous limestone at 49.05-.07m and medium bed of medium brown, moderately porous limestone at 49.07-.35m.

End of Borehole, 50.09 m

NOTES,

1. Maintained circulation to borehole completion.

2. Borehole was terminated due to loss of core barrel.

3. Static water level measured in open borehole at elev. 293.1 m (depth of 28.7 m).

51

52

53

54

55

56

57

58

59

60

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-05

SHEET 1 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

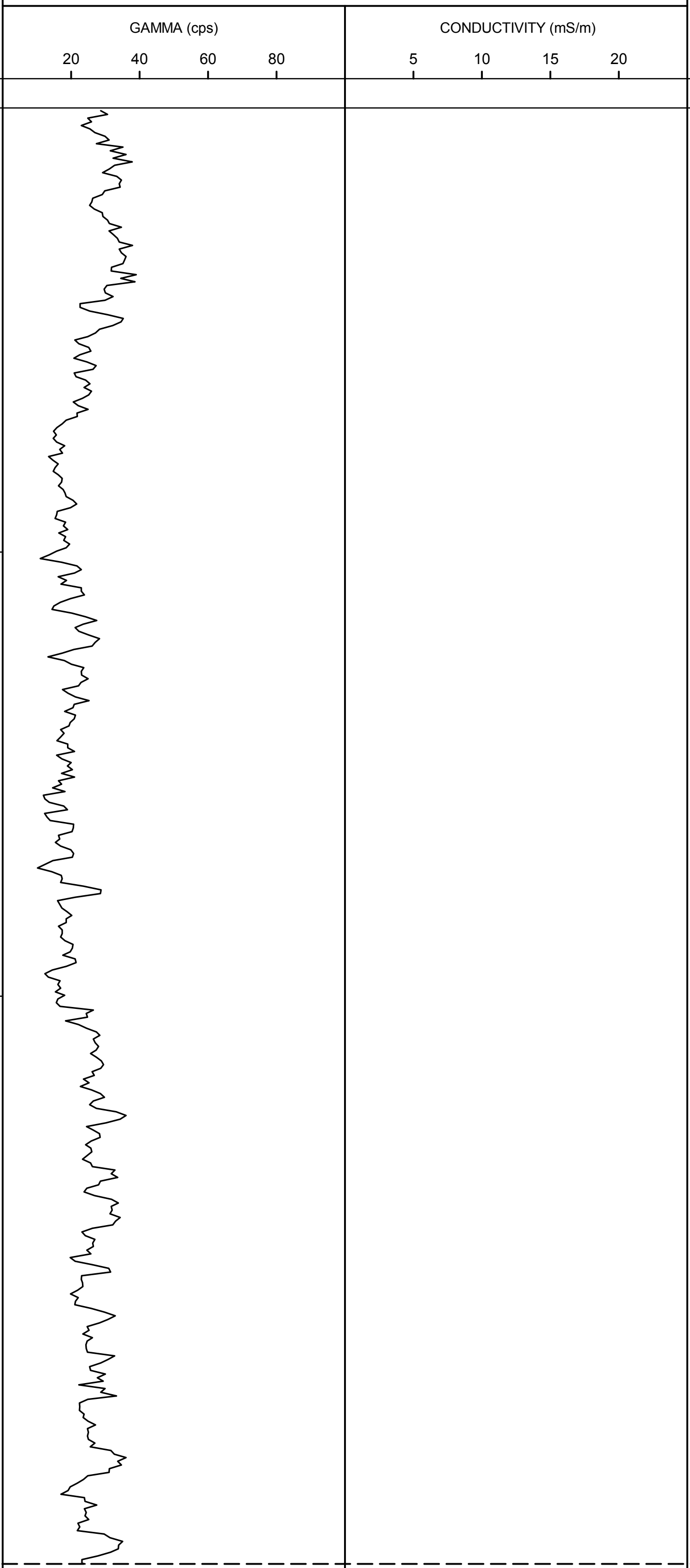
DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		304.36		
0	HW CASING	**SAND and GRAVEL**, trace clay, trace silt; brown **NOTE,** soil sequence interpretation limited to slurry return from mud-rotary drilling.	🟧	0.00		
3		**SAND**, some gravel, trace clay, trace silt; brown	🟨	301.31 3.05		
6		**SAND and GRAVEL**, trace clay, trace silt; brown	🟧	298.26 6.10		
10		*CONTINUED NEXT PAGE*				



DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-05

SHEET 2 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

Depth scale: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

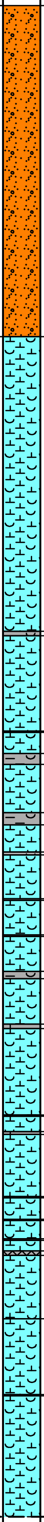
Drilling record: HW CASING; HQ CORING

SAND and GRAVEL, trace clay, trace silt; brown

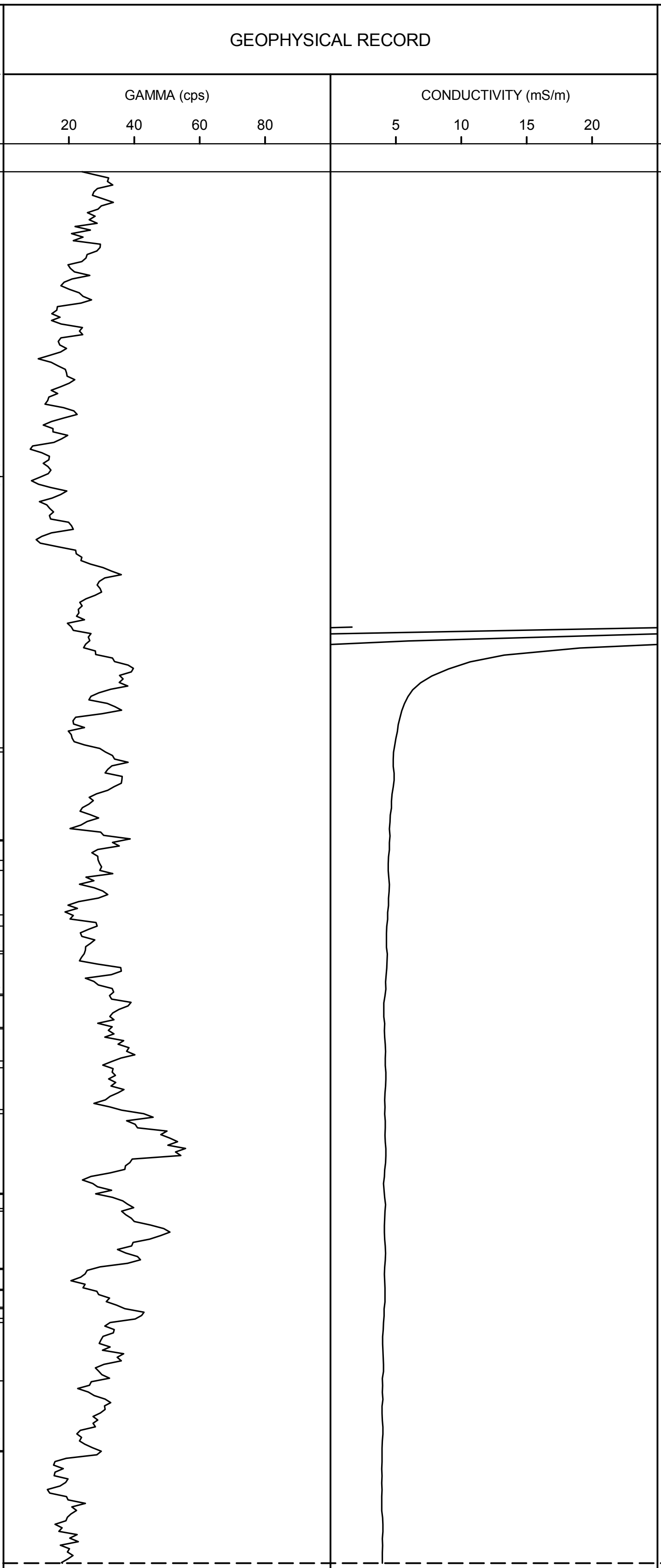
NOTE, 6.625" OD steel casing to 292.1 m

Bedrock Surface, 12.19 m
DUNDEE FORMATION, 12.19 m to 28.05 m
Fresh, faintly weathered on open argillaceous bedding partings to 14.40m, light brownish grey, fine grained crystalline with disseminated medium crystal grains (O.5-1.0mm), non-porous with faintly porous fossiliferous sections, thinly to medium bedded (12.19-18.27m) becoming medium to thickly bedded (18.27-28.05m) **FOSSILIFEROUS LIMESTONE** with fine argillaceous partings (.05mm) and scattered fossil pelecypod shells, crinoid ossicles and rugosa coral.
Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil shell debris in shaley limestone at 14.14-.17m, 14.80-.81m, 14.95-15.02m, 15.34-.42m (brown, argillaceous), 15.91-.92m, 16.15-.16m and 16.39-.44m.
Thin layers of grey clayey soil occur at 15.60-.62m, 18.24-.27m and 26.05-.09m.
Crinoid and pelecypod fossil debris abundant between 19.20-20.80m.
Porous, pitted, faintly petroliferous, rugosa coral fossil limestone beds occur at 23.05-.40m, 23.50-.85m, 25.60-26.05m, 26.10-.70m and 27.24-28.05m.
Nodular limestone beds occur at 23.40-.50m, 24.45-.53m, 26.70-.90m and 27.15-.24m.
Fine black argillaceous bedding partings occur at 15.91-.92m, 16.74-.77m, 17.34-.35m, 17.45-.47m (black shaley limestone), 17.88-.89m, 18.03-.04m, 18.16-.17m, 19.19-.20m, 22.12-.13m, 22.53-.54m and 27.74-.79m. Well developed stylolite at 26.10m.

Sharp basal contact with underlying Lucas Formation. Basal 3 cm of Dundee Fm comprised of fine lag deposit of crinoidal debris in limestone.



ELEV. DEPTH (m)
292.17
12.19
290.22
14.17
289.56
14.81
15.02
289.02
15.34
15.42
288.76
15.62
288.45
15.92
288.21
16.16
287.97
16.44
287.62
16.77
287.02
17.35
17.47
286.48
17.89
18.04
18.27
285.67
18.69
285.17
19.20



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DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-05

SHEET 3 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---			
20	HQ CORING				
				283.56 20.80	
21					
22				282.24 22.13	
				281.83 22.54	
23				281.31 23.05	
				280.96 23.40	
				23.50	
				280.51 23.85	
24					
				279.91 24.45	
				24.53	
25					
				278.76 25.60	
26				278.31 26.09	
				277.66 26.70	
				277.46 26.90	
27				277.21 27.15	
				27.24	
				276.62 27.79	
28				276.34 276.31 28.05	
		LUCAS FORMATION, 28.05 m to 50.19 m **UPPER LUCAS FORMATION, 28.05 m to 37.20 m**		276.05	
				28.38	
				28.48	
		From 28.05 m to 28.67 m, Upper Lucas Dolostone Marker Bed, faintly to moderately weathered, light tan grey to yellowish grey, fine grained crystalline, moderately porous, medium bedded, fine wavy laminar textured **DOLOMITIC LIMESTONE** at 28.05-.31m transitional to medium tan brown, laminated **DOLOSTONE** at 28.31-.56m with several open bedding partings, becoming medium grey at		28.67	
29					
				274.74 29.62	
30					

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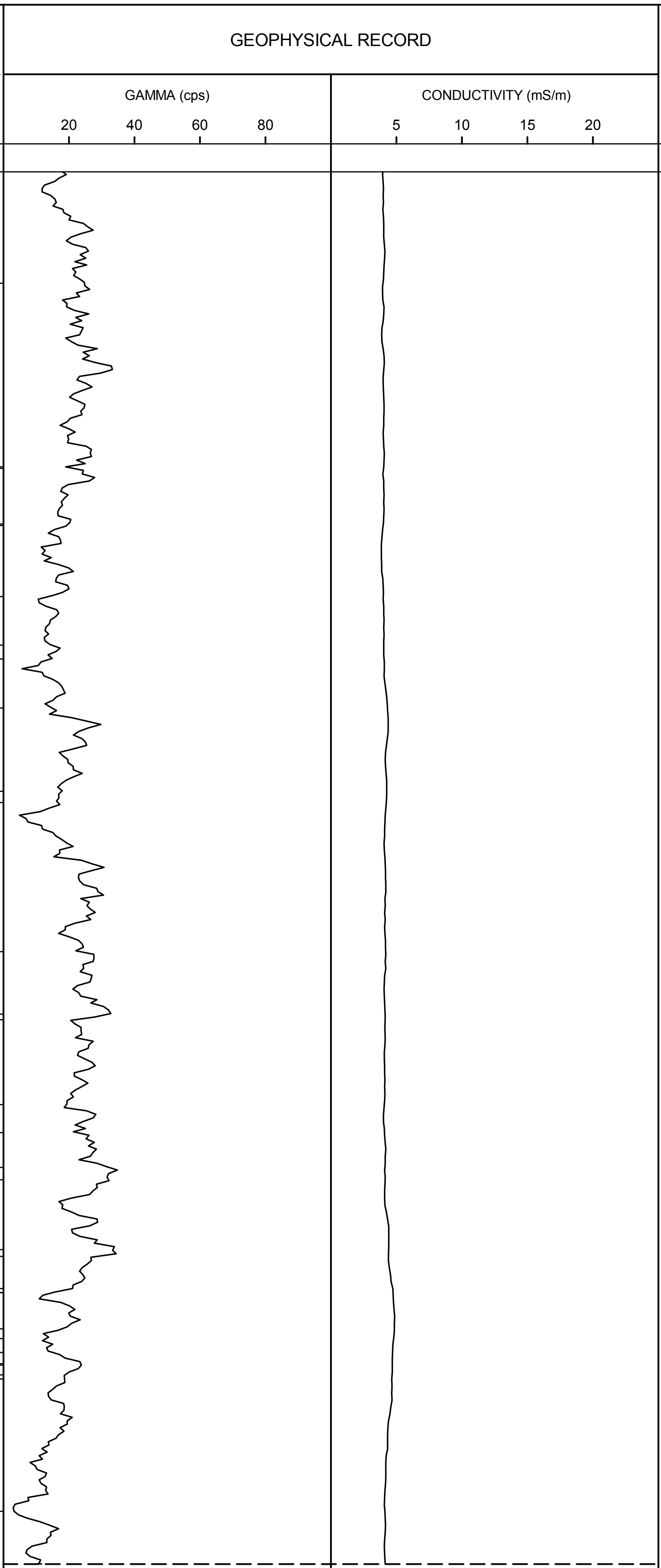


DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

OTTAWA-GEO 1781508 ROCK.GPJ GAL-GTA.GDT 4/17/18 LMK

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-05

SHEET 4 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017
DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES: 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

DRILLING RECORD: HQ CORING

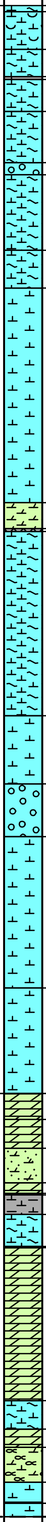
DESCRIPTION

--- CONTINUED FROM PREVIOUS PAGE ---

28.38-.48m. Thin weathered limestone bed at 28.56-.64m with open bedding partings and more prominent black argillaceous parting at 28.56-.57m. Thin dolostone bed at 28.64-.67m. Transitional basal contact.
From 28.67 m to 33.29 m, faintly to moderately weathered, light tan brown, fine grained crystalline, moderately porous, faintly petroliferous, medium to thickly bedded, massive to faintly laminar textured **LIMESTONE** at 28.67-29.62m, and 31.27-33.29m interbedded with medium tan brown, finely laminar textured with thin black argillaceous partings, moderately porous, faintly petroliferous, thinly to medium bedded **LIMESTONE** at 29.62-30.04m, 30.70-31.62m (oolitic bed at 31.04-.12m) and 31.62-.87m (light tan brown). Brownish grey, moderately porous Rugosa coral bed at 30.04-.29m with sharp top and bottom contacts. Brown argillaceous bedding partings at 30.47-.49m.
From 33.29 m to 33.48 m, distinctive thin **marker bed** of medium grey (medium tan brown at 33.29-.35m), fine grained crystalline, faintly porous **ARGILLACEOUS DOLOSTONE** with weathered argillaceous parting at top. Same marker bed as in boreholes BH17-01 at 27.64-.88m, BH17-02 at 31.43-.60m, BH17-03 at 48.40-.52m and BH17-04 at 44.90-.93m. Light grey clayey soil infill at 33.46-.48m.
From 33.48 m to 37.20 m, interbedded sequence of faintly to moderately weathered, light to medium tan brown, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, faintly laminar to massive textured **LIMESTONE.** Interlaminated, medium tan brown, fine to medium grained crystalline, moderately porous **LIMESTONE** at 33.48-34.70m overlying light tan brown, fine grained crystalline, moderately porous, medium to thickly bedded, chalky textured, partly saccharoidal **LIMESTONE** at 34.70-37.20m with interbed of oolitic limestone at 35.15-.50m (light brown at 35.15-.26m, medium brown moderately to highly porous at 35.26-.50m). Light creamy tan, saccharoidal limestone bed associated with broken core at 36.50-37.20m. Section has sharp basal contact.

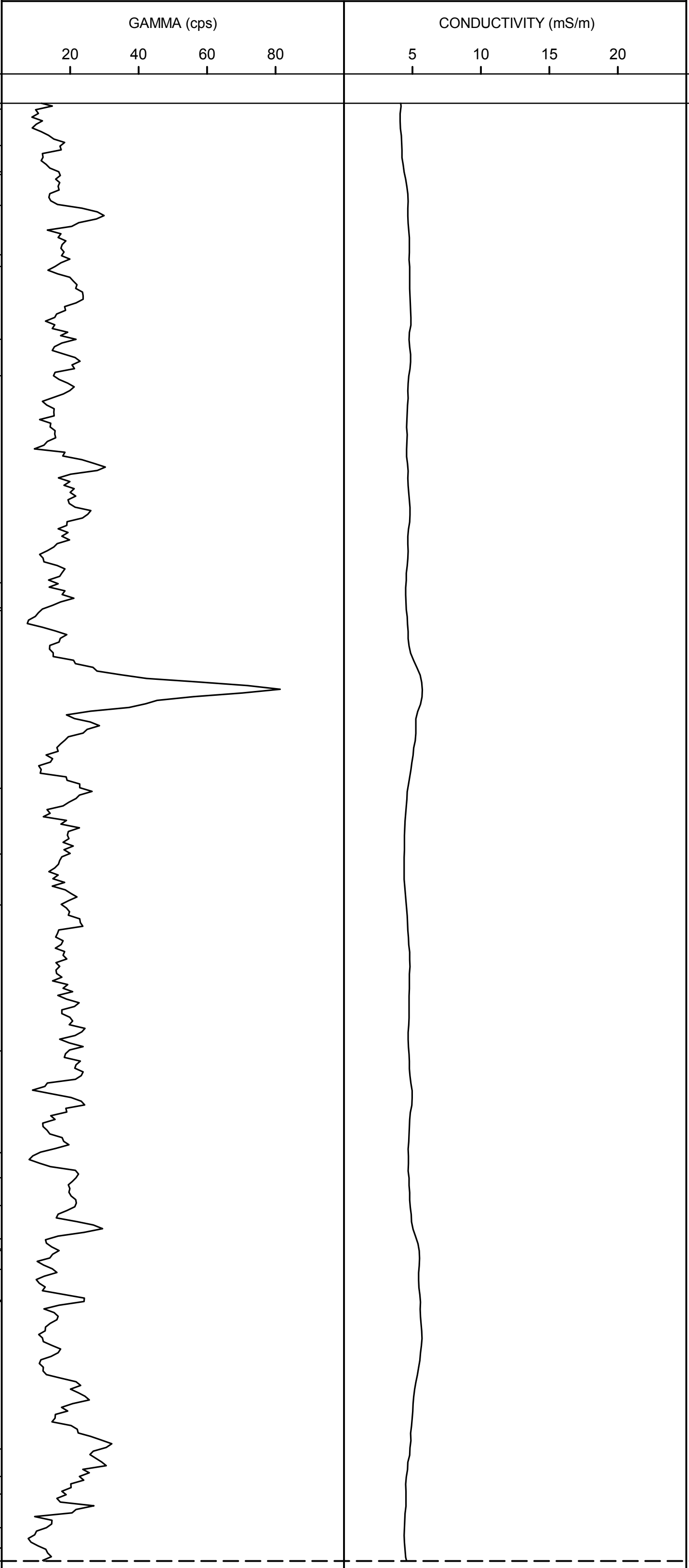
LOWER LUCAS FORMATION, 37.20 m to 50.19 m
From 37.20 m to 40.86 m, faintly to moderately weathered, medium brown, fine grained crystalline, moderately porous, thinly to thickly bedded, laminar textured, faintly petroliferous **DOLOSTONE** with distinct **marker bed** near top of sequence (37.56-.79m) comprised of faintly weathered, light yellowish grey, fine grained crystalline, moderately porous, pitted (0.5-2.0mm), weakly laminated **DOLOSTONE.** Second **marker bed** of medium grey, finely mottled **DOLOSTONE** at 39.54-.77m with sharp, well developed stylolite at 39.77m. Thin porous, pitted (0.5-1.0mm) dolostone bed at 40.00-.20m. Thin, dark brown, laminated dolostone bed at 40.80-.86m. Dark brown, thin bed of finely laminated, faintly to moderately petroliferous **ARGILLACEOUS**

SYMBOLIC LOG



ELEV. DEPTH (m)
274.32
30.04
274.07
30.29
273.89
30.49
273.66
30.70
273.32
31.04
31.12
272.74
31.62
272.49
31.87
271.07
33.29
33.48
269.66
34.70
269.21
35.15
268.86
35.50
267.86
36.50
267.16
37.20
37.37
266.80
266.57
37.87
38.00
266.15
38.22
265.13
39.23
264.94
39.42
39.54
264.59
39.77
39.91

GEOPHYSICAL RECORD



PIEZOMETER OR STANDPIPE INSTALLATION

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-05

SHEET 5 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

Depth scale: 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50

Drilling record: HQ CORING

LIMESTONE occurs at 37.86-38.00m with black argillaceous parting at 37.86-.87m. Medium brown thin beds of **LIMESTONE** occur at 38.00-.21m 39.23-.42m and 39.77-40.00m with black argillaceous parting at 38.21-.22m and 39.90-.91m.

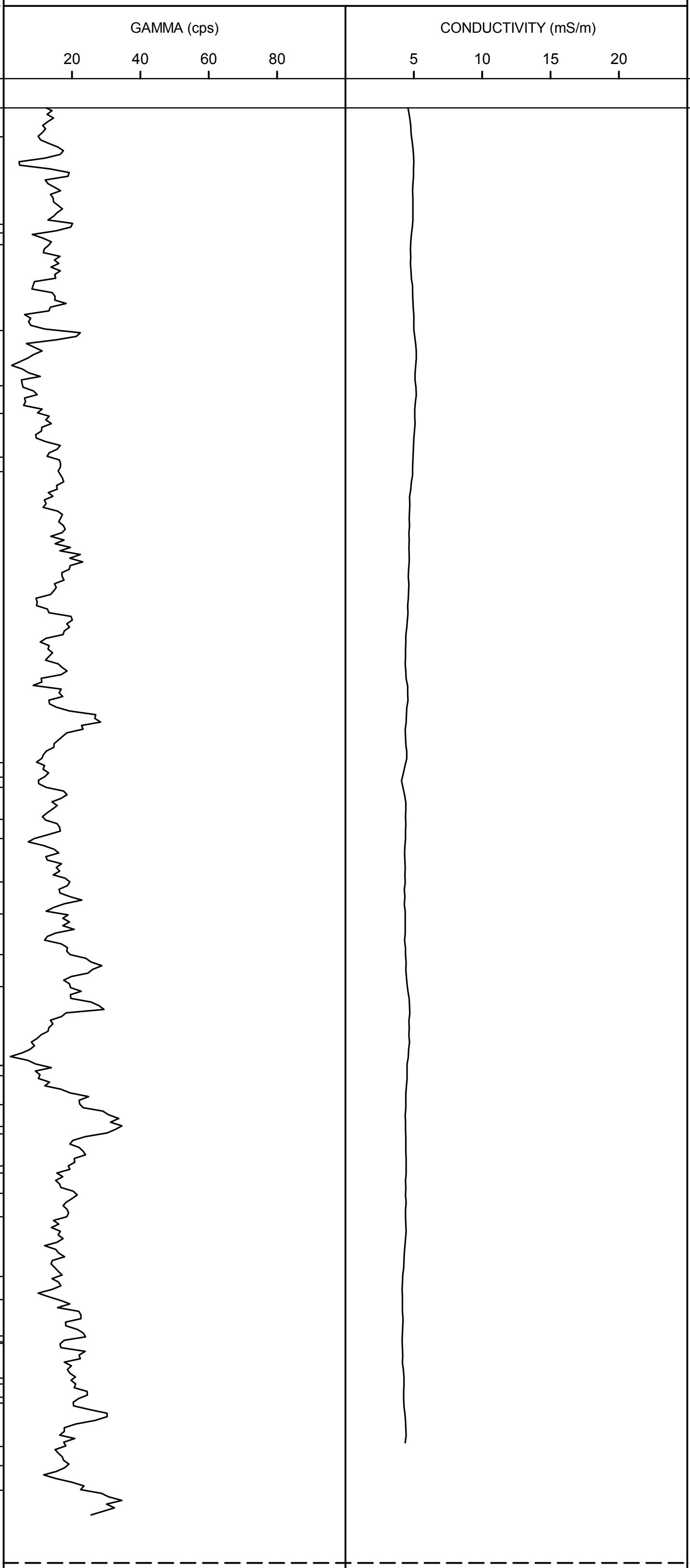
From 40.86 m to 46.58 m, faintly weathered, medium tan brown, fine grained crystalline, moderately porous, medium to thickly bedded, faintly laminar textured **LIMESTONE** with slump structured bed at 41.53-.91m, thin interbeds of **CALCAREOUS DOLOSTONE** at 42.40-.50m, 44.50-.60m, 44.85-45.02m and 45.02-.32m (laminated texture) and thin to medium beds of medium brown, moderately porous, laminar textured **DOLOSTONE** at 41.91-42.10m (slump structure), 42.10-.40m, 44.60-.67m (medium grey marker bed), 45.32-.54m, 45.54-.82m (massive textured) and 45.82-46.04m. Well developed stylolite at 46.48m.

From 46.58 m to 47.32 m, moderately weathered, light grey to brownish grey, medium to coarse grained crystalline, thinly bedded **GYPSUM** at 46.65-.85m and 47.05-.27m with transitional beds of nodular gypsum in dolostone at 46.58-.65m, 46.85-47.00m and 47.27-.32m and thin bed of medium brown laminar textured dolostone at 47.00-.05m. Gypsum beds are porous-pitted (1-5mm) with open weathered bedding partings and broken core with core loss between 46.70-.75m (possible void). Bedded gypsum is calcareous (fizzes) likely due to calcareous dolostone inclusions from bedding laminations.

From 47.32 m to 50.19 m, faintly weathered, light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded **DOLOSTONE** with thin interbeds of laminar textured **CALCAREOUS DOLOSTONE** at 47.46-.62m and **DOLOMITIC LIMESTONE** at 48.03-.19m, 48.44-.73m (argillaceous bedding partings at 48.48-.49m), 48.90-49.20m and 49.33-.50m.

ELEV. DEPTH (m):

40.00
264.16
40.20
263.56
40.86
40.94
262.83
41.53
262.45
41.91
262.26
42.10
261.96
42.40
42.50
259.86
44.50
44.67
259.47
44.89
45.02
259.04
45.32
258.82
45.54
258.54
45.82
258.32
46.04
257.78
46.58
46.65
257.51
46.85
47.05
257.09
47.32
47.46
47.62
256.33
48.03
48.19
255.92
48.49
255.63
48.77
48.90
255.16
49.20
49.33
49.50



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DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: BH17-05

SHEET 6 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD GAMMA (cps) 20 40 60 80	GEOPHYSICAL RECORD CONDUCTIVITY (mS/m) 5 10 15 20	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---					
50		Weathered, open dolostone bed at 48.73-.77m. Thin medium grey limestone marker bed at 48.86-.90m with moderately developed stylolite at top contact.	🟩	254.17 50.19			
		End of Borehole, 50.19 m					
		NOTE,					
51		1. Static water level measured in open borehole at elev. 279.4 m (depth of 25.0 m), cascading water noted in borehole.					
52							
53							
54							
55							
56							
57							
58							
59							
60							

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-01

SHEET 1 OF 5

LOCATION: N 4788470.1 ;E 485482.8

DRILLING DATE: November 24, 2017

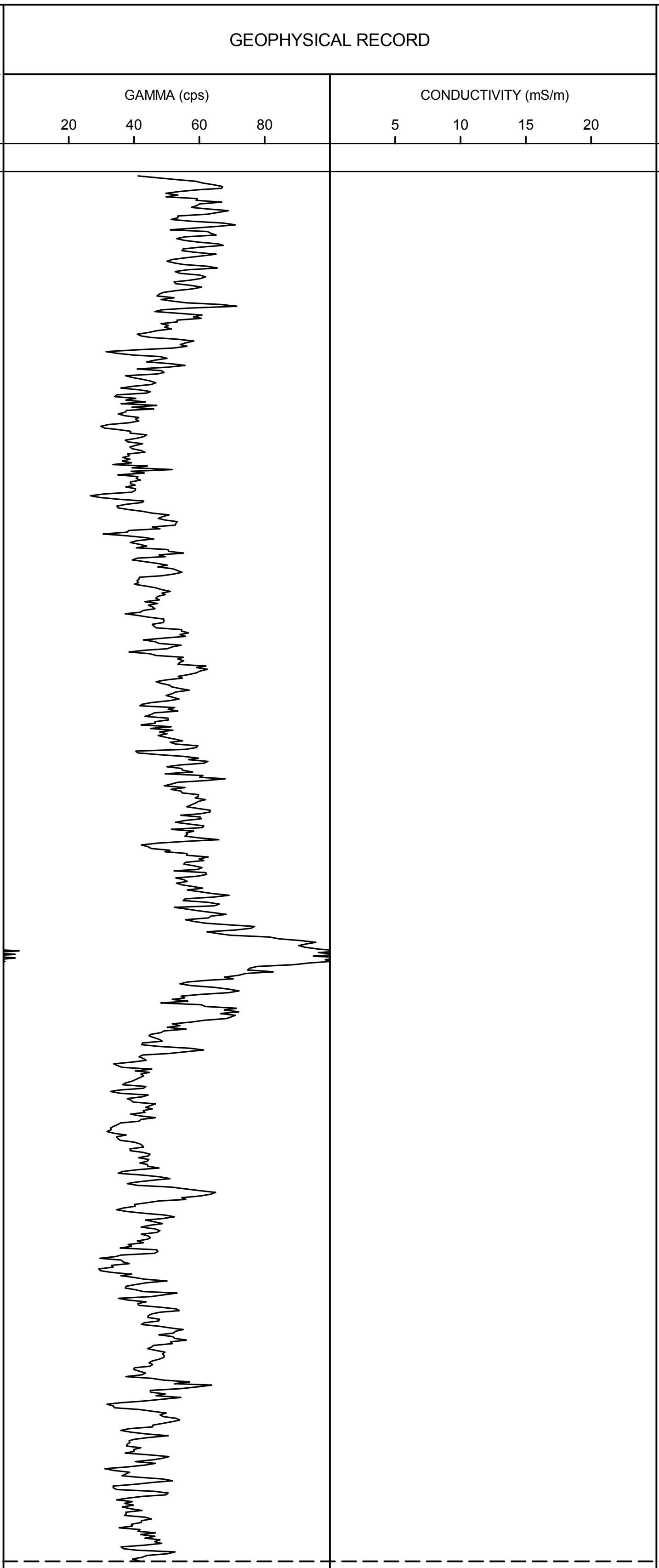
DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		322.49		
0	Mud Rotary - Tricone 6 inch steel casing	**SILTY CLAY to CLAYEY SILT**, trace to some sand, gravel and cobbles. Silty clay layer at 10.8-11.6m. **NOTE,** borehole drilled by mud flush rotary tricone method, 158.75 mm ID steel casing through overburden and 155.60 mm open hole in rock. Overburden stratigraphy based on mud slurry cutting return and natural gamma geophysical logs with bedrock stratigraphic interpretation based on borehole natural gamma, apparent conductivity and optical televiewer geophysical logs with support from chip samples collected during drilling. Well casing annulus sealed with bentonite grout from bottom up.	▨	0.00		
2						
4						
6						
8						
10						
12						
14						
16						
18						
20		*CONTINUED NEXT PAGE*				



DEPTH SCALE

1 : 100

GOLDER

LOGGED: MC/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-01

SHEET 2 OF 5

LOCATION: N 4788470.1 ;E 485482.8

INCLINATION: -90° AZIMUTH: ---

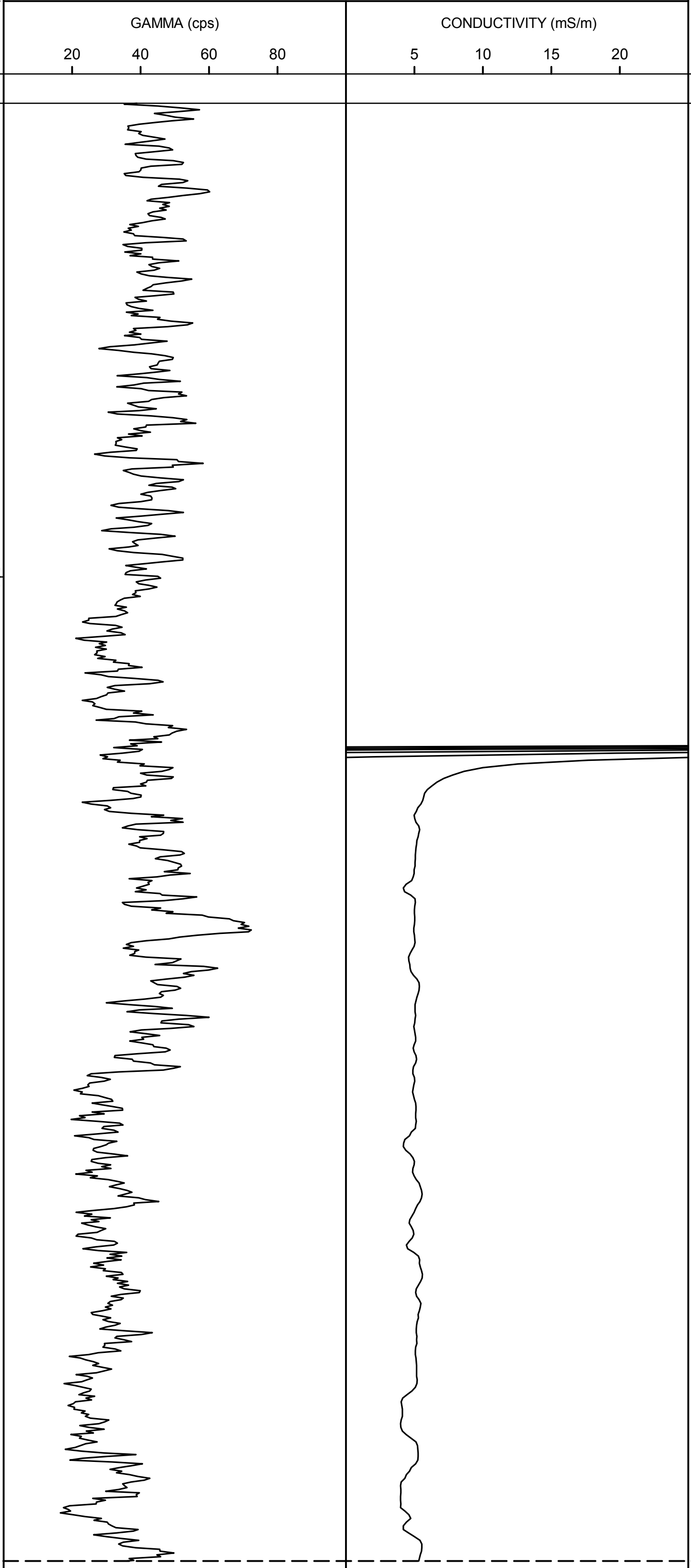
DRILLING DATE: November 24, 2017

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---				
20	Mud Rotary - Tricone 6 inch steel casing	**SILTY CLAY to CLAYEY SILT**, trace to some sand, gravel and cobbles. Silty clay layer at 10.8-11.6m.	▨			
26.50	Air Rotary - Tricone	**Bedrock Surface, 26.50 m** **DUNDEE FORMATION, 26.50 m to 43.00 m** Fresh, light brownish grey, fine grained crystalline, non-porous with faintly porous fossiliferous sections, thinly to thickly bedded **FOSSILIFEROUS LIMESTONE** with laminated to very thin bedded dark grey argillaceous to shaley partings. Becomes medium to thickly bedded below 32.50m.	🟦	295.99 26.50		
40		*CONTINUED NEXT PAGE*				



DEPTH SCALE

1 : 100

GOLDER

LOGGED: MC/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-01

LOCATION: N 4788470.1 ;E 485482.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 24, 2017
DRILL RIG: Mud/Air Rotary
DRILLING CONTRACTOR: McLeod Water Wells

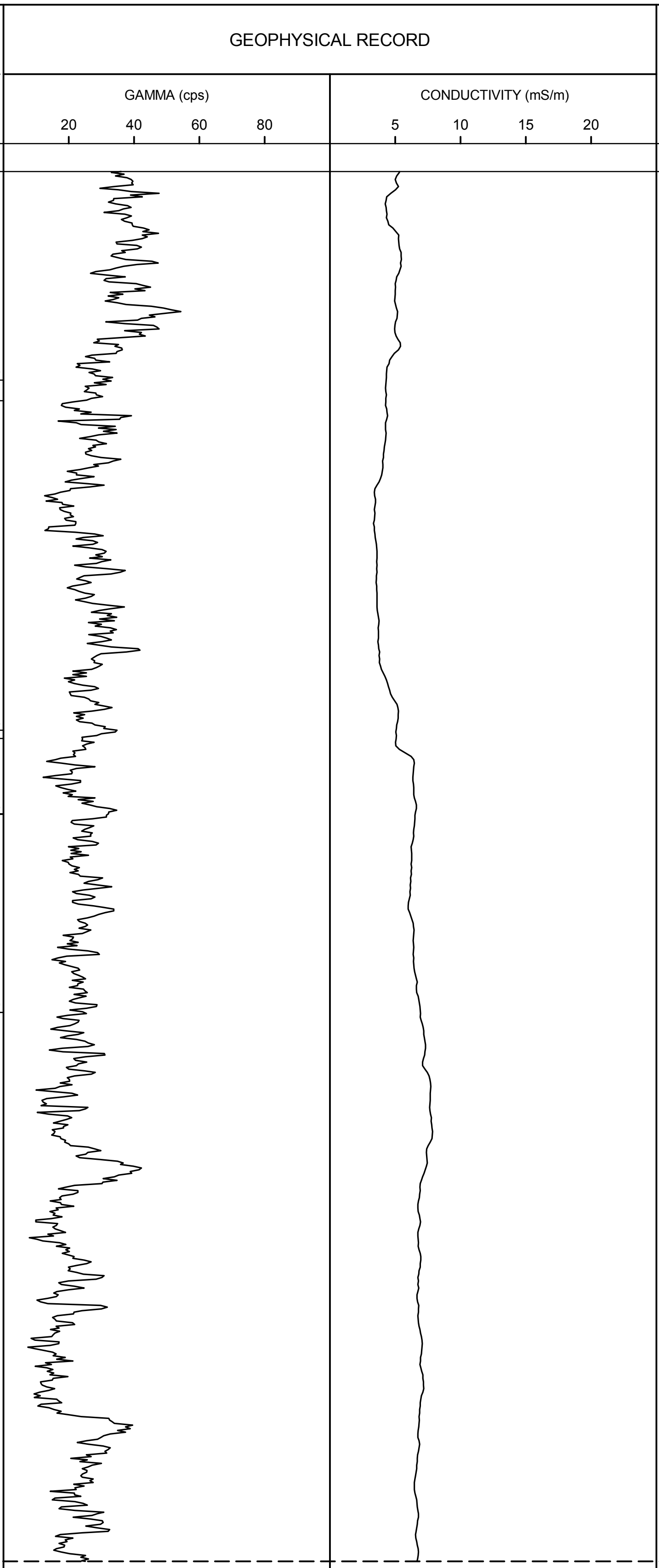
DATUM: Geodetic

DEPTH SCALE METRES: 40 – 60

DRILLING RECORD: Air Rotary - Tricone

--- CONTINUED FROM PREVIOUS PAGE ---

DESCRIPTION	ELEV. DEPTH (m)
Bedrock Surface, 26.50 m **DUNDEE FORMATION, 26.50 m to 43.00 m** Fresh, light brownish grey, fine grained crystalline, non-porous with faintly porous fossiliferous sections, thinly to thickly bedded **FOSSILIFEROUS LIMESTONE** with laminated to very thin bedded dark grey argillaceous to shaley partings. Becomes medium to thickly bedded below 32.50m.	279.49 43.00
LUCAS FORMATION, 43.00 m to 85.50 m **UPPER LUCAS FORMATION, 43.00 m to 52.10 m** Faintly to moderately weathered, light tan brown, fine grained crystalline, moderately porous, faintly petroliferous, medium to thickly bedded, massive to faintly laminar textured **LIMESTONE** with thin black argillaceous partings and moderately porous beds. Top of section marked by medium-dark grey, thin (+/-0.2-.3m) bed of **DOLOSTONE of the Upper Lucas Dolostone Marker Bed and second thin medium-dark grey DOLOSTONE marker bed** at 48.04-.16m. Dark grey **CLAYEY SOIL** layer at 49.24-.25m associated with natural gamma spike.	43.30 274.45 48.16 273.25 49.25 270.39 52.10
LOWER LUCAS FORMATION, 52.10 m to 85.50 m **From 52.10 m to 61.40 m,** faintly to moderately weathered, medium brown, fine grained crystalline, moderately porous, thinly to thickly bedded, laminar textured, faintly petroliferous **DOLOSTONE** with interbeds of medium tan brown, fine grained crystalline, moderately porous, medium to thickly bedded, faintly laminar textured **LIMESTONE** and thin interbeds of **CALCAREOUS DOLOSTONE.**	



PIEZOMETER OR STANDPIPE INSTALLATION

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DEPTH SCALE
1 : 100

GOLDER

LOGGED: MC/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-01

SHEET 4 OF 5

LOCATION: N 4788470.1 ;E 485482.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 24, 2017

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

60

62

64

66

68

70

72

74

76

78

80

Air Rotary - Tricone

From 61.40 m to 62.00 m, moderately weathered, light grey to brownish grey, medium to coarse grained crystalline, thinly bedded **GYPSUM** and **NODULAR GYPSUM in DOLOSTONE.** Gypsum beds are porous-pitted and vuggy. Gypsum layer forms weathered aquifer horizon.

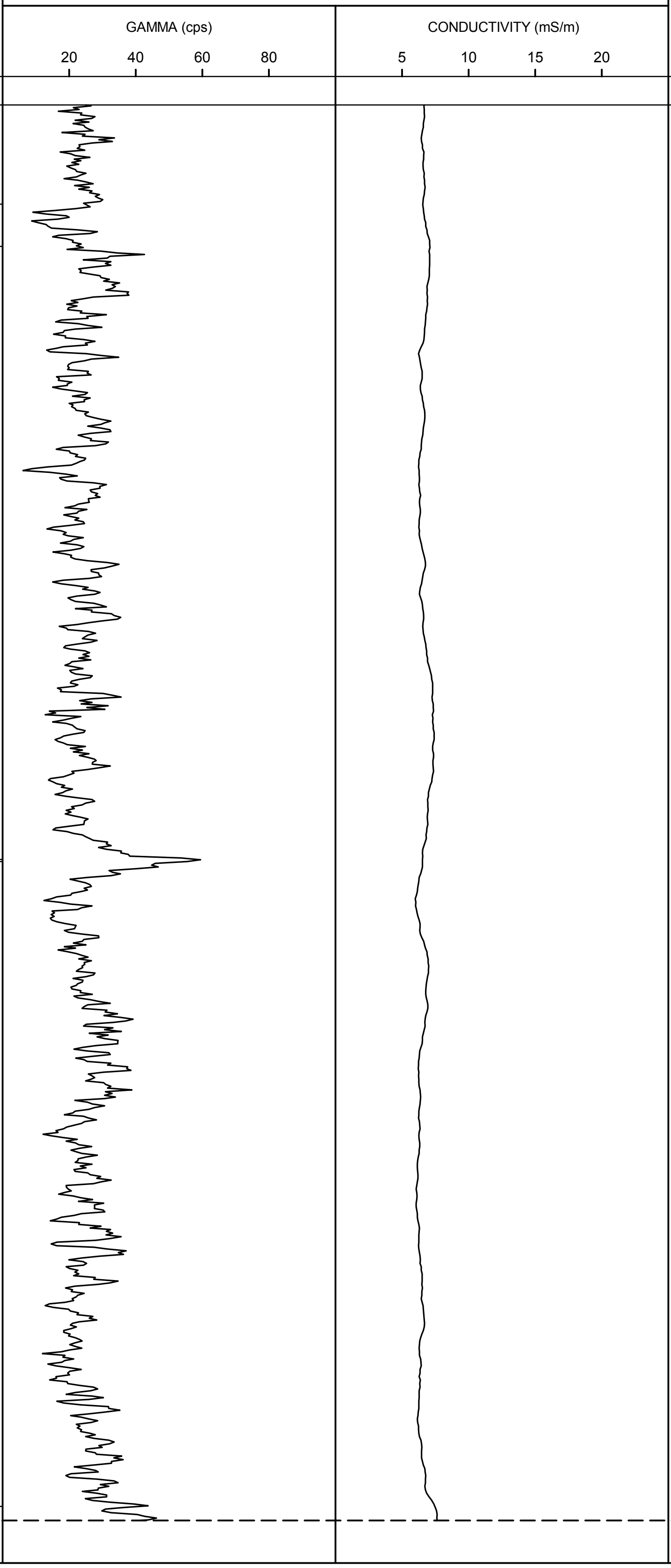
From 62.00 m to 85.50 m, faintly to moderately weathered, light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded **DOLOSTONE** with thin interbeds of laminar textured **CALCAREOUS DOLOSTONE** and **DOLOMITIC LIMESTONE.** Shaley bedding parting associated with gamma spike at 70.66-.69m. Potentially open weathered vuggy horizons occur at 79.80-80.25m and 81.00-.40m.

261.09
61.40

260.49
62.00

251.83
70.69

242.69
79.80



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DEPTH SCALE
1 : 100

LOGGED: MC/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-01

SHEET 5 OF 5

LOCATION: N 4788470.1 ;E 485482.8

DRILLING DATE: November 24, 2017

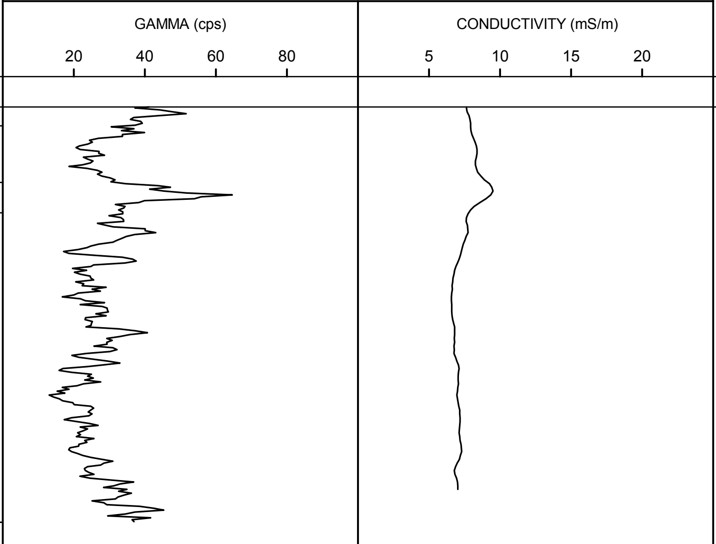
DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---				
80 82 84	Air Rotary - Tricone	**From 61.40 m to 62.00 m,** moderately weathered, light grey to brownish grey, medium to coarse grained crystalline, thinly bedded **GYPSUM** and **NODULAR GYPSUM in DOLOSTONE.** Gypsum beds are porous-pitted and vuggy. Gypsum layer forms weathered aquifer horizon. **From 62.00 m to 85.50 m,** faintly to moderately weathered, light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded **DOLOSTONE** with thin interbeds of laminar textured **CALCAREOUS DOLOSTONE** and **DOLOMITIC LIMESTONE.** Shaley bedding parting associated with gamma spike at 70.66-.69m. Potentially open weathered vuggy horizons occur at 79.80-80.25m and 81.00-.40m.		242.24 80.25 241.49 81.00 241.09 81.40 236.99		
86 88 90 92 94 96 98 100		**End of Borehole, 85.50 m** **NOTE,** 1. Static water level measured in open borehole at elev. 274.8 m (depth of 47.7 m).		85.50		



DEPTH SCALE

1 : 100

GOLDER

LOGGED: MC/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-02

SHEET 1 OF 4

LOCATION: N 4787989.9 ;E 485540.1

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21, 2017

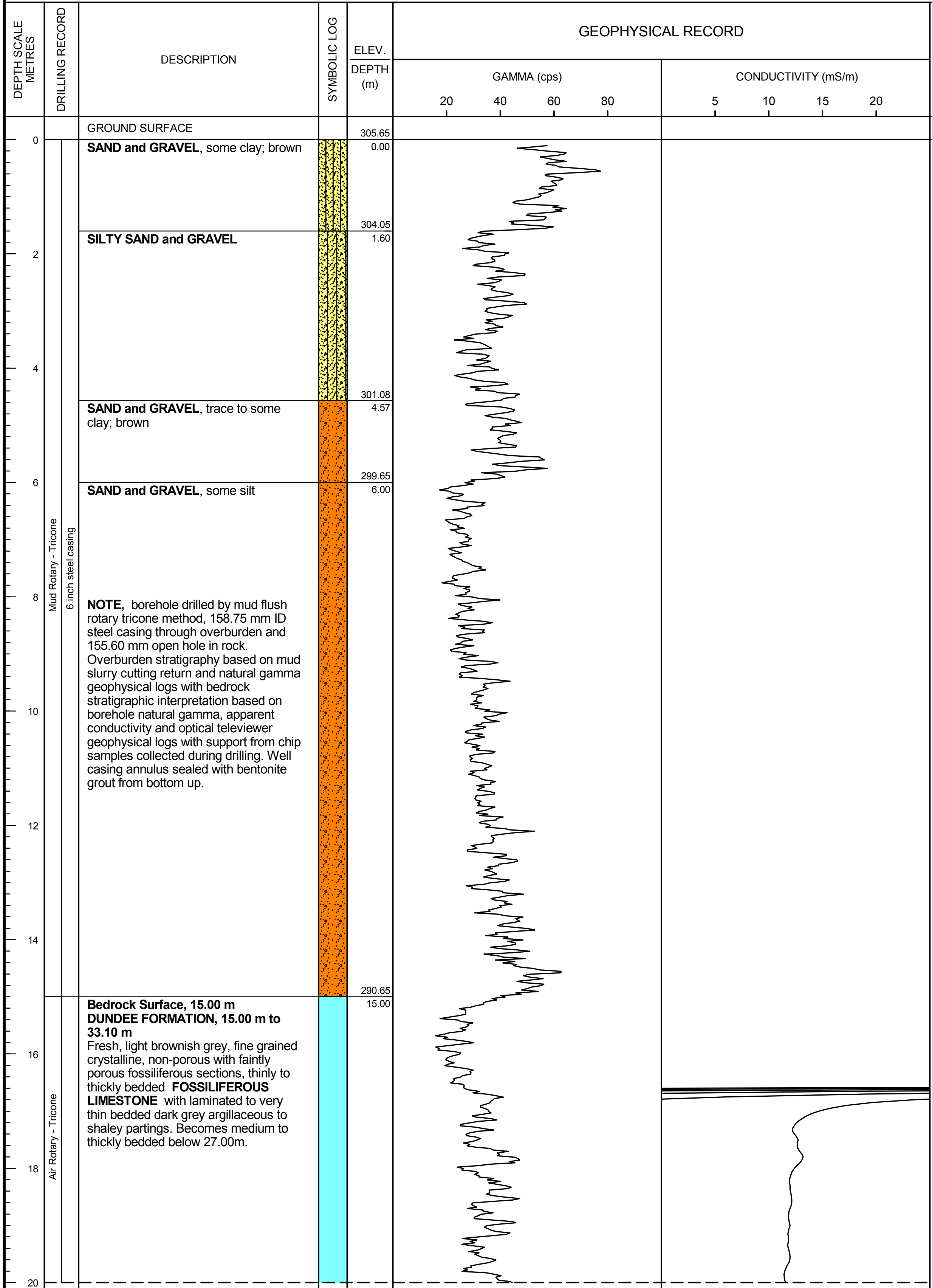
DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DRILLING RECORD: Mud Rotary - Tricone, 6 inch steel casing (0 to 15.00 m); Air Rotary - Tricone (15.00 m to 20 m)

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	305.65
SAND and GRAVEL, some clay; brown	0.00
SILTY SAND and GRAVEL	304.05 1.60
SAND and GRAVEL, trace to some clay; brown	301.08 4.57
SAND and GRAVEL, some silt **NOTE,** borehole drilled by mud flush rotary tricone method, 158.75 mm ID steel casing through overburden and 155.60 mm open hole in rock. Overburden stratigraphy based on mud slurry cutting return and natural gamma geophysical logs with bedrock stratigraphic interpretation based on borehole natural gamma, apparent conductivity and optical televiewer geophysical logs with support from chip samples collected during drilling. Well casing annulus sealed with bentonite grout from bottom up.	299.65 6.00
Bedrock Surface, 15.00 m **DUNDEE FORMATION, 15.00 m to 33.10 m** Fresh, light brownish grey, fine grained crystalline, non-porous with faintly porous fossiliferous sections, thinly to thickly bedded **FOSSILIFEROUS LIMESTONE** with laminated to very thin bedded dark grey argillaceous to shaley partings. Becomes medium to thickly bedded below 27.00m.	290.65 15.00



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DEPTH SCALE
1 : 100

LOGGED: MC/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-02

SHEET 2 OF 4

LOCATION: N 4787989.9 ;E 485540.1

INCLINATION: -90° AZIMUTH: ---

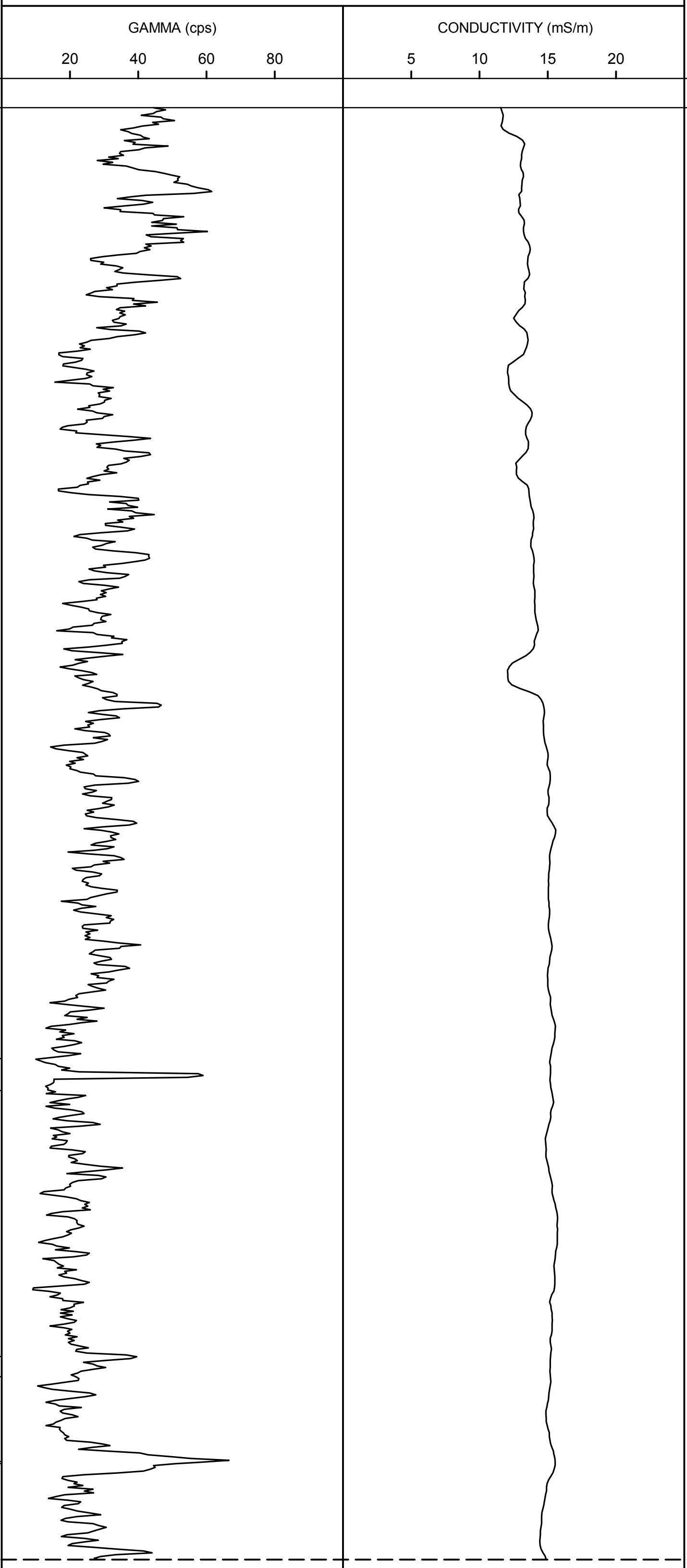
DRILLING DATE: November 21, 2017

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---				
20	Air Rotary - Tricone	**Bedrock Surface, 15.00 m** **DUNDEE FORMATION, 15.00 m to 33.10 m** Fresh, light brownish grey, fine grained crystalline, non-porous with faintly porous fossiliferous sections, thinly to thickly bedded **FOSSILIFEROUS LIMESTONE** with laminated to very thin bedded dark grey argillaceous to shaley partings. Becomes medium to thickly bedded below 27.00m.				
22						
24						
26						
28						
30						
32						
		LUCAS FORMATION, 33.10 m to 61.00 m		272.55 33.10		
34		**UPPER LUCAS FORMATION, 33.10 m to 41.34 m** Faintly to moderately weathered, light tan brown, fine grained crystalline, moderately porous, faintly petroliferous, medium to thickly bedded, massive to faintly laminar textured **LIMESTONE** with thin black argillaceous partings and moderately porous beds. Top of section marked by medium-dark grey, medium bed of **DOLOSTONE of the Upper Lucas Dolostone Marker Bed** at 33.10-.54m and second thin medium-dark grey **DOLOSTONE marker bed** at 37.20-.48m. Dark grey **CLAYEY SOIL** layer at 38.65-.68m associated with natural gamma spike.		272.11 33.54		
36						
				268.45 37.20		
				37.48		
38						
				267.00 38.68		
40						
		CONTINUED NEXT PAGE				



DEPTH SCALE

1 : 100

GOLDER

LOGGED: MC/RB

CHECKED:

OTTAWA-GEO 1781508 ROCK.GPJ GAL-GTA.GDT 4/17/18 LMK

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-02

SHEET 3 OF 4

LOCATION: N 4787989.9 ;E 485540.1

DRILLING DATE: November 21, 2017

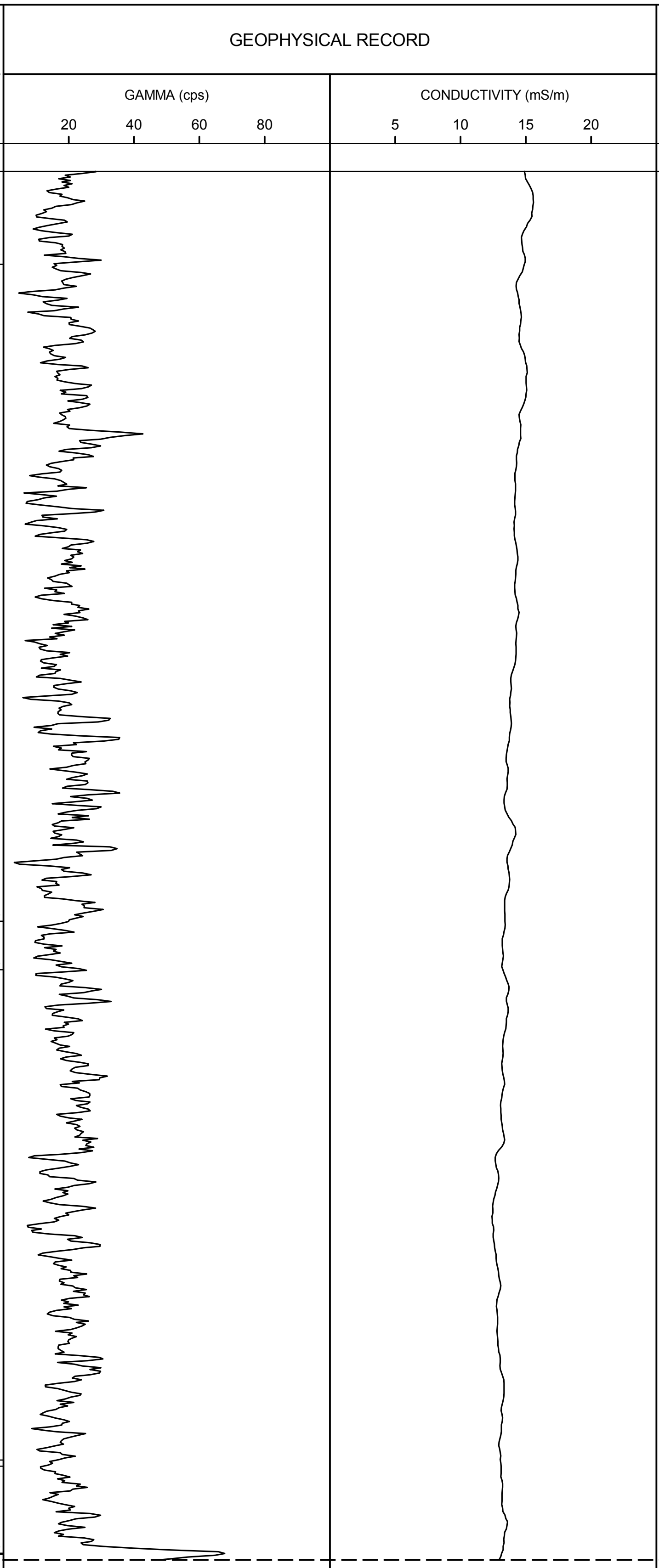
DATUM: Geodetic

DRILL RIG: Mud/Air Rotary

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: McLeod Water Wells

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---			
40	Air Rotary - Tricone		🟦		
		LOWER LUCAS FORMATION, 41.34 m to 61.00 m **From 41.34 m to 50.80 m,** faintly to moderately weathered, medium brown, fine grained crystalline, moderately porous, thinly to thickly bedded, laminar textured, faintly petroliferous **DOLOSTONE** with interbeds of medium tan brown, fine grained crystalline, moderately porous, medium to thickly bedded, faintly laminar textured **LIMESTONE** and thin interbeds of **CALCAREOUS DOLOSTONE.**	🟩	264.31 41.34	
		From 50.80 m to 51.50 m, moderately weathered, light grey to brownish grey, medium to coarse grained crystalline, thinly bedded **GYPSUM** and **NODULAR GYPSUM in DOLOSTONE.** Gypsum beds are porous-pitted and vuggy. Gypsum layer forms weathered aquifer horizon.		254.85 50.80	
		From 51.50 m to 61.00 m, faintly to moderately weathered, light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded **DOLOSTONE** with thin interbeds of laminar textured **CALCAREOUS DOLOSTONE** and **DOLOMITIC LIMESTONE.** Weathered vuggy at 58.56-.65m. Open shaley bedding parting associated with gamma spike at 59.90-.92m.	🟩	254.15 51.50	
				247.09 58.65	
				245.75	
60		*CONTINUED NEXT PAGE*			



DEPTH SCALE

1 : 100

LOGGED: MC/RB

CHECKED:

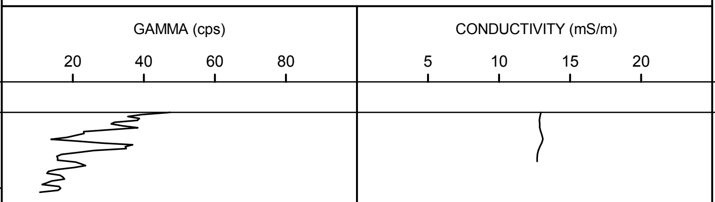
PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-02

SHEET 4 OF 4

LOCATION: N 4787989.9 ;E 485540.1
DRILLING DATE: November 21, 2017
DATUM: Geodetic
INCLINATION: -90° AZIMUTH: ---
DRILL RIG: Mud/Air Rotary
DRILLING CONTRACTOR: McLeod Water Wells

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---				
60			🟩	59.92 244.65 61.00		
		End of Borehole, 61.00 m **NOTE,** 1. Static water level measured in open borehole at elev. 276.4 m (depth of 29.3 m), cascading water noted in borehole.				
62						
64						
66						
68						
70						
72						
74						
76						
78						
80						



DEPTH SCALE
1 : 100

GOLDER

LOGGED: MC/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-03

SHEET 1 OF 4

LOCATION: N 4787503.2 ;E 485616.6

INCLINATION: -90° AZIMUTH: ---

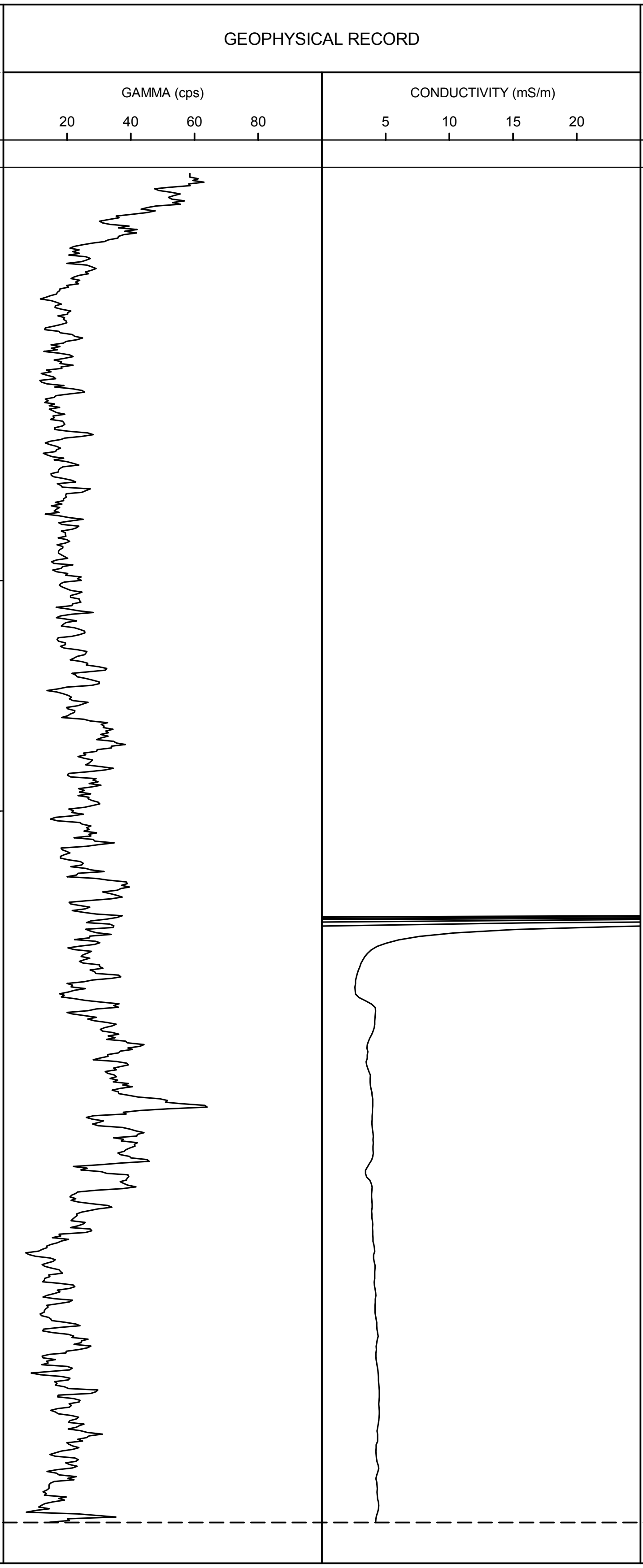
DRILLING DATE: November 22, 2017

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)
		GROUND SURFACE		297.93
0	Mud Rotary - Tricone 6 inch steel casing	**SAND and GRAVEL**, trace clay; brown **NOTE,** borehole drilled by mud flush rotary tricone method, 158.75 mm ID steel casing through overburden and 155.60 mm open hole in rock. Overburden stratigraphy based on mud slurry cutting return and natural gamma geophysical logs with bedrock stratigraphic interpretation based on borehole natural gamma, apparent conductivity and optical televiewer geophysical logs with support from chip samples collected during drilling. Well casing annulus sealed with bentonite grout from bottom up.		0.00
6		**SAND**, trace to some gravel; brown		291.83 6.10
9.50	Air Rotary - Tricone	**Bedrock Surface, 9.50 m** **DUNDEE FORMATION, 9.50 m to 24.46 m** Fresh, light brownish grey, fine grained crystalline, non-porous with faintly porous fossiliferous sections, thinly to thickly bedded **FOSSILIFEROUS LIMESTONE** with laminated to very thin bedded dark grey argillaceous to shaley partings. Becomes medium to thickly bedded below 14.70m.		288.43 9.50
20		*CONTINUED NEXT PAGE*		



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 100

GOLDER

LOGGED: MC/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-03

SHEET 2 OF 4

LOCATION: N 4787503.2 ;E 485616.6

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 22, 2017

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

Bedrock Surface, 9.50 m
DUNDEE FORMATION, 9.50 m to 24.46 m
Fresh, light brownish grey, fine grained crystalline, non-porous with faintly porous fossiliferous sections, thinly to thickly bedded **FOSSILIFEROUS LIMESTONE** with laminated to very thin bedded dark grey argillaceous to shaley partings. Becomes medium to thickly bedded below 14.70m.

273.47
24.46

LUCAS FORMATION, 24.46 m to 65.50 m

273.03
24.90

UPPER LUCAS FORMATION, 24.46 m to 33.16 m

Faintly to moderately weathered, light tan brown, fine grained crystalline, moderately porous, faintly petroliferous, medium to thickly bedded, massive to faintly laminar textured **LIMESTONE** with thin black argillaceous partings and moderately porous beds. Top of section marked by medium-dark grey, medium bed of **DOLOSTONE of the Upper Lucas Dolostone Marker Bed** at 24.46-.90m and second thin medium-dark grey **DOLOSTONE marker bed** at 29.40-.68m. Dark grey **CLAYEY SOIL** layer at 30.62-.64m associated with natural gamma spike.

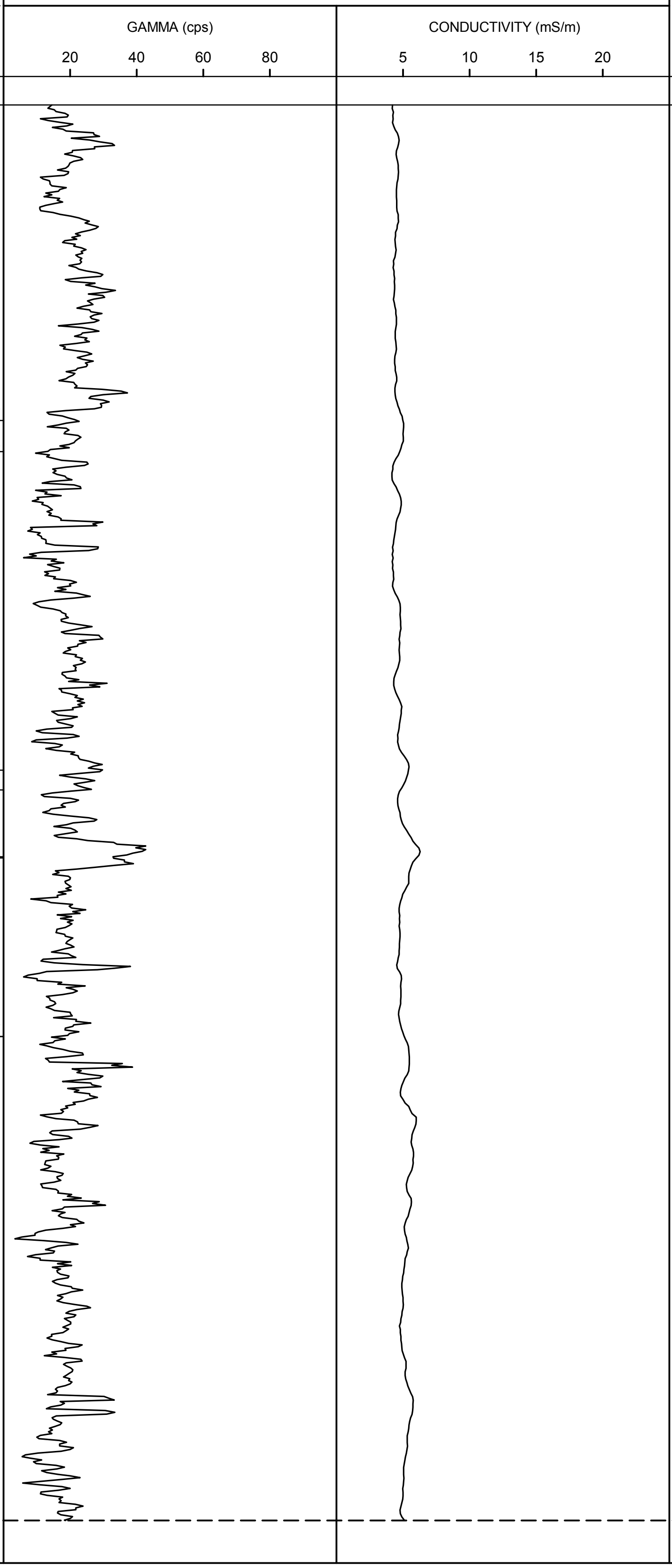
268.53
29.40
29.68

267.31
30.64

264.77
33.16

LOWER LUCAS FORMATION, 33.16 m to 65.50 m
From 33.16 m to 42.40 m, faintly to moderately weathered, medium brown, fine grained crystalline, moderately porous, thinly to thickly bedded, laminar textured, faintly petroliferous **DOLOSTONE** with interbeds of medium tan brown, fine grained crystalline, moderately porous, medium to thickly bedded, faintly laminar textured **LIMESTONE** and thin interbeds of **CALCAREOUS DOLOSTONE.**

Air Rotary - Tricone



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DEPTH SCALE
1 : 100

GOLDER

LOGGED: MC/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-03

SHEET 3 OF 4

LOCATION: N 4787503.2 ;E 485616.6

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 22, 2017
DRILL RIG: Mud/Air Rotary
DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | GEOPHYSICAL RECORD | PIEZOMETER OR STANDPIPE INSTALLATION

--- CONTINUED FROM PREVIOUS PAGE ---

40
42
44
46
48
50
52
54
56
58
60

Air Rotary - Tricone

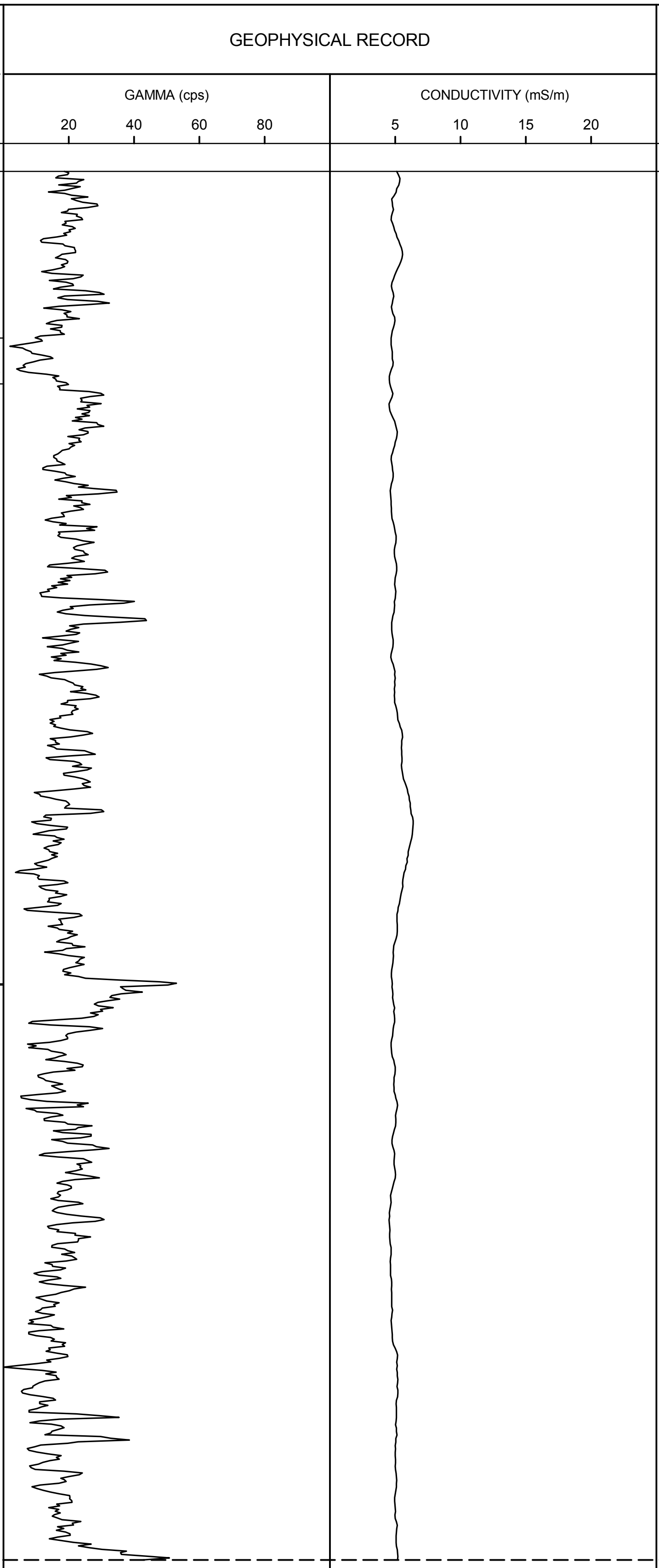
From 42.40 m to 43.06 m, moderately weathered, light grey to brownish grey, medium to coarse grained crystalline, thinly bedded **GYPSUM** and **NODULAR GYPSUM in DOLOSTONE.** Gypsum beds are porous-pitted and vuggy. Gypsum layer forms weathered aquifer horizon.

From 43.06 m to 65.50 m, faintly to moderately weathered, light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded **DOLOSTONE** with thin interbeds of laminar textured **CALCAREOUS DOLOSTONE** and **DOLOMITIC LIMESTONE.** Shaley bedding parting associated with gamma spike at 51.70-.72m and 60.03-.05m. Potentially open weathered vuggy horizons occur at 60.84-.98m and 62.10-.36m.

255.53
42.40

254.87
43.06

246.23
51.72



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DEPTH SCALE
1 : 100

GOLDER

LOGGED: MC/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-03

SHEET 4 OF 4

LOCATION: N 4787503.2 ;E 485616.6

INCLINATION: -90° AZIMUTH: ---

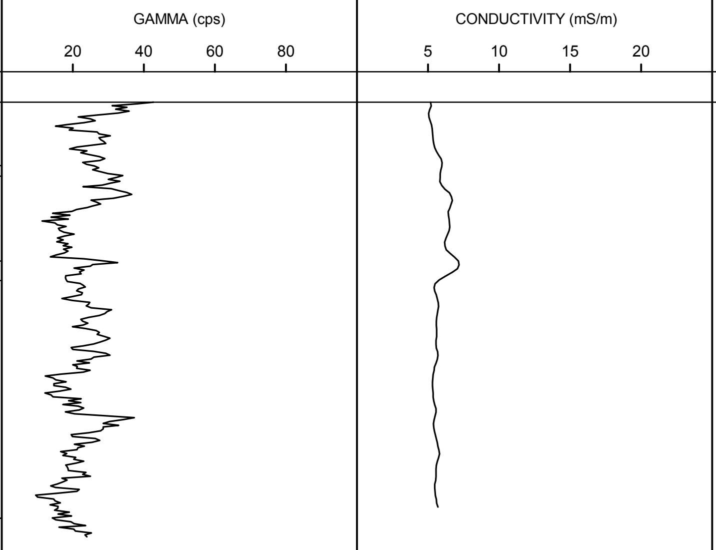
DRILLING DATE: November 22, 2017

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---				
60 62 64	Air Rotary - Tricone	**From 42.40 m to 43.06 m,** moderately weathered, light grey to brownish grey, medium to coarse grained crystalline, thinly bedded **GYPSUM** and **NODULAR GYPSUM in DOLOSTONE.** Gypsum beds are porous-pitted and vuggy. Gypsum layer forms weathered aquifer horizon. **From 43.06 m to 65.50 m,** faintly to moderately weathered, light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded **DOLOSTONE** with thin interbeds of laminar textured **CALCAREOUS DOLOSTONE** and **DOLOMITIC LIMESTONE.** Shaley bedding parting associated with gamma spike at 51.70-.72m and 60.03-.05m. Potentially open weathered vuggy horizons occur at 60.84-.98m and 62.10-.36m.		237.09 60.98 235.83 62.10 62.36 232.43		
66 68 70 72 74 76 78 80		**End of Borehole, 65.50 m** **NOTE,** 1. Static water level measured in open borehole at elev. 281.5 m (depth of 16.4 m), cascading water noted in borehole.		65.50		



DEPTH SCALE
1 : 100

LOGGED: MC/RB
CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-04

SHEET 1 OF 3

LOCATION: N 4787404.4 ;E 485853.1

INCLINATION: -90° AZIMUTH: ---

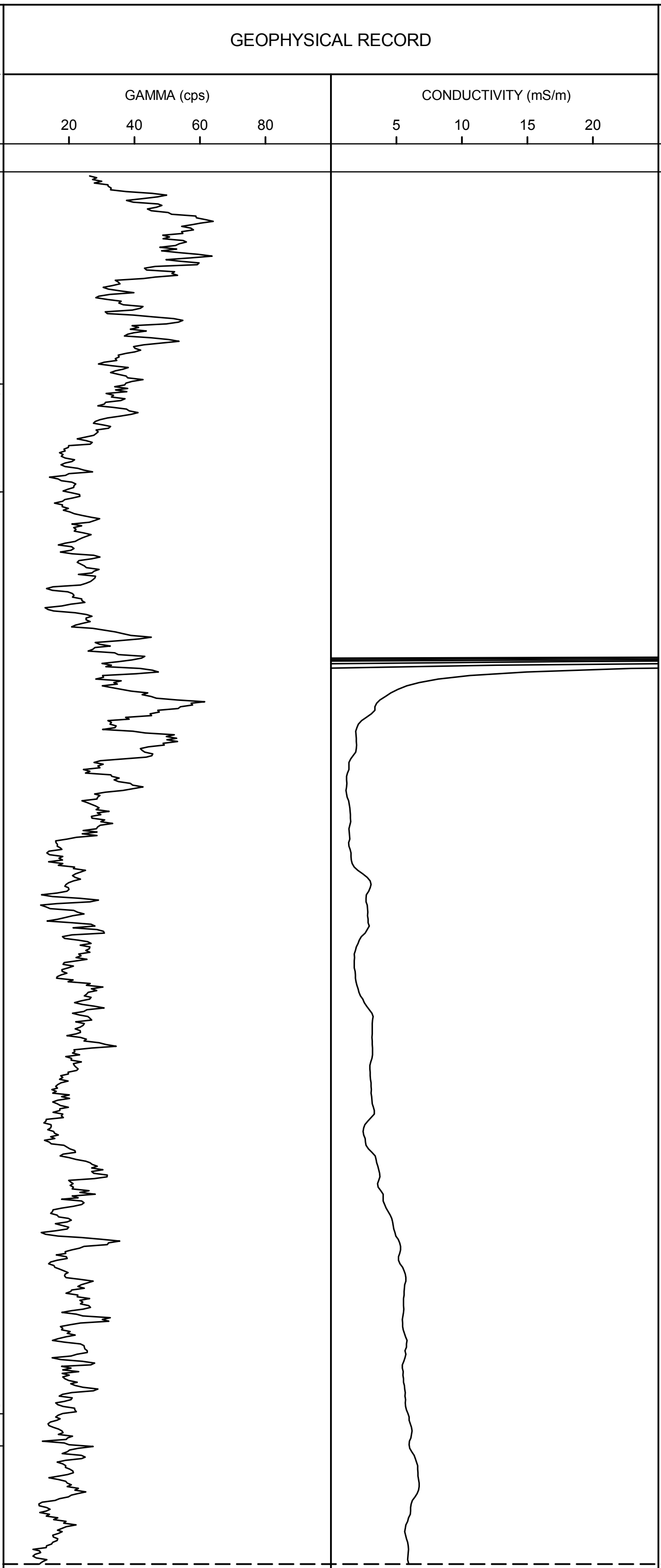
DRILLING DATE: November 23, 2017

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		296.73	
0	Mud Rotary - Tricone 6 inch steel casing	**SAND and GRAVEL**; brown		0.00	
2					
		SAND, some gravel; brown		293.68 3.05	
4					
	Air Rotary - Tricone	**Bedrock Surface, 4.60 m** **DUNDEE FORMATION, 4.60 m to 17.84 m** Fresh, light brownish grey, fine grained crystalline, non-porous with faintly porous fossiliferous sections, thinly to thickly bedded **FOSSILIFEROUS LIMESTONE** with laminated to very thin bedded dark grey argillaceous to shaley partings. Becomes medium to thickly bedded below 8.40m.		292.13 4.60	
6					
8					
10		**NOTE,** borehole drilled by mud flush rotary tricone method, 158.75 mm ID steel casing through overburden and 155.60 mm open hole in rock. Overburden stratigraphy based on mud slurry cutting return and natural gamma geophysical logs with bedrock stratigraphic interpretation based on borehole natural gamma, apparent conductivity and optical televiewer geophysical logs with support from chip samples collected during drilling. Well casing annulus sealed with bentonite grout from bottom up.			
12					
14					
16					
18		**LUCAS FORMATION, 17.84 m to 53.40 m**		278.89 17.84	
		UPPER LUCAS FORMATION, 17.84 m to 27.30 m Faintly to moderately weathered, light tan brown, fine grained crystalline, moderately porous, faintly petroliferous,		278.43 18.30	
20					



CONTINUED NEXT PAGE

DEPTH SCALE

1 : 100

GOLDER

LOGGED: MC/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-04

SHEET 2 OF 3

LOCATION: N 4787404.4 ;E 485853.1

INCLINATION: -90° AZIMUTH: ---

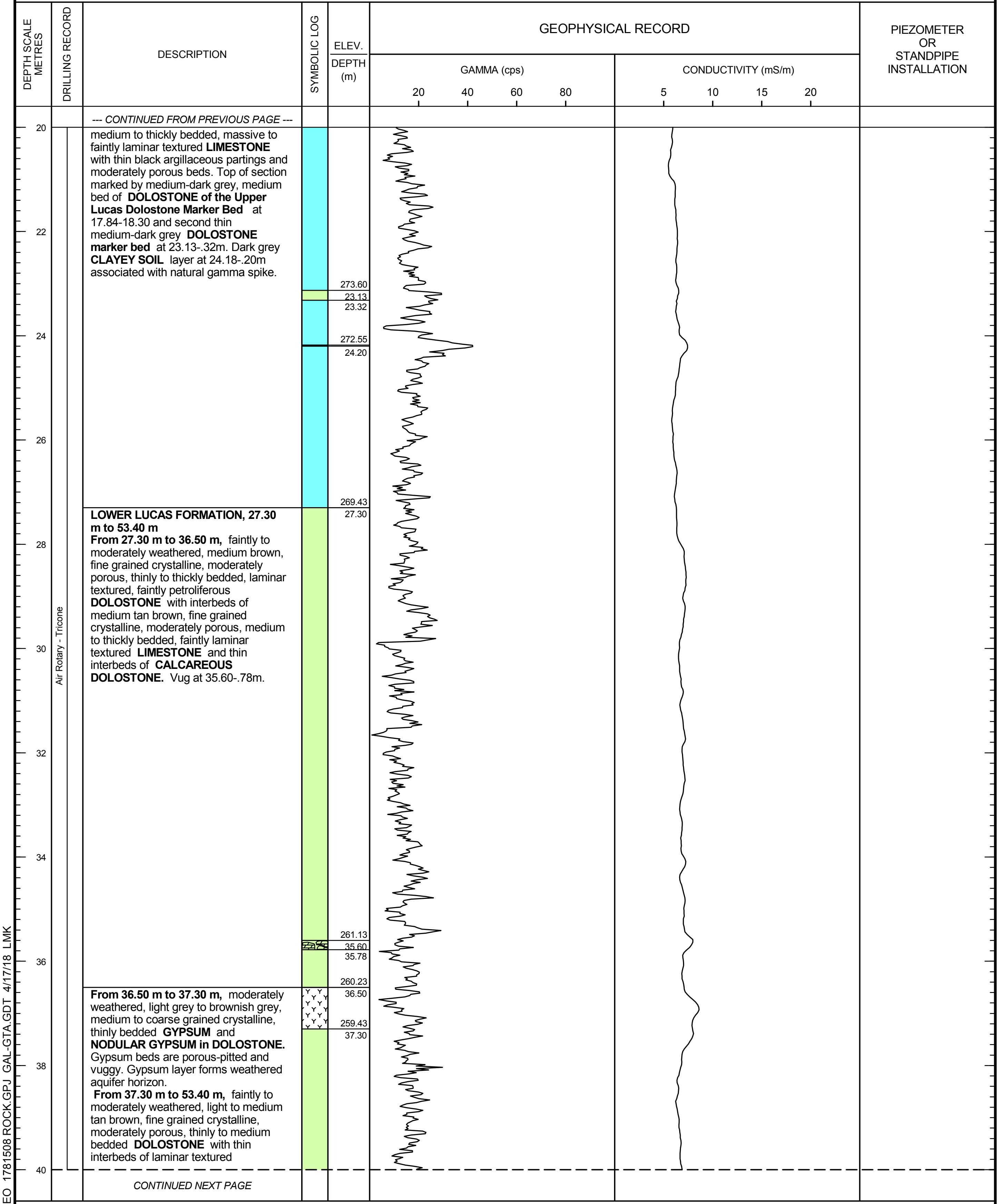
DRILLING DATE: November 23, 2017

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION
20	Air Rotary - Tricone	*--- CONTINUED FROM PREVIOUS PAGE ---* medium to thickly bedded, massive to faintly laminar textured **LIMESTONE** with thin black argillaceous partings and moderately porous beds. Top of section marked by medium-dark grey, medium bed of **DOLOSTONE of the Upper Lucas Dolostone Marker Bed** at 17.84-18.30 and second thin medium-dark grey **DOLOSTONE marker bed** at 23.13-.32m. Dark grey **CLAYEY SOIL** layer at 24.18-.20m associated with natural gamma spike.
27.30		**LOWER LUCAS FORMATION, 27.30 m to 53.40 m** **From 27.30 m to 36.50 m,** faintly to moderately weathered, medium brown, fine grained crystalline, moderately porous, thinly to thickly bedded, laminar textured, faintly petroliferous **DOLOSTONE** with interbeds of medium tan brown, fine grained crystalline, moderately porous, medium to thickly bedded, faintly laminar textured **LIMESTONE** and thin interbeds of **CALCAREOUS DOLOSTONE.** Vug at 35.60-.78m.
36.50		**From 36.50 m to 37.30 m,** moderately weathered, light grey to brownish grey, medium to coarse grained crystalline, thinly bedded **GYPSUM** and **NODULAR GYPSUM in DOLOSTONE.** Gypsum beds are porous-pitted and vuggy. Gypsum layer forms weathered aquifer horizon. **From 37.30 m to 53.40 m,** faintly to moderately weathered, light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded **DOLOSTONE** with thin interbeds of laminar textured
40		*CONTINUED NEXT PAGE*



DEPTH SCALE

1 : 100

GOLDER

LOGGED: MC/RB

CHECKED:

PROJECT: 1781508

GEOPHYSICAL LOG OF: MW17-04

SHEET 3 OF 3

LOCATION: N 4787404.4 ;E 485853.1

INCLINATION: -90° AZIMUTH: ---

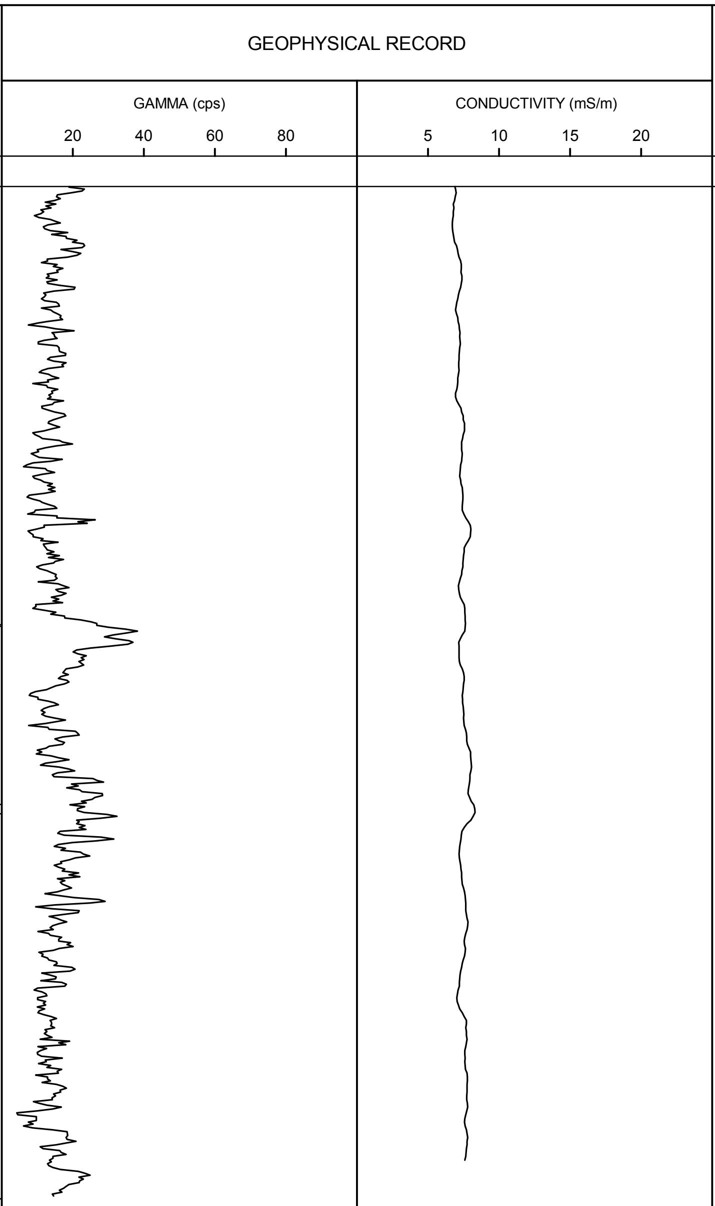
DRILLING DATE: November 23, 2017

DRILL RIG: Mud/Air Rotary

DRILLING CONTRACTOR: McLeod Water Wells

DATUM: Geodetic

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---				
40	Air Rotary - Tricone	**CALCAREOUS DOLOSTONE** and **DOLOMITIC LIMESTONE.** Shaley bedding parting associated with gamma spike at 45.80-.82m. Potentially open weathered vuggy horizons occur at 48.18-.30m.	🟩			
				250.93 45.82		
				248.55 48.30		
				243.33 53.40		
		End of Borehole, 53.40 m **NOTE,** 1. Static water level measured in open borehole at elev. 281.0 m (depth of 15.7 m).				



DEPTH SCALE

1 : 100

GOLDER

LOGGED: MC/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-01

SHEET 1 OF 4

LOCATION: N 4787643.3 ;E 485897.9

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: October 30 - November 3, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

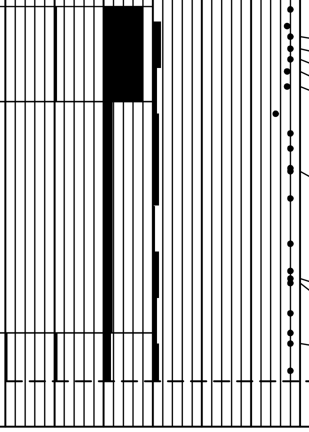
JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

Columns: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH | COLOUR % RETURN | RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER 0.3 m (5 10 15 20) | DISCONTINUITY DATA: B Angle (0 90 180 270), DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-4} 10^{-3} 10^{-2} 10^{-1}) | Diametral Point Load Index (MPa) (2 4 6) | RMC -Q' AVG.

Drilling record: HW CASING (0 to 7.52 m); HQ CORING (7.52 m to 10 m)

DESCRIPTION	ELEV. / DEPTH (m)	RUN No.
GROUND SURFACE	299.58	
TOPSOIL	0.00	
SILT, trace sand, trace organics; brown **NOTE,** soil sequence interpretation based on standard split spoon sample methods to elev. 298.0 m. Below elev. 298.0 m, based on limited recovery in HQ core barrel while coring through overburden with water flush.	299.33 0.25	
sandy **GRAVEL**, trace to some silt, trace to some clay; brown to grey, contains cobbles and boulders	297.98 1.60	
Bedrock Surface, 7.52 m **DUNDEE FORMATION, 7.52 m to 22.26 m** Fresh, faintly weathered on open argillaceous bedding partings to 8.33m, light brownish grey, fine to medium grained crystalline, non-porous with faintly porous sections, thinly to medium bedded (7.52-12.62m) becoming medium to thickly bedded (12.62-22.26m) **FOSSILIFEROUS LIMESTONE** with weakly to moderately developed stylolites below 12.62m, fine argillaceous partings (.05mm) and scattered pelecypod shells, crinoid ossicles and rugosa coral fossils. Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil debris in at	292.06 7.52 291.25 8.34 290.33 9.28 9.44 289.83 9.81	1 2 3



TYPE AND SURFACE DESCRIPTION	Jcon
,PL,Ro	6
,IR,Ro	20
,IR,Ro	6
,IR,Ro	6
,IR,Ro	6
,IR,Ro	6
,CU,Ro	6
,IR,Ro	20
,UN,Ro	0
,IR,Ro	12
,IR,Ro	20
,PL,Ro	12
,PL,SM	20
,PL,Ro	6
,IR,SM	20
,IR,Ro	12
,PL,Ro	12
,UN,Ro	12
,PL,Ro	12
,IR,Ro	6
,IR,Ro	12

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-01

SHEET 2 OF 4

LOCATION: N 4787643.3 ;E 485897.9

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: October 30 - November 3, 2017
DRILL RIG: Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

Columns: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH | COLOUR % RETURN | RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER 0.3 m (5 10 15 20) | DISCONTINUITY DATA: B Angle (0 90 180 270), DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-4} 10^{-3} 10^{-2} 10^{-1}) | Diametral Point Load Index (MPa) (2 4 6) | RMC -Q' AVG.

--- CONTINUED FROM PREVIOUS PAGE ---

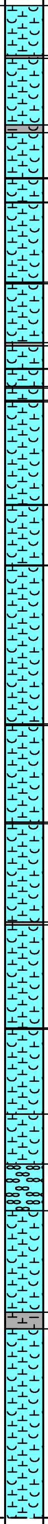
Drilling record: HQ CORING

9.25-.28m, 9.38-44m, 9.75-.81m, 10.33-.35, 10.79-.84m and 11.83-.84m (open, weathered).

More prominent black, argillaceous to argillaceous limestone bedding partings occur at 8.33-.34m (weathered), 11.14m (weathered), 11.30-.305m (with 2mm crystalline, pinkish rhodochrosite lamination), 12.23-.25m, 12.40m, 12.52-.53m, 12.61-.62m, 13.30-.302m, 13.70-.705m, 14.75-.76m, 15.40-.41m, 16.06-.08m, 16.76-.77m, 18.64-.75m (fine argillaceous partings in limestone), 20.25-.32m (fine argillaceous partings in weakly nodular limestone) and 21.76-.83m (fine argillaceous partings in weakly nodular limestone).

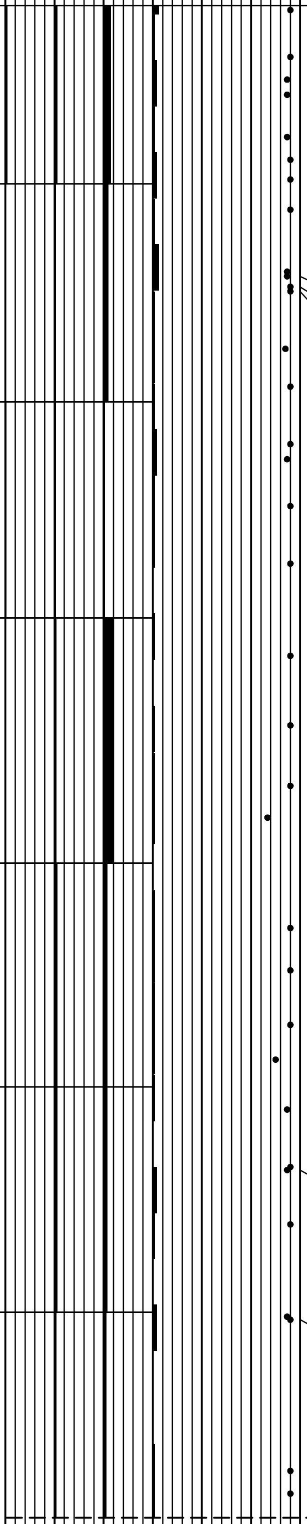
Porous, pitted coral fossil limestone bed with mottled natural petroleum staining occurs at 17.33-.66m. Nodular limestone bed occurs at 17.66-.97m.

Moderately developed stylolites occur at 18.53m, 19.68m and 19.84m.
Porous, pitted limestone with coral fossil traces occurs at 20.32-.50m.
Faint to moderate, dark brown petroleum staining at 21.83-22.26 m.



ELEV.	DEPTH (m)
289.25	10.35
288.79	10.84
288.44	11.15
	11.31
287.75	11.84
287.35	12.25
	12.41
	12.53
	12.62
286.28	13.31
285.88	13.71
284.83	14.76
284.18	15.41
283.52	16.08
282.82	16.77
282.25	17.33
281.92	17.66
281.61	17.97
280.94	18.64
	18.75

RUN No.: 3, 4, 5, 6, 7, 8, 9



TYPE AND SURFACE DESCRIPTION	Jcon
,IR,Ro	12
,IR,Ro	20
,IR,Ro	20
,IR,Ro	12
,IR,Ro	20
,IR,Ro	12
,PL,Ro	20
,IR,Ro	6
,IR,Ro	12
,IR,Ro	12
,IR,Ro	12
,IR,Ro	12
,IR,Ro	20
,PL,Ro	20
,PL,Ro	12
,CU,Ro	20
,PL,Ro	12
,IR,Ro	12
,PL,Ro	12
,IR,Ro	12
,PL,Ro	20
,PL,Ro	20
,IR,Ro	12
,IR,Ro	12
,IR,Ro	6
,IR,Ro	20
,IR,Ro	20
,UN,Ro	12
,UN,Ro	12
,IR,Ro	20
,IR,Ro	12
,IR,Ro	12
,IR,Ro	20
,PL,Ro	6

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-01

SHEET 3 OF 4

LOCATION: N 4787643.3 ;E 485897.9

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: October 30 - November 3, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint	BD- Bedding	PL - Planar	PO- Polished	BR - Broken Rock
FLT - Fault	FO- Foliation	CU- Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR- Shear	CO- Contact	UN- Undulating	SM- Smooth	
VN - Vein	OR- Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB- Mechanical Break	

Column headings: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH | COLOUR % RETURN | RECOVERY: TOTAL CORE % 80 60 40 20, SOLID CORE % 80 60 40 20 | R.Q.D. % 80 60 40 20 | FRACT. INDEX PER 0.3 m 5 10 15 20 | DISCONTINUITY DATA: B Angle 0 90 180 270; DIP w.r.t. CORE AXIS 0 30 60 90; TYPE AND SURFACE DESCRIPTION; Jcon; Jr; Ja | HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1} | Diametral Point Load Index (MPa) 2 4 6 | RMC -Q' AVG.

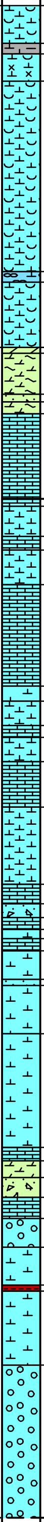
--- CONTINUED FROM PREVIOUS PAGE ---

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

Drilling record: HQ CORING

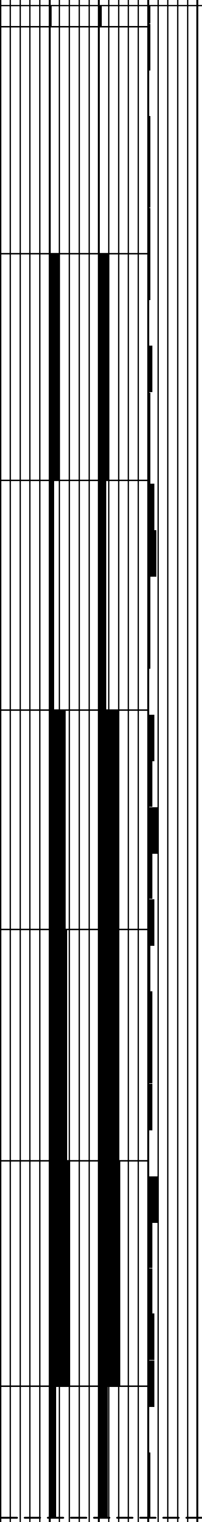
LUCAS FORMATION, 22.26 m to 35.18 m
UPPER LUCAS FORMATION, 22.26 m to 31.48 m

From 22.26 m to 22.70 m, Upper Lucas Dolostone Marker Bed, faintly to moderately weathered, light to medium brownish grey, fine grained crystalline, faintly to moderately porous, medium bedded, wavy laminar textured **ARGILLACEOUS DOLOSTONE** with cap of moderately to highly weathered, light to medium yellowish brown, fine grained, very porous (absorptive), pitted dolostone at 22.26-.30m. Wavy texture imparted by fine argillaceous lamination in the dolostone. Collapse breccia between 22.57-.62m. Sharp, open contact with overlying Dundee Formation is a weathered open bedding fracture, lower contact is transitional.
From 22.70 m to 27.64 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, laminar to massive textured **LIMESTONE.** Finely laminated with thin argillaceous partings, faintly petroliferous limestone at 22.70-23.26m, 23.83-24.50m, 24.76-.84m, 25.00-.30m, 25.81-26.25m (weakly pitted with slumped bedding structure), 27.55-.64m. Dark grey shaley parting at 23.26-.265m. At 23.31-.83m, faint to moderately weathered, light creamy grey, fine grained ,faintly porous, pitted easily broken Limestone. From 26.25m to 26.80m, very light tan grey, moderately porous, weakly laminated Limestone with slumped bedding structures and intraformational breccia at 26.44-.48m. Medium to thick bed of light to medium tan to creamy grey, fine grained crystalline, weakly laminated to massive textured, moderately porous Limestone at 26.80-27.55m.
From 27.64 m to 27.88 m, distinctive thin **marker bed** of medium grey **LITHOCLASTIC ARGILLACEOUS DOLOSTONE** at 27.64-.88m with well developed stylolite at 27.69m and slumped bedding structure of tan limestone in grey dolostone at 27.75-.88m.
From 27.88 m to 31.48 m, Finely laminated, faintly petroliferous limestone sections occur at 27.88-28.02m, 30.06-.59m and 31.00-.12m. Light tan brown, fine grained crystalline, moderately porous, thickly bedded **OOLITIC LIMESTONE**



ELEV. / DEPTH (m):
279.33
20.32
279.08
20.50
277.82
21.83
277.32
22.26
22.30
277.01
22.62
22.70
276.32
23.31
276.07
23.51
23.60
275.75
23.83
275.08
24.50
24.60
24.76
24.84
25.00
274.28
25.30
273.77
25.81
25.94
26.03
26.17
26.25
273.14
26.48
272.78
26.80
272.03
27.55
27.64
27.75
27.88
28.02
271.37
28.21
271.12
28.50
270.59
28.99

RUN No.: 9, 10, 11, 12, 13, 14, 15, 16



TYPE AND SURFACE DESCRIPTION	Jcon
,PL,Ro	12
,IR,Ro	12
,IR,Ro	12
,IR,Ro	12
,IR,Ro	12
,PL,Ro	0
,PL,Ro	12
,PL,Ro	12
,IR,Ro	20
,PL,Ro	12
,CU,Ro	12
,PL,Ro	12
,PL,Ro	20
,PL,Ro	20
,IR,Ro	12
,IR,Ro	12
,ST,Ro	12
,IR,Ro	12
,IR,Ro	12
,PL,SM	12
,PL,SM	12
,IR,Ro	12
,IR,Ro	12
,PL,SM	20
,PL,SM	20
,PL,SM	12
,IR,Ro	12
,IR,Ro	12
,IR,Ro	12
,PL,SM	12
,IR,Ro	12
,PL,SM	12
,IR,Ro	12
,PL,SM	12
,IR,Ro	12
,IR,Ro	12
,IR,Ro	12
,PL,Ro	12
,IR,Ro	20
,IR,Ro	20
,PL,SM	20
,IR,Ro	20
,PL,SM	12
,PL,SM	12
,PL,Ro	20
,PL,SM	12
,PL,SM	
,PL,SM	12
,IR,Ro	20
,PL,Ro	0
,IR,Ro	12
,IR,Ro	20
,IR,SM	20
,IR,Ro	20
,IR,Ro	20
,PL,SM	12
,PL,SM	12

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-01

LOCATION: N 4787643.3 ;E 485897.9

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: October 30 - November 3, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DEPTH (m) | RUN No. | COLOUR / % RETURN | FLUSH | RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER 0.3 m (5 10 15 20) | DISCONTINUITY DATA: B Angle (0 90 180 270), DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-4} 10^{-3} 10^{-2} 10^{-1}) | Diametral Point Load Index (MPa) (2 4 6) | RMC -Q' AVG.

Depth scale: 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

Drilling record: HQ CORING

--- CONTINUED FROM PREVIOUS PAGE ---

beds occur at 28.02-.21m and 28.99-30.06m. Medium to thick bed of light to medium tan to creamy grey, fine grained crystalline, weakly laminated to massive textured, moderately porous **LIMESTONE** at 28.21-.99m, 30.59-31.00m, 31.12-.48m. Slumped bedding structure occurs at 31.12-.16m with 1-2mm argillaceous parting at 31.16m.
Very thin layer of dark brown, laminated calcareous **CLAYEY SILT SOIL** at 28.46-.50m.

LOWER LUCAS FORMATION, 31.48 m to 35.18 m
Transitional upper contact into distinct **marker bed** of light grey, fine grained crystalline, moderately porous, pitted (1-5mm), weakly laminated **DOLOSTONE** at 31.48-.70m with disseminated pyrite veinlets. Individual beds of medium brown, laminated **DOLOSTONE** occur at 31.70-.85m (black bituminous partings at 31.77-.78m), 32.24-.61m (porous, pitted with black argillaceous partings at 32.24-.26m), 32.95-33.07m, 33.45-.67m (light tan brown with argillaceous partings at 33.61-.62m), 34.30-.45m (slump breccia), 33.45-.67m (argillite partings at 33.61-.62m) and 34.30-.38m. Second **marker bed** of medium grey, fine grained crystalline, faintly to moderately porous argillaceous dolostone at 33.67-34.00m with well developed stylolite at 33.80m and lithoclastic breccia at 33.80-34.00m (angular light tan grey calcareous dolostone lithoclasts from underlying bed in medium grey dolostone matrix) with sharp basal contact. Light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded, finely laminated **CALCAREOUS DOLOSTONE** beds occur at 32.61-.95m, and 33.30-34.30m with slump breccia at 33.30-.45m and light tan grey, massive textured calcareous dolostone beds at 34.00-.30m and 34.45-.83m (dark brown laminated with bituminous partings and black argillaceous partings at 34.60-.63m).
Medium brown, fine grained crystalline, faintly to moderately porous, thin beds of **DOLOMITIC LIMESTONE** at 32.01-32.24m (finely laminated) with black argillaceous partings at 32.24-.26m, 33.07-.30m, 34.38-.45m and 34.63-.83m (dark brown laminated with bituminous partings). Medium to dark brown, finely laminated, bituminous **LIMESTONE** beds at 31.85-32.00m (black bituminous, argillaceous partings at 32.00-.01m) and 34.83-35.18m.

End of Borehole, 35.18 m

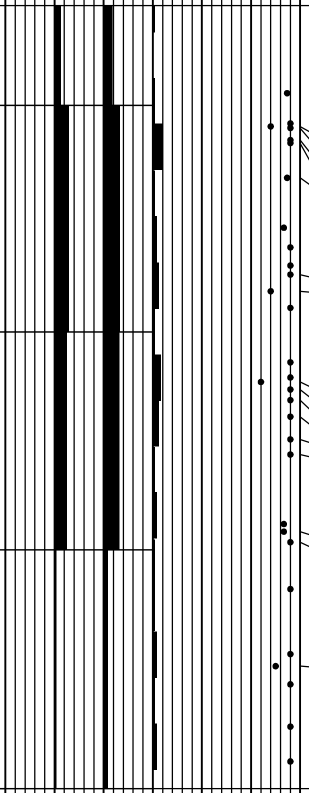
NOTES,

1. 60% loss of circulation around elev. 282.5 m (depth of 17.1 m) and complete loss of circulation at 265.6 m (depth of 34.0 m).

2. Static water level measured in open borehole at elev. 279.7 m (depth of 19.9 m), cascading water noted in borehole.

ELEV. / DEPTH (m)
269.52
30.06
268.99
30.59
268.58
31.00
31.17
268.10
31.48
267.88
31.70
31.85
32.01
267.34
32.26
266.97
32.61
266.63
32.95
33.07
266.28
33.30
33.45
33.67
265.58
34.00
265.28
34.30
34.45
34.63
264.75
34.83
264.40
35.18

RUN No.: 16, 17, 18, 19



TYPE AND SURFACE DESCRIPTION	Jcon
,IR,Ro	12
,PL,SM	12
,IR,Ro	12
,CU,Ro	12
,PL,Ro	12
,PL,Ro	12
,IR,VR	0
,IR,Ro	12
,IR,Ro	12
,PL,SM	12
,PL,SM	12
,IR,Ro	20
,IR,Ro	12
,PL,SM	12
,PL,SM	12
,ST,SM	12
,PL,Ro	12
,,	
,PL,SM	12
,PL,SM	12
,PL,Ro	12
,IR,Ro	12
,IR,Ro	12
,,	
,IR,Ro	12
,IR,Ro	0
,IR,Ro	12
,PL,SM	12
,IR,Ro	12
,IR,Ro	12

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-02

LOCATION: N 4787714.4 ;E 485673.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN / FLUSH	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DIP w.r.t. CORE AXIS 0 30 60 90	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		GROUND SURFACE	300.57															
0	HW CASING	**SILT**, some gravel, trace sand; brown **NOTE,** soil sequence interpretation based on limited recovery using standard split spoon sample methods to elev. 296.4 m. Below elev. 296.4 m, based on limited recovery in HQ core barrel while coring through overburden with water flush.	0.00															
1			299.05 1.52															
2		**SAND and GRAVEL**; brown																
3																		
4			296.23 4.34															
5		**GRAVEL**, some sand; brown, contains cobbles and boulders																
6			293.94 6.63															
7		**GRAVEL**, some silt, some clay, some sand; brown, contains cobbles																
8			292.42 8.15															
9		**SAND and GRAVEL**; brown, contains cobbles																
		Bedrock Surface, 9.85 m	290.72 9.85	1														
10																		

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-02

SHEET 2 OF 5

LOCATION: N 4787714.4 ;E 485673.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
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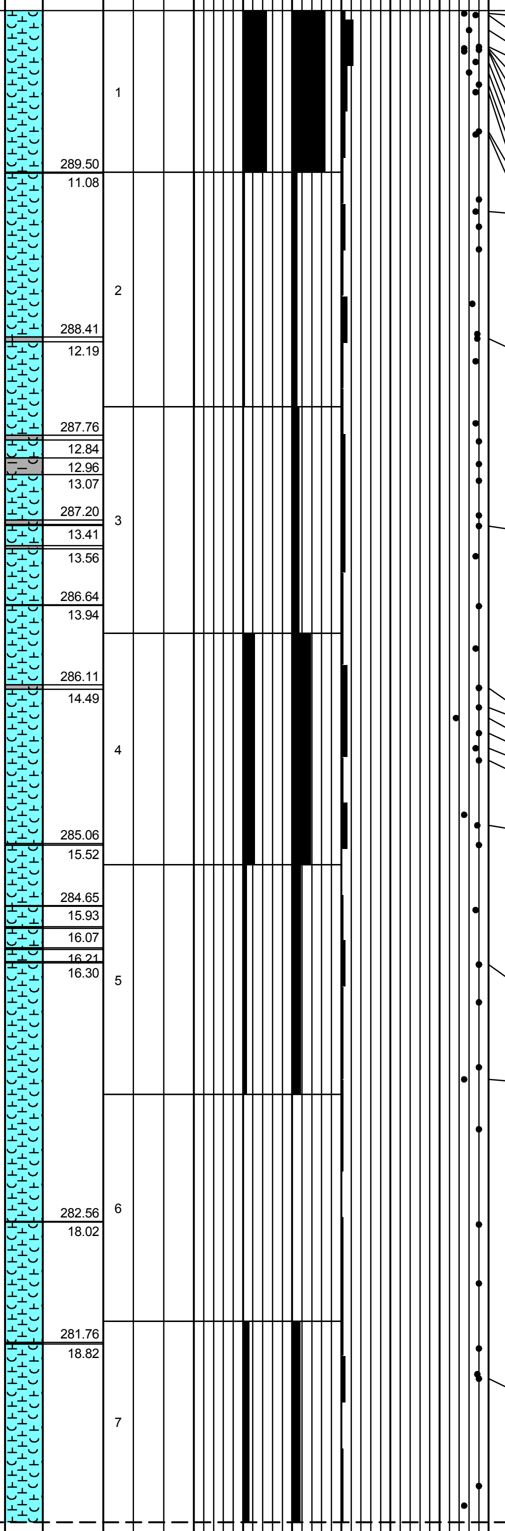
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | COLOUR % RETURN | FLUSH | RECOVERY TOTAL CORE % | SOLID CORE % | R.Q.D. % | FRACT. INDEX PER 0.3 m | DISCONTINUITY DATA: B Angle | DIP w.r.t. CORE AXIS | TYPE AND SURFACE DESCRIPTION | Jcon | Jr | Ja | HYDRAULIC CONDUCTIVITY K, cm/sec | Diametral Point Load Index (MPa) | RMC -Q' AVG.



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DUNDEE FORMATION, 9.85 m to 26.00 m
Fresh, faintly weathered on open argillaceous bedding partings to 12.16m, light brownish grey, fine to medium grained crystalline, non-porous with faintly porous sections, thinly to medium bedded (9.85-16.30m) becoming medium to thickly bedded (16.30-26.00m) **FOSSILIFEROUS LIMESTONE** with weakly to moderately developed stylolites below16.30m, fine argillaceous partings (.05mm) and scattered pelecypod shells, crinoid ossicles and rugosa coral fossils.

Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil debris in at 12.81-.84m, 12.96-13.07m, 13.37-.40m, 13.54-.56m, 14.46-.49m and 15.51-.52m.

More prominent black, argillaceous to argillaceous limestone bedding partings occur at 11.07-.075m, 12.16-.19m (weathered), 13.40-.405M, 13.93-.935m, 15.51-.52m, 15.92-.925m, 16.06-.07m, 16.20-.21m, 16.29-.30m (with 2-3mm crystalline, pinkish rhodochrosite lamination), 18.81-.82m and 19.73-.735m.

Weakly developed stylolite occur at 18.01m.

Porous, pitted coral fossil limestone bed with mottled natural petroleum staining occurs at 21.05-.35m.
Nodular limestone bed occurs at 21.35-.75m.
Porous, pitted limestone with coral fossil traces occurs at 25.20-.40m.
Weak, dark brown petroleum staining at 25.71-26.00 m.

ELEV.	DEPTH (m)
289.50	11.08
288.41	12.19
287.76	12.84
	12.96
	13.07
287.20	13.41
	13.56
286.64	13.94
286.11	14.49
285.06	15.52
284.65	15.93
	16.07
	16.21
	16.30
282.56	18.02
281.76	18.82

TYPE AND SURFACE DESCRIPTION	Jcon
,IR,Ro	12
,IR,Ro	12
,IR,Ro	12
,IR,Ro	12
,IR,Ro	12
,PL,Ro	12
,IR,Ro	12
,IR,Ro	12
,IR,Ro	0
,PL,Ro	6
,CU,Ro	0
,IR,Ro	20
,IR,Ro	6
,IR,Ro	20
,IR,Ro	6
,PL,Ro	6
,IR,Ro	6
,IR,Ro	6
,UN,Ro	20
,IR,Ro	0
,PL,Ro	12
,IR,Ro	6
,PL,Ro	0
,IR,Ro	6
,IR,Ro	6
,PL,Ro	12
,PL,Ro	20
,IR,Ro	6
,IR,Ro	0
,IR,Ro	0
,PL,Ro	12
,IR,Ro	6
,PL,Ro	20
,IR,Ro	20
,IR,Ro	12
,PL,Ro	12
,PL,SM	6
,IR,Ro	20
,IR,Ro	12
,PL,Ro	6
,IR,Ro	20
,PL,Ro	0
,PL,Ro	0
,PL,Ro	6
,PL,Ro	12
,PL,Ro	20
,PL,Ro	6
,PL,Ro	6
,PL,SM	12
,PL,Ro	12
,IR,Ro	12
,PL,SM	6
,IR,Ro	12
,IR,Ro	6

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MIS-RCK 004 1781508 ROCK.GPJ GAL-MISS.GDT 10/31/18 LMK

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-02

LOCATION: N 4787714.4 ;E 485673.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.

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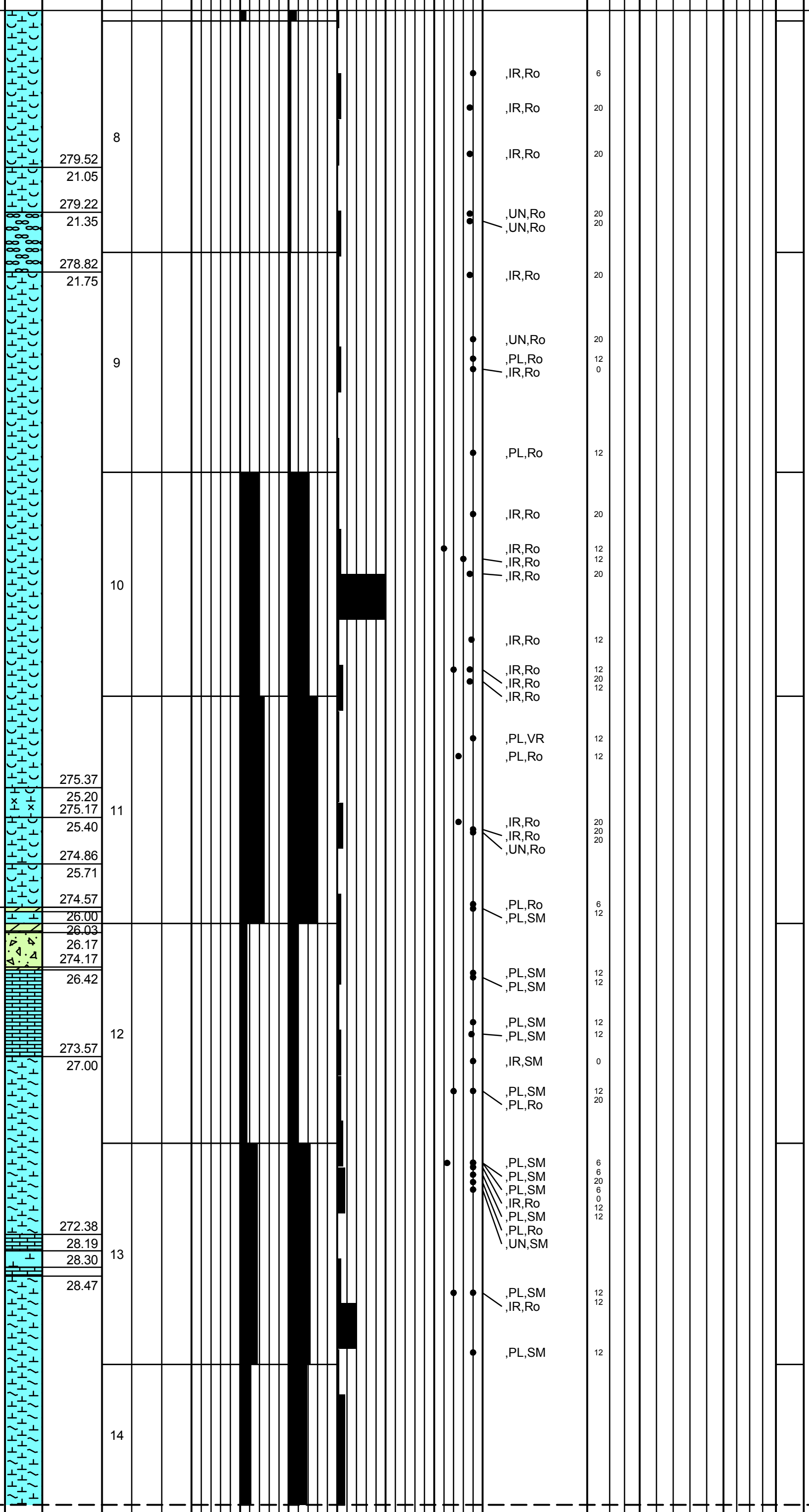

ELEV. / DEPTH (m)
279.52
21.05
279.22
21.35
278.82
21.75
275.37
25.20
275.17
25.40
274.86
25.71
274.57
26.00
26.03
26.17
274.17
26.42
273.57
27.00
272.38
28.19
28.30
28.47

RUN No.: 8, 9, 10, 11, 12, 13, 14

TYPE AND SURFACE DESCRIPTION	Jcon
,IR,Ro	6
,IR,Ro	20
,IR,Ro	20
,UN,Ro	20
,UN,Ro	20
,IR,Ro	20
,UN,Ro	20
,PL,Ro	12
,IR,Ro	0
,PL,Ro	12
,IR,Ro	20
,IR,Ro	12
,IR,Ro	12
,IR,Ro	20
,IR,Ro	12
,IR,Ro	12
,IR,Ro	20
,IR,Ro	12
,PL,VR	12
,PL,Ro	12
,IR,Ro	20
,IR,Ro	20
,UN,Ro	20
,PL,Ro	6
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	12
,IR,SM	0
,PL,SM	12
,PL,Ro	20
,PL,SM	6
,PL,SM	6
,PL,SM	20
,IR,Ro	6
,PL,SM	0
,PL,Ro	12
,UN,SM	12
,PL,SM	12
,IR,Ro	12
,PL,SM	12

LUCAS FORMATION, 26.00 m to 42.70 m
UPPER LUCAS FORMATION, 26.00 m to 35.57 m

From 26.00 m to 26.42 m, Upper Lucas Dolostone Marker Bed, faintly weathered, medium grey, fine grained crystalline, faintly porous, medium bedded, wavy laminar textured **ARGILLACEOUS DOLOSTONE** with laminar argillaceous dolostone at 26.00-.03m, 26.11-.17m and 26.40-.42m transitional into underlying limestone. Medium grey, argillaceous calcareous dolostone at 26.03-.11m. Wavy texture imparted by fine argillaceous lamination in the dolostone. Lithoclastic dolostone possibly associated with collapse breccia at 26.17-.40m. Sharp, (possibly open) contact with overlying Dundee Formation and base associated with transition to laminated limestone.
From 26.42 m to 31.43 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, laminar textured **LIMESTONE.** Medium brown, finely laminated with thin argillaceous partings, moderately porous, faintly petroliferous limestone

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-02

LOCATION: N 4787714.4 ;E 485673.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017
DRILL RIG: Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
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NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH | COLOUR % RETURN | RECOVERY TOTAL CORE % | SOLID CORE % | R.Q.D. % | FRACT. INDEX PER 0.3 m | DISCONTINUITY DATA B Angle | DIP w.r.t. CORE AXIS | TYPE AND SURFACE DESCRIPTION | Jcon | Jr | Ja | HYDRAULIC CONDUCTIVITY K, cm/sec | Diametral Point Load Index (MPa) | RMC -Q' AVG.

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sections occur at 26.42-27.00m, 28.19-.30m, 28.41-.47m, and 31.31-.43m. Intervening sections are weakly laminated. From 30.12 m to 30.60 m, very light tan grey, moderately porous, weakly laminated Limestone with thin bands of intraformational breccia at 30.12-.18m, 30.38-.40m and 30.56-.60m. Medium to thick bed of light to medium tan to creamy grey, fine grained crystalline, weakly laminated to massive textured, moderately porous Limestone at 30.60-31.31m with very thin band of intraformational breccia at 30.82-.85m.

From 31.43 m to 31.60 m, distinctive thin **marker bed** of medium grey, fine grained crystalline, faintly porous, pitted (1-2mm) **LITHOCLASTIC ARGILLACEOUS DOLOSTONE** with well developed stylolite at 31.49m.

From 31.60 m to 35.57 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, faintly laminar to massive textured **LIMESTONE.** Moderately to well developed stylolites occur at 31.62m and 31.79m.
Very thin layer of dark brown, laminated calcareous **CLAYEY SILT SOIL** at 32.56-.57m (same layer in BH17-01 at 28.46-.50m and BH17-03 at 49.62-.71m).
Slumped limestone bedding structure occurs at 32.83-.90m. Light to medium tan brown, fine grained crystalline, moderately porous, cross laminated, thickly bedded **OOLITIC LIMESTONE** bed occurs at 33.33-34.00m.
Thin dolostone layers occur at 35.26-.30m (brownish grey) and 35.30-.34m (medium grey, argillaceous). Transitional basal contact.

LOWER LUCAS FORMATION, 35.57 m to 42.70 m

From 35.57 m to 35.86 m, thin bed of **CALCAREOUS DOLOSTONE** at 35.57-.63m overlying distinct **marker bed** at top of sequence comprised of light grey, fine grained crystalline, moderately porous, pitted (1-5mm), weakly laminated **DOLOSTONE** with disseminated pyrite veinlets.

From 35.86 m to 38.92 m, medium brown, fine grained crystalline, faintly to moderately porous, thinly to medium bedded, laminar textured, faintly petroliferous **DOLOSTONE** at 35.86-.94m and 36.33-37.38m with weathered, porous, pitted dolostone at 36.45-.70m. Second **marker bed** of faintly to moderately weathered, medium grey, fine grained, non-porous **ARGILLACEOUS DOLOSTONE** at 37.38-.58m with moderately to highly weathered, light yellowish brown, moderately porous, laminated **DOLOSTONE** at 37.58-.70m with open bedding partings and dark grey, thin **ARGILLACEOUS DOLOSTONE** at 37.70-.75m grading at 37.75-83m to slump breccia with fragments of underlying bed. Mottled textured dolostone at 37.83-38.15m, laminar textured dolostone at 38.15-.50m, massive textured at 38.50-.81m.
Interbeds of medium to dark brown, moderately porous, thin, moderately petroliferous, bituminous **DOLOMITIC**

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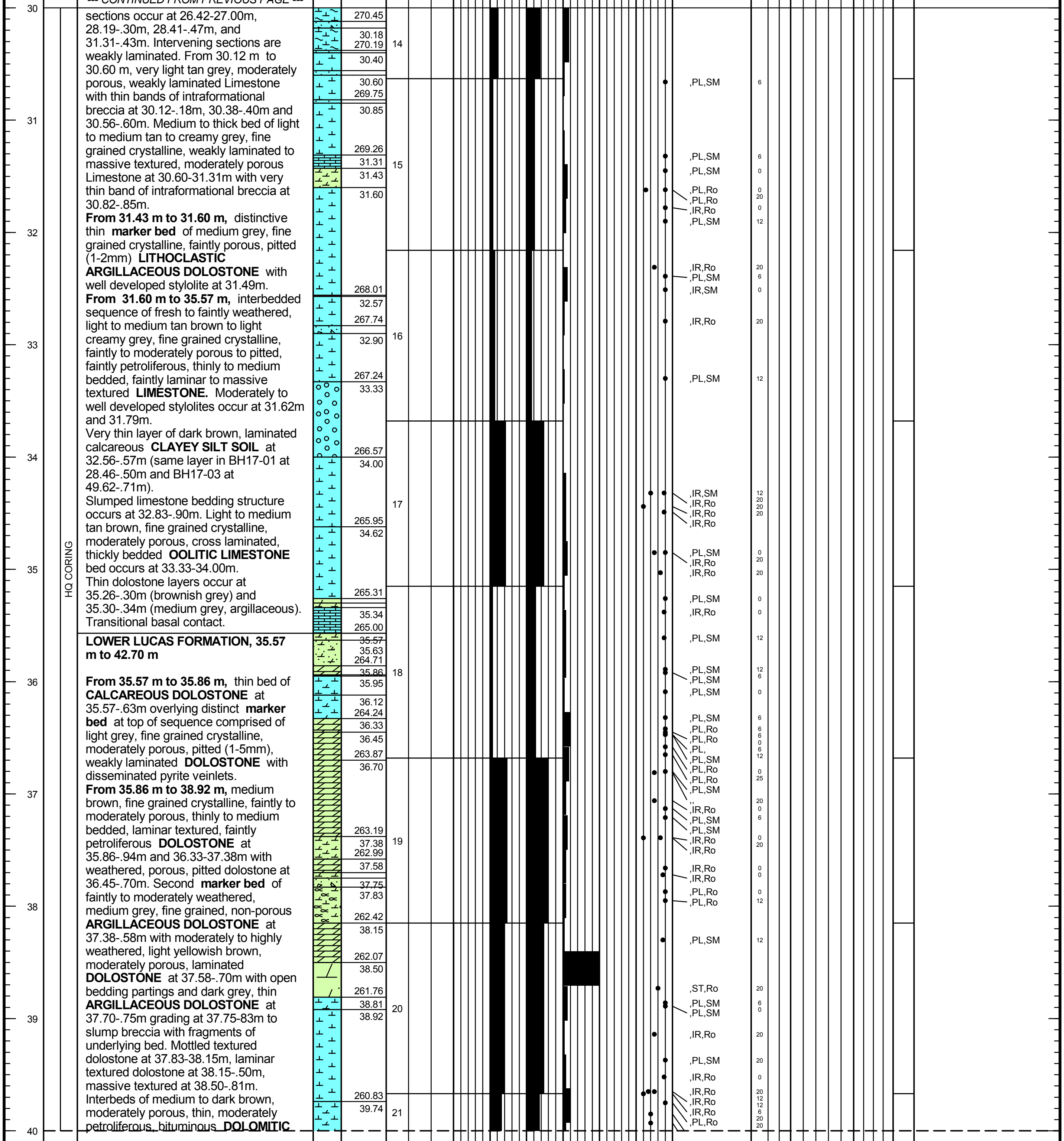

ELEV. / DEPTH (m)	RUN No.
270.45	
30.18	
270.19	14
30.40	
30.60	
269.75	
30.85	
269.26	
31.31	15
31.43	
31.60	
268.01	
32.57	
267.74	
32.90	16
267.24	
33.33	
266.57	
34.00	
	17
265.95	
34.62	
265.31	
35.34	
265.00	
35.57	
35.63	
264.71	
35.86	18
35.95	
36.12	
264.24	
36.33	
36.45	
263.87	
36.70	
263.19	
37.38	19
262.99	
37.58	
37.75	
37.83	
262.42	
38.15	
262.07	
38.50	
261.76	
38.81	20
38.92	
260.83	
39.74	21

TYPE AND SURFACE DESCRIPTION	Jcon
,PL,SM	6
,PL,SM	6
,PL,SM	0
,PL,Ro	0
,PL,Ro	20
,IR,Ro	0
,PL,SM	12
,IR,Ro	20
,PL,SM	6
,IR,SM	0
,IR,Ro	20
,PL,SM	12
,IR,SM	12
,IR,Ro	20
,IR,Ro	20
,IR,Ro	20
,PL,SM	0
,IR,Ro	20
,IR,Ro	20
,PL,SM	0
,IR,Ro	0
,PL,SM	12
,PL,SM	12
,PL,SM	6
,PL,SM	0
,PL,SM	6
,PL,Ro	6
,PL,Ro	6
,PL,	0
,PL,SM	6
,PL,Ro	12
,PL,Ro	0
,PL,SM	25
,,	20
,IR,Ro	0
,PL,SM	6
,PL,SM	
,IR,Ro	0
,IR,Ro	20
,IR,Ro	0
,IR,Ro	0
,PL,Ro	0
,PL,Ro	12
,PL,SM	12
,ST,Ro	20
,PL,SM	6
,PL,SM	0
,IR,Ro	20
,PL,SM	20
,IR,Ro	0
,IR,Ro	20
,IR,Ro	12
,IR,Ro	12
,PL,Ro	6 20 20

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-02

SHEET 5 OF 5

LOCATION: N 4787714.4 ;E 485673.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 6-9, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
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Ro - Rough
MB- Mechanical Break
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DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | COLOUR % RETURN | FLUSH | RECOVERY (TOTAL CORE % 80 60 40 20; SOLID CORE % 80 60 40 20) | R.Q.D. % 80 60 40 20 | FRACT. INDEX PER 0.3 m 5 10 15 20 | DISCONTINUITY DATA (B Angle 0 90 180 270; DIP w.r.t. CORE AXIS 0 30 60 90; TYPE AND SURFACE DESCRIPTION; Jcon; Jr; Ja) | HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1} | Diametral Point Load Index (MPa) 2 4 6 | RMC -Q' AVG.

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Drilling record: HQ CORING

LIMESTONE at 35.94-36.12m (dark brown with black argillaceous partings at 35.94-.95m), 36.12-.33m (medium brown laminated) and 38.81-.92m with black argillaceous partings.
From 38.92 m to 42.70 m, fresh, light to medium brown, fine grained crystalline, faintly to moderately porous, medium bedded, massive to faintly laminar textured **LIMESTONE** with light tan brown laminar **DOLOMITIC LIMESTONE** with slumped bedding structure at 39.74-40.16m, medium to dark grey argillaceous dolostone bed at 40.16-.19m overlying medium brown dolostone at 40.19-.60 m transitional to medium brown **CALCAREOUS DOLOSTONE** at 40.60-.93m and medium brown, medium to thickly bedded **DOLOMITIC LIMESTONE** at 40.93-42.50m with 2mm black argillaceous parting at 41.10m. Light grey, laminated **DOLOSTONE** at 42.50-.70m.

End of Borehole, 42.70 m

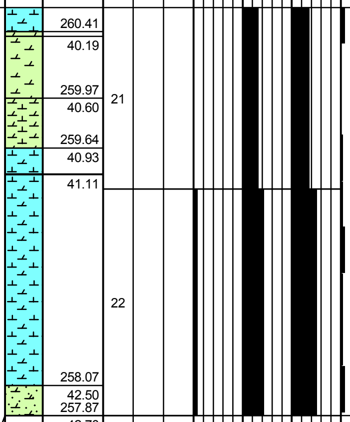
NOTES,

1. Complete loss of circulation around elev. 285 m (depth of 15.6 m).

2. Static water level measured in open borehole at elev. 284.1 m (depth of 16.5 m), cascading water noted in borehole.

ELEV.	DEPTH (m)
260.41	40.19
259.97	40.60
259.64	40.93
	41.11
258.07	42.50
257.87	42.70

RUN No.: 21, 22



TYPE AND SURFACE DESCRIPTION	Jcon
,IR,Ro	
,IR,Ro	0
,IR,Ro	
,IR,Ro	20
,PL,Ro	20
,IR,Ro	20
,PL,Ro	12
,PL,Ro	20
,PL,Ro	6
,IR,Ro	0
,IR,Ro	6

DEPTH SCALE METRES: 40 41 42 43 44 45 46 47 48 49 50

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-03

SHEET 1 OF 7

LOCATION: N 4788205.6 ;E 485703.7

DRILLING DATE: November 10-20, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		GROUND SURFACE		320.69																
0	HW CASING	**TOPSOIL**		0.00																
		SILT, some sand, some gravel, trace to some clay; brown to brownish grey at about elev. 316.3m , **TILL** **NOTE,** soil sequence interpretation based on limited recovery using standard split spoon sample methods at intervals while triconing to elev. 299.9 m. Below elev. 299.9 m, based on limited recovery in HQ core barrel while coring through overburd		320.49 0.20																
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-03

SHEET 2 OF 7

LOCATION: N 4788205.6 ;E 485703.7

DRILLING DATE: November 10-20, 2017

DATUM: Geodetic

DRILL RIG: Track Mounted Acker Soil - Max

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: Orbit Garant

JN - Joint	BD- Bedding	PL - Planar	PO- Polished	BR - Broken Rock
FLT - Fault	FO- Foliation	CU- Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR- Shear	CO- Contact	UN- Undulating	SM- Smooth	
VN - Vein	OR- Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB- Mechanical Break	

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DIP w.r.t. CORE AXIS 0 30 60 90	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		--- CONTINUED FROM PREVIOUS PAGE ---																		
10	HW CASING	**SILT**, some sand, some gravel, trace to some clay; brown to brownish grey at about elev. 316.3m , **TILL**																		
11																				
12																				
13																				
14																				
15																				
16																				
17				303.01 17.68																
		sandy **CLAYEY SILT**, some gravel; brownish grey, contains cobbles **TILL**																		
18																				
19																				
20																				

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-03

SHEET 3 OF 7

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	

--- *CONTINUED FROM PREVIOUS PAGE* ---

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.
20	HW CASING	sandy **CLAYEY SILT**, some gravel; brownish grey, contains cobbles **TILL**		
23		gravelly **SILTY SAND**, trace clay brownish grey, contains cobbles **TILL**	297.65 23.04	
26.38	HQ CORING	**Bedrock Surface, 26.38 m** **DUNDEE FORMATION, 26.38 m to 43.22 m** Fresh, faintly weathered on open argillaceous bedding partings to 27.80m, light brownish grey, fine to medium grained crystalline, non-porous with faintly porous fossiliferous sections, thinly to medium bedded (26.38-33.58m) becoming medium to thickly bedded (33.58-43.22m) **FOSSILIFEROUS LIMESTONE** with weakly to moderately developed stylolites below 33.58m, fine argillaceous partings (.05mm) and scattered pelecypod shells, crinoid ossicles and rugosa coral fossils. Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil shell debris in at 29.52-.56m, 29.70-.75m, 30.08-.15m and 31.22-.24m. More prominent black, argillaceous to argillaceous limestone bedding partings occur at 28.045-.050m (open with grey clay), 28.63-.64 (open with grey clay), 28.86-.87m (open with grey clay), 30.26-.27m (fine argillaceous partings in	294.31 26.38	1
28			292.65 28.05	2
			292.06 28.64	
			291.83 28.87	
29			291.38 29.44	3
			29.56	
			29.75	
30				

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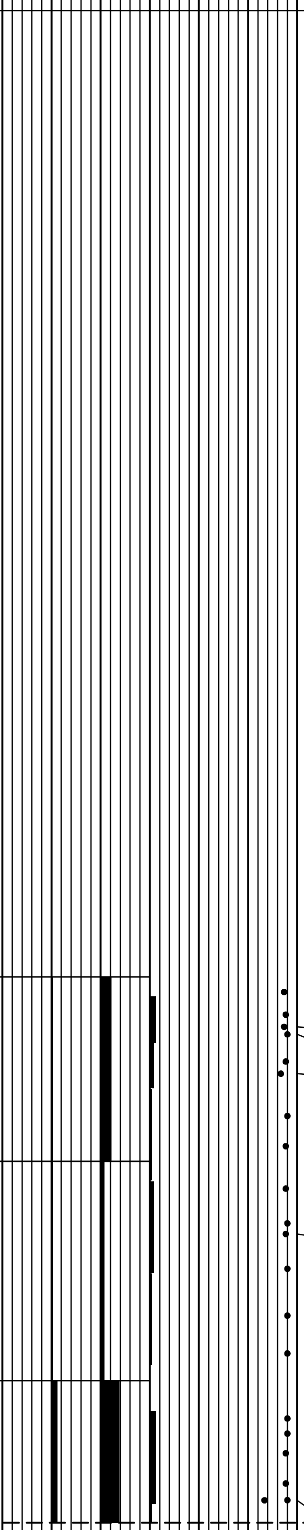


TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja
,IR,Ro	20		
,PL,Ro	20		
,IR,Ro	6		
,PL,Ro	6		
,UN,Ro	20		
,PL,Ro	20		
,IR,Ro	20		
,IR,Ro	12		
,IR,Ro	12		
,UN,Ro	12		
,IR,Ro	0		
,PL,Ro	6		
,UN,SM	0		
,IR,SM	0		
,PL,SM	0		
,IR,Ro	0		
,UN,Ro	20		
,UN,Ro	20		
,ST,Ro	20		
,IR,Ro	20		

HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1} | Diametral Point Load Index (MPa) 2 4 6 | RMC -Q' AVG.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-03

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

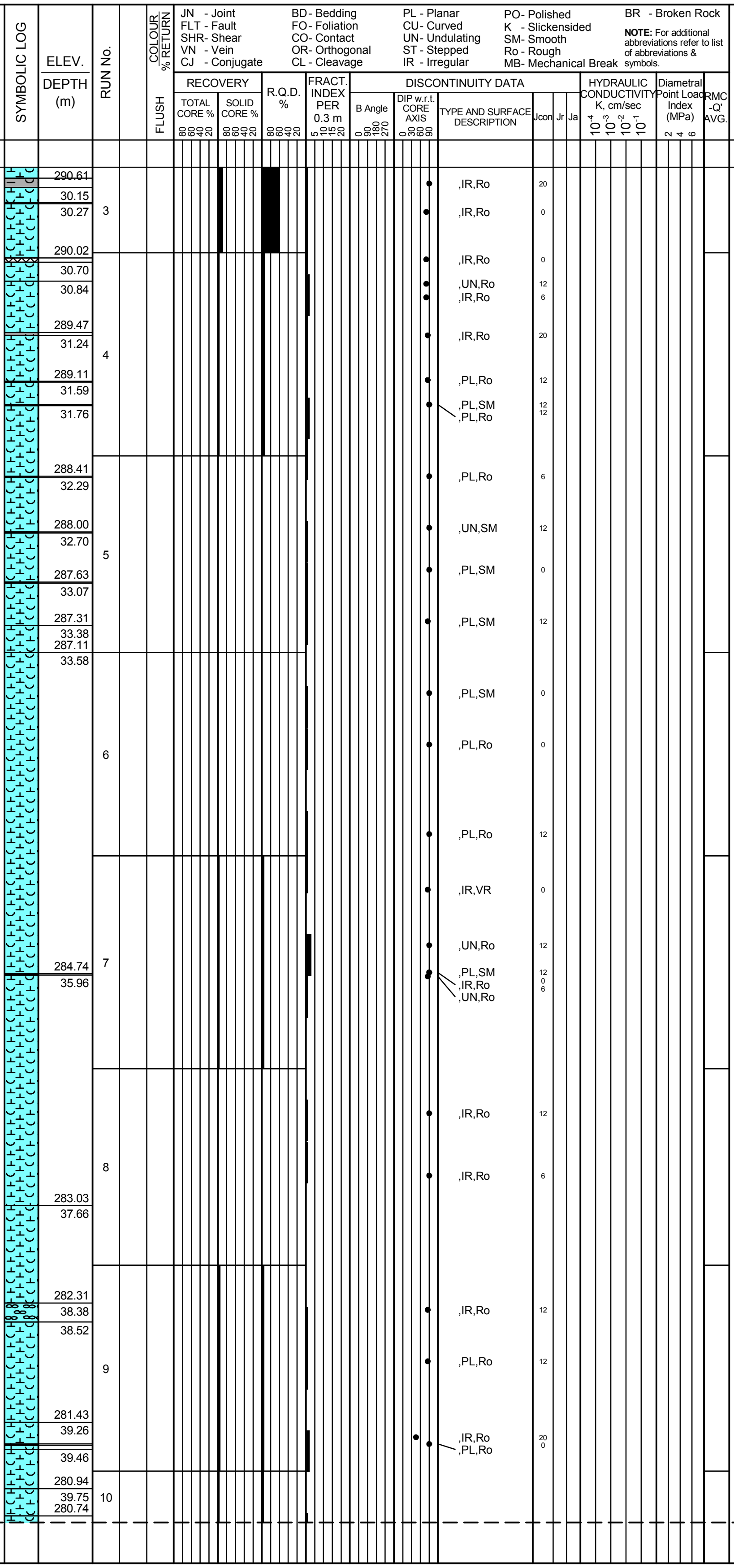
DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	



DEPTH SCALE METRES: 30 – 40

DRILLING RECORD: HQ CORING

DESCRIPTION

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limestone), 30.84m (1-2mm parting), 31.58m (2mm parting), 31.75-.76m (argillaceous parting with 2-3mm crystalline pinkish rhodochrosite lamination), 32.28-.29m, 32.69m (2mm), 32.70m (3mm), 33.06-.07m, 33.38m (1-2mm), 33.58m (1mm), 35.95-.96m (open weathered parting with grey clay), 39.42-.43m (open weathered partings with grey clay), 39.46m (2mm), and 42.73-.77m as fine partings in argillaceous limestone.

Weakly developed stylolite occur at 33.90m.

Seams of grey calcareous clay soil occur at 29.31-.36m, 29.41-.44m, 30.67-.70m and 40.61-.64m.

Porous, pitted, medium bedded coral fossil limestone beds with mottled faint natural petroleum staining occur at 37.66-38.38m (pitted at 37.97-38.28m), 38.52-39.26m, 39.75-.95m, 39.95-40.30m (minor petroleum staining) and 40.75-41.10m.

Section from 41.10 m to 43.22 m is faintly to moderately porous, absorptive, with minor coral fossil pitting and faint petroleum staining.

Nodular limestone beds occur at 38.30-.52m and 42.20-.38m.

Sharp basal contact with underlying Lucas Formation.

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ELEV.	DEPTH (m)
290.61	
	30.15
	30.27
290.02	
	30.70
	30.84
289.47	
	31.24
289.11	
	31.59
	31.76
288.41	
	32.29
288.00	
	32.70
287.63	
	33.07
287.31	
	33.38
287.11	
	33.58
284.74	
	35.96
283.03	
	37.66
282.31	
	38.38
	38.52
281.43	
	39.26
	39.46
280.94	
	39.75
280.74	

RUN No.: 3, 4, 5, 6, 7, 8, 9, 10

TYPE AND SURFACE DESCRIPTION	Jcon
,IR,Ro	20
,IR,Ro	0
,IR,Ro	0
,UN,Ro	12
,IR,Ro	6
,IR,Ro	20
,PL,Ro	12
,PL,SM	12
,PL,Ro	12
,PL,Ro	6
,UN,SM	12
,PL,SM	0
,PL,SM	12
,PL,SM	0
,PL,Ro	0
,PL,Ro	12
,IR,VR	0
,UN,Ro	12
,PL,SM	12
,IR,Ro	0
,UN,Ro	6
,IR,Ro	12
,IR,Ro	6
,IR,Ro	12
,PL,Ro	12
,IR,Ro	20
,PL,Ro	0

DEPTH SCALE

1 : 50

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-03

SHEET 5 OF 7

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

PL - Planar
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ST - Stepped
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PO- Polished
K - Slickensided
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MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | COLOUR % RETURN | FLUSH | RECOVERY: TOTAL CORE % 80 60 40 20, SOLID CORE % 80 60 40 20 | R.Q.D. % 80 60 40 20 | FRACT. INDEX PER 0.3 m 5 10 15 20 | DISCONTINUITY DATA: B Angle 0 90 180 270, DIP w.r.t. CORE AXIS 0 30 60 90, TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1} | Diametral Point Load Index (MPa) 2 4 6 | RMC -Q' AVG.

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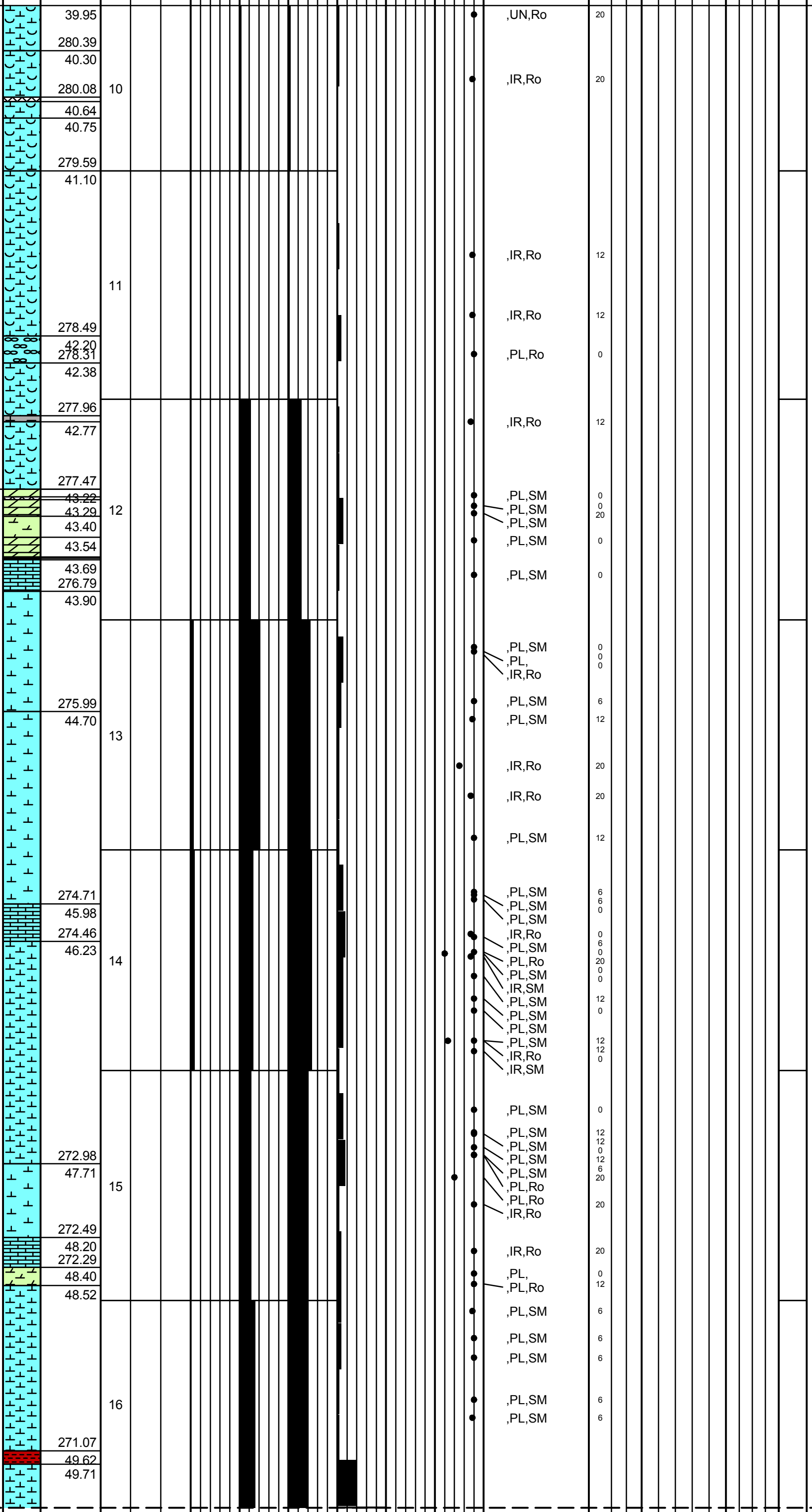

ELEV. / DEPTH (m)	RUN No.
39.95 280.39 40.30 280.08 40.64 40.75 279.59	10
41.10 278.49 42.20 278.31 42.38	11
277.96 42.77 277.47 43.22 43.29 43.40 43.54 43.69 276.79 43.90	12
275.99 44.70	13
274.71 45.98 274.46 46.23	14
272.98 47.71 272.49 48.20 272.29 48.40 48.52	15
271.07 49.62 49.71	16

TYPE AND SURFACE DESCRIPTION	Jcon
,UN,Ro	20
,IR,Ro	20
,IR,Ro	12
,IR,Ro	12
,PL,Ro	0
,IR,Ro	12
,PL,SM	0
,PL,SM	0
,PL,SM	20
,PL,SM	0
,PL,SM	0
,PL,SM	0
,PL,	0
,IR,Ro	0
,PL,SM	6
,PL,SM	12
,IR,Ro	20
,IR,Ro	20
,PL,SM	12
,PL,SM	6
,PL,SM	6
,PL,SM	0
,IR,Ro	0
,PL,SM	6
,PL,Ro	0
,PL,SM	20
,IR,SM	0
,PL,SM	0
,PL,SM	12
,PL,SM	0
,PL,SM	12
,IR,Ro	12
,IR,SM	0
,PL,SM	0
,PL,SM	12
,PL,SM	12
,PL,SM	0
,PL,SM	12
,PL,Ro	6
,PL,Ro	20
,IR,Ro	20
,IR,Ro	20
,PL,	0
,PL,Ro	12
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,SM	6

LUCAS FORMATION, 43.22 m to 57.58 m
UPPER LUCAS FORMATION, 43.22 m to 52.45 m

From 43.22 m to 43.67 m, Upper Lucas Dolostone Marker Bed, faintly to moderately weathered, medium grey to yellowish grey, fine grained crystalline, faintly porous, medium bedded, wavy laminar textured **ARGILLACEOUS DOLOSTONE** with seam of weathered grey clay soil at 43.27-.29m. Massive textured medium grey dolostone bed at 43.40-.54m. Laminated transitional basal contact.

From 43.67 m to 48.40 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, laminar textured **LIMESTONE.** Medium brown, finely laminated with thin argillaceous partings, moderately porous, faintly petroliferous limestone sections occur at 43.67-.90m with prominent black bituminous shaley partings at 43.68-.69m, 45.98-46.23m with open weathered partings at 45.98-46.05m and 48.20-.40m. Medium to thick bed of light to medium tan brown to creamy grey, fine grained crystalline, weakly laminated to massive textured, moderately porous, faintly petroliferous limestone beds occur at 43.90-45.98m (open 2mm argillaceous parting at 45.70m) and 46.23-47.71m. Light tan, fine grained, thick bed of massive textured limestone at 47.71-48.20m.

From 48.40 m to 48.52 m, distinctive thin **marker bed** of medium grey, fine grained crystalline, faintly porous **ARGILLACEOUS DOLOSTONE** with open weathered top contact and well developed stylolite at bottom contact.

From 48.52 m to 52.80 m, interbedded sequence of fresh to faintly weathered, light to medium tan brown to light creamy grey, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, faintly laminar to massive textured **LIMESTONE.**
Thin layer of dark brown, laminated

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-03

SHEET 6 OF 7

LOCATION: N 4788205.6 ;E 485703.7
INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 10-20, 2017
DRILL RIG: Track Mounted Acker Soil - Max
DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
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NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DEPTH (m) | RUN No. | COLOUR / % RETURN | FLUSH | RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER 0.3 m (5 10 15 20) | DISCONTINUITY DATA: B Angle (0 90 180 270), DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-4} 10^{-3} 10^{-2} 10^{-1}) | Diametral Point Load Index (MPa) (2 4 6) | RMC -Q' AVG.

--- CONTINUED FROM PREVIOUS PAGE ---

Depth scale: 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60

DRILLING RECORD: HQ CORING

CLAYEY SILT SOIL at 49.62-.71m (same layer in BH17-01 at 28.46-.50m and BH17-2 at 32.56-.57m). Moderately to highly weathered, medium tan brown, fine grained crystalline, moderately porous, cross laminated, thickly bedded **OOLITIC LIMESTONE** bed occurs at 50.10-51.20m. Core is very broken into disks and friable from 50.10 m to 51.40m. Mottled light brown limestone and medium brown porous dolomitic limestone bed at 51.20-.50m reflecting partial dolomatization of individual bed. Friable light tan, thickly bedded massive textured limestone at 51.50-52.45m associated with very broken up core.

LOWER LUCAS FORMATION, 52.45 m to 57.58 m

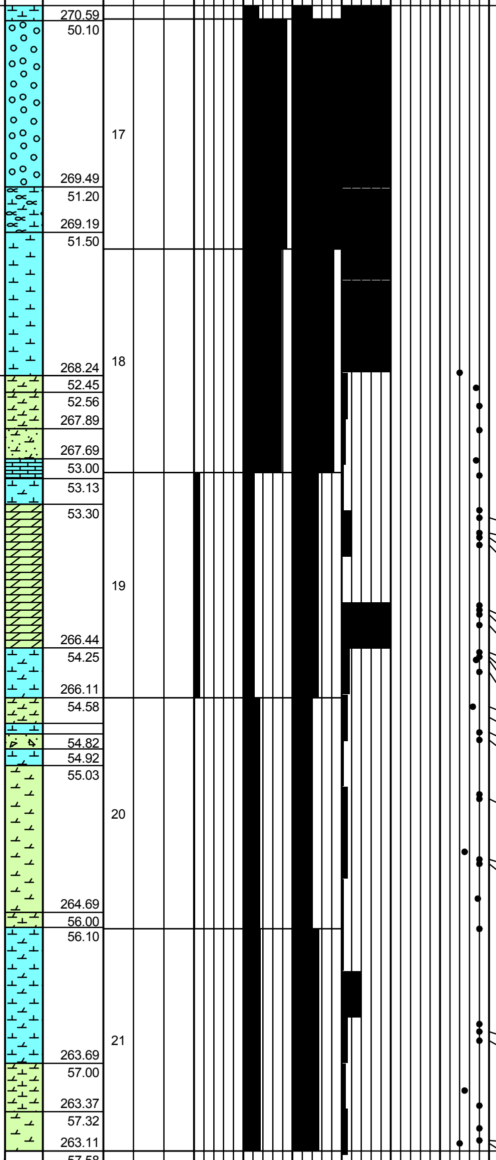
From 52.45 m to 53.00 m, faintly to moderately weathered, medium tan brown (52.45-.56m) to light yellowish tan brown (52.56-.80m , fine grained crystalline, moderately porous, thinly bedded, laminar textured, faintly petroliferous **DOLOSTONE** overlying distinct **marker bed** at 52.80-53.00m comprised of faintly weathered, light yellowish grey, fine grained crystalline, moderately porous, pitted (1-5mm), weakly laminated **DOLOSTONE** with disseminated pyrite veinlets.
From 53.00 m to 56.10 m, medium brown, fine grained crystalline, faintly to moderately porous, thinly to medium bedded, laminar textured, faintly petroliferous **DOLOSTONE** with interbed of dark brown, faintly petroliferous laminated bituminous **LIMESTONE** at 53.00-.13m (black argillaceous-bituminous partings at 53.04-.05m) and 53.30-.63m (moderately porous). Medium brown, moderately porous, thin, moderately petroliferous laminated **DOLOMITIC LIMESTONE** at 53.13-.30m, 54.25-.58m, 54.75-.82m and 54.82-.92m (intraformational breccia) and 54.92-55.03m. Second **marker bed** of faintly to moderately weathered, light to medium grey, fine grained, moderately porous, slump textured **DOLOSTONE** at 54.58-.75m. Porous pitted dolostone at 55.90-56.00m and laminated calcareous dolostone at 56.00-.10m.
From 56.10 m to 57.58 m, medium tan brown, fine grained crystalline, faintly laminated to massive textured, thickly bedded <<B>LIMESTONE **at 56.10-.80 overlying medium be of DOLOMITIC LIMESTONE** at 56.80-57.00m and light to medium tan brown, thinly bedded, laminar textured **CALCAREOUS DOLOSTONE** at 57.00-.32m (light grey, slump structured at 57.12-.32m with stylolite at base) overlying medium brown, moderately porous **DOLOSTONE** at 57.32-.58m.

End of Borehole, 57.58 m

NOTES,

1. Complete loss of circulation upon commencing coring within upper rock.

2. Static water level measured in open



TYPE AND SURFACE DESCRIPTION	Jcon
,IR,Ro	6
,IR,Ro	0
,PL,SM	0
,PL,Ro	0
,PL,SM	0
,PL,SM	0
,PL,SM	0
,PL,SM	6
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,	6
,PL,	0
,IR,	0
,PL,	12
,CU,Ro	0
,,	12
,PL,SM	0
,IR,Ro	
,IR,Ro	0
,IR,Ro	0
,,	
,PL,Ro	20
,PL,SM	6
,PL,SM	0
,IR,Ro	0
,PL,SM	12
,IR,Ro	0
,PL,SM	12
,PL,Ro	0
,IR,Ro	20
,PL,Ro	0
,PL,Ro	0
,PL,Ro	6
,PL,Ro	6

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-03

SHEET 7 OF 7

LOCATION: N 4788205.6 ;E 485703.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 10-20, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
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ST - Stepped
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PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		--- CONTINUED FROM PREVIOUS PAGE ---																	
60		borehole at elev. 276.9 m (depth of 43.8 m), cascading water noted in borehole.																	
61																			
62																			
63																			
64																			
65																			
66																			
67																			
68																			
69																			
70																			

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-04

SHEET 1 OF 6

LOCATION: N 4788423.2 ;E 485883.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21-27, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH / COLOUR % RETURN	RECOVERY: TOTAL CORE % (80 60 40 20)	RECOVERY: SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.3 m (5 10 15 20)	DISCONTINUITY DATA: B Angle (0 90 180 270)	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-4} 10^{-3} 10^{-2} 10^{-1})	Diametral Point Load Index (MPa) (2 4 6)	RMC -Q' AVG.
		GROUND SURFACE		321.76															
0	HW CASING	**CLAY**, some gravel, trace sand, trace silt; brown, contains cobbles		0.00															
1		**NOTE,** soil sequence interpretation based on variable recovery in HQ core barrel while coring through overburden with water flush.																	
4		**SILTY CLAY**, some sand, some gravel; brownish grey, contains cobbles **TILL**		317.34 4.42															
8		**CLAYEY SILT**, some sand, some gravel; brownish grey, contains cobbles **TILL**		313.68 8.08															
9		**SILTY CLAY**, some sand, some gravel; brownish grey, contains cobbles **TILL**		312.16 9.60															
10																			

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-04

SHEET 2 OF 6

LOCATION: N 4788423.2 ;E 485883.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21-27, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
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PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		--- CONTINUED FROM PREVIOUS PAGE ---																	
10	HW CASING	**SILTY CLAY**, some sand, some gravel; brownish grey, contains cobbles **TILL**																	
12		Boulder from about elev. 310.0m to 309.8m																	
14		sandy **SILTY CLAY**, some gravel; brownish grey, contains cobbles **TILL**		307.69 14.07															
15		sandy **CLAYEY SILT**, some gravel; brownish grey, contains cobbles **TILL**		306.16 15.60															
17		**SILTY SAND**, some gravel; brownish grey, contains cobbles **TILL**		304.69 17.07															
20				301.80															

Depth scale marks: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-04

SHEET 3 OF 6

LOCATION: N 4788423.2 ;E 485883.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21-27, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
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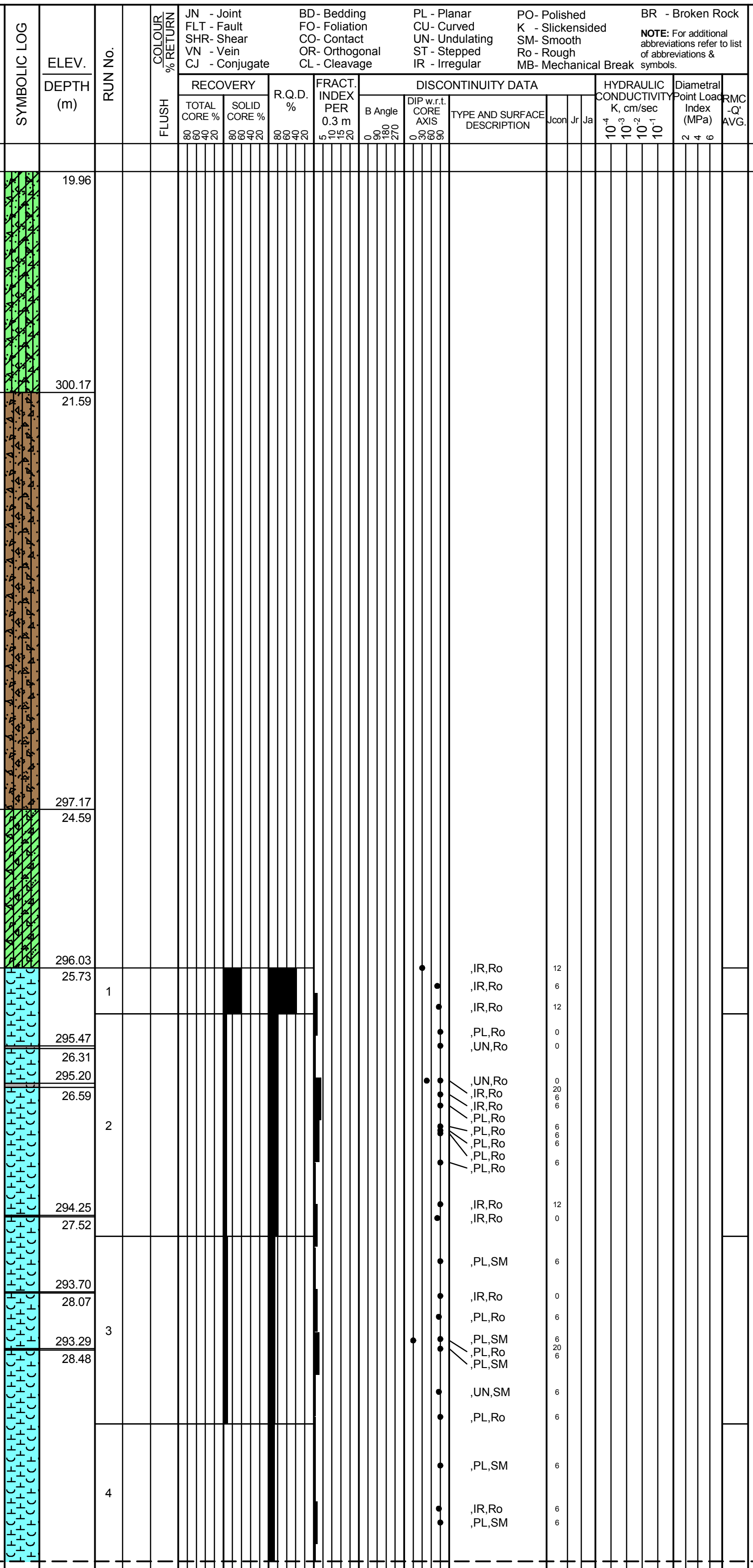
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)
		--- CONTINUED FROM PREVIOUS PAGE ---	
20	HW CASING	sandy **CLAYEY SILT**, some gravel; brownish grey, contains cobbles **TILL**	19.96
21			300.17
		SILTY SAND, some gravel; brownish grey, contains cobbles **TILL**	21.59
22			
23			
24			297.17
		SILTY CLAY to CLAYEY SILT, some sand, trace gravel; brownish grey **TILL**	24.59
25			296.03
	HQ CORING	**Bedrock Surface, 25.73 m** **DUNDEE FORMATION, 25.73 m to 39.57 m** Fresh, faintly weathered on open argillaceous bedding partings to 27.52m, light brownish grey, fine grained crystalline with disseminated medium crystal grains (O.5-1.0mm), non-porous with faintly porous fossiliferous sections, thinly to medium bedded (25.73-28.48m) becoming medium to thickly bedded (28.48-39.57m) **FOSSILIFEROUS LIMESTONE** with fine argillaceous partings (.05mm) and scattered pelecypod shells, crinoid ossicles and rugosa coral fossils. Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil shell debris in shaley limestone at 26.29-.31m and 26.56-.59m. Crinoid fossil debris abundant between 29.70-31.40m. Section from 31.40m to 39.57m is faintly petroliferous with localized natural petroleum staining. Moderately developed stylolite occurs at 34.29m. Porous, pitted coral fossil limestone beds occur at 32.95-33.20m and 38.04-.23m. Nodular limestone beds occur at 33.86-34.00m and 38.25-.50m. Fine black argillaceous bedding partings	25.73 295.47 26.31 295.20 26.59 294.25 27.52 293.70 28.07 293.29 28.48
26			
27			
28			
29			
30			



TYPE AND SURFACE DESCRIPTION	Jcon
,IR,Ro	12
,IR,Ro	6
,IR,Ro	12
,PL,Ro	0
,UN,Ro	0
,UN,Ro ,IR,Ro ,IR,Ro ,PL,Ro ,PL,Ro ,PL,Ro ,PL,Ro ,PL,Ro	0 20 6 6 6 6 6 6
,IR,Ro	12
,IR,Ro	0
,PL,SM	6
,IR,Ro	0
,PL,Ro	6
,PL,SM ,PL,Ro ,PL,SM	6 20 6
,UN,SM	6
,PL,Ro	6
,PL,SM	6
,IR,Ro	6
,PL,SM	6

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-04

SHEET 4 OF 6

LOCATION: N 4788423.2 ;E 485883.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21-27, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint	BD- Bedding	PL - Planar	PO- Polished	BR - Broken Rock
FLT - Fault	FO- Foliation	CU- Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR- Shear	CO- Contact	UN- Undulating	SM- Smooth	
VN - Vein	OR- Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB- Mechanical Break	

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | COLOUR % RETURN | FLUSH | RECOVERY (TOTAL CORE % / SOLID CORE %) | R.Q.D. % | FRACT. INDEX PER 0.3 m | DISCONTINUITY DATA (B Angle / DIP w.r.t. CORE AXIS / TYPE AND SURFACE DESCRIPTION / Jcon / Jr / Ja) | HYDRAULIC CONDUCTIVITY K, cm/sec | Diametral Point Load Index (MPa) | RMC -Q' AVG.

--- CONTINUED FROM PREVIOUS PAGE ---

occur at 26.06m, 26.20m, 26.74m, 26.88m, 26.91m, 28.38m, 28.77m, 31.40m, 32.17m, 32.45m, 35.00m, 35.14m and 35.95m. More prominent black 27.51-.52m, 28.06-.07m, 28.47-.48m, 30.78-.79m, 32.90-.91m, 36.58-.59m, 37.34-.35m and 37.83-.84m. Faint to moderate weathering noted by clay or brown staining occurs on majority of bedding partings.

Basal section of Dundee at 39.22-.57m comprised of faintly to moderately weathered, friable, medium brown, moderately porous, absorptive, mottled limestone with open, weathered basal contact with underlying Lucas Formation.

LUCAS FORMATION, 39.57 m to 50.09 m
UPPER LUCAS FORMATION, 39.57 m

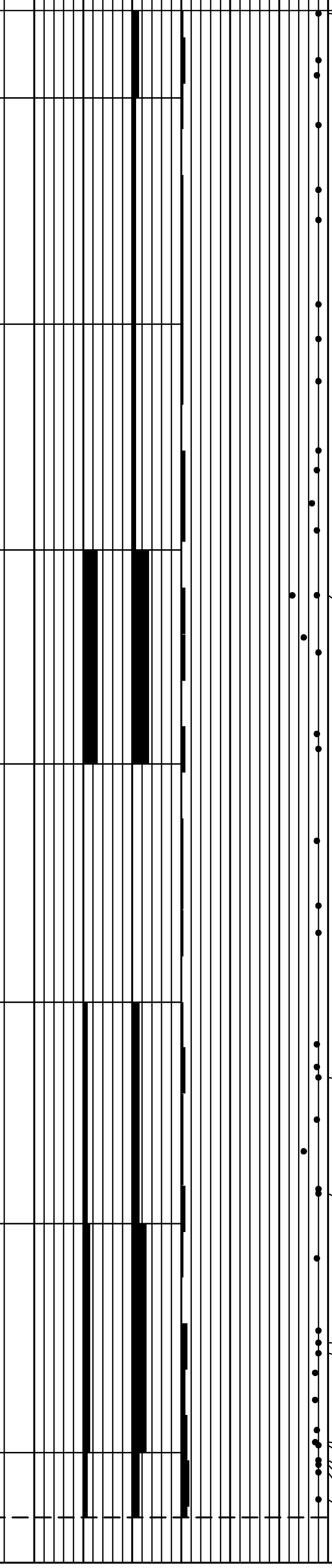
CONTINUED NEXT PAGE

Depth scale: 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

Drilling record: HQ CORING

ELEV.	DEPTH (m)
290.98	30.79
290.36	31.40
288.86	32.91
287.90	33.86
	34.00
285.18	36.59
284.42	37.35
283.93	37.84
283.51	38.25
283.26	38.50
282.54	39.22
282.19	39.57
281.81	

Run No.: 4, 5, 6, 7, 8, 9, 10, 11



TYPE AND SURFACE DESCRIPTION	Jcon
,IR,Ro	6
,PL,Ro	6
,IR,Ro	6
,PL,Ro	0
,PL,Ro	0
,PL,SM	6
,UN,Ro	20
,UN,Ro	6
,PL,Ro	12
,PL,SM	6
,UN,Ro	0
,IR,Ro	6
,IR,Ro	12
,UN,Ro	6
,IR,Ro	20
,IR,Ro	20
,IR,Ro	6
,UN,Ro	20
,PL,SM	0
,IR,Ro	12
,CU,Ro	12
,PL,Ro	0
,IR,Ro	12
,IR,Ro	6
,IR,Ro	6
,IR,Ro	6
,IR,Ro	20
,UN,Ro	6
,UN,Ro	6
,IR,Ro	12
,IR,Ro	6
,IR,Ro	6
,IR,Ro	6
,IR,SM	6
,IR,Ro	6
,IR,SM	20
,PL,SM	20
,IR,SM	0
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,SM	12

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-04

SHEET 5 OF 6

LOCATION: N 4788423.2 ;E 485883.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21-27, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | COLOUR % RETURN | FLUSH | RECOVERY (TOTAL CORE %, SOLID CORE %) | R.Q.D. % | FRACT. INDEX PER 0.3 m | DISCONTINUITY DATA (B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja) | HYDRAULIC CONDUCTIVITY K, cm/sec | Diametral Point Load Index (MPa) | RMC -Q' AVG.

Drilling record: HQ CORING

--- CONTINUED FROM PREVIOUS PAGE ---

to 48.49 m

From 39.57 m to 40.14 m, Upper Lucas Dolostone Marker Bed, moderately weathered, light tan grey to yellowish grey, fine grained crystalline, moderately porous, medium bedded, fine wavy laminar textured **DOLOSTONE** with medium grey, weathered, weakly laminated argillaceous dolostone at 39.95-40.09m, porous, pitted at 39.85-40.00m, open weathered bedding fractures at 39.57m, 39.60m, 39.67m, 39.84m and brown weathered bedding fractures at 40.06m, 40.14m and 40.17m. Transitional basal contact.

From 40.14 m to 44.90 m, interbedded sequence of faintly to moderately weathered, light to medium tan brown, fine grained crystalline, faintly to moderately porous, faintly petroliferous, thinly to medium bedded, finely laminar textured **LIMESTONE.**

Medium brown, finely laminated with thin black argillaceous partings, moderately porous, faintly petroliferous limestone sections occur at 40.14-.45m, 42.52-.79m,43.50-.64m and 44.78-.90m.

Fine argillaceous partings in limestone at 40.69-.71m. Laminated, porous fossiliferous limestone bed at 40.78-41.25m with transitional contacts.

Moderately porous rugosa coral fossil bed at 42.14-.27m.

Medium to thick beds of medium tan brown, fine grained crystalline, saccharoidal textured, faintly petroliferous limestone occur at 42.79-43.50m (weakly laminated), 43.64-44.30m (weakly laminated) and 44.30-.78m (massive textured).

From 44.90 m to 44.93 m, distinctive thin **marker bed** of medium grey, fine grained crystalline, faintly porous **ARGILLACEOUS DOLOSTONE** with weathered argillaceous parting at top and well developed irregular stylolite at base. Same marker bed as in boreholes BH17-01 at 27.64-.88m, BH17-02 at 31.43-.60m and BH17-03 at 48.40-.52m. Top of bed appears to have been eroded leaving 3cm remnant compared to occurrence in the other boreholes.

From 44.93 m to 48.75 m, interbedded sequence of faintly to moderately weathered, medium tan brown, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, faintly laminar to massive textured **LIMESTONE.**

Argillaceous bedding parting (2mm) at 45.80m. Thin layer of dark brown, laminated clayey silt soil at 49.62-.71m (same layer in BH17-01 at 28.46-.50m, BH17-2 at 32.56-.57m and BH17-03 at 49.62-.71m).

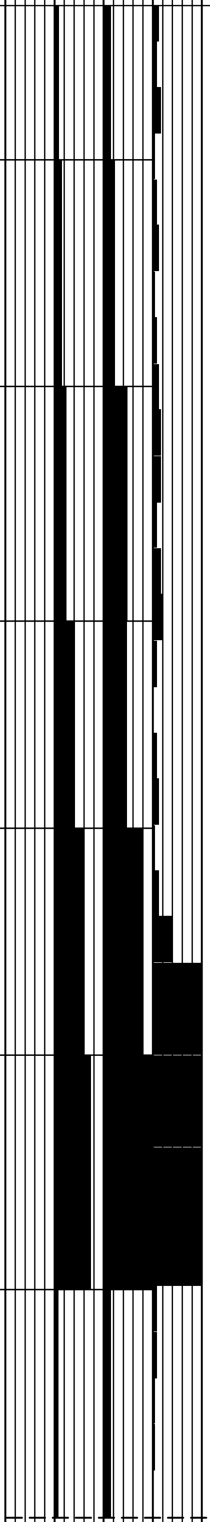
Moderately weathered, medium brown, friable, finely laminated limestone beds occur at 46.20-.35m and 47.30-48.00m (both very broken core).

Moderately to highly weathered, medium tan brown, fine grained crystalline, moderately porous, laminated, thickly bedded **OOLITIC LIMESTONE** bed occurs at 46.35-47.30m. Core is very broken into disks and friable from 46.25 m to 48.50 m.

Friable light tan, medium bedded, massive textured saccharoidal limestone at 48.00-.49m associated with broken up core. Transitional basal contact.

CONTINUED NEXT PAGE

Depth scale (m)	Elev. / Depth (m)	Run No.
40	39.95 40.14 281.31 40.45 281.07 40.78	11
41	280.51 41.25	12
42	279.62 42.14 42.27 279.24 42.52 278.98 42.78	13
43	278.26 43.50 43.64	
44	277.46 44.30 276.98 44.78	14
45	44.93 275.96 45.80 45.91	
46	275.56 46.20 46.35	15
47	274.46 47.30 273.76	16
48	48.00 273.27 48.49 48.60 48.75 272.76	
49	49.07 272.46 49.30	17
50		



Type and surface description	Jcon
,PL,SM	0
,PL,SM	0
,PL,SM	0
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,SM	12
,IR,Ro	20
,PL,SM	0
,PL,SM	0
,PL,SM	0
,PL,SM	0
,PL,SM	0
,PL,SM	6
,PL,SM	12
,PL,Ro	20
,PL,SM	12
,PL,Ro	20
,PL,SM	0
,PL,SM	12
,PL,SM	6
,PL,SM	6
,IR,SM	6
,PL,Ro	12
,PL,SM	12
,PL,SM	12
,PL,SM	20
,CU,SM	20
,PL,SM	20
,PL,SM	20
,PL,SM	20
,PL,SM	20
,PL,SM	20
,PL,SM	20
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,Ro	20
,IR,SM	20
,IR,SM	0
,PL,Ro	12
,PL,Ro	12
,PL,SM	0
,PL,SM	6
,PL,SM	0
,PL,SM	6
,PL,SM	6
,PL,SM	6
,PL,SM	12
,PL,SM	12
,IR,SM	0
,PL,SM	0
,PL,SM	12
,PL,SM	12

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-04

SHEET 6 OF 6

LOCATION: N 4788423.2 ;E 485883.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 21-27, 2017

DRILL RIG: Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
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CJ - Conjugate
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NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		--- CONTINUED FROM PREVIOUS PAGE ---																		
50		**LOWER LUCAS FORMATION, 48.49 m to 50.09 m**		271.67 50.09																

From 48.49 m to 49.00 m, faintly weathered, medium tan grey, thinly bedded, massive textured **DOLOSTONE** occur at 48.49-.75m (weathered friable upper contact) with angular rip-up clasts at 48.55-.60m and weakly laminated light tan dolostone at 48.60-.75m overlying distinct **marker bed** at top of sequence comprised of faintly weathered, light yellowish grey, fine grained crystalline, moderately porous, pitted (1-5mm), weakly laminated **DOLOSTONE** with disseminated pyrite veinlets.

From 49.00 m to 50.09 m, faintly weathered, medium brown, fine grained crystalline, moderately porous, finely laminated textured, medium to thickly bedded, faintly petroliferous **DOLOSTONE** with thin bed of calcareous dolostone at 49.00-.05m, dark brown to black, finely laminated bituminous limestone at 49.05-.07m and medium bed of medium brown, moderately porous limestone at 49.07-.35m.

End of Borehole, 50.09 m

NOTES,

1. Maintained circulation to borehole completion.

2. Borehole was terminated due to loss of core barrel.

3. Static water level measured in open borehole at elev. 293.1 m (depth of 28.7 m).

51

52

53

54

55

56

57

58

59

60

MIS-RCK 004 1781508 ROCK.GPJ GAL-MISS.GDT 10/31/18 LMK

DEPTH SCALE

1 : 50

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-05

SHEET 1 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
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NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DIP w.r.t. CORE AXIS 0 30 60 90	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		GROUND SURFACE		304.36																
0	HW CASING	**SAND and GRAVEL**, trace clay, trace silt; brown **NOTE,** soil sequence interpretation limited to slurry return from mud-rotary drilling.		0.00																
3		**SAND**, some gravel, trace clay, trace silt; brown		301.31 3.05																
6		**SAND and GRAVEL**, trace clay, trace silt; brown		298.26 6.10																
10		*CONTINUED NEXT PAGE*																		

DEPTH SCALE
1 : 50

LOGGED: AS/RB
CHECKED:

MIS-RCK 004 1781508 ROCK.GPJ GAL-MISS.GDT 10/31/18 LMK

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-05

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

JN - Joint	BD- Bedding	PL - Planar	PO- Polished	BR - Broken Rock
FLT - Fault	FO- Foliation	CU- Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR- Shear	CO- Contact	UN- Undulating	SM- Smooth	
VN - Vein	OR- Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB- Mechanical Break	

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH COLOUR % RETURN | RECOVERY TOTAL CORE % 80 60 40 20 SOLID CORE % 80 60 40 20 | R.Q.D. % 80 60 40 20 | FRACT. INDEX PER 0.3 m 5 10 15 20 | DISCONTINUITY DATA B Angle 0 90 180 270 DIP w.r.t. CORE AXIS 0 30 60 90 TYPE AND SURFACE DESCRIPTION Jcon Jr Ja | HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1} | Diametral Point Load Index (MPa) 2 4 6 | RMC -Q' AVG.

--- CONTINUED FROM PREVIOUS PAGE ---

10 11 12 13 14 15 16 17 18 19 20

HW CASING

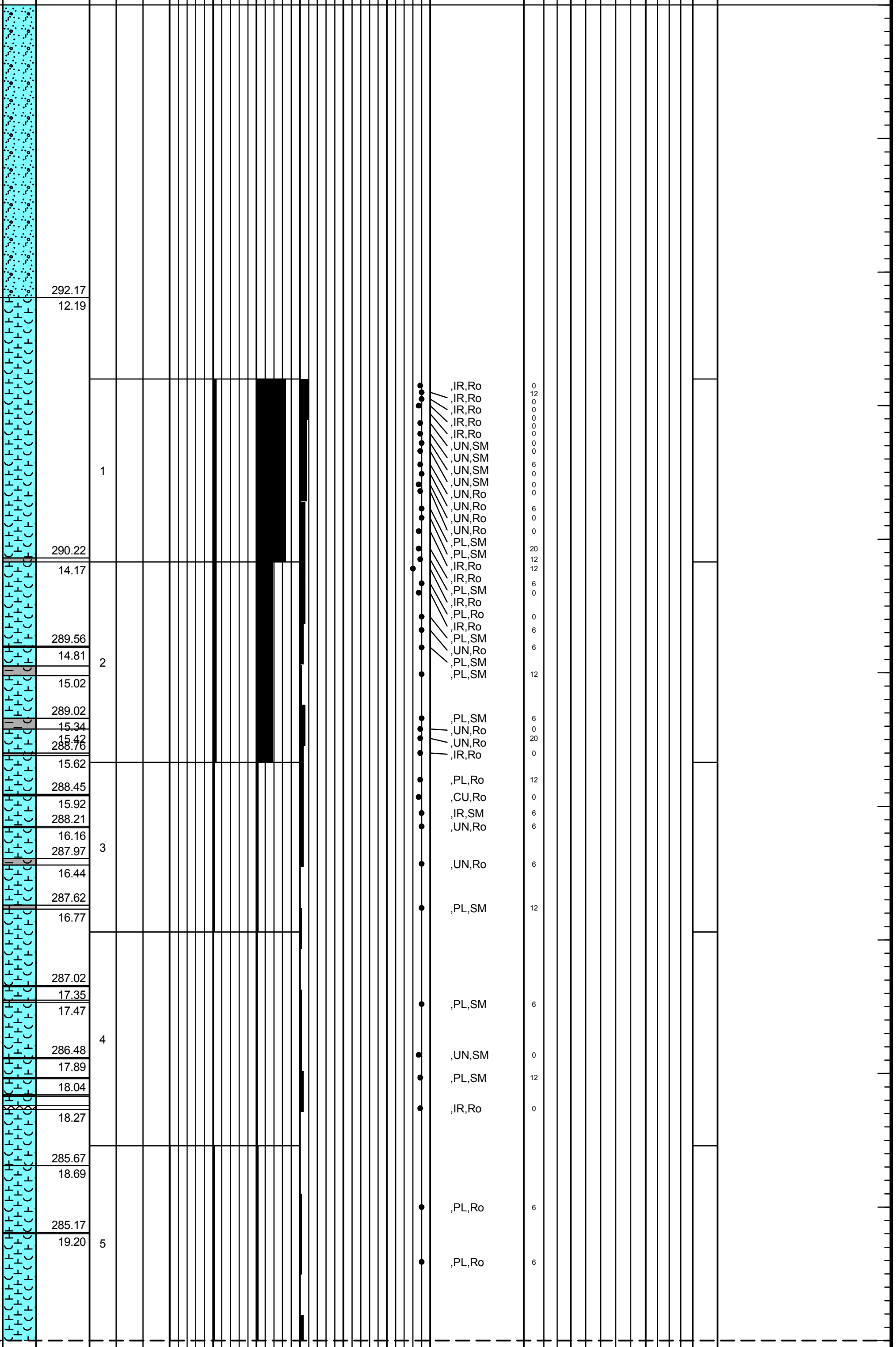
HQ CORING

SAND and GRAVEL, trace clay, trace silt; brown

NOTE, 6.625" OD steel casing to 292.1 m

Bedrock Surface, 12.19 m
DUNDEE FORMATION, 12.19 m to 28.05 m
Fresh, faintly weathered on open argillaceous bedding partings to 14.40m, light brownish grey, fine grained crystalline with disseminated medium crystal grains (O.5-1.0mm), non-porous with faintly porous fossiliferous sections, thinly to medium bedded (12.19-18.27m) becoming medium to thickly bedded (18.27-28.05m) **FOSSILIFEROUS LIMESTONE** with fine argillaceous partings (.05mm) and scattered fossil pelecypod shells, crinoid ossicles and rugosa coral.
Laminated to very thin argillaceous to shaley bioclastic limestone beds containing pelecypod fossil shell debris in shaley limestone at 14.14-.17m, 14.80-.81m, 14.95-15.02m, 15.34-.42m (brown, argillaceous), 15.91-.92m, 16.15-.16m and 16.39-.44m.
Thin layers of grey clayey soil occur at 15.60-.62m, 18.24-.27m and 26.05-.09m.
Crinoid and pelecypod fossil debris abundant between 19.20-20.80m.
Porous, pitted, faintly petroliferous, rugosa coral fossil limestone beds occur at 23.05-.40m, 23.50-.85m, 25.60-26.05m, 26.10-.70m and 27.24-28.05m.
Nodular limestone beds occur at 23.40-.50m, 24.45-.53m, 26.70-.90m and 27.15-.24m.
Fine black argillaceous bedding partings occur at 15.91-.92m, 16.74-.77m, 17.34-.35m, 17.45-.47m (black shaley limestone), 17.88-.89m, 18.03-.04m, 18.16-.17m, 19.19-.20m, 22.12-.13m, 22.53-.54m and 27.74-.79m. Well developed stylolite at 26.10m.

Sharp basal contact with underlying Lucas Formation. Basal 3 cm of Dundee Fm comprised of fine lag deposit of crinoidal debris in limestone.



CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-05

SHEET 3 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN	FLUSH	RECOVERY TOTAL CORE % (80 60 40 20)	RECOVERY SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.3 m (5 10 15 20)	B Angle (0 90 180 270)	DIP w.r.t. CORE AXIS (0 30 60 90)	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-4} 10^{-3} 10^{-2} 10^{-1})	Diametral Point Load Index (MPa) (2 4 6)	RMC -Q' AVG.

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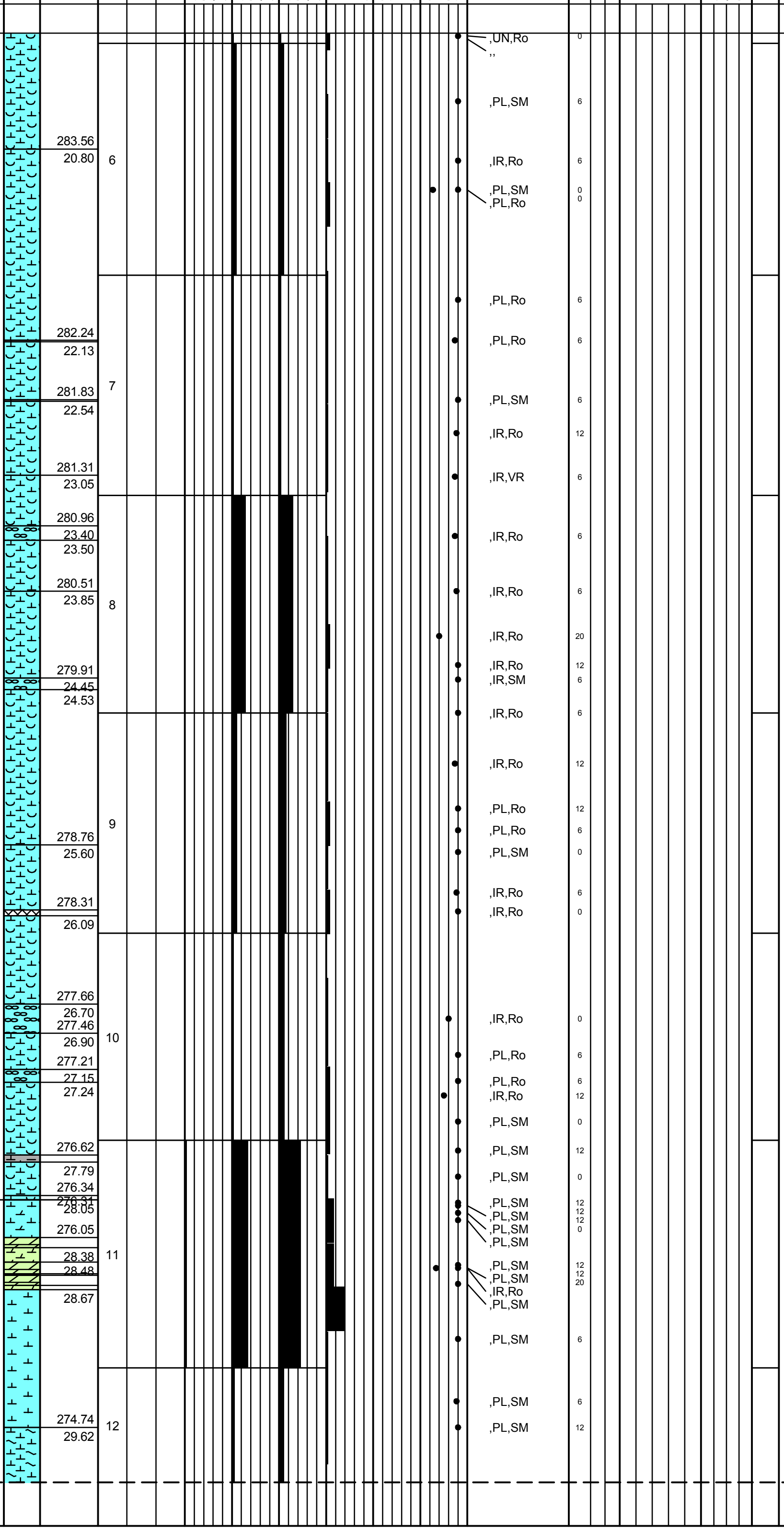


Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

DRILLING RECORD: HQ CORING

ELEV.	DEPTH (m)
283.56	20.80
282.24	22.13
281.83	22.54
281.31	23.05
280.96	23.40
	23.50
280.51	23.85
279.91	24.45
	24.53
278.76	25.60
278.31	26.09
277.66	26.70
277.46	26.90
277.21	27.15
	27.24
276.62	27.79
276.34	
276.31	28.05
276.05	28.38
	28.48
	28.67
274.74	29.62

RUN No.: 6, 7, 8, 9, 10, 11, 12

TYPE AND SURFACE DESCRIPTION	Jcon
,UN,Ro	0
,,	
,PL,SM	6
,IR,Ro	6
,PL,SM	0
,PL,Ro	0
,PL,Ro	6
,PL,Ro	6
,PL,SM	6
,IR,Ro	12
,IR,VR	6
,IR,Ro	6
,IR,Ro	6
,IR,Ro	20
,IR,Ro	12
,IR,SM	6
,IR,Ro	6
,IR,Ro	12
,PL,Ro	12
,PL,Ro	6
,PL,SM	0
,IR,Ro	6
,IR,Ro	0
,IR,Ro	0
,PL,Ro	6
,PL,Ro	6
,IR,Ro	12
,PL,SM	0
,PL,SM	12
,PL,SM	0
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	0
,PL,SM	12
,PL,SM	12
,IR,Ro	20
,PL,SM	
,PL,SM	6
,PL,SM	6
,PL,SM	12

LUCAS FORMATION, 28.05 m to 50.19 m
UPPER LUCAS FORMATION, 28.05 m to 37.20 m

From 28.05 m to 28.67 m, Upper Lucas Dolostone Marker Bed, faintly to moderately weathered, light tan grey to yellowish grey, fine grained crystalline, moderately porous, medium bedded, fine wavy laminar textured **DOLOMITIC LIMESTONE** at 28.05-.31m transitional to medium tan brown, laminated **DOLOSTONE** at 28.31-.56m with several open bedding partings, becoming medium grey at

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AS/RB
CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-05

SHEET 4 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

JN - Joint	BD- Bedding	PL - Planar	PO- Polished	BR - Broken Rock	
FLT - Fault	FO- Foliation	CU- Curved	K - Slickensided	NOTE: For additional abbreviations refer to list of abbreviations & symbols.	
SHR- Shear	CO- Contact	UN- Undulating	SM- Smooth		
VN - Vein	OR- Orthogonal	ST - Stepped	Ro - Rough		
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB- Mechanical Break		

DEPTH SCALE METRES | DRILLING RECORD: HQ CORING | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH COLOUR % RETURN | RECOVERY TOTAL CORE % / SOLID CORE % | R.Q.D. % | FRACT. INDEX PER 0.3 m | DISCONTINUITY DATA: B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec | Diametral Point Load Index (MPa) | RMC -Q' AVG.

--- CONTINUED FROM PREVIOUS PAGE ---

28.38-.48m. Thin weathered limestone bed at 28.56-.64m with open bedding partings and more prominent black argillaceous parting at 28.56-.57m. Thin dolostone bed at 28.64-.67m. Transitional basal contact.

From 28.67 m to 33.29 m, faintly to moderately weathered, light tan brown, fine grained crystalline, moderately porous, faintly petroliferous, medium to thickly bedded, massive to faintly laminar textured **LIMESTONE** at 28.67-29.62m, and 31.27-33.29m interbedded with medium tan brown, finely laminar textured with thin black argillaceous partings, moderately porous, faintly petroliferous, thinly to medium bedded **LIMESTONE** at 29.62-30.04m, 30.70-31.62m (oolitic bed at 31.04-.12m) and 31.62-.87m (light tan brown). Brownish grey, moderately porous Rugosa coral bed at 30.04-.29m with sharp top and bottom contacts. Brown argillaceous bedding partings at 30.47-.49m.

From 33.29 m to 33.48 m, distinctive thin **marker bed** of medium grey (medium tan brown at 33.29-.35m), fine grained crystalline, faintly porous **ARGILLACEOUS DOLOSTONE** with weathered argillaceous parting at top. Same marker bed as in boreholes BH17-01 at 27.64-.88m, BH17-02 at 31.43-.60m, BH17-03 at 48.40-.52m and BH17-04 at 44.90-.93m. Light grey clayey soil infill at 33.46-.48m.

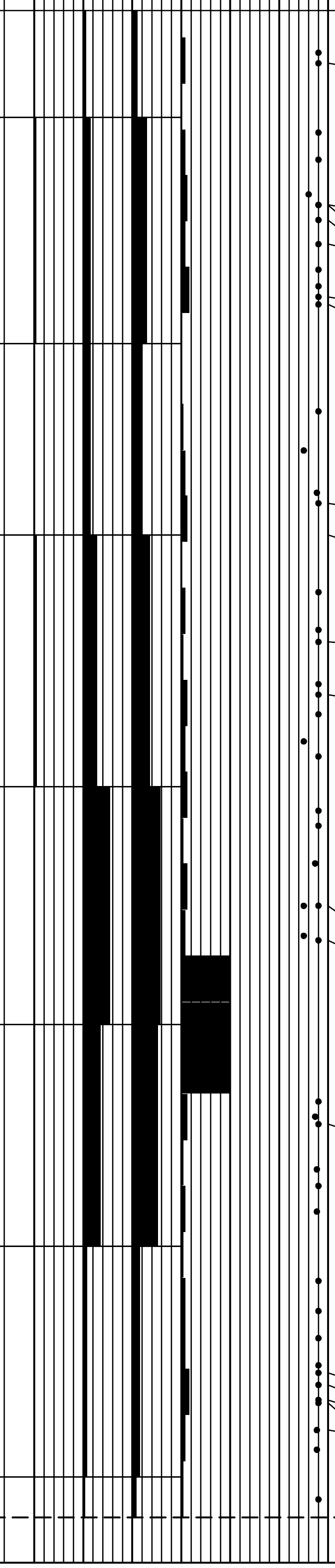
From 33.48 m to 37.20 m, interbedded sequence of faintly to moderately weathered, light to medium tan brown, fine grained crystalline, faintly to moderately porous to pitted, faintly petroliferous, thinly to medium bedded, faintly laminar to massive textured **LIMESTONE.** Interlaminated, medium tan brown, fine to medium grained crystalline, moderately porous **LIMESTONE** at 33.48-34.70m overlying light tan brown, fine grained crystalline, moderately porous, medium to thickly bedded, chalky textured, partly saccharoidal **LIMESTONE** at 34.70-37.20m with interbed of oolitic limestone at 35.15-.50m (light brown at 35.15-.26m, medium brown moderately to highly porous at 35.26-.50m). Light creamy tan, saccharoidal limestone bed associated with broken core at 36.50-37.20m. Section has sharp basal contact.

LOWER LUCAS FORMATION, 37.20 m to 50.19 m

From 37.20 m to 40.86 m, faintly to moderately weathered, medium brown, fine grained crystalline, moderately porous, thinly to thickly bedded, laminar textured, faintly petroliferous **DOLOSTONE** with distinct **marker bed** near top of sequence (37.56-.79m) comprised of faintly weathered, light yellowish grey, fine grained crystalline, moderately porous, pitted (0.5-2.0mm), weakly laminated **DOLOSTONE.** Second **marker bed** of medium grey, finely mottled **DOLOSTONE** at 39.54-.77m with sharp, well developed stylolite at 39.77m. Thin porous, pitted (0.5-1.0mm) dolostone bed at 40.00-.20m. Thin, dark brown, laminated dolostone bed at 40.80-.86m. Dark brown, thin bed of finely laminated, faintly to moderately petroliferous **ARGILLACEOUS**

ELEV.	DEPTH (m)
274.32	30.04
274.07	30.29
273.89	30.49
273.66	30.70
273.32	31.04
	31.12
272.74	31.62
272.49	31.87
271.07	33.29
	33.48
269.66	34.70
269.21	35.15
268.86	35.50
267.86	36.50
267.16	37.20
	37.37
266.80	
266.57	
	37.87
	38.00
266.15	38.22
265.13	39.23
264.94	39.42
	39.54
264.59	39.77
	39.91

RUN No.
12
13
14
15
16
17
18
19



TYPE AND SURFACE DESCRIPTION	Jcon
,PL,Ro	20
,PL,SM	12
,PL,SM	20
,PL,SM	6
,IR,Ro	12
,PL,SM	12
,PL,SM	12
,PL,SM	6
,PL,SM	6
,PL,SM	20
,PL,SM	12
,PL,	0
,PL,SM	12
,PL,SM	20
,IR,Ro	20
,UN,Ro	20
,PL,SM	12
,,	0
,,	
,PL,SM	12
,PL,SM	6
,PL,SM	6
,CU,SM	0
,PL,SM	12
,PL,SM	6
,PL,Ro	28
,IR,Ro	20
,,	
,,	
,PL,SM	12
,PL,SM	12
,IR,Ro	6
,PL,Ro	6
,IR,Ro	12
,ST,Ro	20
,PL,SM	20
,IR,Ro	0
,IR,VR	0
,IR,VR	0
,PL,Ro	0
,PL,SM	6
,PL,SM	6
,,	
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	12
,PL,SM	12
,IR,Ro	0
,PL,SM	6
,PL,SM	12
,PL,SM	6
,PL,SM	20

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-05

SHEET 5 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
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K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN / FLUSH	RECOVERY: TOTAL CORE % (80 60 40 20)	RECOVERY: SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.3 m (5 10 15 20)	DISCONTINUITY DATA: B Angle (0 90 180 270)	DIP w.r.t. CORE AXIS (0 30 60 90)	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-4} 10^{-3} 10^{-2} 10^{-1})	Diametral Point Load Index (MPa) (2 4 6)	RMC -Q' AVG.

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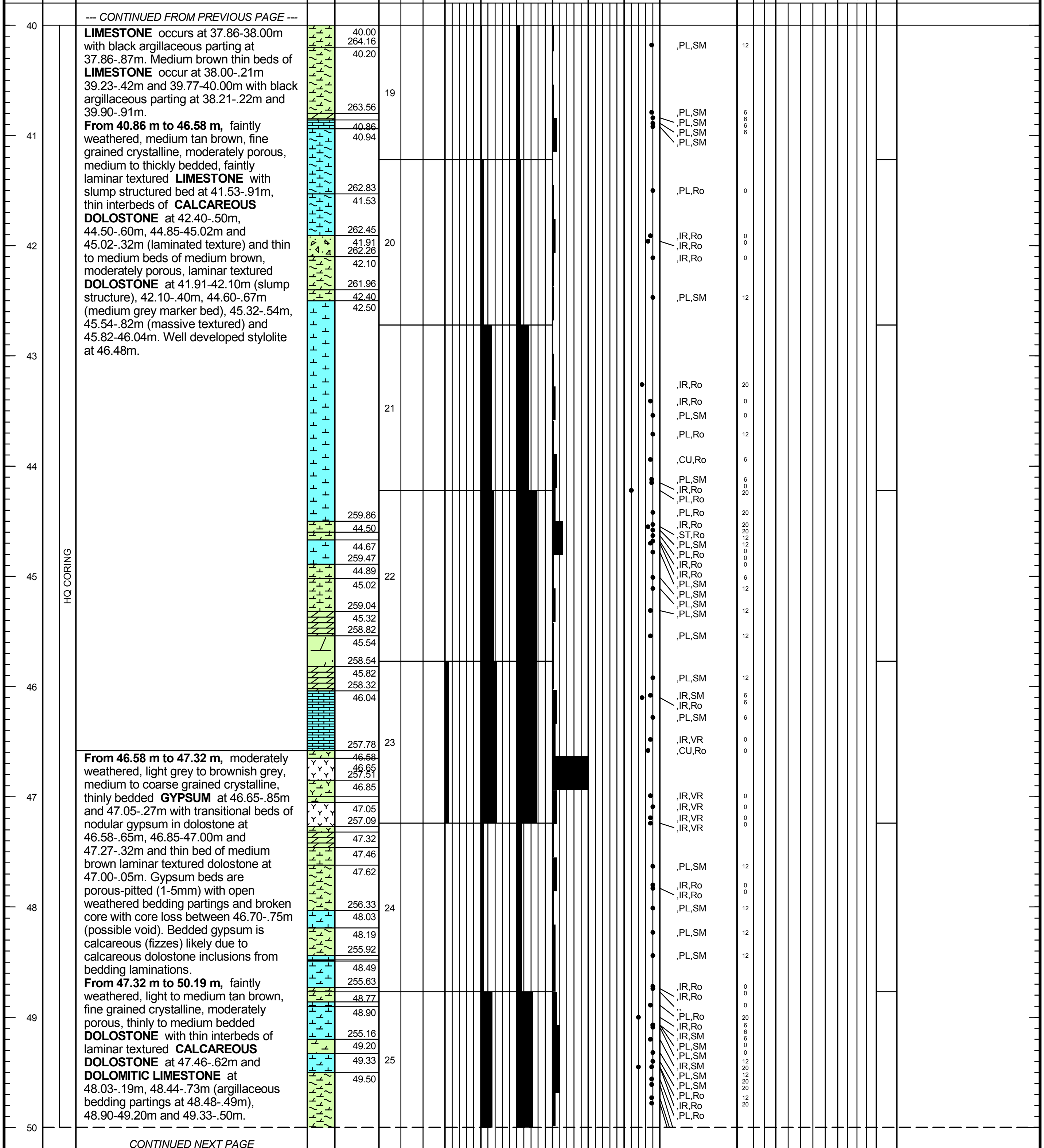
LIMESTONE occurs at 37.86-38.00m with black argillaceous parting at 37.86-.87m. Medium brown thin beds of **LIMESTONE** occur at 38.00-.21m 39.23-.42m and 39.77-40.00m with black argillaceous parting at 38.21-.22m and 39.90-.91m.

From 40.86 m to 46.58 m, faintly weathered, medium tan brown, fine grained crystalline, moderately porous, medium to thickly bedded, faintly laminar textured **LIMESTONE** with slump structured bed at 41.53-.91m, thin interbeds of **CALCAREOUS DOLOSTONE** at 42.40-.50m, 44.50-.60m, 44.85-45.02m and 45.02-.32m (laminated texture) and thin to medium beds of medium brown, moderately porous, laminar textured **DOLOSTONE** at 41.91-42.10m (slump structure), 42.10-.40m, 44.60-.67m (medium grey marker bed), 45.32-.54m, 45.54-.82m (massive textured) and 45.82-46.04m. Well developed stylolite at 46.48m.

From 46.58 m to 47.32 m, moderately weathered, light grey to brownish grey, medium to coarse grained crystalline, thinly bedded **GYPSUM** at 46.65-.85m and 47.05-.27m with transitional beds of nodular gypsum in dolostone at 46.58-.65m, 46.85-47.00m and 47.27-.32m and thin bed of medium brown laminar textured dolostone at 47.00-.05m. Gypsum beds are porous-pitted (1-5mm) with open weathered bedding partings and broken core with core loss between 46.70-.75m (possible void). Bedded gypsum is calcareous (fizzes) likely due to calcareous dolostone inclusions from bedding laminations.

From 47.32 m to 50.19 m, faintly weathered, light to medium tan brown, fine grained crystalline, moderately porous, thinly to medium bedded **DOLOSTONE** with thin interbeds of laminar textured **CALCAREOUS DOLOSTONE** at 47.46-.62m and **DOLOMITIC LIMESTONE** at 48.03-.19m, 48.44-.73m (argillaceous bedding partings at 48.48-.49m), 48.90-49.20m and 49.33-.50m.



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DEPTH SCALE

1 : 50

LOGGED: AS/RB

CHECKED:

PROJECT: 1781508

RECORD OF DRILLHOLE: BH17-05

SHEET 6 OF 6

LOCATION: N 4787930.6 ;E 485746.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: November 27-30, 2017

DRILL RIG: Mud Rotary/Track Mounted Acker Soil - Max

DRILLING CONTRACTOR: McLeod Water Wells/Orbit Garant

DATUM: Geodetic

JN - Joint
FLT - Fault
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K - Slickensided
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NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.		COLOUR % RETURN FLUSH	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-4} 10^{-3} 10^{-2} 10^{-1}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		--- CONTINUED FROM PREVIOUS PAGE ---																		
50		Weathered, open dolostone bed at 48.73-.77m. Thin medium grey limestone marker bed at 48.86-.90m with moderately developed stylolite at top contact.		254.17 50.19	25									,PL,Ro ,PL,SM ,PL,SM						
		End of Borehole, 50.19 m																		
		NOTE,																		
51		1. Static water level measured in open borehole at elev. 279.4 m (depth of 25.0 m), cascading water noted in borehole.																		
52																				
53																				
54																				
55																				
56																				
57																				
58																				
59																				
60																				

MIS-RCK 004 1781508 ROCK.GPJ GAL-MISS.GDT 10/31/18 LMK

DEPTH SCALE
1 : 50

LOGGED: AS/RB
CHECKED:

Client: Votorantim Cimentos

Original Format is Tabloid 279mm x 432mm

Drawing file: 1781508-8000-R010B1.dwg Mar 13, 2020 - 1:24pm

LEGEND

– – –	APPROXIMATE LICENSE BOUNDARY
▬	APPROXIMATE CURRENT LIMIT OF EXTRACTION
▬	APPROXIMATE LIMIT OF BONIS PROPERTY
■	TEST PIT

REFERENCE

DRAWING BASED ON 2017 DRONE CAPTURE;
BING IMAGERY AS OF JULY 5, 2017 (IMAGE DATE UNKNOWN); AND
ARCH 2010 SURVEY OF THOMAS ST. QUARRY BY AGM, FILE NAME SM0906T1C3D.DWG, DATED MARCH 2010.
BASE MAP FROM ST. MARYS CEMENT INC.

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

BING IMAGERY USED FOR ILLUSTRATION PURPOSES ONLY AND NOT TO BE USED FOR MEASUREMENTS.

ALL LOCATIONS ARE APPROXIMATE.

PROJECT

THOMAS ST. QUARRY EXPANSION

TITLE

TEST PIT LOCATION PLAN

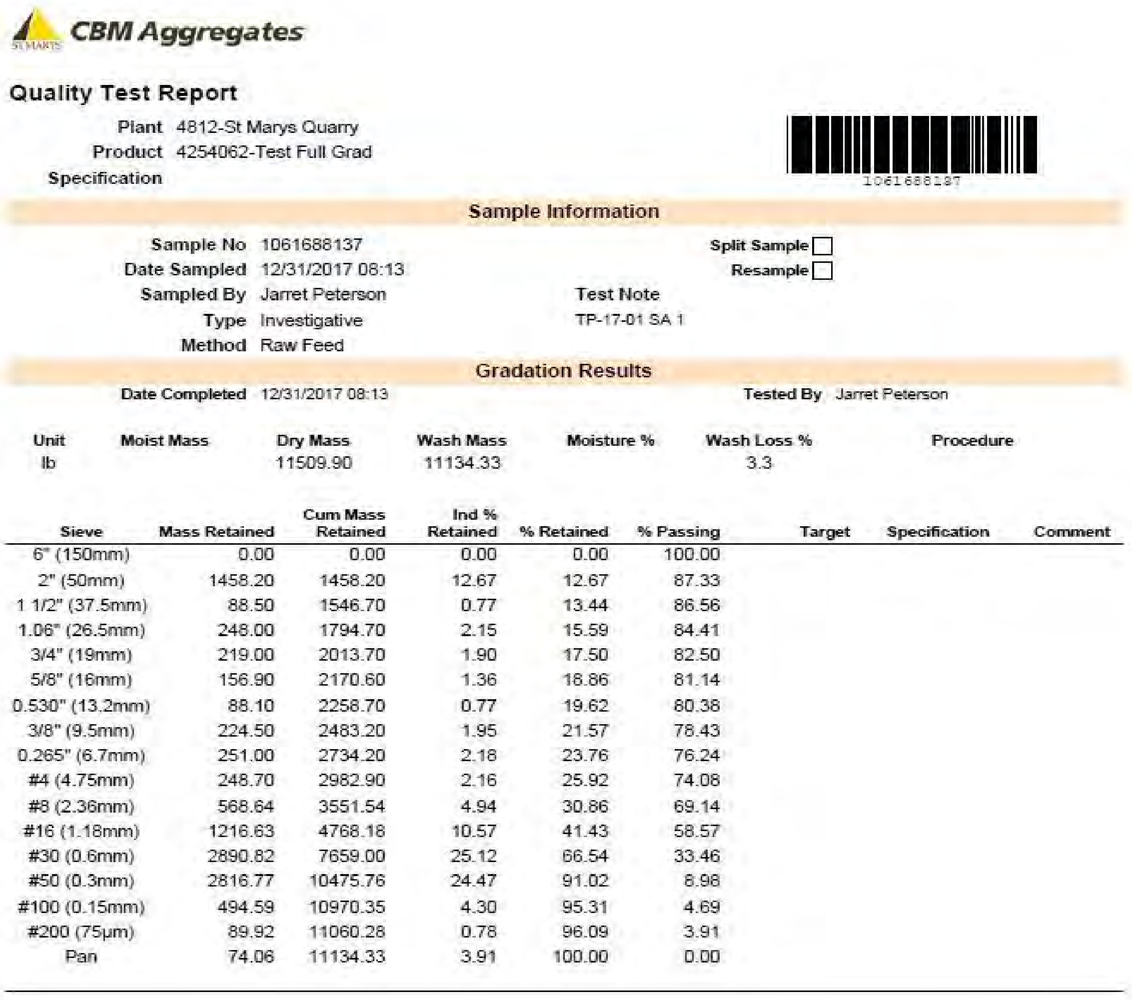
GOLDER

PROJECT No.		1781508	FILE No. 1781508-8000-R010B1	
CADD	DCH/ZJB	Mar 11/20	SCALE AS SHOWN	REV.
CHECK	DH	Mar 11/20	FIGURE B-1	
REVIEWED	DH	Mar 11/20		
APPROVED	SM	Mar 11/20		

Table B.1
Hydraulic Conductivity Estimates from Test Pit Grain Size Curves
Hydrogeology and Hydrology Level 1 and 2 Study
Proposed Thomas Street Quarry Expansion

TP	Sample	Depth (from)	Depth (to)	D10 (mm)	K (m/s)
TP17-01	TP17-01-1	Unknown	Unknown	0.3	9.0E-04
TP17-02	TP17-02-1	1.70	3.00	0.35	1.2E-03
TP17-02	TP17-02-2	3.50	4.30	0.6	3.6E-03
TP17-03	TP17-03-2	3.80	4.60	0.6	3.6E-03
TP17-04	TP17-04-1	1.80	2.80	0.4	1.6E-03
TP17-04	TP17-04-2	3.50	4.50	0.4	1.6E-03
TP17-05	TP17-05-1	0.20	1.00	N/A	-
TP17-05	TP17-05-3	2.00	3.00	0.4	1.6E-03
TP17-06	TP17-06-1	1.80	2.80	N/A	-
TP17-06	TP17-06-2	3.50	4.50	0.3	9.0E-04
TP17-06	TP17-06-3	3.50	4.50	0.1	1.0E-04
TP17-06	TP17-06-4	3.50	4.50	0.65	4.2E-03
TP17-07	TP17-07-1	0.60	1.50	0.45	2.0E-03
TP17-07	TP17-07-2	2.00	3.20	0.65	4.2E-03
TP17-08	TP17-08-1	1.80	2.80	0.65	4.2E-03
TP17-08	TP17-08-3	4.00	5.00	0.7	4.9E-03
TP17-08	TP17-08-4	Unknown	Unknown	0.6	3.6E-03
TP17-09	TP17-09-2	2.00	3.00	0.55	3.0E-03
TP17-09	TP17-09-3	3.50	4.00	0.7	4.9E-03
TP17-10	TP17-10-1	1.20	2.30	0.5	2.5E-03
TP17-10	TP17-10-2	3.00	4.00	0.7	4.9E-03
TP17-11	TP17-11-1	0.35	0.90	N/A	-
TP17-11	TP17-11-2	1.20	2.20	0.6	3.6E-03
TP17-11	TP17-11-3	2.50	3.50	0.5	2.5E-03
TP17-11	TP17-11-4	3.70	4.60	0.65	4.2E-03
TP17-12	TP17-12-1	1.00	2.50	0.55	3.0E-03
TP17-12	TP17-12-2	3.50	4.50	0.7	4.9E-03
TP17-13	TP17-13-1	2.80	4.00	N/A	-
TP17-15	TP17-15-1	0.35	0.90	0.5	2.5E-03
TP17-15	TP17-15-2	1.20	2.20	0.5	2.5E-03
TP17-17	TP17-17-1	2.20	4.00	0.4	1.6E-03
TP17-18	TP17-18-1	2.50	3.50	0.075	5.6E-05
TP17-20	TP17-20-1	2.50	3.50	0.7	4.9E-03
TP17-20	TP17-20-2	4.50	4.80	0.7	4.9E-03

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1061688137

Sample Information

Sample No 1061688137
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐
Test Note TP-17-01 SA 1

Gradation Results

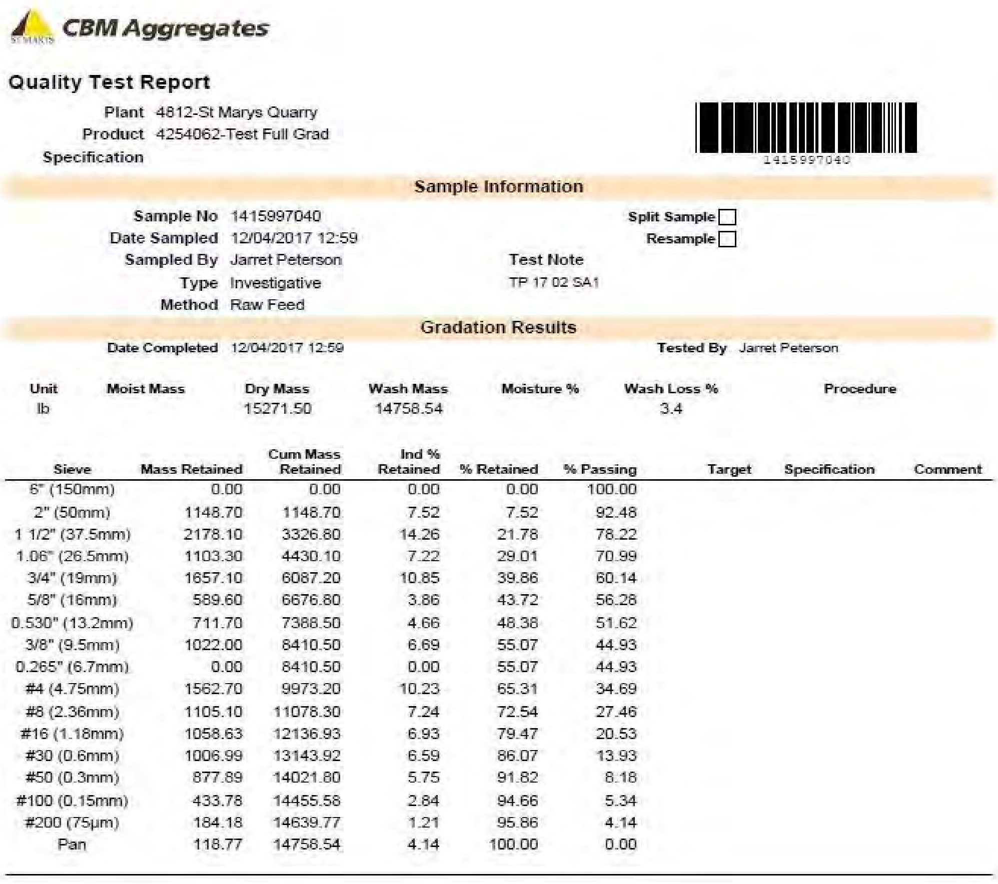
Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		11509.90	11134.33		3.3	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	1458.20	1458.20	12.67	12.67	87.33			
1 1/2" (37.5mm)	88.50	1546.70	0.77	13.44	86.56			
1.06" (26.5mm)	248.00	1794.70	2.15	15.59	84.41			
3/4" (19mm)	219.00	2013.70	1.90	17.50	82.50			
5/8" (16mm)	156.90	2170.60	1.36	18.86	81.14			
0.530" (13.2mm)	88.10	2258.70	0.77	19.62	80.38			
3/8" (9.5mm)	224.50	2483.20	1.95	21.57	78.43			
0.265" (6.7mm)	251.00	2734.20	2.18	23.76	76.24			
#4 (4.75mm)	248.70	2982.90	2.16	25.92	74.08			
#8 (2.36mm)	568.64	3551.54	4.94	30.86	69.14			
#16 (1.18mm)	1216.63	4768.18	10.57	41.43	58.57			
#30 (0.6mm)	2890.82	7659.00	25.12	66.54	33.46			
#50 (0.3mm)	2816.77	10475.76	24.47	91.02	8.98			
#100 (0.15mm)	494.59	10970.35	4.30	95.31	4.69			
#200 (75μm)	89.92	11060.28	0.78	96.09	3.91			
Pan	74.06	11134.33	3.91	100.00	0.00			

FM=2.64

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415997040

Sample Information

Sample No 1415997040
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 02 SA1

Gradation Results

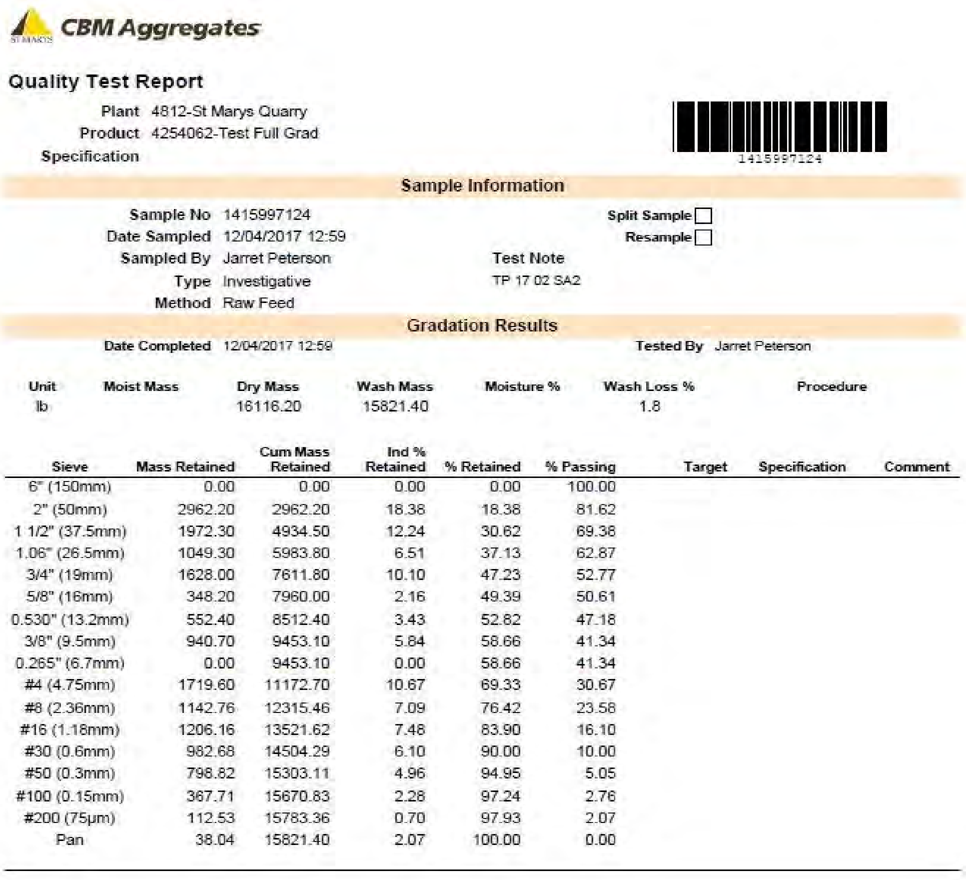
Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		15271.50	14758.54		3.4	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	1148.70	1148.70	7.52	7.52	92.48			
1 1/2" (37.5mm)	2178.10	3326.80	14.26	21.78	78.22			
1.06" (26.5mm)	1103.30	4430.10	7.22	29.01	70.99			
3/4" (19mm)	1657.10	6087.20	10.85	39.86	60.14			
5/8" (16mm)	589.60	6676.80	3.86	43.72	56.28			
0.530" (13.2mm)	711.70	7388.50	4.66	48.38	51.62			
3/8" (9.5mm)	1022.00	8410.50	6.69	55.07	44.93			
0.265" (6.7mm)	0.00	8410.50	0.00	55.07	44.93			
#4 (4.75mm)	1562.70	9973.20	10.23	65.31	34.69			
#8 (2.36mm)	1105.10	11078.30	7.24	72.54	27.46			
#16 (1.18mm)	1058.63	12136.93	6.93	79.47	20.53			
#30 (0.6mm)	1006.99	13143.92	6.59	86.07	13.93			
#50 (0.3mm)	877.89	14021.80	5.75	91.82	8.18			
#100 (0.15mm)	433.78	14455.58	2.84	94.66	5.34			
#200 (75µm)	184.18	14639.77	1.21	95.86	4.14			
Pan	118.77	14758.54	4.14	100.00	0.00			

FM = 2.83

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415997124

Sample Information

Sample No 1415997124
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 02 SA2

Gradation Results

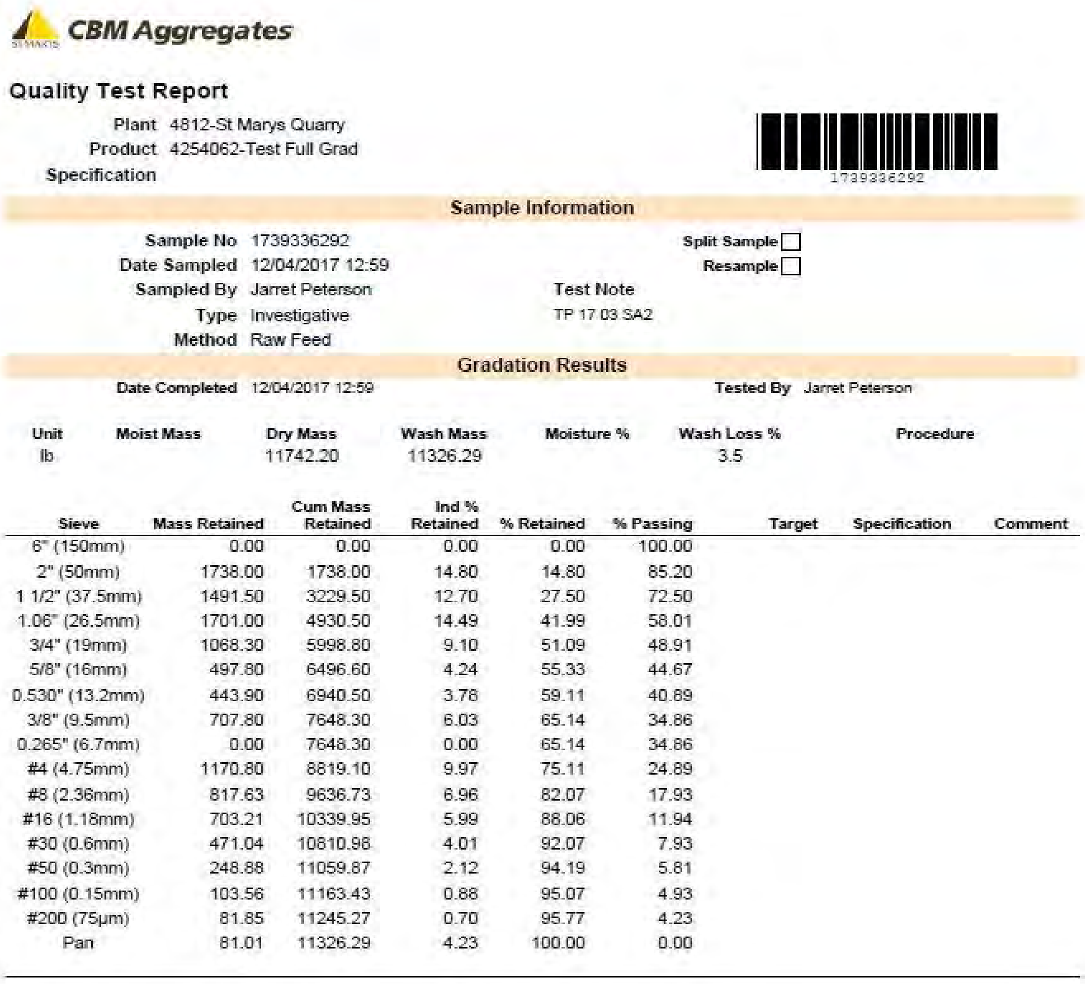
Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		16116.20	15821.40		1.8	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	2962.20	2962.20	18.38	18.38	81.62			
1 1/2" (37.5mm)	1972.30	4934.50	12.24	30.62	69.38			
1.06" (26.5mm)	1049.30	5983.80	6.51	37.13	62.87			
3/4" (19mm)	1628.00	7611.80	10.10	47.23	52.77			
5/8" (16mm)	348.20	7960.00	2.16	49.39	50.61			
0.530" (13.2mm)	552.40	8512.40	3.43	52.82	47.18			
3/8" (9.5mm)	940.70	9453.10	5.84	58.66	41.34			
0.265" (6.7mm)	0.00	9453.10	0.00	58.66	41.34			
#4 (4.75mm)	1719.60	11172.70	10.67	69.33	30.67			
#8 (2.36mm)	1142.76	12315.46	7.09	76.42	23.58			
#16 (1.18mm)	1206.16	13521.62	7.48	83.90	16.10			
#30 (0.6mm)	982.68	14504.29	6.10	90.00	10.00			
#50 (0.3mm)	798.82	15303.11	4.96	94.95	5.05			
#100 (0.15mm)	367.71	15670.83	2.28	97.24	2.76			
#200 (75µm)	112.53	15783.36	0.70	97.93	2.07			
Pan	38.04	15821.40	2.07	100.00	0.00			

FM = 3.13

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1739336292

Sample Information

Sample No 1739336292
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 03 SA2

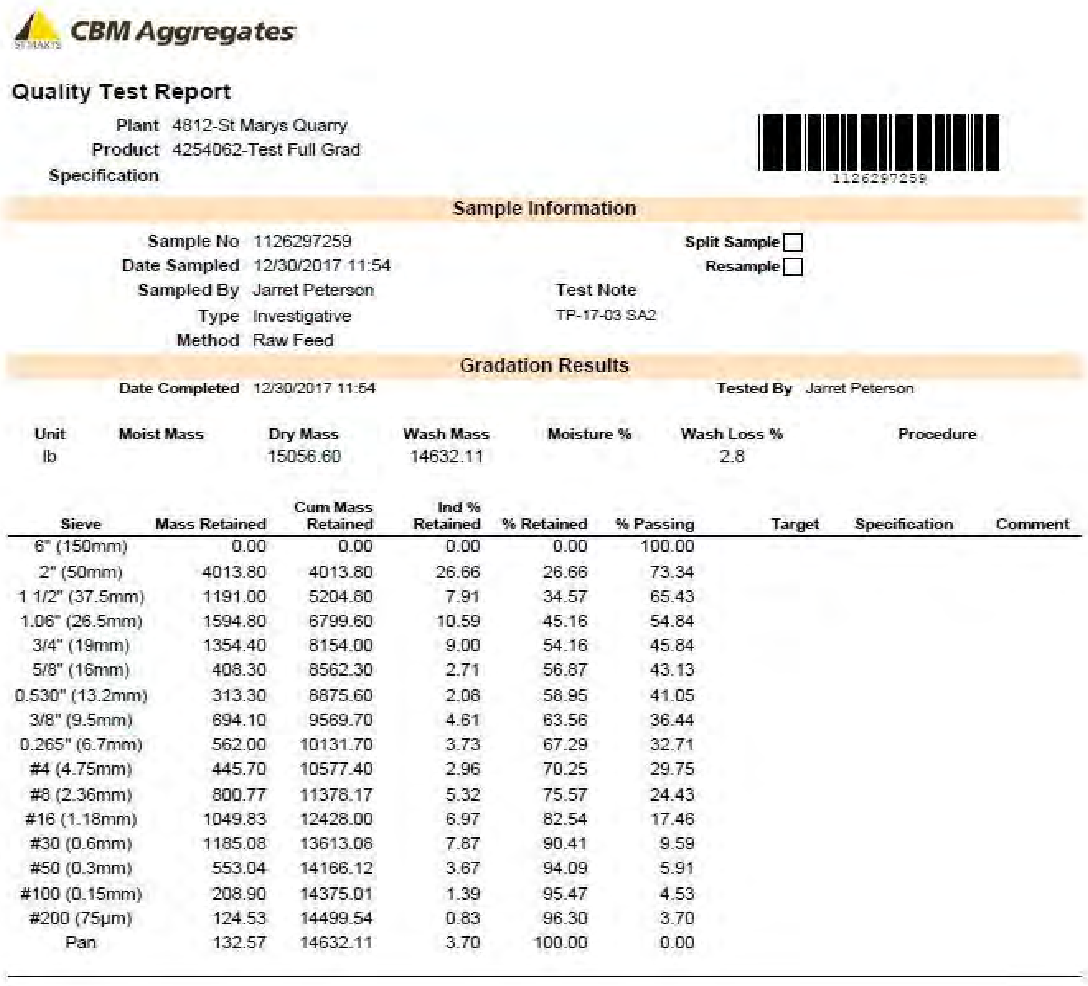
Gradation Results

Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		11742.20	11326.29		3.5	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	1738.00	1738.00	14.80	14.80	85.20			
1 1/2" (37.5mm)	1491.50	3229.50	12.70	27.50	72.50			
1.06" (26.5mm)	1701.00	4930.50	14.49	41.99	58.01			
3/4" (19mm)	1068.30	5998.80	9.10	51.09	48.91			
5/8" (16mm)	497.80	6496.60	4.24	55.33	44.67			
0.530" (13.2mm)	443.90	6940.50	3.78	59.11	40.89			
3/8" (9.5mm)	707.80	7648.30	6.03	65.14	34.86			
0.265" (6.7mm)	0.00	7648.30	0.00	65.14	34.86			
#4 (4.75mm)	1170.80	8819.10	9.97	75.11	24.89			
#8 (2.36mm)	817.63	9636.73	6.96	82.07	17.93			
#16 (1.18mm)	703.21	10339.95	5.99	88.06	11.94			
#30 (0.6mm)	471.04	10810.98	4.01	92.07	7.93			
#50 (0.3mm)	248.88	11059.87	2.12	94.19	5.81			
#100 (0.15mm)	103.56	11163.43	0.88	95.07	4.93			
#200 (75µm)	81.85	11245.27	0.70	95.77	4.23			
Pan	81.01	11326.29	4.23	100.00	0.00			

FM = 3.05



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1126297259

Sample Information

Sample No 1126297259
Date Sampled 12/30/2017 11:54
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-03 SA2

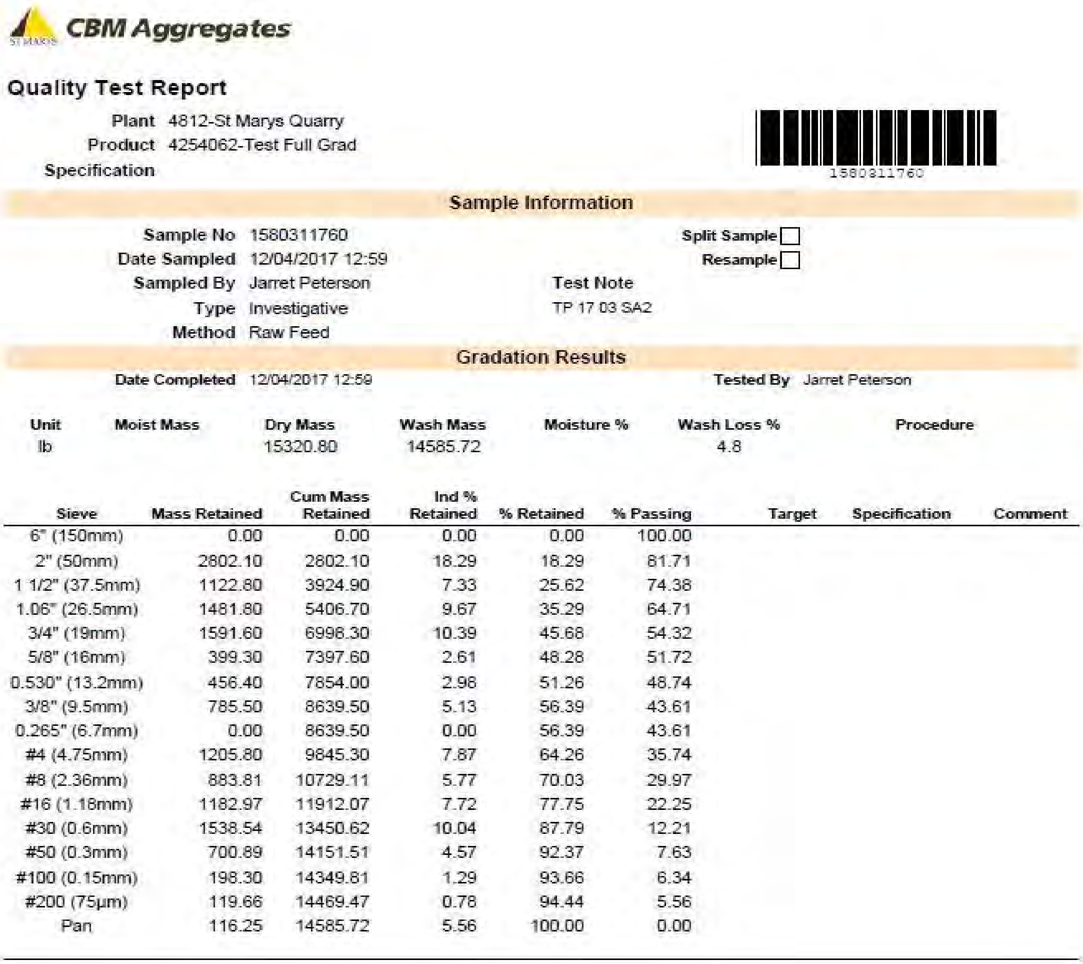
Gradation Results

Date Completed 12/30/2017 11:54
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		15056.60	14632.11		2.8	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	4013.80	4013.80	26.66	26.66	73.34			
1 1/2" (37.5mm)	1191.00	5204.80	7.91	34.57	65.43			
1.06" (26.5mm)	1594.80	6799.60	10.59	45.16	54.84			
3/4" (19mm)	1354.40	8154.00	9.00	54.16	45.84			
5/8" (16mm)	408.30	8562.30	2.71	56.87	43.13			
0.530" (13.2mm)	313.30	8875.60	2.08	58.95	41.05			
3/8" (9.5mm)	694.10	9569.70	4.61	63.56	36.44			
0.265" (6.7mm)	562.00	10131.70	3.73	67.29	32.71			
#4 (4.75mm)	445.70	10577.40	2.96	70.25	29.75			
#8 (2.36mm)	800.77	11378.17	5.32	75.57	24.43			
#16 (1.18mm)	1049.83	12428.00	6.97	82.54	17.46			
#30 (0.6mm)	1185.08	13613.08	7.87	90.41	9.59			
#50 (0.3mm)	553.04	14166.12	3.67	94.09	5.91			
#100 (0.15mm)	208.90	14375.01	1.39	95.47	4.53			
#200 (75µm)	124.53	14499.54	0.83	96.30	3.70			
Pan	132.57	14632.11	3.70	100.00	0.00			

FM = 2.92



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1580311760

Sample Information

Sample No 1580311760
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 03 SA2

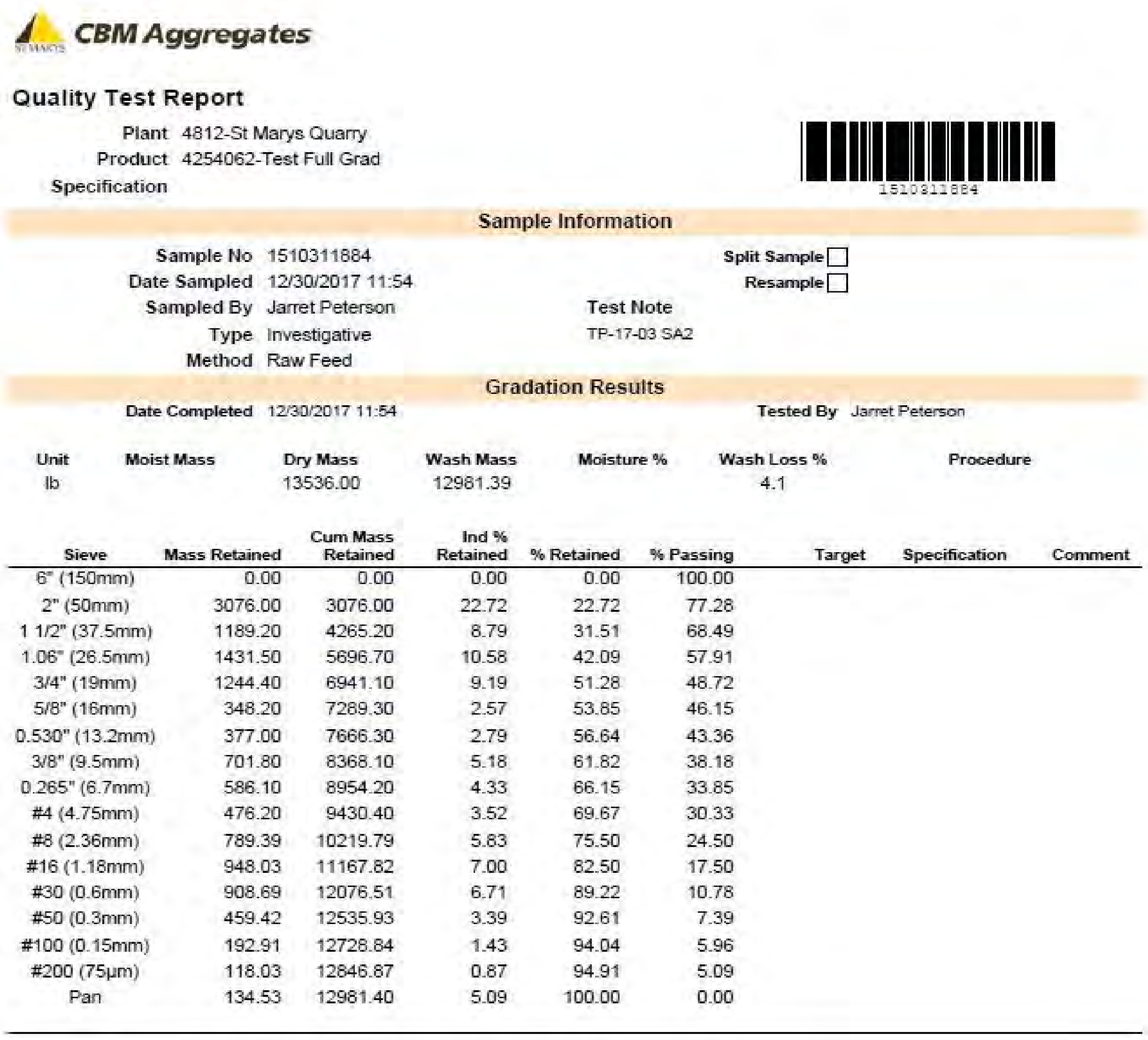
Gradation Results

Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		15320.80	14585.72		4.8	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	2802.10	2802.10	18.29	18.29	81.71			
1 1/2" (37.5mm)	1122.80	3924.90	7.33	25.62	74.38			
1.06" (26.5mm)	1481.80	5406.70	9.67	35.29	64.71			
3/4" (19mm)	1591.60	6998.30	10.39	45.68	54.32			
5/8" (16mm)	399.30	7397.60	2.61	48.28	51.72			
0.530" (13.2mm)	456.40	7854.00	2.98	51.26	48.74			
3/8" (9.5mm)	785.50	8639.50	5.13	56.39	43.61			
0.265" (6.7mm)	0.00	8639.50	0.00	56.39	43.61			
#4 (4.75mm)	1205.80	9845.30	7.87	64.26	35.74			
#8 (2.36mm)	883.81	10729.11	5.77	70.03	29.97			
#16 (1.18mm)	1182.97	11912.07	7.72	77.75	22.25			
#30 (0.6mm)	1538.54	13450.62	10.04	87.79	12.21			
#50 (0.3mm)	700.89	14151.51	4.57	92.37	7.63			
#100 (0.15mm)	198.30	14349.81	1.29	93.66	6.34			
#200 (75µm)	119.66	14469.47	0.78	94.44	5.56			
Pan	116.25	14585.72	5.56	100.00	0.00			

FM = 2.81



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1510311884

Sample Information

Sample No 1510311884
Date Sampled 12/30/2017 11:54
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-03 SA2

Gradation Results

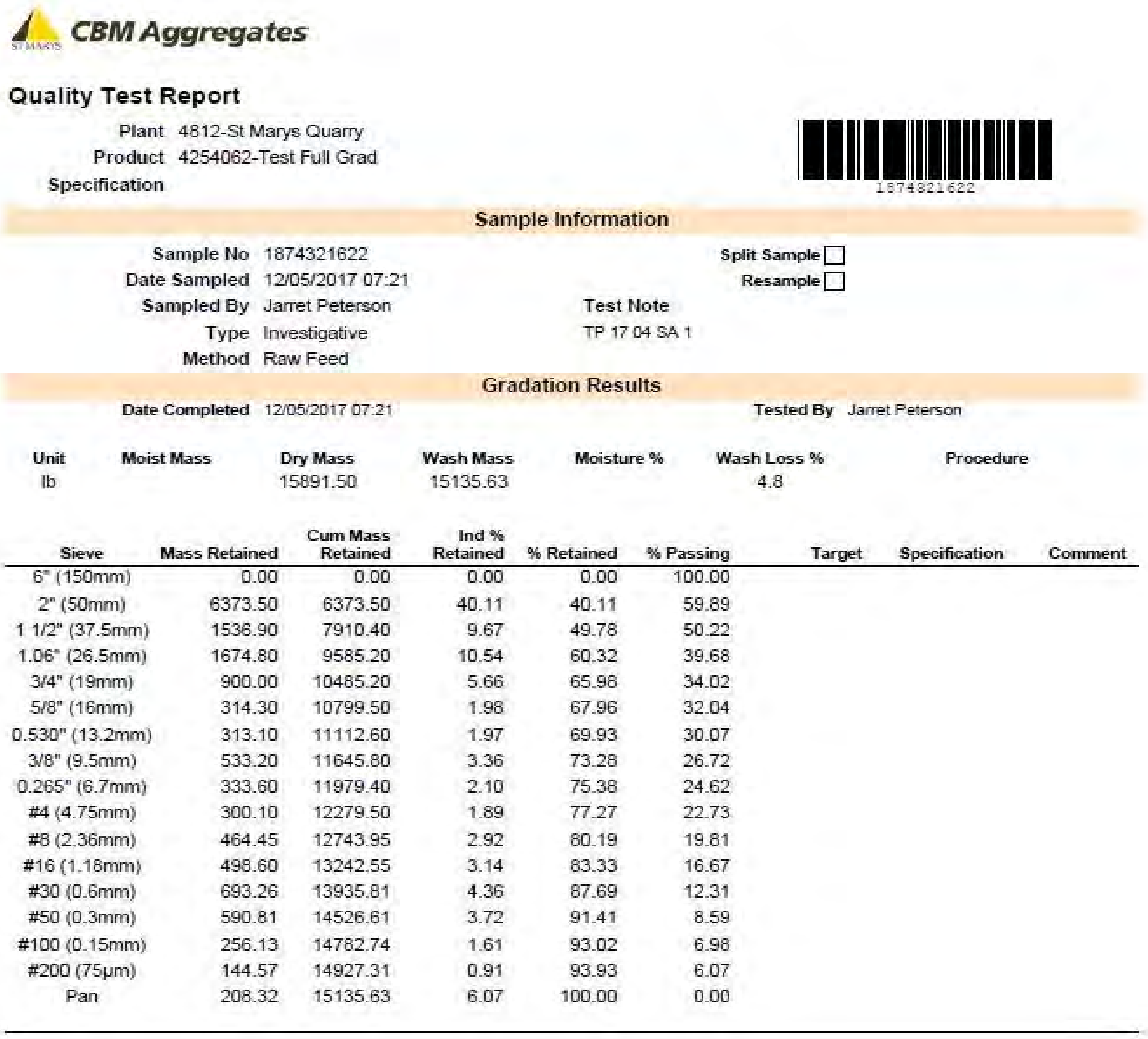
Date Completed 12/30/2017 11:54
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		13536.00	12981.39		4.1	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3076.00	3076.00	22.72	22.72	77.28			
1 1/2" (37.5mm)	1189.20	4265.20	8.79	31.51	68.49			
1.06" (26.5mm)	1431.50	5696.70	10.58	42.09	57.91			
3/4" (19mm)	1244.40	6941.10	9.19	51.28	48.72			
5/8" (16mm)	348.20	7289.30	2.57	53.85	46.15			
0.530" (13.2mm)	377.00	7666.30	2.79	56.64	43.36			
3/8" (9.5mm)	701.80	8368.10	5.18	61.82	38.18			
0.265" (6.7mm)	586.10	8954.20	4.33	66.15	33.85			
#4 (4.75mm)	476.20	9430.40	3.52	69.67	30.33			
#8 (2.36mm)	789.39	10219.79	5.83	75.50	24.50			
#16 (1.18mm)	948.03	11167.82	7.00	82.50	17.50			
#30 (0.6mm)	908.69	12076.51	6.71	89.22	10.78			
#50 (0.3mm)	459.42	12535.93	3.39	92.61	7.39			
#100 (0.15mm)	192.91	12728.84	1.43	94.04	5.96			
#200 (75µm)	118.03	12846.87	0.87	94.91	5.09			
Pan	134.53	12981.40	5.09	100.00	0.00			

FM = 2.82

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1874321622

Sample Information

Sample No 1874321622
Date Sampled 12/05/2017 07:21
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 04 SA 1

Gradation Results

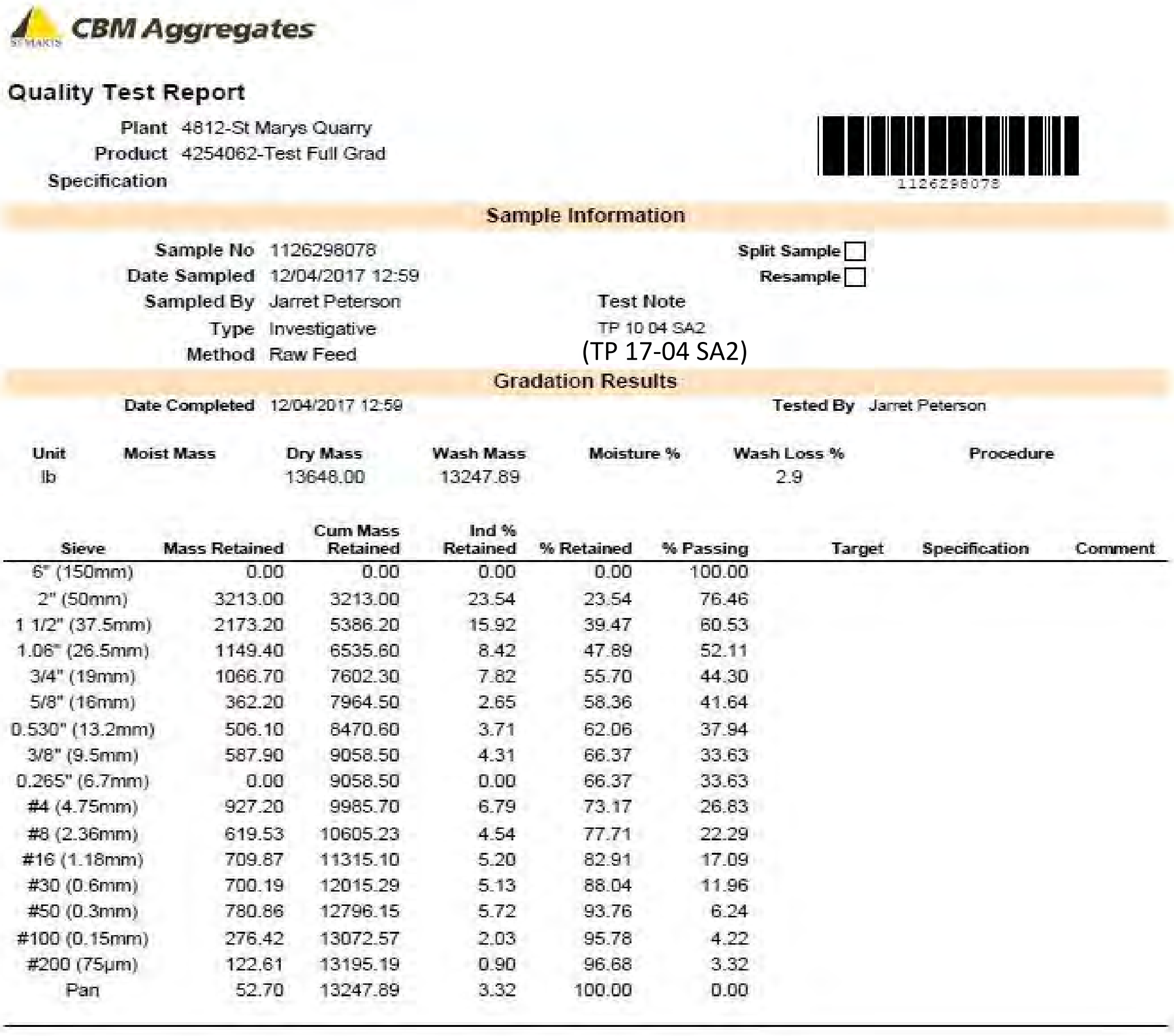
Date Completed 12/05/2017 07:21
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		15891.50	15135.63		4.8	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	6373.50	6373.50	40.11	40.11	59.89			
1 1/2" (37.5mm)	1536.90	7910.40	9.67	49.78	50.22			
1.06" (26.5mm)	1674.80	9585.20	10.54	60.32	39.68			
3/4" (19mm)	900.00	10485.20	5.66	65.98	34.02			
5/8" (16mm)	314.30	10799.50	1.98	67.96	32.04			
0.530" (13.2mm)	313.10	11112.60	1.97	69.93	30.07			
3/8" (9.5mm)	533.20	11645.80	3.36	73.28	26.72			
0.265" (6.7mm)	333.60	11979.40	2.10	75.38	24.62			
#4 (4.75mm)	300.10	12279.50	1.89	77.27	22.73			
#8 (2.36mm)	464.45	12743.95	2.92	80.19	19.81			
#16 (1.18mm)	498.60	13242.55	3.14	83.33	16.67			
#30 (0.6mm)	693.26	13935.81	4.36	87.69	12.31			
#50 (0.3mm)	590.81	14526.61	3.72	91.41	8.59			
#100 (0.15mm)	256.13	14782.74	1.61	93.02	6.98			
#200 (75µm)	144.57	14927.31	0.91	93.93	6.07			
Pan	208.32	15135.63	6.07	100.00	0.00			

FM = 2.17

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1126298078

Sample Information

Sample No 1126298078
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 10 04 SA2
(TP 17-04 SA2)

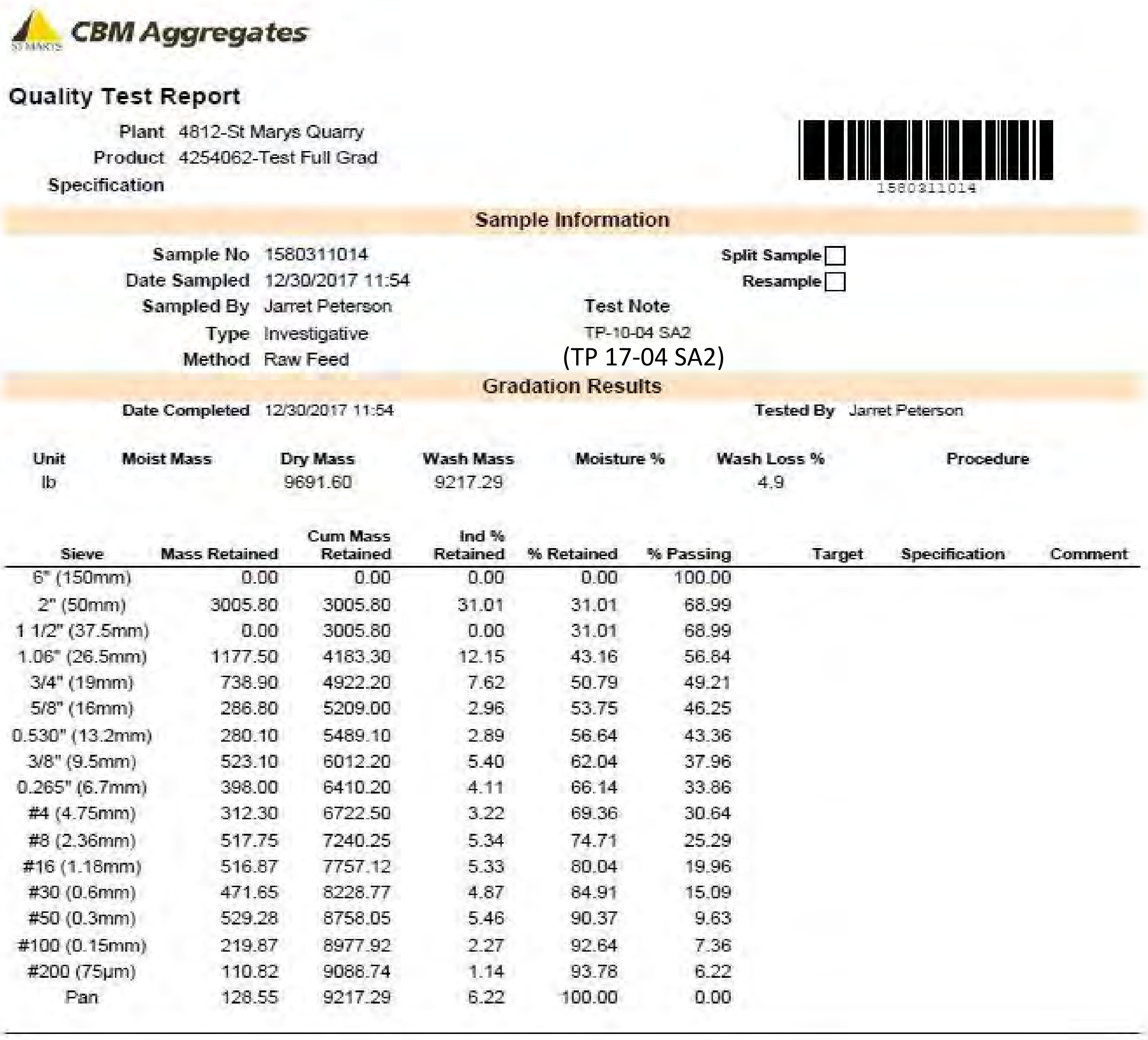
Gradation Results

Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		13648.00	13247.89		2.9	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3213.00	3213.00	23.54	23.54	76.46			
1 1/2" (37.5mm)	2173.20	5386.20	15.92	39.47	60.53			
1.06" (26.5mm)	1149.40	6535.60	8.42	47.89	52.11			
3/4" (19mm)	1066.70	7602.30	7.82	55.70	44.30			
5/8" (16mm)	362.20	7964.50	2.65	58.36	41.64			
0.530" (13.2mm)	506.10	8470.60	3.71	62.06	37.94			
3/8" (9.5mm)	587.90	9058.50	4.31	66.37	33.63			
0.265" (6.7mm)	0.00	9058.50	0.00	66.37	33.63			
#4 (4.75mm)	927.20	9985.70	6.79	73.17	26.83			
#8 (2.36mm)	619.53	10605.23	4.54	77.71	22.29			
#16 (1.18mm)	709.87	11315.10	5.20	82.91	17.09			
#30 (0.6mm)	700.19	12015.29	5.13	88.04	11.96			
#50 (0.3mm)	780.86	12796.15	5.72	93.76	6.24			
#100 (0.15mm)	276.42	13072.57	2.03	95.78	4.22			
#200 (75µm)	122.61	13195.19	0.90	96.68	3.32			
Pan	52.70	13247.89	3.32	100.00	0.00			

FM = 2.70



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1580311014

Sample Information

Sample No 1580311014
Date Sampled 12/30/2017 11:54
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-10-04 SA2
(TP 17-04 SA2)

Gradation Results

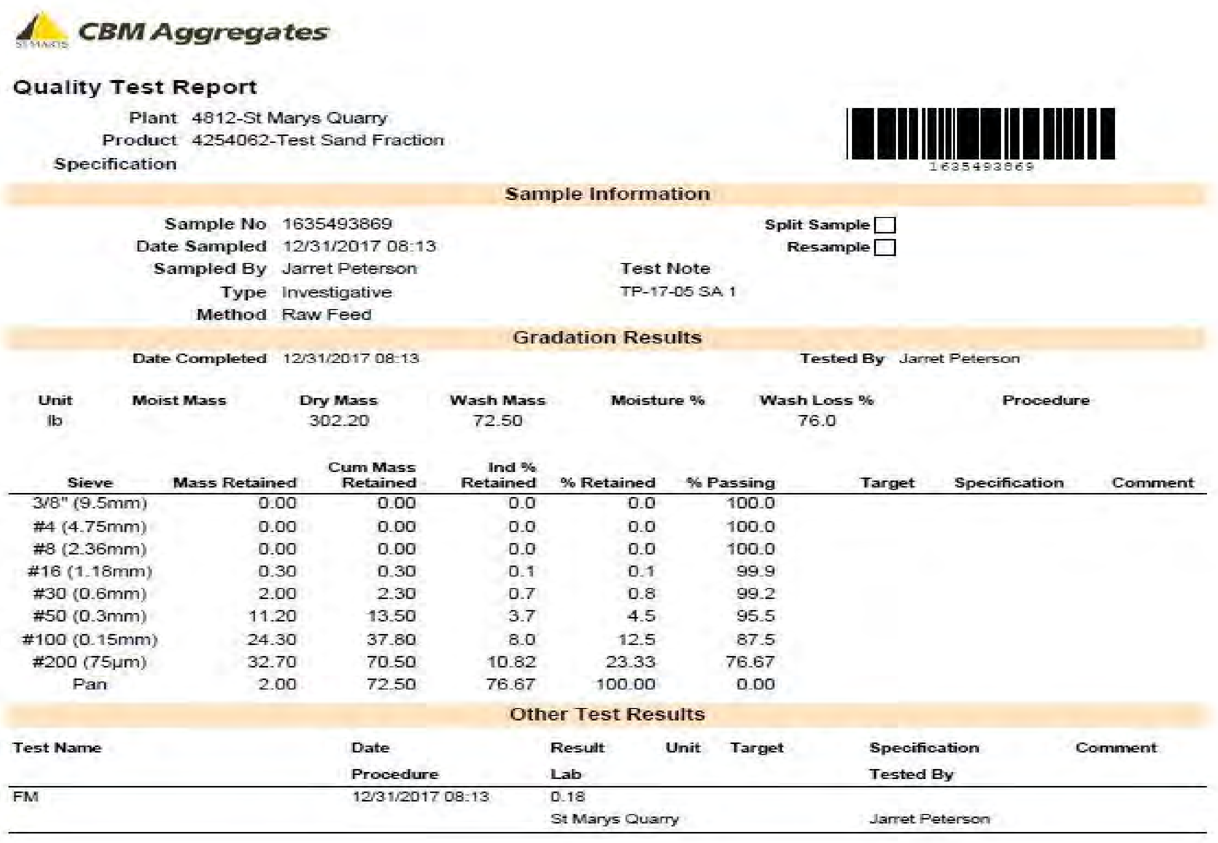
Date Completed 12/30/2017 11:54
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		9691.60	9217.29		4.9	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3005.80	3005.80	31.01	31.01	68.99			
1 1/2" (37.5mm)	0.00	3005.80	0.00	31.01	68.99			
1.06" (26.5mm)	1177.50	4183.30	12.15	43.16	56.84			
3/4" (19mm)	738.90	4922.20	7.62	50.79	49.21			
5/8" (16mm)	286.80	5209.00	2.96	53.75	46.25			
0.530" (13.2mm)	280.10	5489.10	2.89	56.64	43.36			
3/8" (9.5mm)	523.10	6012.20	5.40	62.04	37.96			
0.265" (6.7mm)	398.00	6410.20	4.11	66.14	33.86			
#4 (4.75mm)	312.30	6722.50	3.22	69.36	30.64			
#8 (2.36mm)	517.75	7240.25	5.34	74.71	25.29			
#16 (1.18mm)	516.87	7757.12	5.33	80.04	19.96			
#30 (0.6mm)	471.65	8228.77	4.87	84.91	15.09			
#50 (0.3mm)	529.28	8758.05	5.46	90.37	9.63			
#100 (0.15mm)	219.87	8977.92	2.27	92.64	7.36			
#200 (75µm)	110.82	9088.74	1.14	93.78	6.22			
Pan	128.55	9217.29	6.22	100.00	0.00			

FM = 2.48

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Sand Fraction
Specification

1635493869

Sample Information

Sample No 1635493869
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-05 SA 1

Gradation Results

Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		302.20	72.50		76.0	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
3/8" (9.5mm)	0.00	0.00	0.0	0.0	100.0			
#4 (4.75mm)	0.00	0.00	0.0	0.0	100.0			
#8 (2.36mm)	0.00	0.00	0.0	0.0	100.0			
#16 (1.18mm)	0.30	0.30	0.1	0.1	99.9			
#30 (0.6mm)	2.00	2.30	0.7	0.8	99.2			
#50 (0.3mm)	11.20	13.50	3.7	4.5	95.5			
#100 (0.15mm)	24.30	37.80	8.0	12.5	87.5			
#200 (75μm)	32.70	70.50	10.82	23.33	76.67			
Pan	2.00	72.50	76.67	100.00	0.00			

Other Test Results

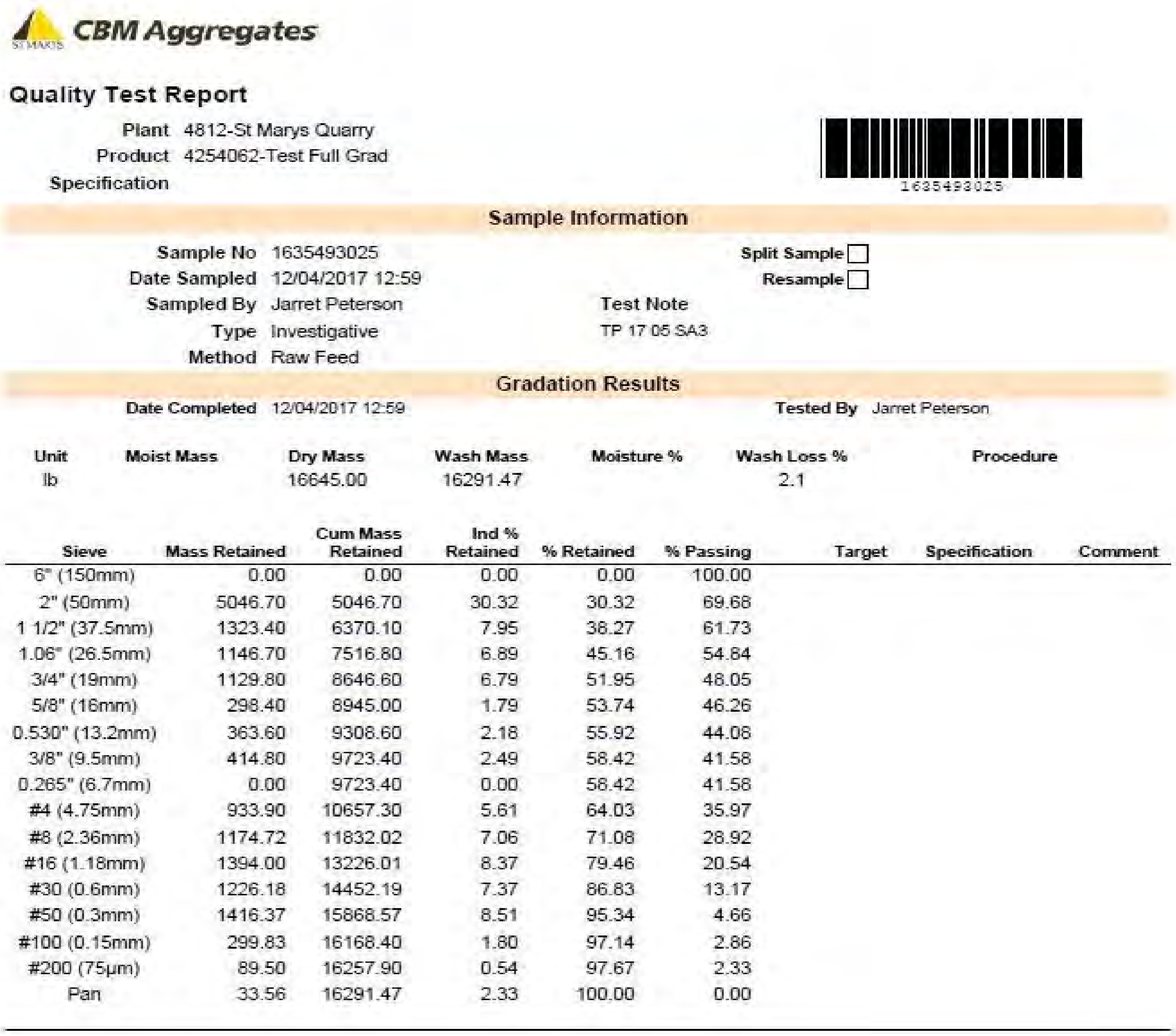
Test Name	Date Procedure	Result Lab	Unit	Target	Specification Tested By	Comment
FM	12/31/2017 08:13	0.18 St Marys Quarry			Jarret Peterson	

FM = 0.18

Sample 2

Clay, Unable to run

Sample 3



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1635493025

Sample Information

Sample No 1635493025
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 05 SA3

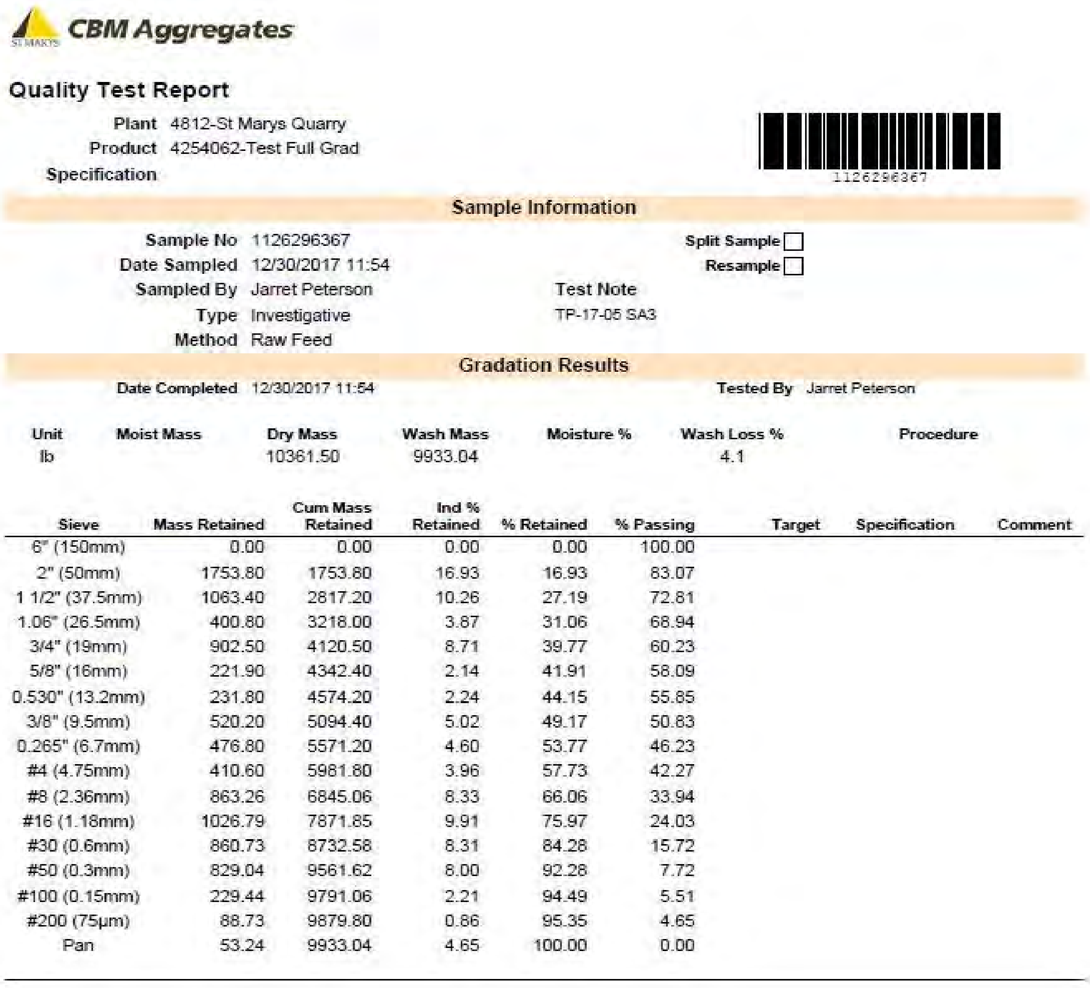
Gradation Results

Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		16645.00	16291.47		2.1	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	5046.70	5046.70	30.32	30.32	69.68			
1 1/2" (37.5mm)	1323.40	6370.10	7.95	38.27	61.73			
1.06" (26.5mm)	1146.70	7516.80	6.89	45.16	54.84			
3/4" (19mm)	1129.80	8646.60	6.79	51.95	48.05			
5/8" (16mm)	298.40	8945.00	1.79	53.74	46.26			
0.530" (13.2mm)	363.60	9308.60	2.18	55.92	44.08			
3/8" (9.5mm)	414.80	9723.40	2.49	58.42	41.58			
0.265" (6.7mm)	0.00	9723.40	0.00	58.42	41.58			
#4 (4.75mm)	933.90	10657.30	5.61	64.03	35.97			
#8 (2.36mm)	1174.72	11832.02	7.06	71.08	28.92			
#16 (1.18mm)	1394.00	13226.01	8.37	79.46	20.54			
#30 (0.6mm)	1226.18	14452.19	7.37	86.83	13.17			
#50 (0.3mm)	1416.37	15868.57	8.51	95.34	4.66			
#100 (0.15mm)	299.83	16168.40	1.80	97.14	2.86			
#200 (75µm)	89.50	16257.90	0.54	97.67	2.33			
Pan	33.56	16291.47	2.33	100.00	0.00			

FM = 3.05



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1126296367

Sample Information

Sample No 1126296367
Date Sampled 12/30/2017 11:54
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-05 SA3

Gradation Results

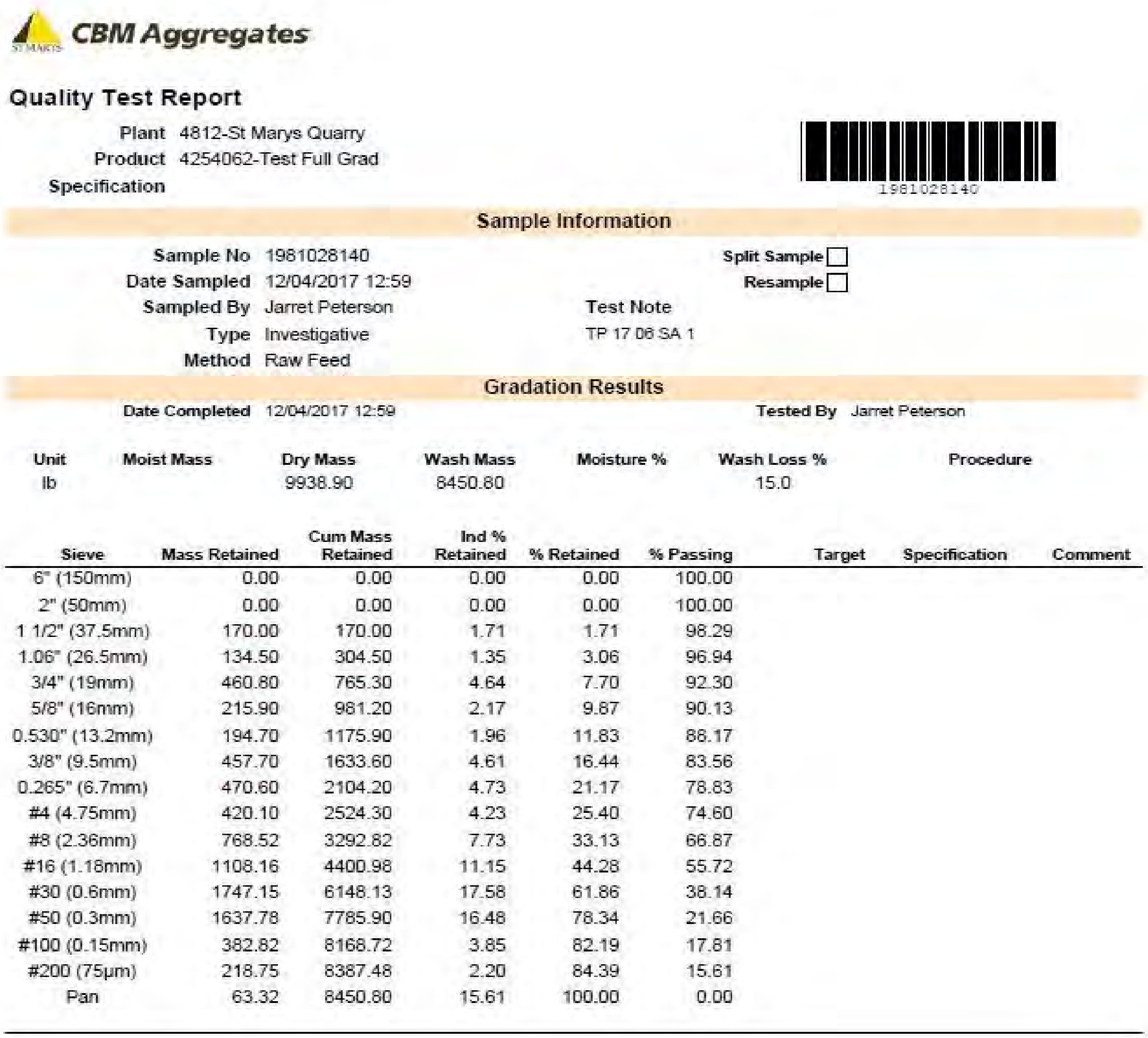
Date Completed 12/30/2017 11:54
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		10361.50	9933.04		4.1	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	1753.80	1753.80	16.93	16.93	83.07			
1 1/2" (37.5mm)	1063.40	2817.20	10.26	27.19	72.81			
1.06" (26.5mm)	400.80	3218.00	3.87	31.06	68.94			
3/4" (19mm)	902.50	4120.50	8.71	39.77	60.23			
5/8" (16mm)	221.90	4342.40	2.14	41.91	58.09			
0.530" (13.2mm)	231.80	4574.20	2.24	44.15	55.85			
3/8" (9.5mm)	520.20	5094.40	5.02	49.17	50.83			
0.265" (6.7mm)	476.80	5571.20	4.60	53.77	46.23			
#4 (4.75mm)	410.60	5981.80	3.96	57.73	42.27			
#8 (2.36mm)	863.26	6845.06	8.33	66.06	33.94			
#16 (1.18mm)	1026.79	7871.85	9.91	75.97	24.03			
#30 (0.6mm)	860.73	8732.58	8.31	84.28	15.72			
#50 (0.3mm)	829.04	9561.62	8.00	92.28	7.72			
#100 (0.15mm)	229.44	9791.06	2.21	94.49	5.51			
#200 (75µm)	88.73	9879.80	0.86	95.35	4.65			
Pan	53.24	9933.04	4.65	100.00	0.00			

FM = 2.94

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1981028140

Sample Information

Sample No 1981028140
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 06 SA 1

Gradation Results

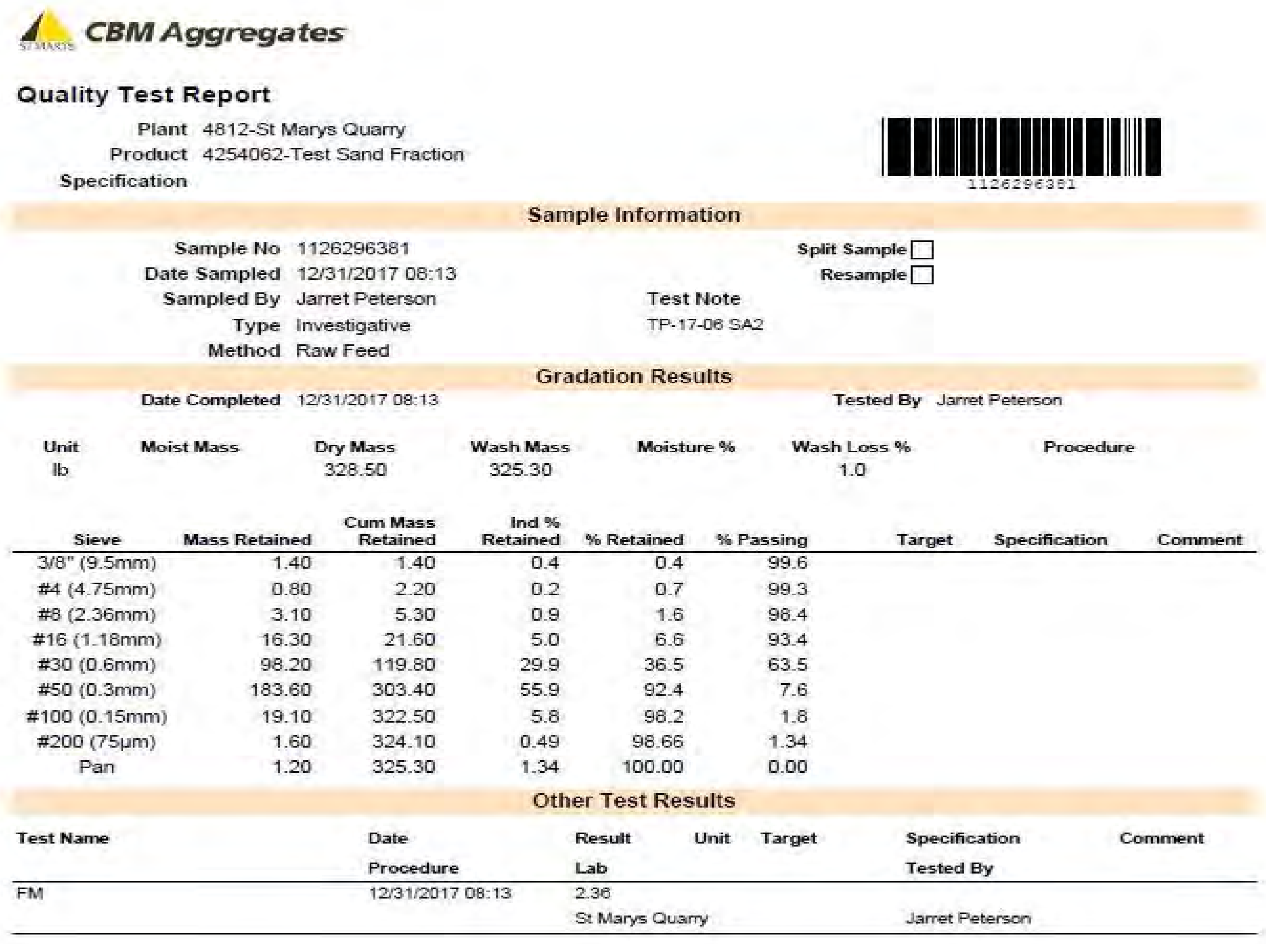
Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		9938.90	8450.80		15.0	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	0.00	0.00	0.00	0.00	100.00			
1 1/2" (37.5mm)	170.00	170.00	1.71	1.71	98.29			
1.06" (26.5mm)	134.50	304.50	1.35	3.06	96.94			
3/4" (19mm)	460.80	765.30	4.64	7.70	92.30			
5/8" (16mm)	215.90	981.20	2.17	9.87	90.13			
0.530" (13.2mm)	194.70	1175.90	1.96	11.83	88.17			
3/8" (9.5mm)	457.70	1633.60	4.61	16.44	83.56			
0.265" (6.7mm)	470.60	2104.20	4.73	21.17	78.83			
#4 (4.75mm)	420.10	2524.30	4.23	25.40	74.60			
#8 (2.36mm)	768.52	3292.82	7.73	33.13	66.87			
#16 (1.18mm)	1108.16	4400.98	11.15	44.28	55.72			
#30 (0.6mm)	1747.15	6148.13	17.58	61.86	38.14			
#50 (0.3mm)	1637.78	7785.90	16.48	78.34	21.66			
#100 (0.15mm)	382.82	8168.72	3.85	82.19	17.81			
#200 (75μm)	218.75	8387.48	2.20	84.39	15.61			
Pan	63.32	8450.80	15.61	100.00	0.00			

FM = 2.32

Sample 2



CBM Aggregates

ST MARYS

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Sand Fraction
Specification

1126296381

Sample Information

Sample No 1126296381
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-06 SA2

Gradation Results

Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		328.50	325.30		1.0	

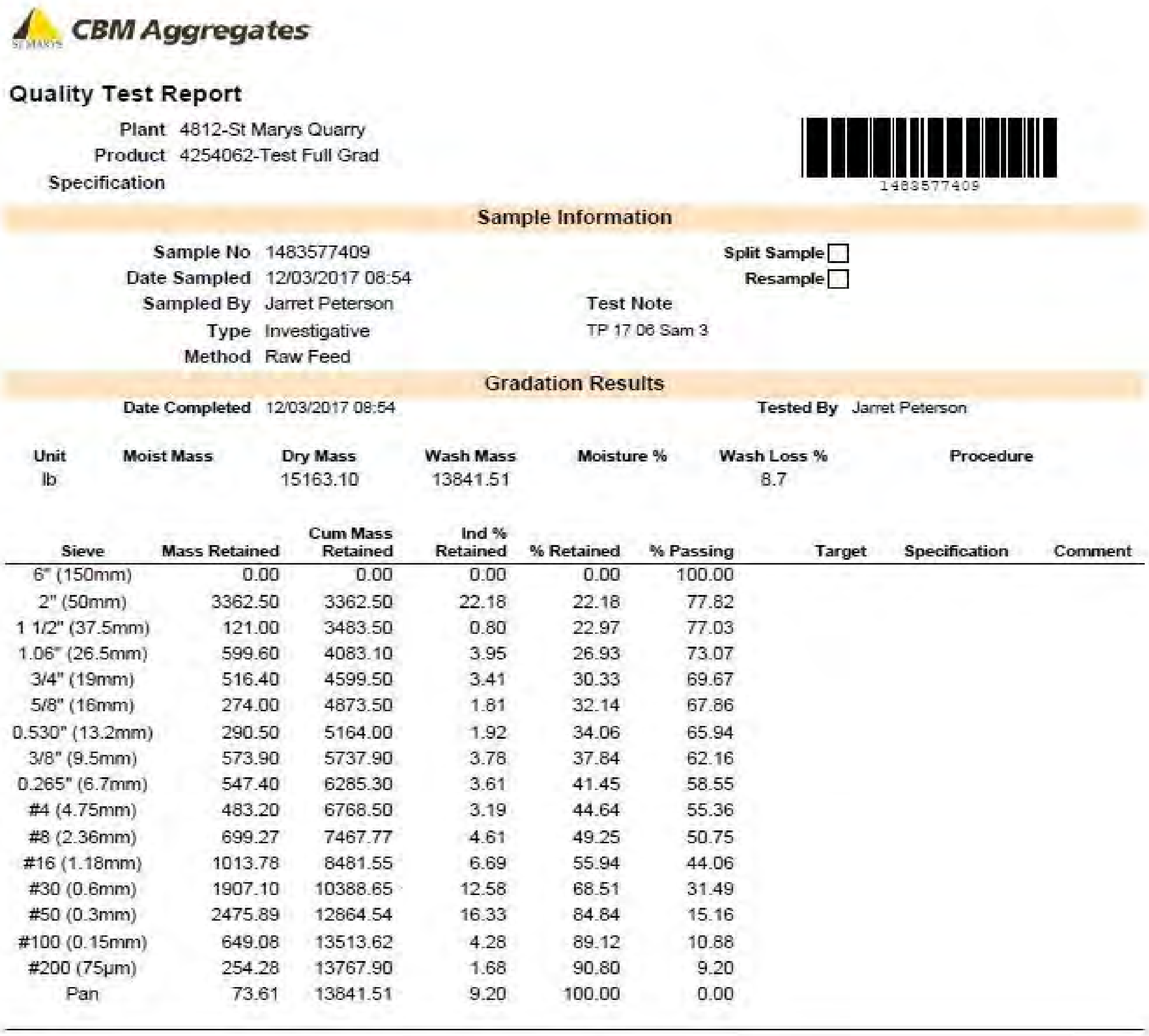
Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
3/8" (9.5mm)	1.40	1.40	0.4	0.4	99.6			
#4 (4.75mm)	0.80	2.20	0.2	0.7	99.3			
#8 (2.36mm)	3.10	5.30	0.9	1.6	98.4			
#16 (1.18mm)	16.30	21.60	5.0	6.6	93.4			
#30 (0.6mm)	98.20	119.80	29.9	36.5	63.5			
#50 (0.3mm)	183.60	303.40	55.9	92.4	7.6			
#100 (0.15mm)	19.10	322.50	5.8	98.2	1.8			
#200 (75μm)	1.60	324.10	0.49	98.66	1.34			
Pan	1.20	325.30	1.34	100.00	0.00			

Other Test Results

Test Name	Date	Result	Unit	Target	Specification	Comment
	Procedure	Lab			Tested By	
FM	12/31/2017 08:13	2.36				
		St Marys Quarry			Jarret Peterson	

FM = 2.36

Sample 3



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1483577409

Sample Information

Sample No 1483577409
Date Sampled 12/03/2017 08:54
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 06 Sam 3

Gradation Results

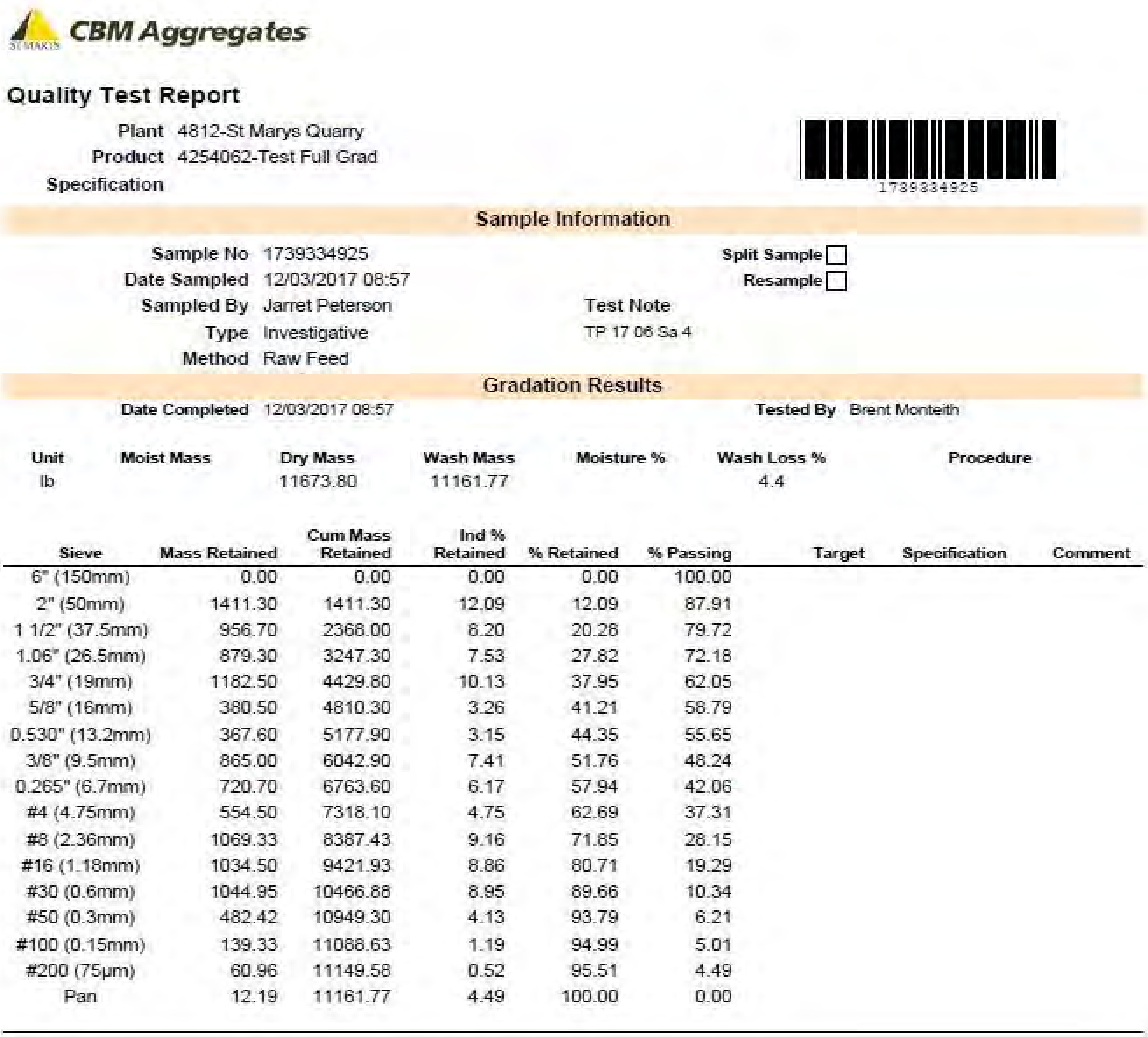
Date Completed 12/03/2017 08:54
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		15163.10	13841.51		8.7	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3362.50	3362.50	22.18	22.18	77.82			
1 1/2" (37.5mm)	121.00	3483.50	0.80	22.97	77.03			
1.06" (26.5mm)	599.60	4083.10	3.95	26.93	73.07			
3/4" (19mm)	516.40	4599.50	3.41	30.33	69.67			
5/8" (16mm)	274.00	4873.50	1.81	32.14	67.86			
0.530" (13.2mm)	290.50	5164.00	1.92	34.06	65.94			
3/8" (9.5mm)	573.90	5737.90	3.78	37.84	62.16			
0.265" (6.7mm)	547.40	6285.30	3.61	41.45	58.55			
#4 (4.75mm)	483.20	6768.50	3.19	44.64	55.36			
#8 (2.36mm)	699.27	7467.77	4.61	49.25	50.75			
#16 (1.18mm)	1013.78	8481.55	6.69	55.94	44.06			
#30 (0.6mm)	1907.10	10388.65	12.58	68.51	31.49			
#50 (0.3mm)	2475.89	12864.54	16.33	84.84	15.16			
#100 (0.15mm)	649.08	13513.62	4.28	89.12	10.88			
#200 (75µm)	254.28	13767.90	1.68	90.80	9.20			
Pan	73.61	13841.51	9.20	100.00	0.00			

FM = 2.25

Sample 4



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1739334925

Sample Information

Sample No	1739334925	**Split Sample**	☐
Date Sampled	12/03/2017 08:57	**Resample**	☐
Sampled By	Jarret Peterson	**Test Note**	
Type	Investigative	TP 17 06 Sa 4	
Method	Raw Feed		

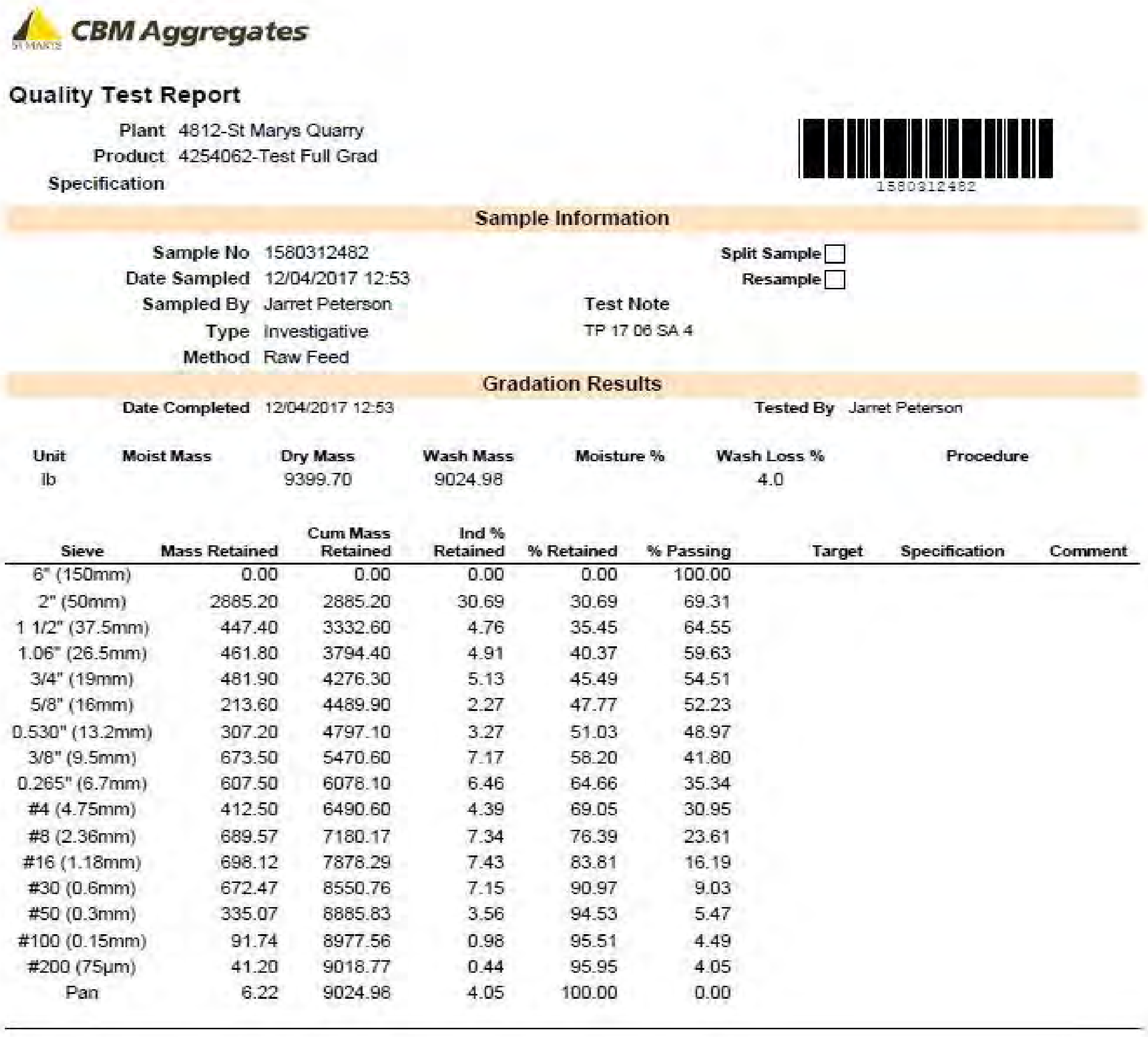
Gradation Results

Date Completed 12/03/2017 08:57 **Tested By** Brent Monteith

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		11673.80	11161.77		4.4	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	1411.30	1411.30	12.09	12.09	87.91			
1 1/2" (37.5mm)	956.70	2368.00	8.20	20.28	79.72			
1.06" (26.5mm)	879.30	3247.30	7.53	27.82	72.18			
3/4" (19mm)	1182.50	4429.80	10.13	37.95	62.05			
5/8" (16mm)	380.50	4810.30	3.26	41.21	58.79			
0.530" (13.2mm)	367.60	5177.90	3.15	44.35	55.65			
3/8" (9.5mm)	865.00	6042.90	7.41	51.76	48.24			
0.265" (6.7mm)	720.70	6763.60	6.17	57.94	42.06			
#4 (4.75mm)	554.50	7318.10	4.75	62.69	37.31			
#8 (2.36mm)	1069.33	8387.43	9.16	71.85	28.15			
#16 (1.18mm)	1034.50	9421.93	8.86	80.71	19.29			
#30 (0.6mm)	1044.95	10466.88	8.95	89.66	10.34			
#50 (0.3mm)	482.42	10949.30	4.13	93.79	6.21			
#100 (0.15mm)	139.33	11088.63	1.19	94.99	5.01			
#200 (75μm)	60.96	11149.58	0.52	95.51	4.49			
Pan	12.19	11161.77	4.49	100.00	0.00			

FM = 3.15



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1580312482

Sample Information

Sample No 1580312482
Date Sampled 12/04/2017 12:53
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 06 SA 4

Gradation Results

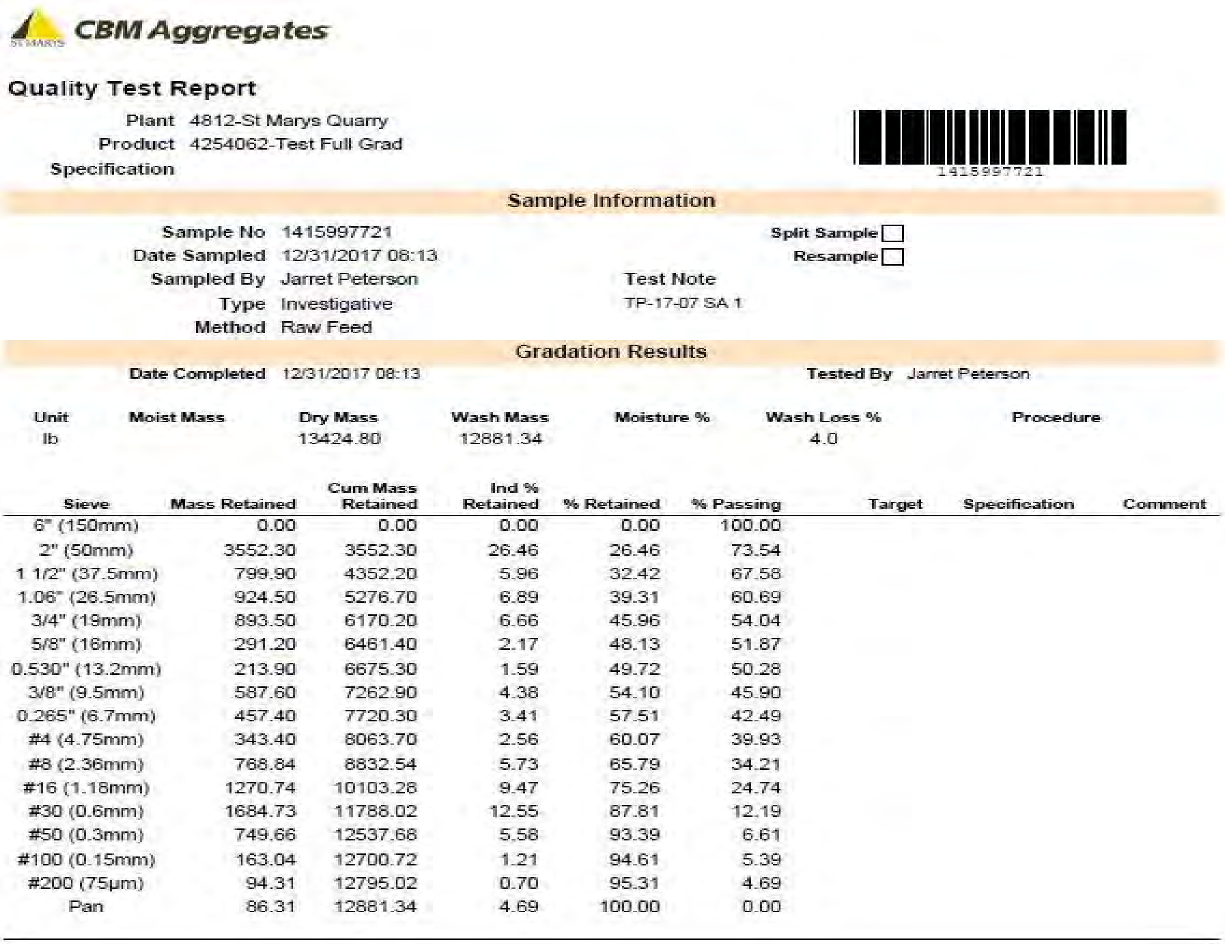
Date Completed 12/04/2017 12:53
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		9399.70	9024.98		4.0	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	2885.20	2885.20	30.69	30.69	69.31			
1 1/2" (37.5mm)	447.40	3332.60	4.76	35.45	64.55			
1.06" (26.5mm)	461.80	3794.40	4.91	40.37	59.63			
3/4" (19mm)	481.90	4276.30	5.13	45.49	54.51			
5/8" (16mm)	213.60	4489.90	2.27	47.77	52.23			
0.530" (13.2mm)	307.20	4797.10	3.27	51.03	48.97			
3/8" (9.5mm)	673.50	5470.60	7.17	58.20	41.80			
0.265" (6.7mm)	607.50	6078.10	6.46	64.66	35.34			
#4 (4.75mm)	412.50	6490.60	4.39	69.05	30.95			
#8 (2.36mm)	689.57	7180.17	7.34	76.39	23.61			
#16 (1.18mm)	698.12	7878.29	7.43	83.81	16.19			
#30 (0.6mm)	672.47	8550.76	7.15	90.97	9.03			
#50 (0.3mm)	335.07	8885.83	3.56	94.53	5.47			
#100 (0.15mm)	91.74	8977.56	0.98	95.51	4.49			
#200 (75µm)	41.20	9018.77	0.44	95.95	4.05			
Pan	6.22	9024.98	4.05	100.00	0.00			

FM = 3.10

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415997721

Sample Information

Sample No 1415997721
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-07 SA 1

Gradation Results

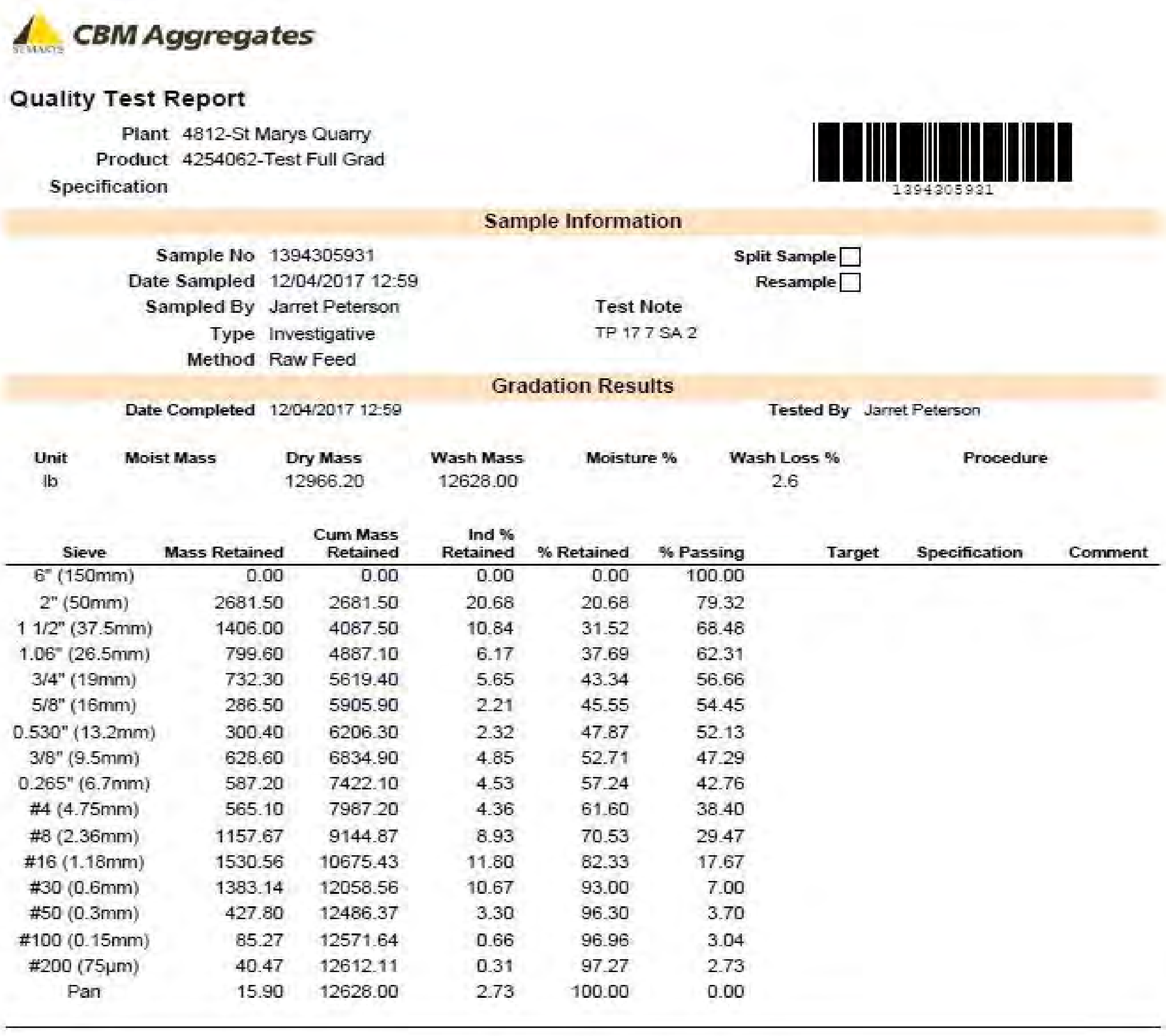
Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		13424.80	12881.34		4.0	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3552.30	3552.30	26.46	26.46	73.54			
1 1/2" (37.5mm)	799.90	4352.20	5.96	32.42	67.58			
1.06" (26.5mm)	924.50	5276.70	6.89	39.31	60.69			
3/4" (19mm)	893.50	6170.20	6.66	45.96	54.04			
5/8" (16mm)	291.20	6461.40	2.17	48.13	51.87			
0.530" (13.2mm)	213.90	6675.30	1.59	49.72	50.28			
3/8" (9.5mm)	587.60	7262.90	4.38	54.10	45.90			
0.265" (6.7mm)	457.40	7720.30	3.41	57.51	42.49			
#4 (4.75mm)	343.40	8063.70	2.56	60.07	39.93			
#8 (2.36mm)	768.84	8832.54	5.73	65.79	34.21			
#16 (1.18mm)	1270.74	10103.28	9.47	75.26	24.74			
#30 (0.6mm)	1684.73	11788.02	12.55	87.81	12.19			
#50 (0.3mm)	749.66	12537.68	5.58	93.39	6.61			
#100 (0.15mm)	163.04	12700.72	1.21	94.61	5.39			
#200 (75µm)	94.31	12795.02	0.70	95.31	4.69			
Pan	86.31	12881.34	4.69	100.00	0.00			

FM = 2.92

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1394305931

Sample Information

Sample No 1394305931
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 7 SA 2

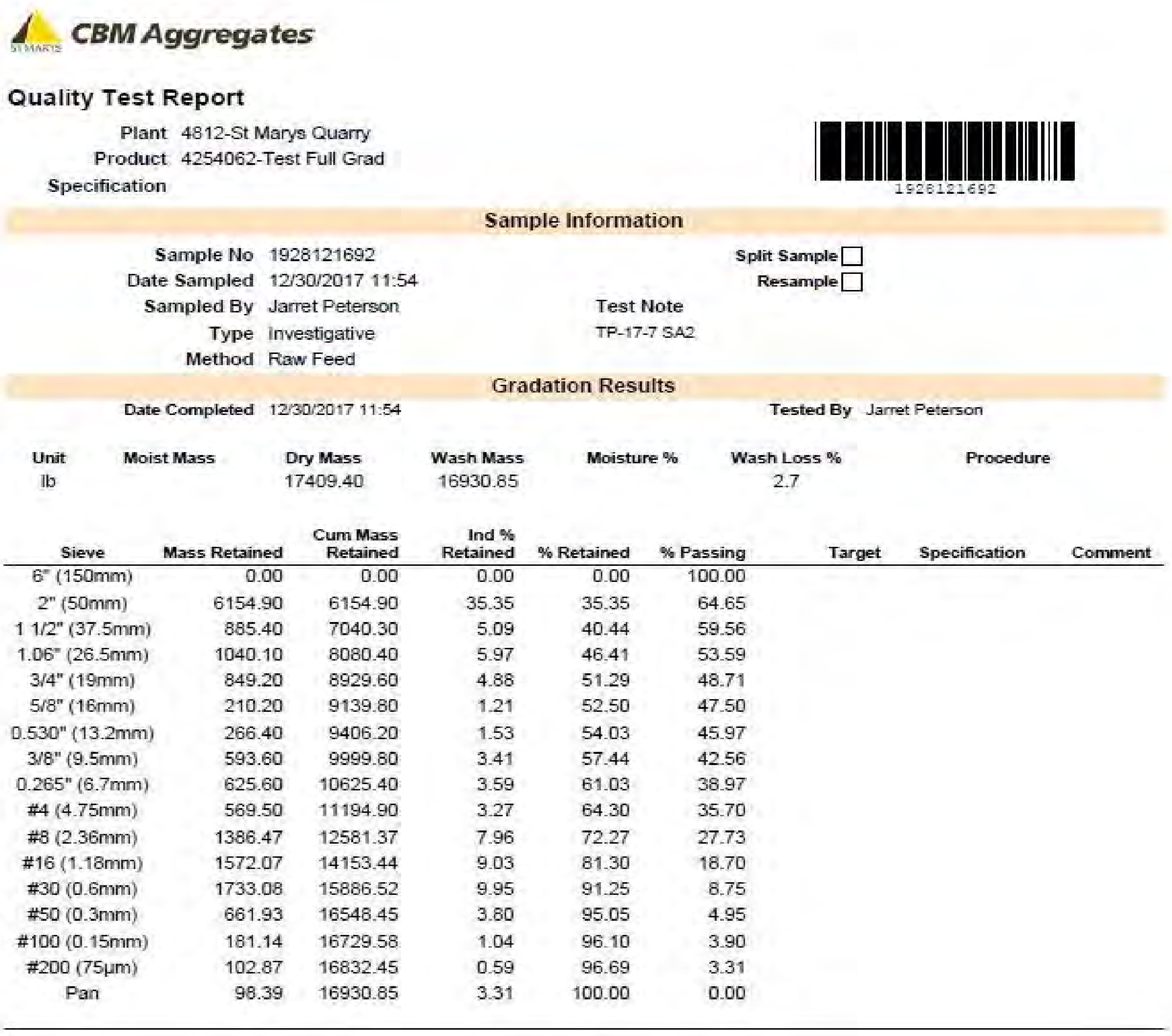
Gradation Results

Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		12966.20	12628.00		2.6	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	2681.50	2681.50	20.68	20.68	79.32			
1 1/2" (37.5mm)	1406.00	4087.50	10.84	31.52	68.48			
1.06" (26.5mm)	799.60	4887.10	6.17	37.69	62.31			
3/4" (19mm)	732.30	5619.40	5.65	43.34	56.66			
5/8" (16mm)	286.50	5905.90	2.21	45.55	54.45			
0.530" (13.2mm)	300.40	6206.30	2.32	47.87	52.13			
3/8" (9.5mm)	628.60	6834.90	4.85	52.71	47.29			
0.265" (6.7mm)	587.20	7422.10	4.53	57.24	42.76			
#4 (4.75mm)	565.10	7987.20	4.36	61.60	38.40			
#8 (2.36mm)	1157.67	9144.87	8.93	70.53	29.47			
#16 (1.18mm)	1530.56	10675.43	11.80	82.33	17.67			
#30 (0.6mm)	1383.14	12058.56	10.67	93.00	7.00			
#50 (0.3mm)	427.80	12486.37	3.30	96.30	3.70			
#100 (0.15mm)	85.27	12571.64	0.66	96.96	3.04			
#200 (75µm)	40.47	12612.11	0.31	97.27	2.73			
Pan	15.90	12628.00	2.73	100.00	0.00			

FM = 3.42



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1928121692

Sample Information

Sample No 1928121692
Date Sampled 12/30/2017 11:54
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-7 SA2

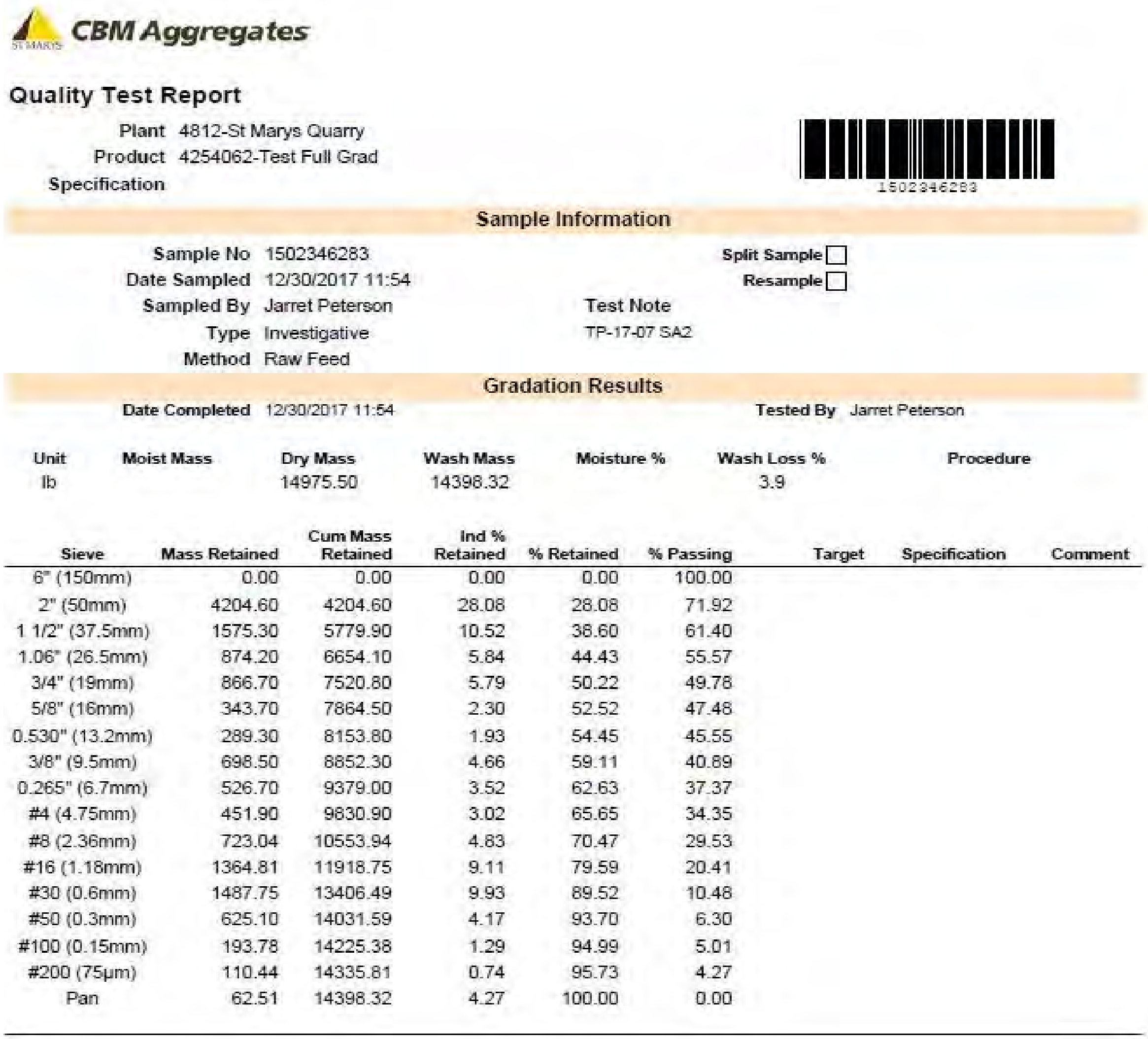
Gradation Results

Date Completed 12/30/2017 11:54
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		17409.40	16930.85		2.7	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	6154.90	6154.90	35.35	35.35	64.65			
1 1/2" (37.5mm)	885.40	7040.30	5.09	40.44	59.56			
1.06" (26.5mm)	1040.10	8080.40	5.97	46.41	53.59			
3/4" (19mm)	849.20	8929.60	4.88	51.29	48.71			
5/8" (16mm)	210.20	9139.80	1.21	52.50	47.50			
0.530" (13.2mm)	266.40	9406.20	1.53	54.03	45.97			
3/8" (9.5mm)	593.60	9999.80	3.41	57.44	42.56			
0.265" (6.7mm)	625.60	10625.40	3.59	61.03	38.97			
#4 (4.75mm)	569.50	11194.90	3.27	64.30	35.70			
#8 (2.36mm)	1386.47	12581.37	7.96	72.27	27.73			
#16 (1.18mm)	1572.07	14153.44	9.03	81.30	18.70			
#30 (0.6mm)	1733.08	15886.52	9.95	91.25	8.75			
#50 (0.3mm)	661.93	16548.45	3.80	95.05	4.95			
#100 (0.15mm)	181.14	16729.58	1.04	96.10	3.90			
#200 (75µm)	102.87	16832.45	0.59	96.69	3.31			
Pan	98.39	16930.85	3.31	100.00	0.00			

FM = 3.21



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1502346283

Sample Information

Sample No 1502346283
Date Sampled 12/30/2017 11:54
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-07 SA2

Gradation Results

Date Completed 12/30/2017 11:54

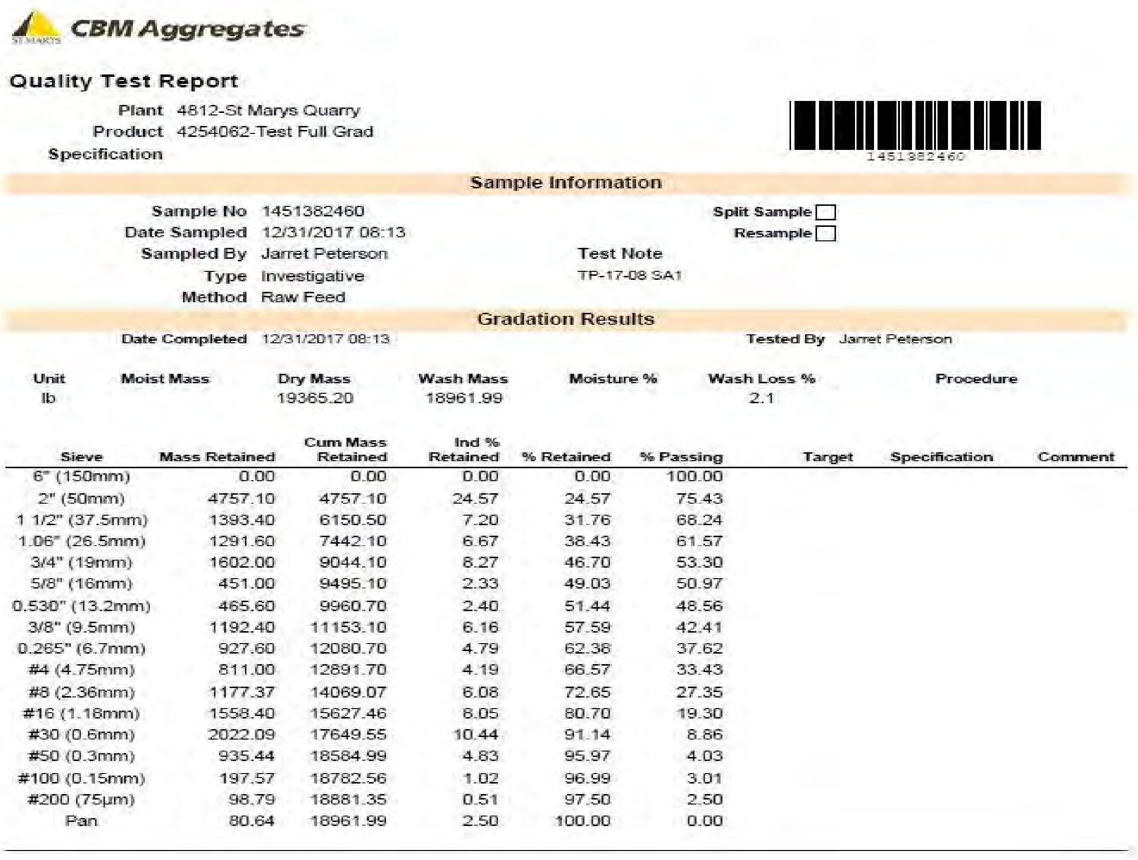
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		14975.50	14398.32		3.9	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	4204.60	4204.60	28.08	28.08	71.92			
1 1/2" (37.5mm)	1575.30	5779.90	10.52	38.60	61.40			
1.06" (26.5mm)	874.20	6654.10	5.84	44.43	55.57			
3/4" (19mm)	866.70	7520.80	5.79	50.22	49.78			
5/8" (16mm)	343.70	7864.50	2.30	52.52	47.48			
0.530" (13.2mm)	289.30	8153.80	1.93	54.45	45.55			
3/8" (9.5mm)	698.50	8852.30	4.66	59.11	40.89			
0.265" (6.7mm)	526.70	9379.00	3.52	62.63	37.37			
#4 (4.75mm)	451.90	9830.90	3.02	65.65	34.35			
#8 (2.36mm)	723.04	10553.94	4.83	70.47	29.53			
#16 (1.18mm)	1364.81	11918.75	9.11	79.59	20.41			
#30 (0.6mm)	1487.75	13406.49	9.93	89.52	10.48			
#50 (0.3mm)	625.10	14031.59	4.17	93.70	6.30			
#100 (0.15mm)	193.78	14225.38	1.29	94.99	5.01			
#200 (75µm)	110.44	14335.81	0.74	95.73	4.27			
Pan	62.51	14398.32	4.27	100.00	0.00			

FM = 2.91

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1451382460

Sample Information

Sample No 1451382460
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-08 SA1

Gradation Results

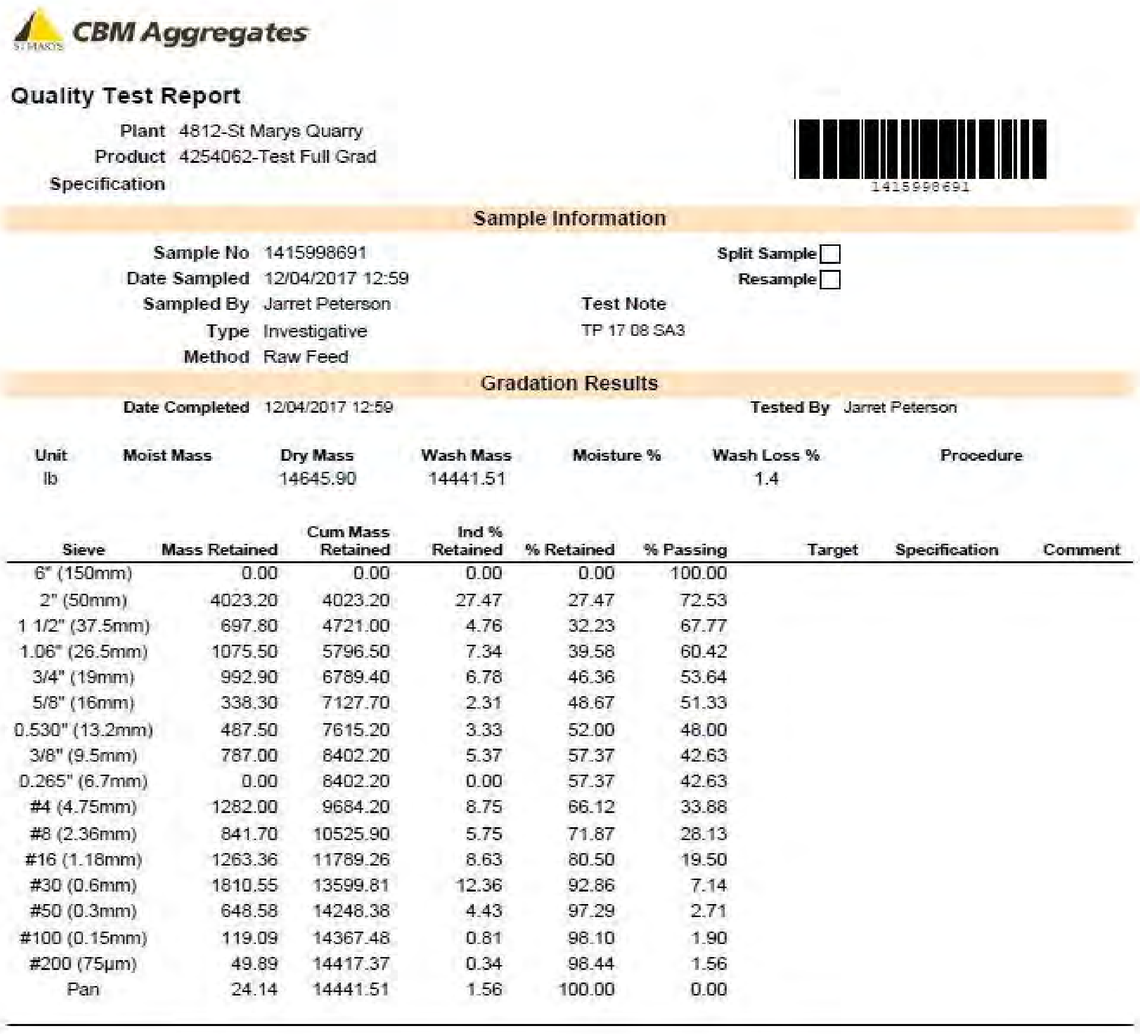
Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		19365.20	18961.99		2.1	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	4757.10	4757.10	24.57	24.57	75.43			
1 1/2" (37.5mm)	1393.40	6150.50	7.20	31.76	68.24			
1.06" (26.5mm)	1291.60	7442.10	6.67	38.43	61.57			
3/4" (19mm)	1602.00	9044.10	8.27	46.70	53.30			
5/8" (16mm)	451.00	9495.10	2.33	49.03	50.97			
0.530" (13.2mm)	465.60	9960.70	2.40	51.44	48.56			
3/8" (9.5mm)	1192.40	11153.10	6.16	57.59	42.41			
0.265" (6.7mm)	927.60	12080.70	4.79	62.38	37.62			
#4 (4.75mm)	811.00	12891.70	4.19	66.57	33.43			
#8 (2.36mm)	1177.37	14069.07	6.08	72.65	27.35			
#16 (1.18mm)	1558.40	15627.46	8.05	80.70	19.30			
#30 (0.6mm)	2022.09	17649.55	10.44	91.14	8.86			
#50 (0.3mm)	935.44	18584.99	4.83	95.97	4.03			
#100 (0.15mm)	197.57	18782.56	1.02	96.99	3.01			
#200 (75µm)	98.79	18881.35	0.51	97.50	2.50			
Pan	80.64	18961.99	2.50	100.00	0.00			

FM = 3.13

Sample 3



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415998691

Sample Information

Sample No 1415998691
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 08 SA3

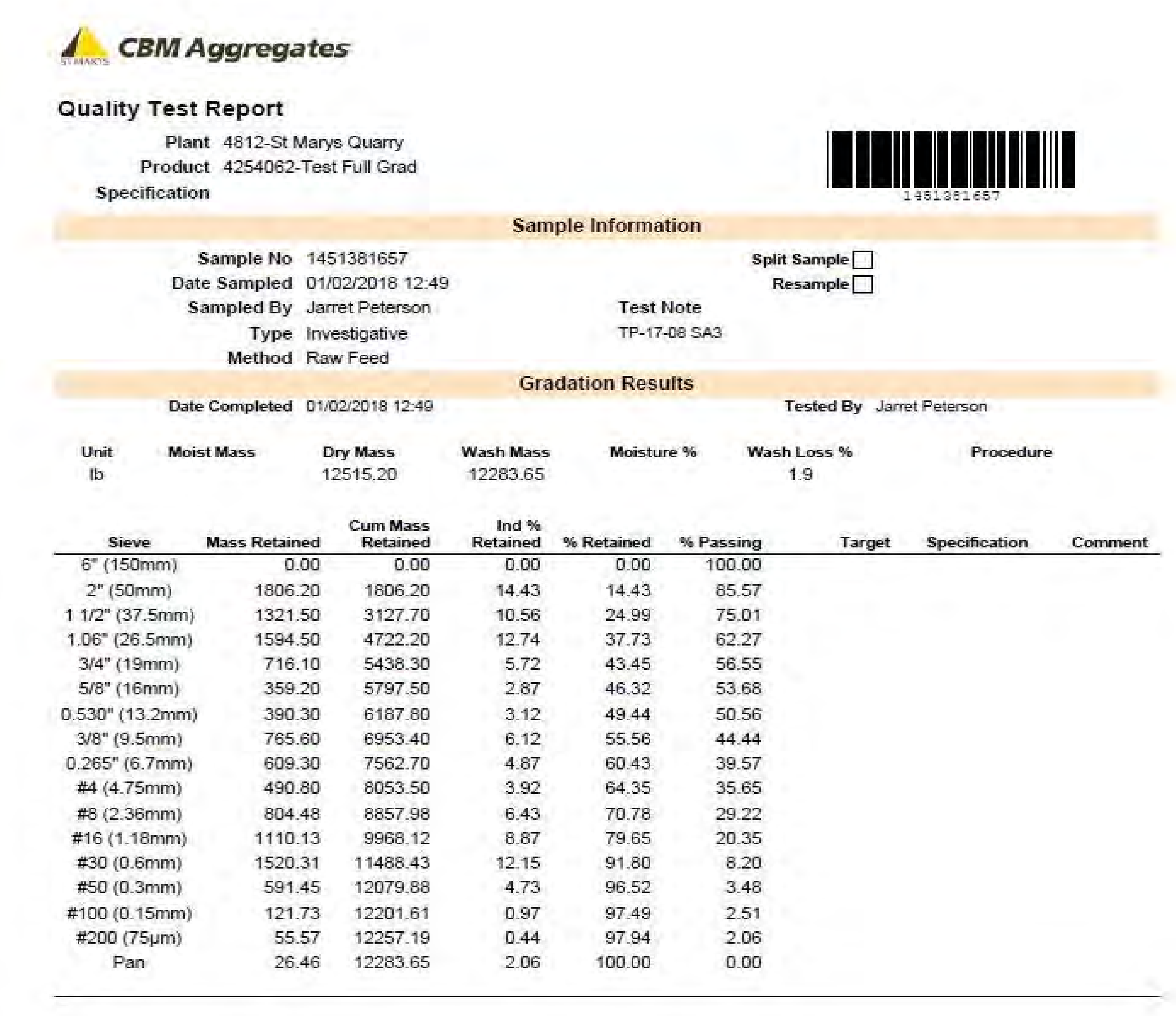
Gradation Results

Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		14645.90	14441.51		1.4	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	4023.20	4023.20	27.47	27.47	72.53			
1 1/2" (37.5mm)	697.80	4721.00	4.76	32.23	67.77			
1.06" (26.5mm)	1075.50	5796.50	7.34	39.58	60.42			
3/4" (19mm)	992.90	6789.40	6.78	46.36	53.64			
5/8" (16mm)	338.30	7127.70	2.31	48.67	51.33			
0.530" (13.2mm)	487.50	7615.20	3.33	52.00	48.00			
3/8" (9.5mm)	787.00	8402.20	5.37	57.37	42.63			
0.265" (6.7mm)	0.00	8402.20	0.00	57.37	42.63			
#4 (4.75mm)	1282.00	9684.20	8.75	66.12	33.88			
#8 (2.36mm)	841.70	10525.90	5.75	71.87	28.13			
#16 (1.18mm)	1263.36	11789.26	8.63	80.50	19.50			
#30 (0.6mm)	1810.55	13599.81	12.36	92.86	7.14			
#50 (0.3mm)	648.58	14248.38	4.43	97.29	2.71			
#100 (0.15mm)	119.09	14367.48	0.81	98.10	1.90			
#200 (75µm)	49.89	14417.37	0.34	98.44	1.56			
Pan	24.14	14441.51	1.56	100.00	0.00			

FM = 3.25



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1451381657

Sample Information

Sample No 1451381657
Date Sampled 01/02/2018 12:49
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-08 SA3

Gradation Results

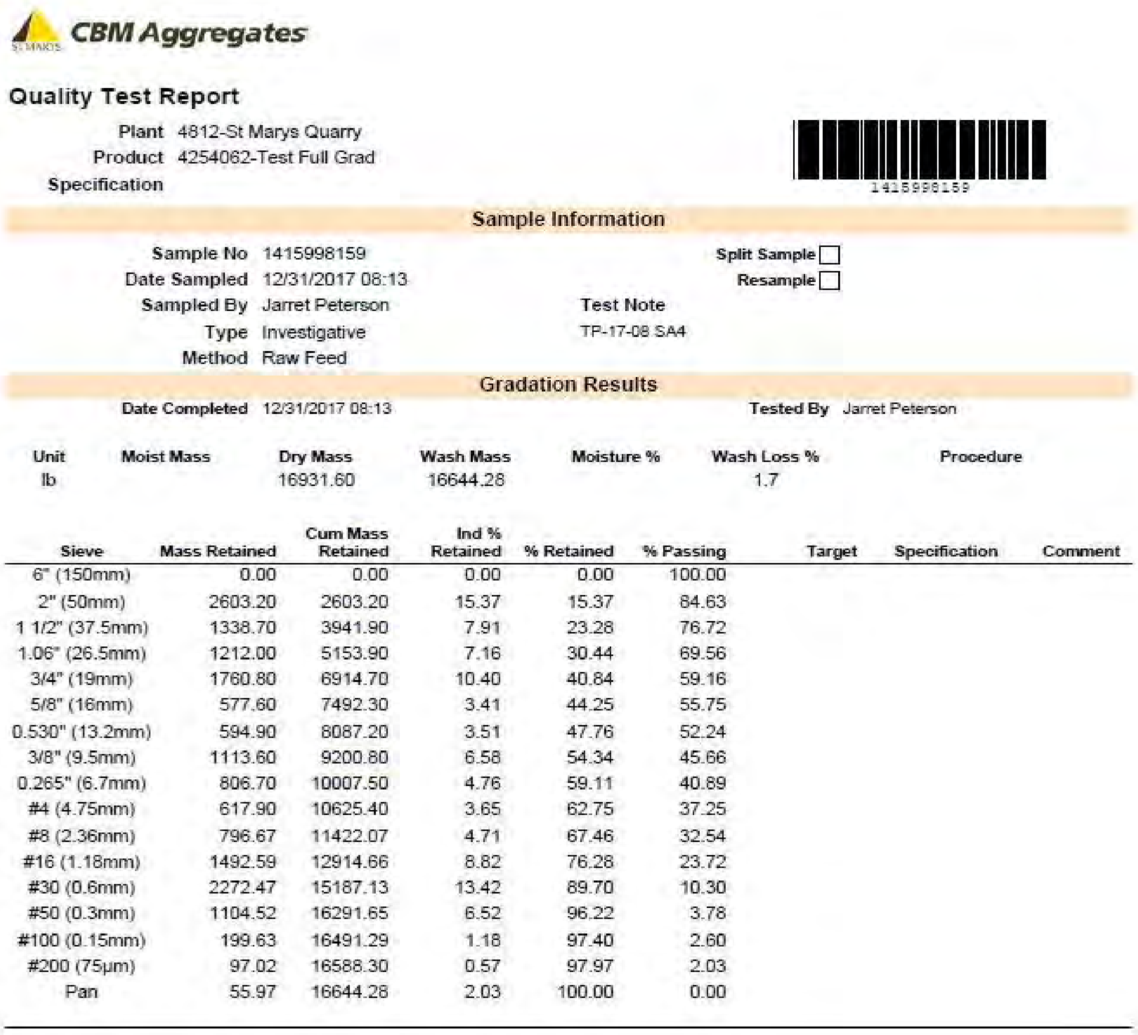
Date Completed 01/02/2018 12:49
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		12515.20	12283.65		1.9	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	1806.20	1806.20	14.43	14.43	85.57			
1 1/2" (37.5mm)	1321.50	3127.70	10.56	24.99	75.01			
1.06" (26.5mm)	1594.50	4722.20	12.74	37.73	62.27			
3/4" (19mm)	716.10	5438.30	5.72	43.45	56.55			
5/8" (16mm)	359.20	5797.50	2.87	46.32	53.68			
0.530" (13.2mm)	390.30	6187.80	3.12	49.44	50.56			
3/8" (9.5mm)	765.60	6953.40	6.12	55.56	44.44			
0.265" (6.7mm)	609.30	7562.70	4.87	60.43	39.57			
#4 (4.75mm)	490.80	8053.50	3.92	64.35	35.65			
#8 (2.36mm)	804.48	8857.98	6.43	70.78	29.22			
#16 (1.18mm)	1110.13	9968.12	8.87	79.65	20.35			
#30 (0.6mm)	1520.31	11488.43	12.15	91.80	8.20			
#50 (0.3mm)	591.45	12079.88	4.73	96.52	3.48			
#100 (0.15mm)	121.73	12201.61	0.97	97.49	2.51			
#200 (75µm)	55.57	12257.19	0.44	97.94	2.06			
Pan	26.46	12283.65	2.06	100.00	0.00			

FM = 3.21

Sample 4



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415998159

Sample Information

Sample No 1415998159
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐
Test Note TP-17-08 SA4

Gradation Results

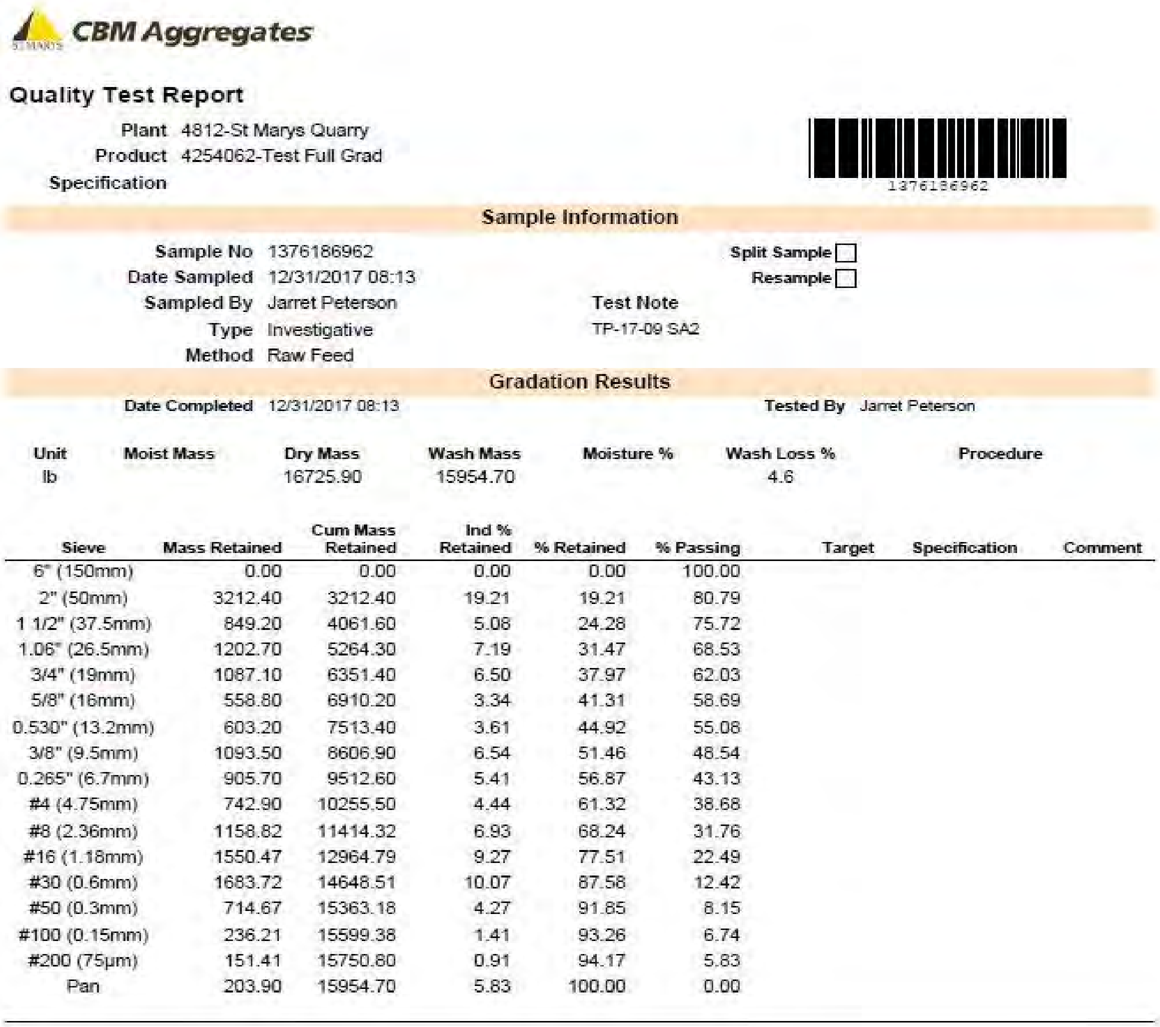
Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		16931.60	16644.28		1.7	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	2603.20	2603.20	15.37	15.37	84.63			
1 1/2" (37.5mm)	1338.70	3941.90	7.91	23.28	76.72			
1.06" (26.5mm)	1212.00	5153.90	7.16	30.44	69.56			
3/4" (19mm)	1760.80	6914.70	10.40	40.84	59.16			
5/8" (16mm)	577.60	7492.30	3.41	44.25	55.75			
0.530" (13.2mm)	594.90	8087.20	3.51	47.76	52.24			
3/8" (9.5mm)	1113.60	9200.80	6.58	54.34	45.66			
0.265" (6.7mm)	806.70	10007.50	4.76	59.11	40.89			
#4 (4.75mm)	617.90	10625.40	3.65	62.75	37.25			
#8 (2.36mm)	796.67	11422.07	4.71	67.46	32.54			
#16 (1.18mm)	1492.59	12914.66	8.82	76.28	23.72			
#30 (0.6mm)	2272.47	15187.13	13.42	89.70	10.30			
#50 (0.3mm)	1104.52	16291.65	6.52	96.22	3.78			
#100 (0.15mm)	199.63	16491.29	1.18	97.40	2.60			
#200 (75µm)	97.02	16588.30	0.57	97.97	2.03			
Pan	55.97	16644.28	2.03	100.00	0.00			

FM = 3.04

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1376186962

Sample Information

Sample No 1376186962
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐
Test Note
TP-17-09 SA2

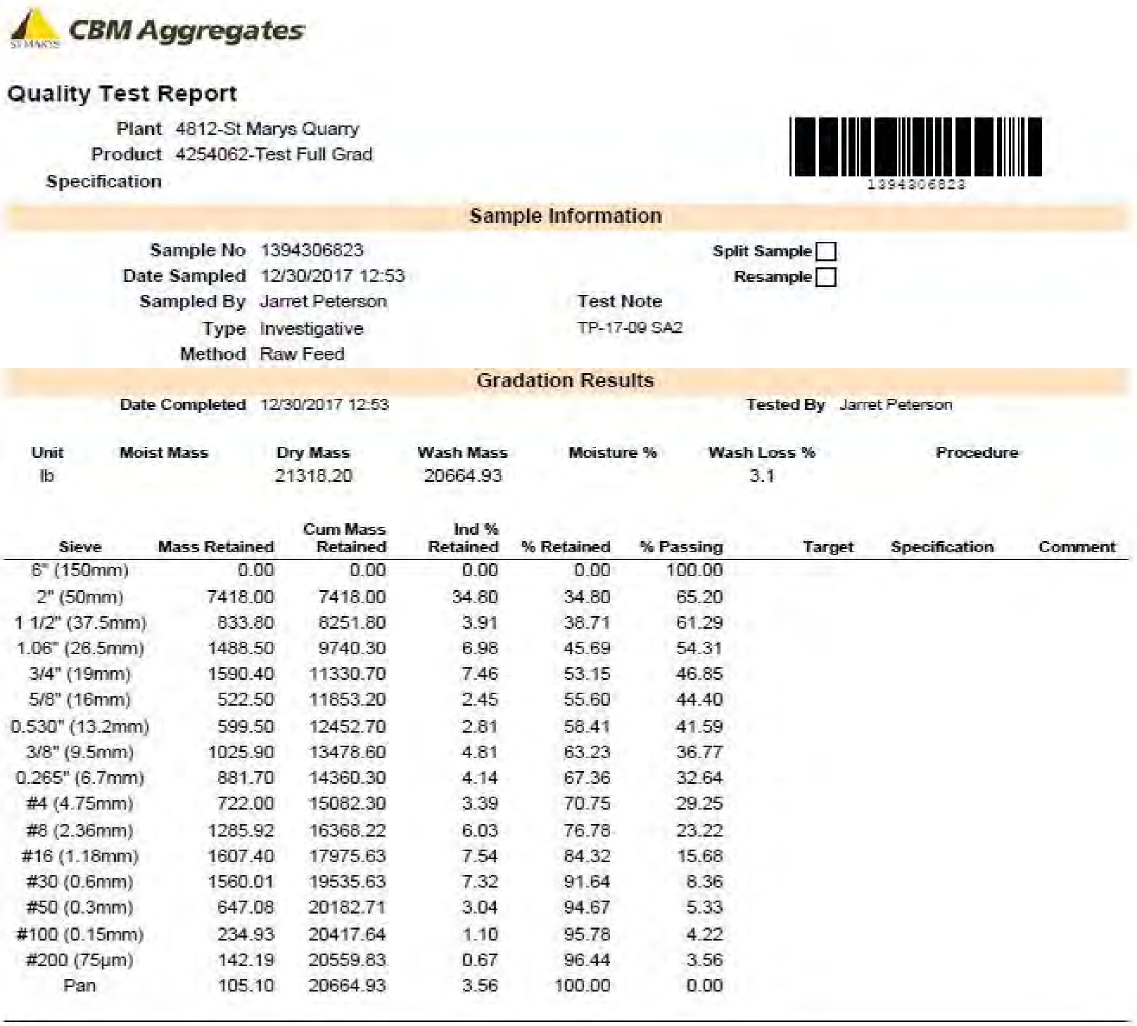
Gradation Results

Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		16725.90	15954.70		4.6	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3212.40	3212.40	19.21	19.21	80.79			
1 1/2" (37.5mm)	849.20	4061.60	5.08	24.28	75.72			
1.06" (26.5mm)	1202.70	5264.30	7.19	31.47	68.53			
3/4" (19mm)	1087.10	6351.40	6.50	37.97	62.03			
5/8" (16mm)	558.80	6910.20	3.34	41.31	58.69			
0.530" (13.2mm)	603.20	7513.40	3.61	44.92	55.08			
3/8" (9.5mm)	1093.50	8606.90	6.54	51.46	48.54			
0.265" (6.7mm)	905.70	9512.60	5.41	56.87	43.13			
#4 (4.75mm)	742.90	10255.50	4.44	61.32	38.68			
#8 (2.36mm)	1158.82	11414.32	6.93	68.24	31.76			
#16 (1.18mm)	1550.47	12964.79	9.27	77.51	22.49			
#30 (0.6mm)	1683.72	14648.51	10.07	87.58	12.42			
#50 (0.3mm)	714.67	15363.18	4.27	91.85	8.15			
#100 (0.15mm)	236.21	15599.38	1.41	93.26	6.74			
#200 (75µm)	151.41	15750.80	0.91	94.17	5.83			
Pan	203.90	15954.70	5.83	100.00	0.00			

FM = 2.89



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1394306823

Sample Information

Sample No 1394306823
Date Sampled 12/30/2017 12:53
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-09 SA2

Gradation Results

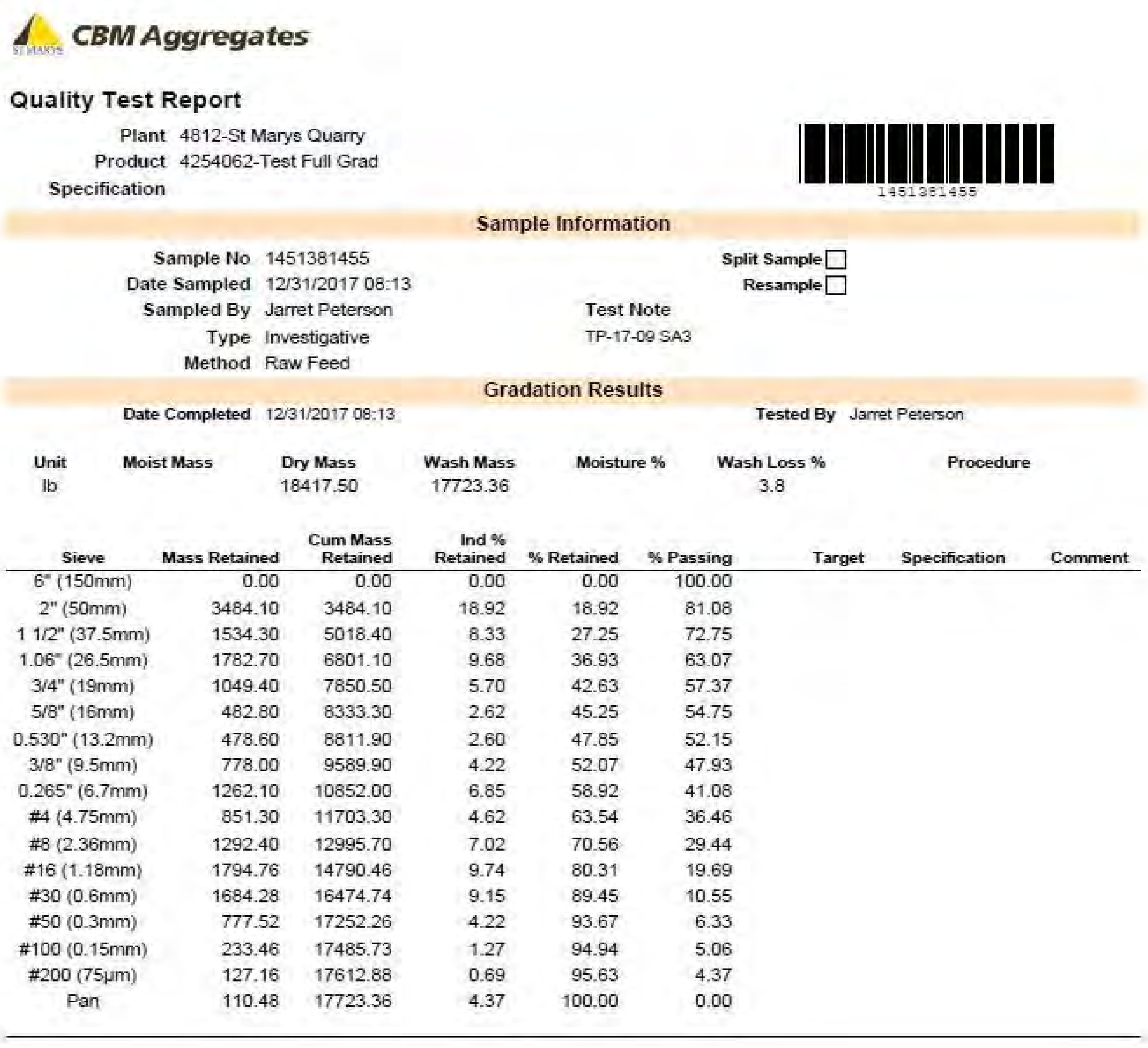
Date Completed 12/30/2017 12:53
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		21318.20	20664.93		3.1	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	7418.00	7418.00	34.80	34.80	65.20			
1 1/2" (37.5mm)	833.80	8251.80	3.91	38.71	61.29			
1.06" (26.5mm)	1488.50	9740.30	6.98	45.69	54.31			
3/4" (19mm)	1590.40	11330.70	7.46	53.15	46.85			
5/8" (16mm)	522.50	11853.20	2.45	55.60	44.40			
0.530" (13.2mm)	599.50	12452.70	2.81	58.41	41.59			
3/8" (9.5mm)	1025.90	13478.60	4.81	63.23	36.77			
0.265" (6.7mm)	881.70	14360.30	4.14	67.36	32.64			
#4 (4.75mm)	722.00	15082.30	3.39	70.75	29.25			
#8 (2.36mm)	1285.92	16368.22	6.03	76.78	23.22			
#16 (1.18mm)	1607.40	17975.63	7.54	84.32	15.68			
#30 (0.6mm)	1560.01	19535.63	7.32	91.64	8.36			
#50 (0.3mm)	647.08	20182.71	3.04	94.67	5.33			
#100 (0.15mm)	234.93	20417.64	1.10	95.78	4.22			
#200 (75µm)	142.19	20559.83	0.67	96.44	3.56			
Pan	105.10	20664.93	3.56	100.00	0.00			

FM = 3.06

Sample 3



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1451381455

Sample Information

Sample No 1451381455
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-09 SA3

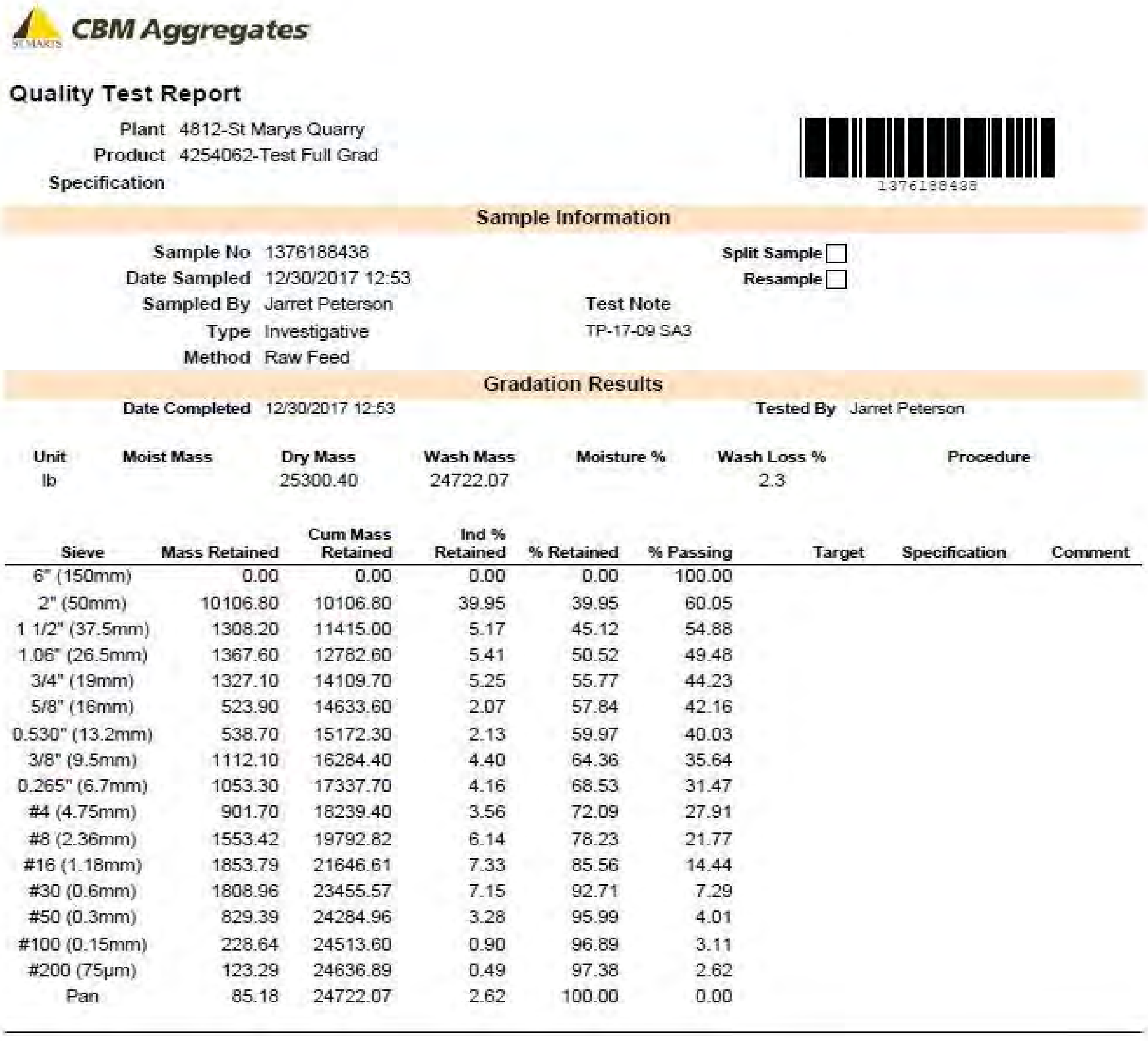
Gradation Results

Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		18417.50	17723.36		3.8	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3484.10	3484.10	18.92	18.92	81.08			
1 1/2" (37.5mm)	1534.30	5018.40	8.33	27.25	72.75			
1.06" (26.5mm)	1782.70	6801.10	9.68	36.93	63.07			
3/4" (19mm)	1049.40	7850.50	5.70	42.63	57.37			
5/8" (16mm)	482.80	8333.30	2.62	45.25	54.75			
0.530" (13.2mm)	478.60	8811.90	2.60	47.85	52.15			
3/8" (9.5mm)	778.00	9589.90	4.22	52.07	47.93			
0.265" (6.7mm)	1262.10	10852.00	6.85	58.92	41.08			
#4 (4.75mm)	851.30	11703.30	4.62	63.54	36.46			
#8 (2.36mm)	1292.40	12995.70	7.02	70.56	29.44			
#16 (1.18mm)	1794.76	14790.46	9.74	80.31	19.69			
#30 (0.6mm)	1684.28	16474.74	9.15	89.45	10.55			
#50 (0.3mm)	777.52	17252.26	4.22	93.67	6.33			
#100 (0.15mm)	233.46	17485.73	1.27	94.94	5.06			
#200 (75µm)	127.16	17612.88	0.69	95.63	4.37			
Pan	110.48	17723.36	4.37	100.00	0.00			

FM = 3.05



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1376188438

Sample Information

Sample No 1376188438
Date Sampled 12/30/2017 12:53
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-09 SA3

Gradation Results

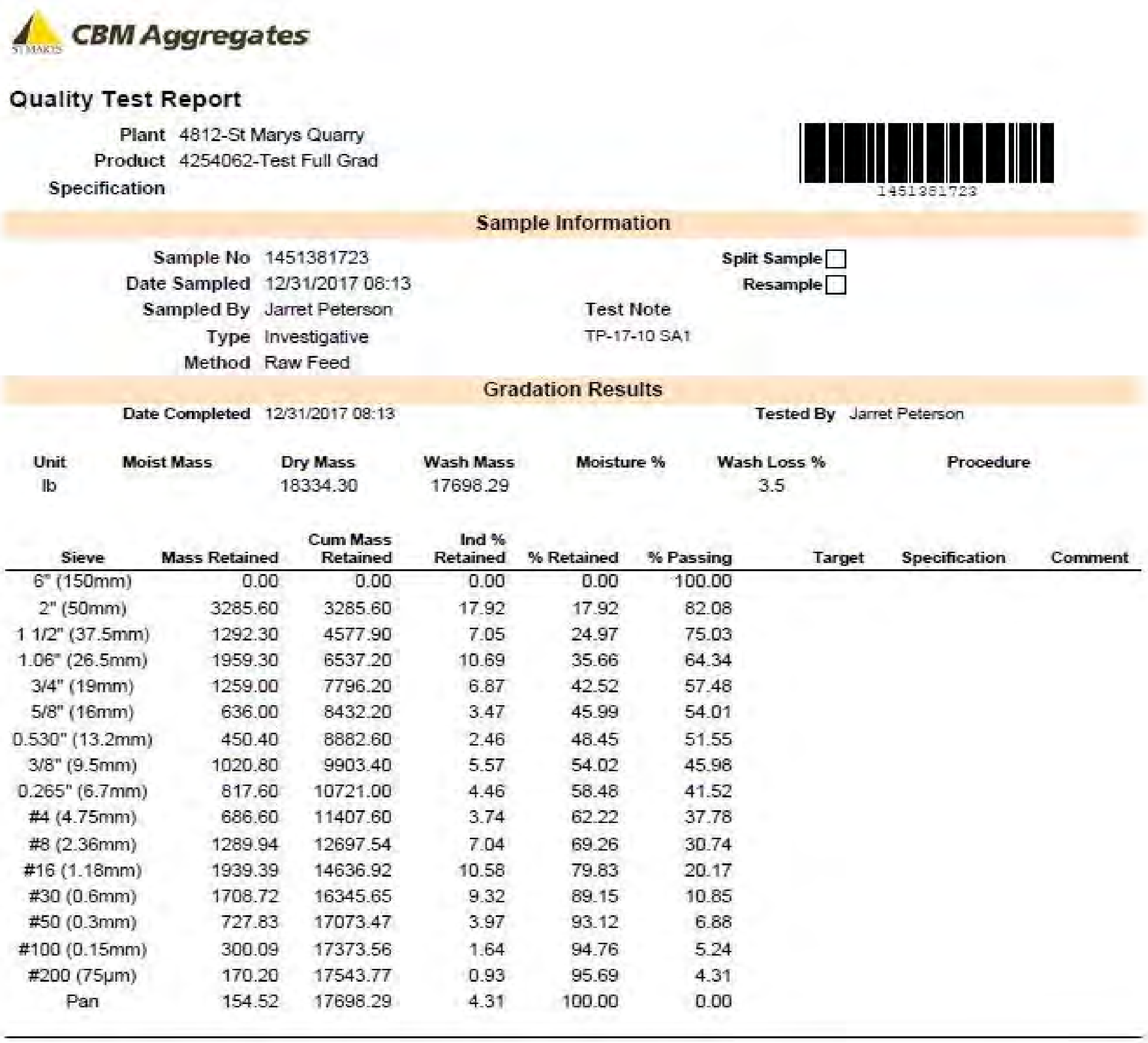
Date Completed 12/30/2017 12:53
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		25300.40	24722.07		2.3	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	10106.80	10106.80	39.95	39.95	60.05			
1 1/2" (37.5mm)	1308.20	11415.00	5.17	45.12	54.88			
1.06" (26.5mm)	1367.60	12782.60	5.41	50.52	49.48			
3/4" (19mm)	1327.10	14109.70	5.25	55.77	44.23			
5/8" (16mm)	523.90	14633.60	2.07	57.84	42.16			
0.530" (13.2mm)	538.70	15172.30	2.13	59.97	40.03			
3/8" (9.5mm)	1112.10	16284.40	4.40	64.36	35.64			
0.265" (6.7mm)	1053.30	17337.70	4.16	68.53	31.47			
#4 (4.75mm)	901.70	18239.40	3.56	72.09	27.91			
#8 (2.36mm)	1553.42	19792.82	6.14	78.23	21.77			
#16 (1.18mm)	1853.79	21646.61	7.33	85.56	14.44			
#30 (0.6mm)	1808.96	23455.57	7.15	92.71	7.29			
#50 (0.3mm)	829.39	24284.96	3.28	95.99	4.01			
#100 (0.15mm)	228.64	24513.60	0.90	96.89	3.11			
#200 (75µm)	123.29	24636.89	0.49	97.38	2.62			
Pan	85.18	24722.07	2.62	100.00	0.00			

FM = 3.19

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1451381723

Sample Information

Sample No 1451381723
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-10 SA1

Gradation Results

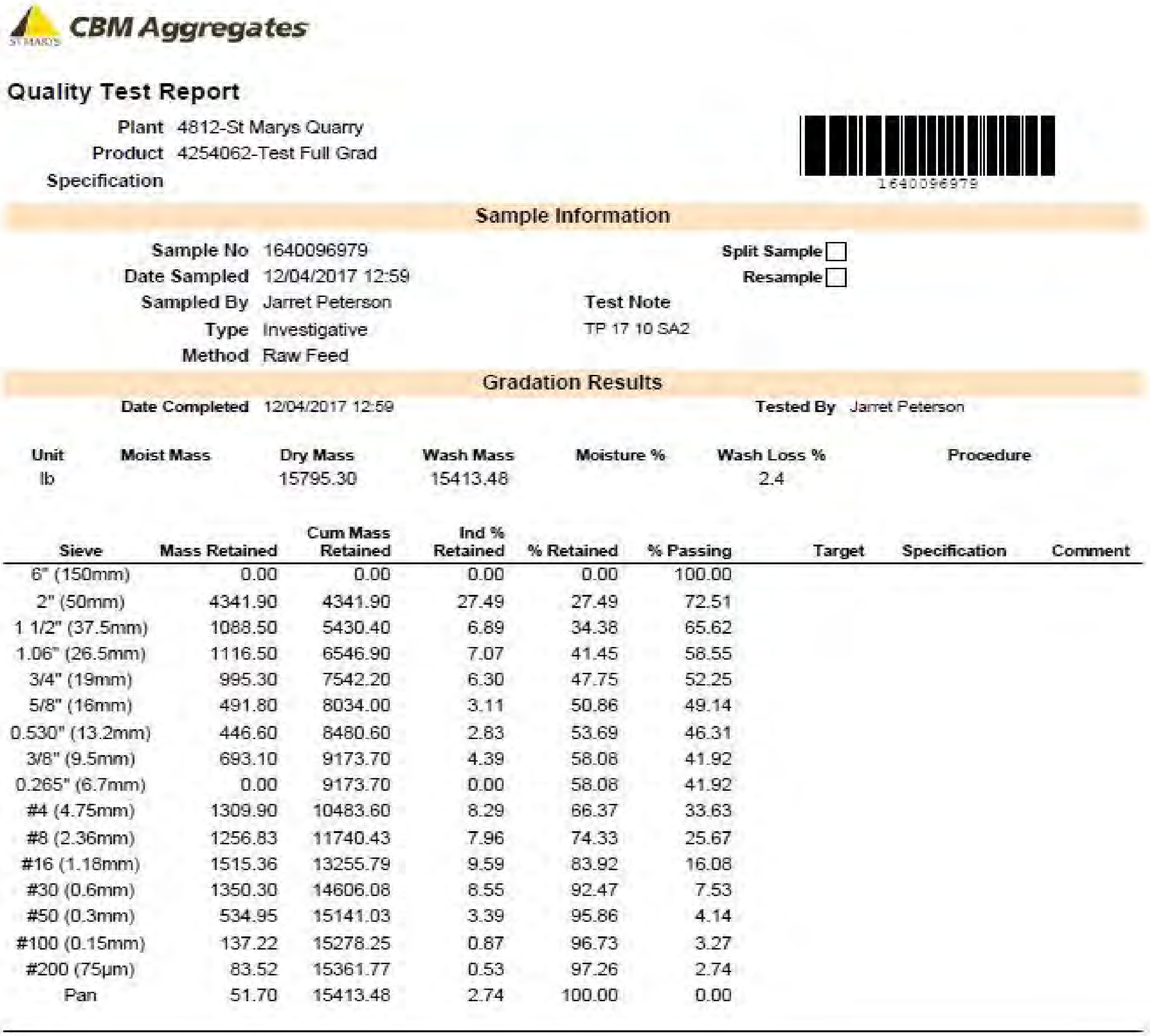
Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		18334.30	17698.29		3.5	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3285.60	3285.60	17.92	17.92	82.08			
1 1/2" (37.5mm)	1292.30	4577.90	7.05	24.97	75.03			
1.06" (26.5mm)	1959.30	6537.20	10.69	35.66	64.34			
3/4" (19mm)	1259.00	7796.20	6.87	42.52	57.48			
5/8" (16mm)	636.00	8432.20	3.47	45.99	54.01			
0.530" (13.2mm)	450.40	8882.60	2.46	48.45	51.55			
3/8" (9.5mm)	1020.80	9903.40	5.57	54.02	45.98			
0.265" (6.7mm)	817.60	10721.00	4.46	58.48	41.52			
#4 (4.75mm)	686.60	11407.60	3.74	62.22	37.78			
#8 (2.36mm)	1289.94	12697.54	7.04	69.26	30.74			
#16 (1.18mm)	1939.39	14636.92	10.58	79.83	20.17			
#30 (0.6mm)	1708.72	16345.65	9.32	89.15	10.85			
#50 (0.3mm)	727.83	17073.47	3.97	93.12	6.88			
#100 (0.15mm)	300.09	17373.56	1.64	94.76	5.24			
#200 (75µm)	170.20	17543.77	0.93	95.69	4.31			
Pan	154.52	17698.29	4.31	100.00	0.00			

FM = 3.04

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1640096979

Sample Information

Sample No 1640096979
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 10 SA2

Gradation Results

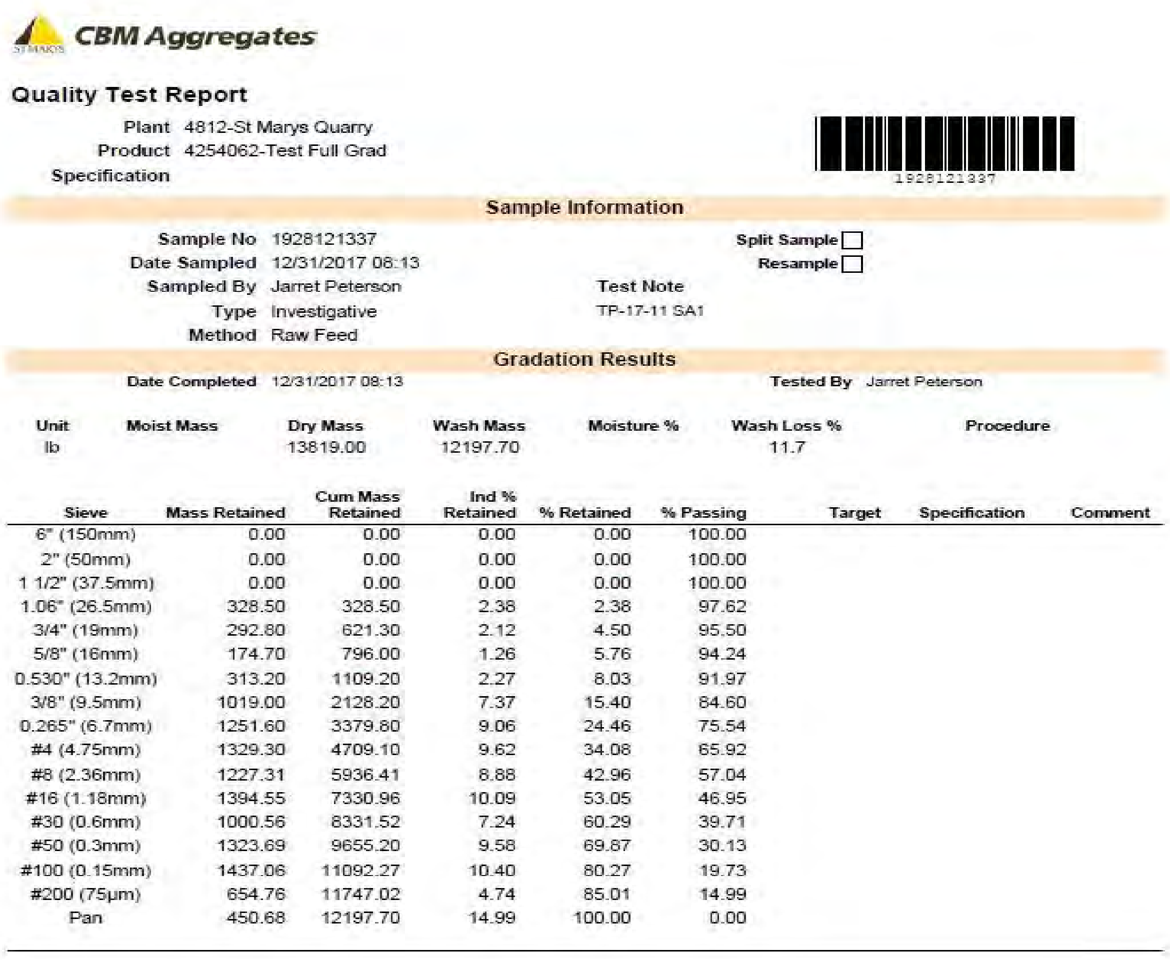
Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		15795.30	15413.48		2.4	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	4341.90	4341.90	27.49	27.49	72.51			
1 1/2" (37.5mm)	1088.50	5430.40	6.89	34.38	65.62			
1.06" (26.5mm)	1116.50	6546.90	7.07	41.45	58.55			
3/4" (19mm)	995.30	7542.20	6.30	47.75	52.25			
5/8" (16mm)	491.80	8034.00	3.11	50.86	49.14			
0.530" (13.2mm)	446.60	8480.60	2.83	53.69	46.31			
3/8" (9.5mm)	693.10	9173.70	4.39	58.08	41.92			
0.265" (6.7mm)	0.00	9173.70	0.00	58.08	41.92			
#4 (4.75mm)	1309.90	10483.60	8.29	66.37	33.63			
#8 (2.36mm)	1256.83	11740.43	7.96	74.33	25.67			
#16 (1.18mm)	1515.36	13255.79	9.59	83.92	16.08			
#30 (0.6mm)	1350.30	14606.08	8.55	92.47	7.53			
#50 (0.3mm)	534.95	15141.03	3.39	95.86	4.14			
#100 (0.15mm)	137.22	15278.25	0.87	96.73	3.27			
#200 (75µm)	83.52	15361.77	0.53	97.26	2.74			
Pan	51.70	15413.48	2.74	100.00	0.00			

FM = 3.31

Sample 1



CBM Aggregates

ST MARYS

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1928121337

Sample Information

Sample No 1928121337
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-11 SA1

Gradation Results

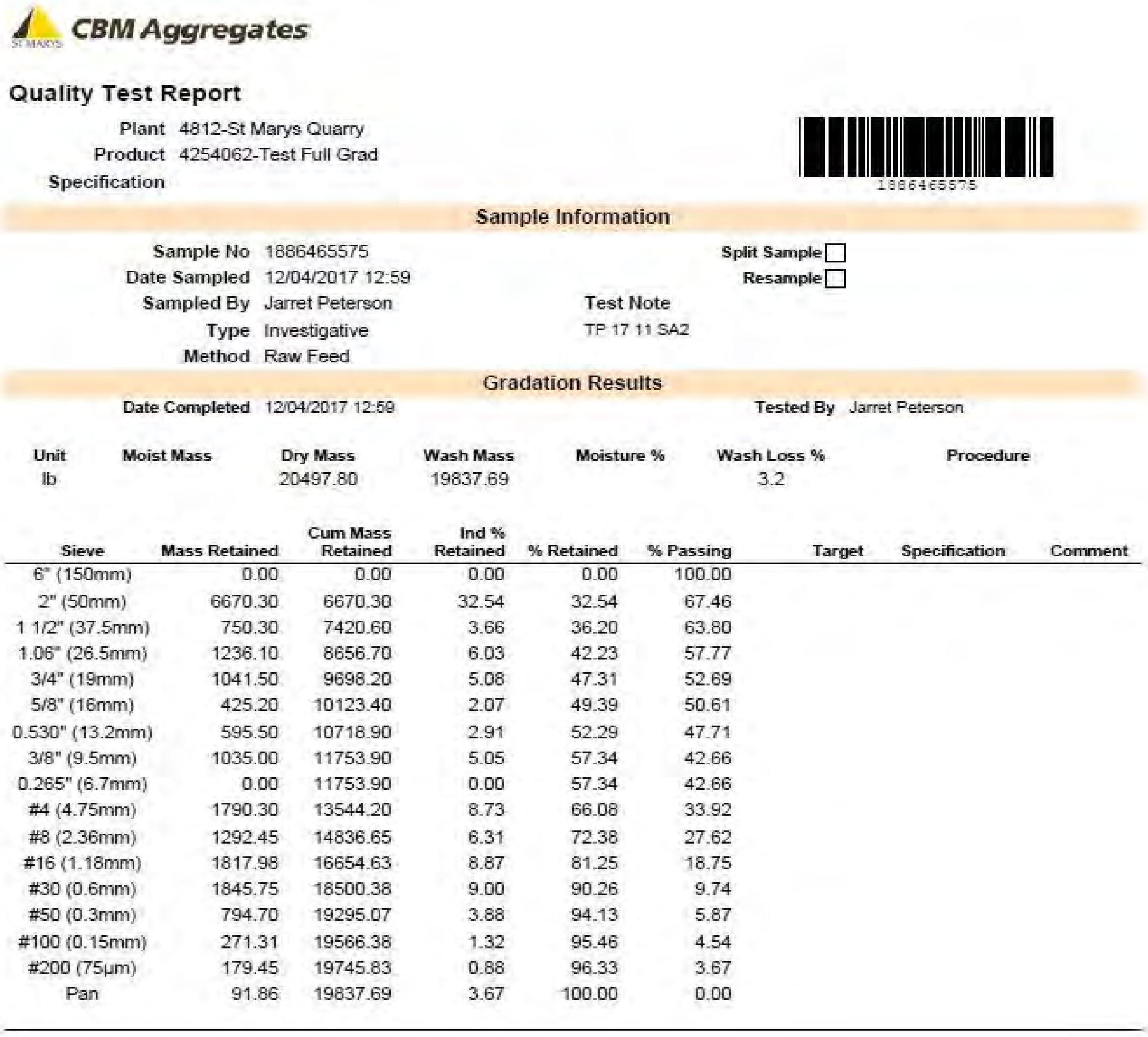
Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		13819.00	12197.70		11.7	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	0.00	0.00	0.00	0.00	100.00			
1 1/2" (37.5mm)	0.00	0.00	0.00	0.00	100.00			
1.06" (26.5mm)	328.50	328.50	2.38	2.38	97.62			
3/4" (19mm)	292.80	621.30	2.12	4.50	95.50			
5/8" (16mm)	174.70	796.00	1.26	5.76	94.24			
0.530" (13.2mm)	313.20	1109.20	2.27	8.03	91.97			
3/8" (9.5mm)	1019.00	2128.20	7.37	15.40	84.60			
0.265" (6.7mm)	1251.60	3379.80	9.06	24.46	75.54			
#4 (4.75mm)	1329.30	4709.10	9.62	34.08	65.92			
#8 (2.36mm)	1227.31	5936.41	8.88	42.96	57.04			
#16 (1.18mm)	1394.55	7330.96	10.09	53.05	46.95			
#30 (0.6mm)	1000.56	8331.52	7.24	60.29	39.71			
#50 (0.3mm)	1323.69	9655.20	9.58	69.87	30.13			
#100 (0.15mm)	1437.06	11092.27	10.40	80.27	19.73			
#200 (75µm)	654.76	11747.02	4.74	85.01	14.99			
Pan	450.68	12197.70	14.99	100.00	0.00			

FM = 2.06

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1886465575

Sample Information

Sample No 1886465575
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 11 SA2

Gradation Results

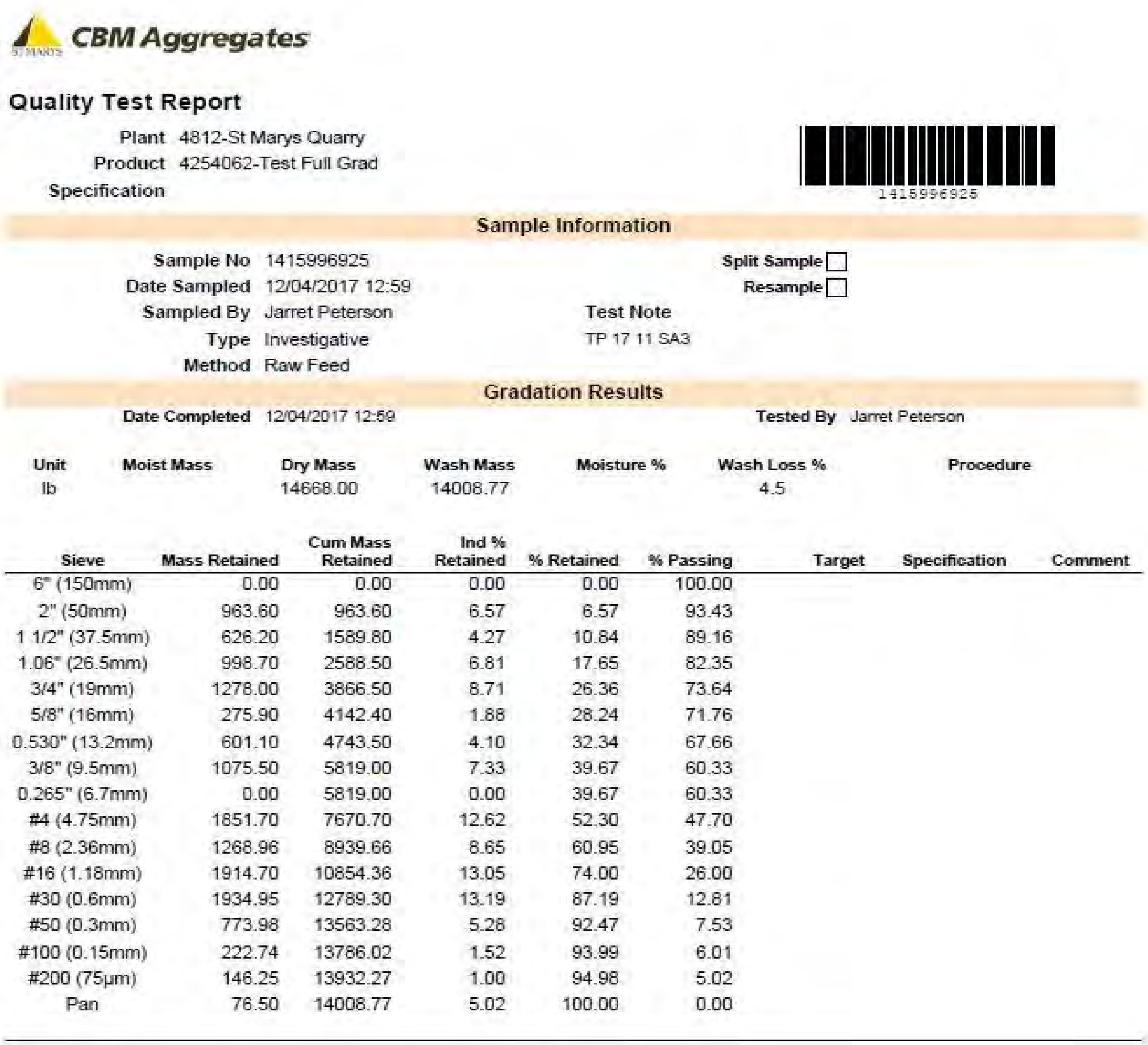
Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		20497.80	19837.69		3.2	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	6670.30	6670.30	32.54	32.54	67.46			
1 1/2" (37.5mm)	750.30	7420.60	3.66	36.20	63.80			
1.06" (26.5mm)	1236.10	8656.70	6.03	42.23	57.77			
3/4" (19mm)	1041.50	9698.20	5.08	47.31	52.69			
5/8" (16mm)	425.20	10123.40	2.07	49.39	50.61			
0.530" (13.2mm)	595.50	10718.90	2.91	52.29	47.71			
3/8" (9.5mm)	1035.00	11753.90	5.05	57.34	42.66			
0.265" (6.7mm)	0.00	11753.90	0.00	57.34	42.66			
#4 (4.75mm)	1790.30	13544.20	8.73	66.08	33.92			
#8 (2.36mm)	1292.45	14836.65	6.31	72.38	27.62			
#16 (1.18mm)	1817.98	16654.63	8.87	81.25	18.75			
#30 (0.6mm)	1845.75	18500.38	9.00	90.26	9.74			
#50 (0.3mm)	794.70	19295.07	3.88	94.13	5.87			
#100 (0.15mm)	271.31	19566.38	1.32	95.46	4.54			
#200 (75µm)	179.45	19745.83	0.88	96.33	3.67			
Pan	91.86	19837.69	3.67	100.00	0.00			

FM = 3.04

Sample 3



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415996925

Sample Information

Sample No 1415996925
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 11 SA3

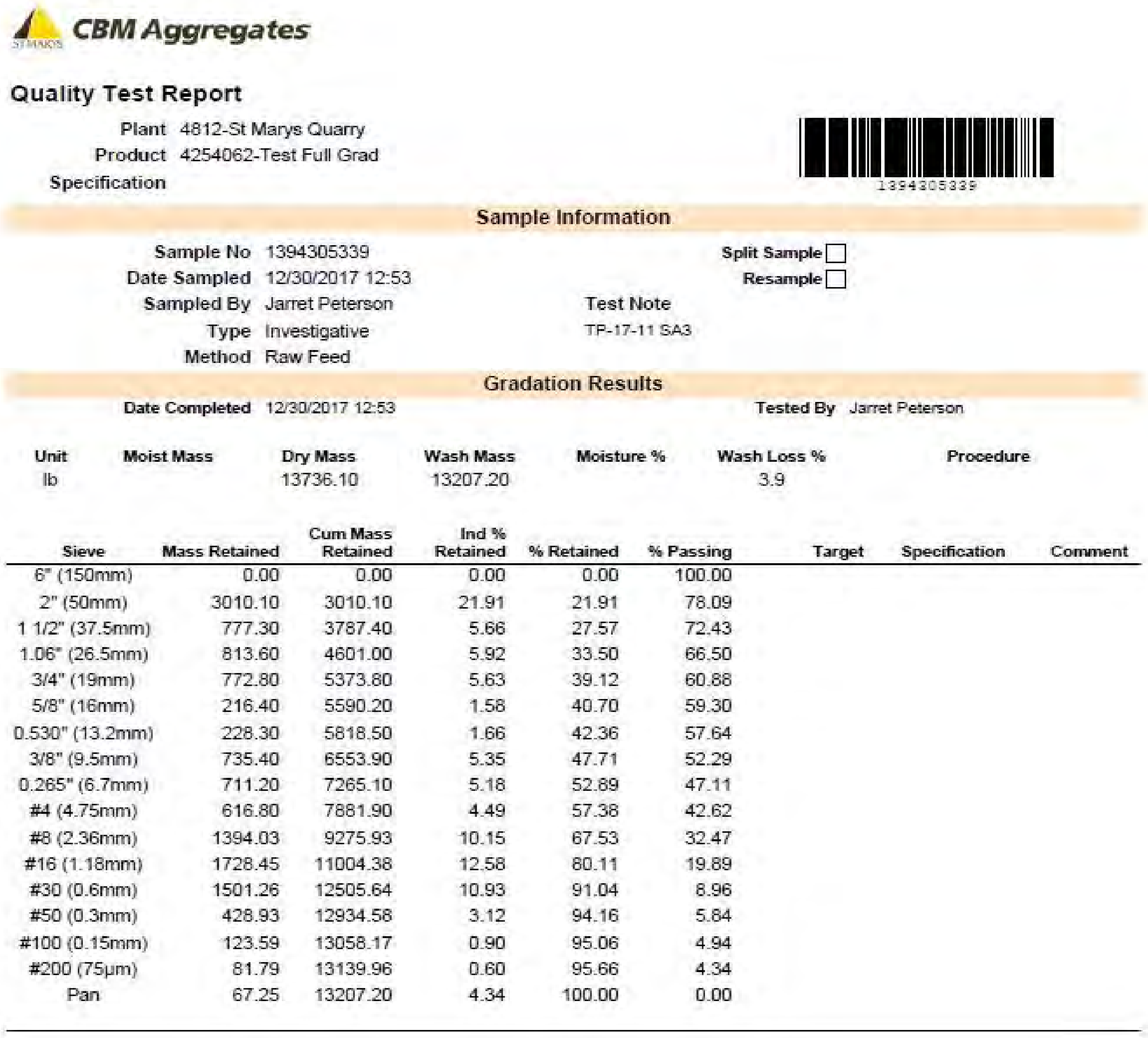
Gradation Results

Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		14668.00	14008.77		4.5	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	963.60	963.60	6.57	6.57	93.43			
1 1/2" (37.5mm)	626.20	1589.80	4.27	10.84	89.16			
1.06" (26.5mm)	998.70	2588.50	6.81	17.65	82.35			
3/4" (19mm)	1278.00	3866.50	8.71	26.36	73.64			
5/8" (16mm)	275.90	4142.40	1.88	28.24	71.76			
0.530" (13.2mm)	601.10	4743.50	4.10	32.34	67.66			
3/8" (9.5mm)	1075.50	5819.00	7.33	39.67	60.33			
0.265" (6.7mm)	0.00	5819.00	0.00	39.67	60.33			
#4 (4.75mm)	1851.70	7670.70	12.62	52.30	47.70			
#8 (2.36mm)	1268.96	8939.66	8.65	60.95	39.05			
#16 (1.18mm)	1914.70	10854.36	13.05	74.00	26.00			
#30 (0.6mm)	1934.95	12789.30	13.19	87.19	12.81			
#50 (0.3mm)	773.98	13563.28	5.28	92.47	7.53			
#100 (0.15mm)	222.74	13786.02	1.52	93.99	6.01			
#200 (75µm)	146.25	13932.27	1.00	94.98	5.02			
Pan	76.50	14008.77	5.02	100.00	0.00			

FM = 3.08



CBM Aggregates

ST MARYS

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1394305339

Sample Information

Sample No 1394305339
Date Sampled 12/30/2017 12:53
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Test Note
TP-17-11 SA3

Split Sample ☐
Resample ☐

Gradation Results

Date Completed 12/30/2017 12:53

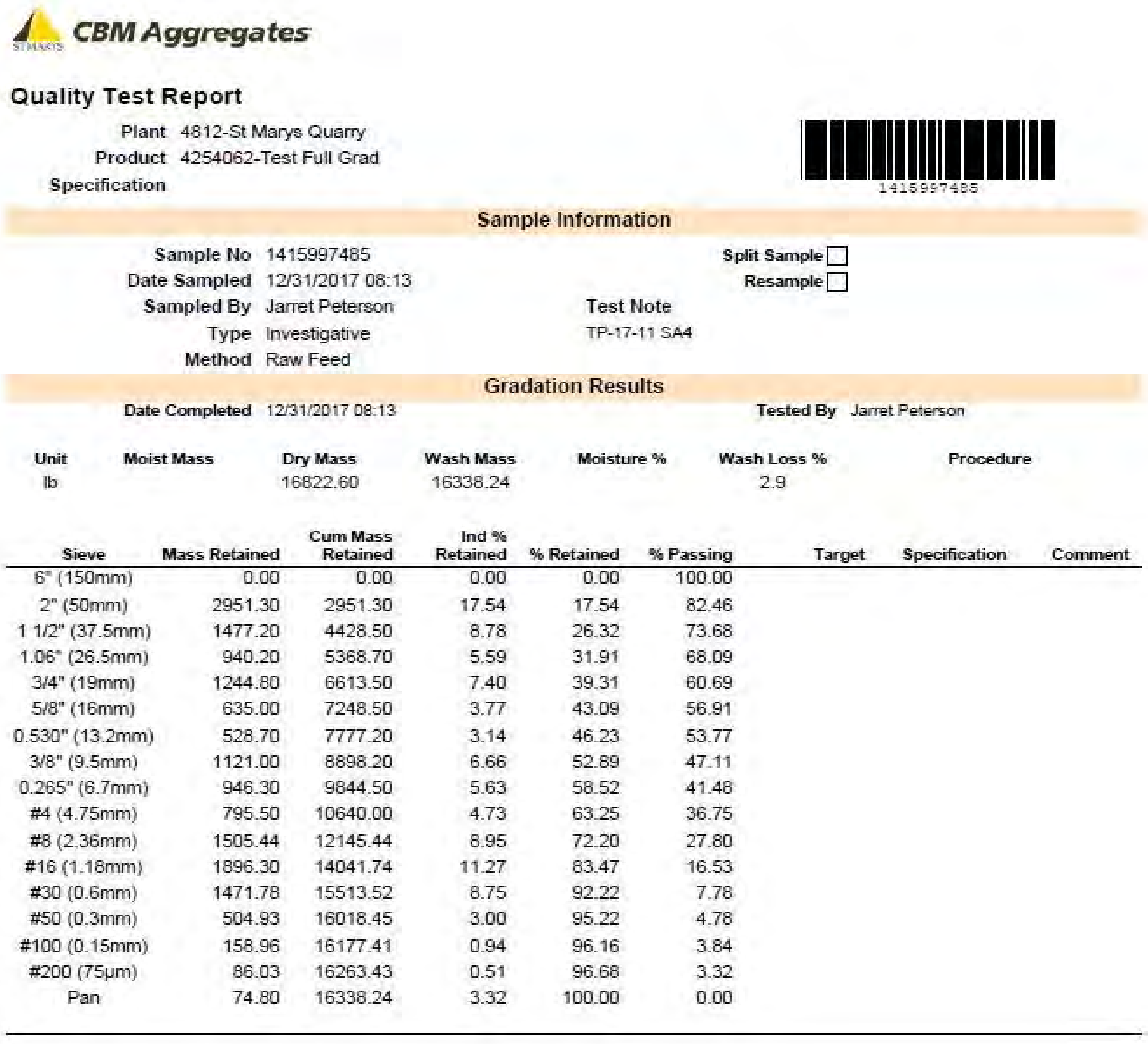
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		13736.10	13207.20		3.9	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3010.10	3010.10	21.91	21.91	78.09			
1 1/2" (37.5mm)	777.30	3787.40	5.66	27.57	72.43			
1.06" (26.5mm)	813.60	4601.00	5.92	33.50	66.50			
3/4" (19mm)	772.80	5373.80	5.63	39.12	60.88			
5/8" (16mm)	216.40	5590.20	1.58	40.70	59.30			
0.530" (13.2mm)	228.30	5818.50	1.66	42.36	57.64			
3/8" (9.5mm)	735.40	6553.90	5.35	47.71	52.29			
0.265" (6.7mm)	711.20	7265.10	5.18	52.89	47.11			
#4 (4.75mm)	616.80	7881.90	4.49	57.38	42.62			
#8 (2.36mm)	1394.03	9275.93	10.15	67.53	32.47			
#16 (1.18mm)	1728.45	11004.38	12.58	80.11	19.89			
#30 (0.6mm)	1501.26	12505.64	10.93	91.04	8.96			
#50 (0.3mm)	428.93	12934.58	3.12	94.16	5.84			
#100 (0.15mm)	123.59	13058.17	0.90	95.06	4.94			
#200 (75µm)	81.79	13139.96	0.60	95.66	4.34			
Pan	67.25	13207.20	4.34	100.00	0.00			

FM = 3.31

Sample 4



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415997485

Sample Information

Sample No 1415997485
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-11 SA4

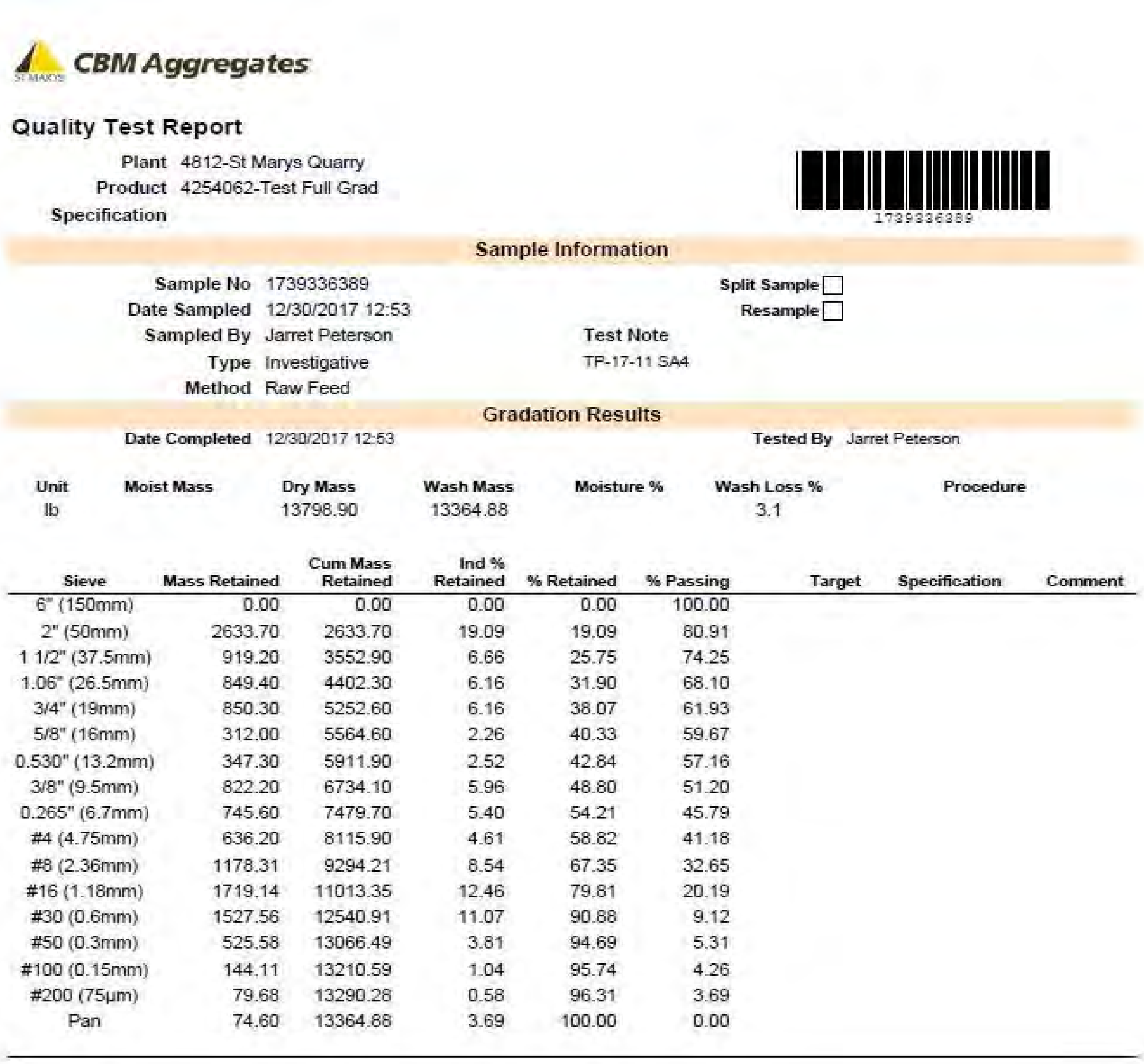
Gradation Results

Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		16822.60	16338.24		2.9	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	2951.30	2951.30	17.54	17.54	82.46			
1 1/2" (37.5mm)	1477.20	4428.50	8.78	26.32	73.68			
1.06" (26.5mm)	940.20	5368.70	5.59	31.91	68.09			
3/4" (19mm)	1244.80	6613.50	7.40	39.31	60.69			
5/8" (16mm)	635.00	7248.50	3.77	43.09	56.91			
0.530" (13.2mm)	528.70	7777.20	3.14	46.23	53.77			
3/8" (9.5mm)	1121.00	8898.20	6.66	52.89	47.11			
0.265" (6.7mm)	946.30	9844.50	5.63	58.52	41.48			
#4 (4.75mm)	795.50	10640.00	4.73	63.25	36.75			
#8 (2.36mm)	1505.44	12145.44	8.95	72.20	27.80			
#16 (1.18mm)	1896.30	14041.74	11.27	83.47	16.53			
#30 (0.6mm)	1471.78	15513.52	8.75	92.22	7.78			
#50 (0.3mm)	504.93	16018.45	3.00	95.22	4.78			
#100 (0.15mm)	158.96	16177.41	0.94	96.16	3.84			
#200 (75µm)	86.03	16263.43	0.51	96.68	3.32			
Pan	74.80	16338.24	3.32	100.00	0.00			

FM = 3.35



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1739336389

Sample Information

Sample No 1739336389
Date Sampled 12/30/2017 12:53
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-11 SA4

Gradation Results

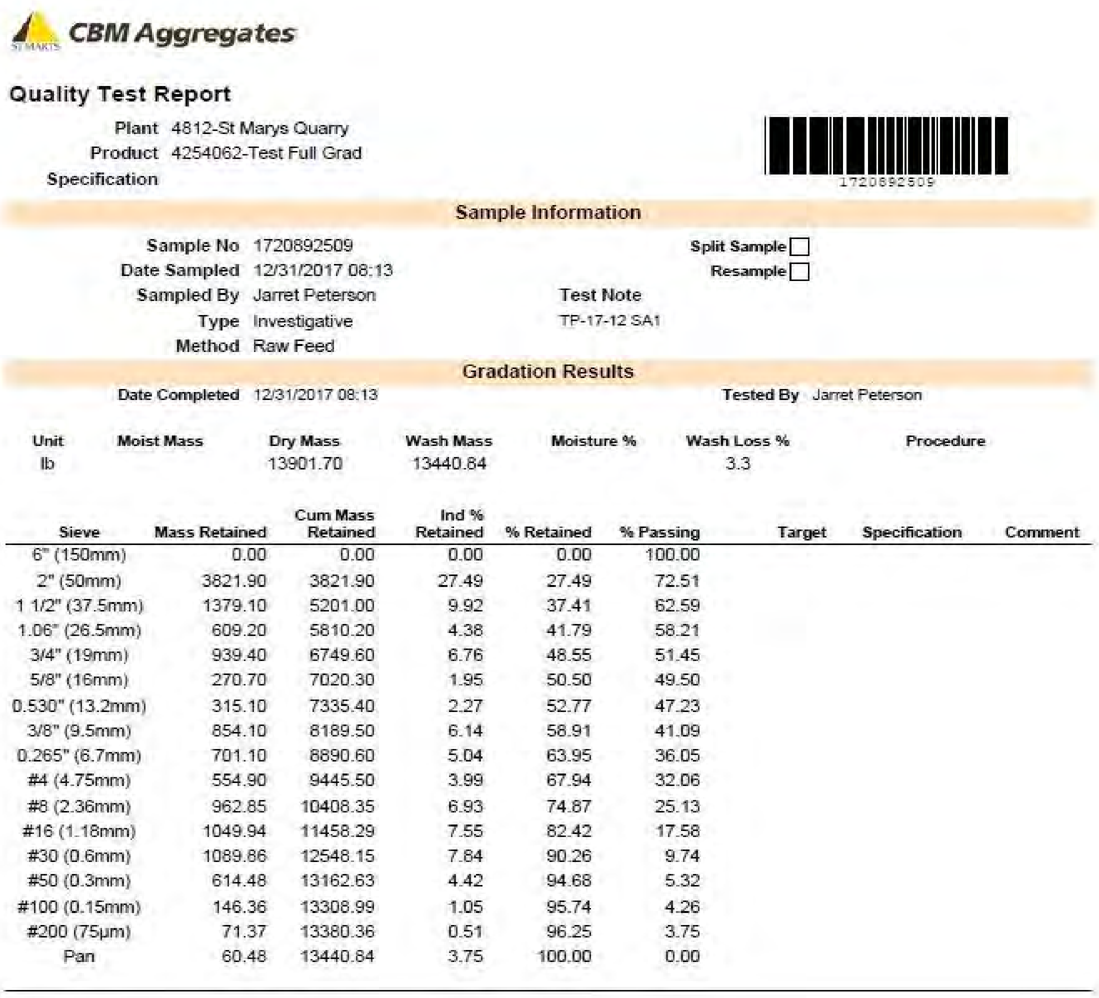
Date Completed 12/30/2017 12:53
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		13798.90	13364.88		3.1	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	2633.70	2633.70	19.09	19.09	80.91			
1 1/2" (37.5mm)	919.20	3552.90	6.66	25.75	74.25			
1.06" (26.5mm)	849.40	4402.30	6.16	31.90	68.10			
3/4" (19mm)	850.30	5252.60	6.16	38.07	61.93			
5/8" (16mm)	312.00	5564.60	2.26	40.33	59.67			
0.530" (13.2mm)	347.30	5911.90	2.52	42.84	57.16			
3/8" (9.5mm)	822.20	6734.10	5.96	48.80	51.20			
0.265" (6.7mm)	745.60	7479.70	5.40	54.21	45.79			
#4 (4.75mm)	636.20	8115.90	4.61	58.82	41.18			
#8 (2.36mm)	1178.31	9294.21	8.54	67.35	32.65			
#16 (1.18mm)	1719.14	11013.35	12.46	79.81	20.19			
#30 (0.6mm)	1527.56	12540.91	11.07	90.88	9.12			
#50 (0.3mm)	525.58	13066.49	3.81	94.69	5.31			
#100 (0.15mm)	144.11	13210.59	1.04	95.74	4.26			
#200 (75µm)	79.68	13290.28	0.58	96.31	3.69			
Pan	74.60	13364.88	3.69	100.00	0.00			

FM = 3.26

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1720892509

Sample Information

Sample No 1720892509
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-12 SA1

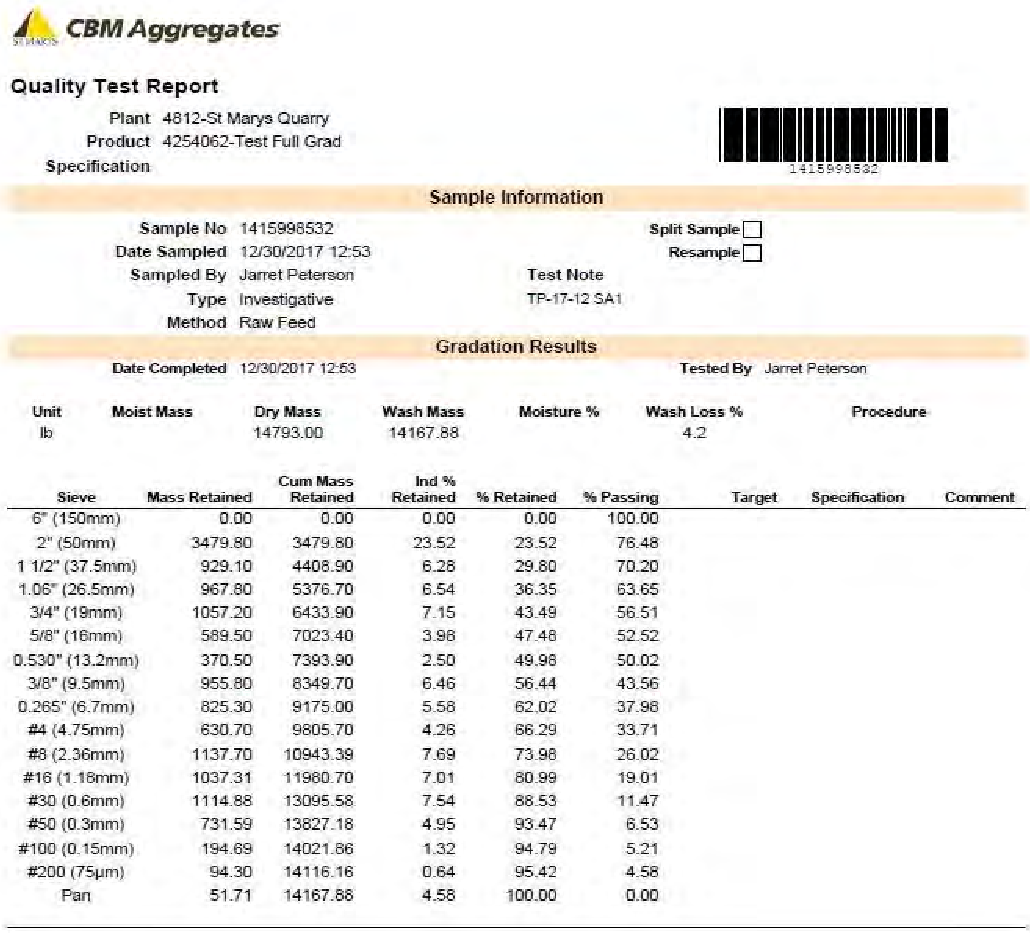
Gradation Results

Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		13901.70	13440.84		3.3	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3821.90	3821.90	27.49	27.49	72.51			
1 1/2" (37.5mm)	1379.10	5201.00	9.92	37.41	62.59			
1.06" (26.5mm)	609.20	5810.20	4.38	41.79	58.21			
3/4" (19mm)	939.40	6749.60	6.76	48.55	51.45			
5/8" (16mm)	270.70	7020.30	1.95	50.50	49.50			
0.530" (13.2mm)	315.10	7335.40	2.27	52.77	47.23			
3/8" (9.5mm)	854.10	8189.50	6.14	58.91	41.09			
0.265" (6.7mm)	701.10	8890.60	5.04	63.95	36.05			
#4 (4.75mm)	554.90	9445.50	3.99	67.94	32.06			
#8 (2.36mm)	962.85	10408.35	6.93	74.87	25.13			
#16 (1.18mm)	1049.94	11458.29	7.55	82.42	17.58			
#30 (0.6mm)	1089.86	12548.15	7.84	90.26	9.74			
#50 (0.3mm)	614.48	13162.63	4.42	94.68	5.32			
#100 (0.15mm)	146.36	13308.99	1.05	95.74	4.26			
#200 (75µm)	71.37	13380.36	0.51	96.25	3.75			
Pan	60.48	13440.84	3.75	100.00	0.00			

FM = 3.06



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415998532

Sample Information

Sample No 1415998532
Date Sampled 12/30/2017 12:53
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-12 SA1

Gradation Results

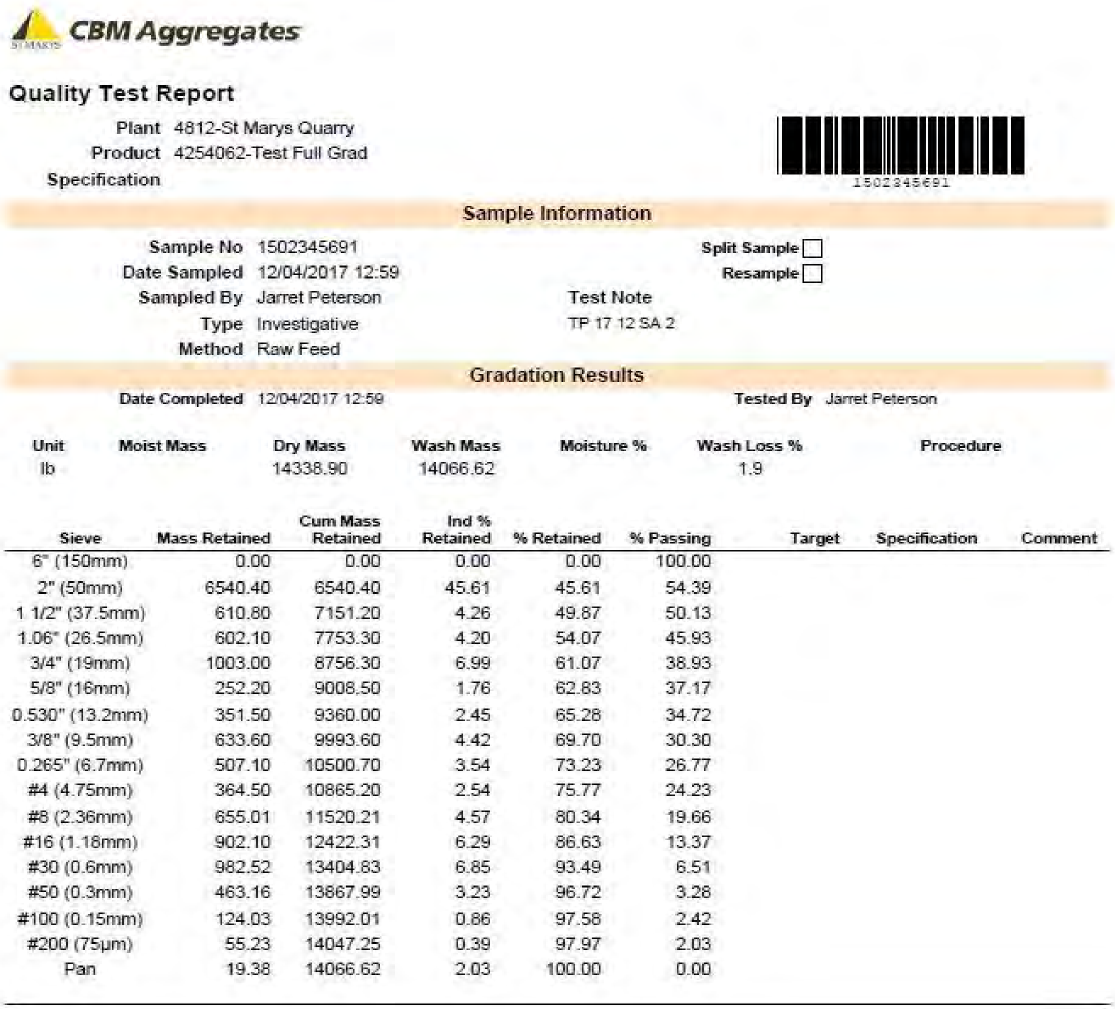
Date Completed 12/30/2017 12:53
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		14793.00	14167.88		4.2	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3479.80	3479.80	23.52	23.52	76.48			
1 1/2" (37.5mm)	929.10	4408.90	6.28	29.80	70.20			
1.06" (26.5mm)	967.80	5376.70	6.54	36.35	63.65			
3/4" (19mm)	1057.20	6433.90	7.15	43.49	56.51			
5/8" (16mm)	589.50	7023.40	3.98	47.48	52.52			
0.530" (13.2mm)	370.50	7393.90	2.50	49.98	50.02			
3/8" (9.5mm)	955.80	8349.70	6.46	56.44	43.56			
0.265" (6.7mm)	825.30	9175.00	5.58	62.02	37.98			
#4 (4.75mm)	630.70	9805.70	4.26	66.29	33.71			
#8 (2.36mm)	1137.70	10943.39	7.69	73.98	26.02			
#16 (1.18mm)	1037.31	11980.70	7.01	80.99	19.01			
#30 (0.6mm)	1114.88	13095.58	7.54	88.53	11.47			
#50 (0.3mm)	731.59	13827.18	4.95	93.47	6.53			
#100 (0.15mm)	194.69	14021.86	1.32	94.79	5.21			
#200 (75µm)	94.30	14116.16	0.64	95.42	4.58			
Pan	51.71	14167.88	4.58	100.00	0.00			

FM = 2.98

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1502345691

Sample Information

Sample No 1502345691
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 12 SA 2

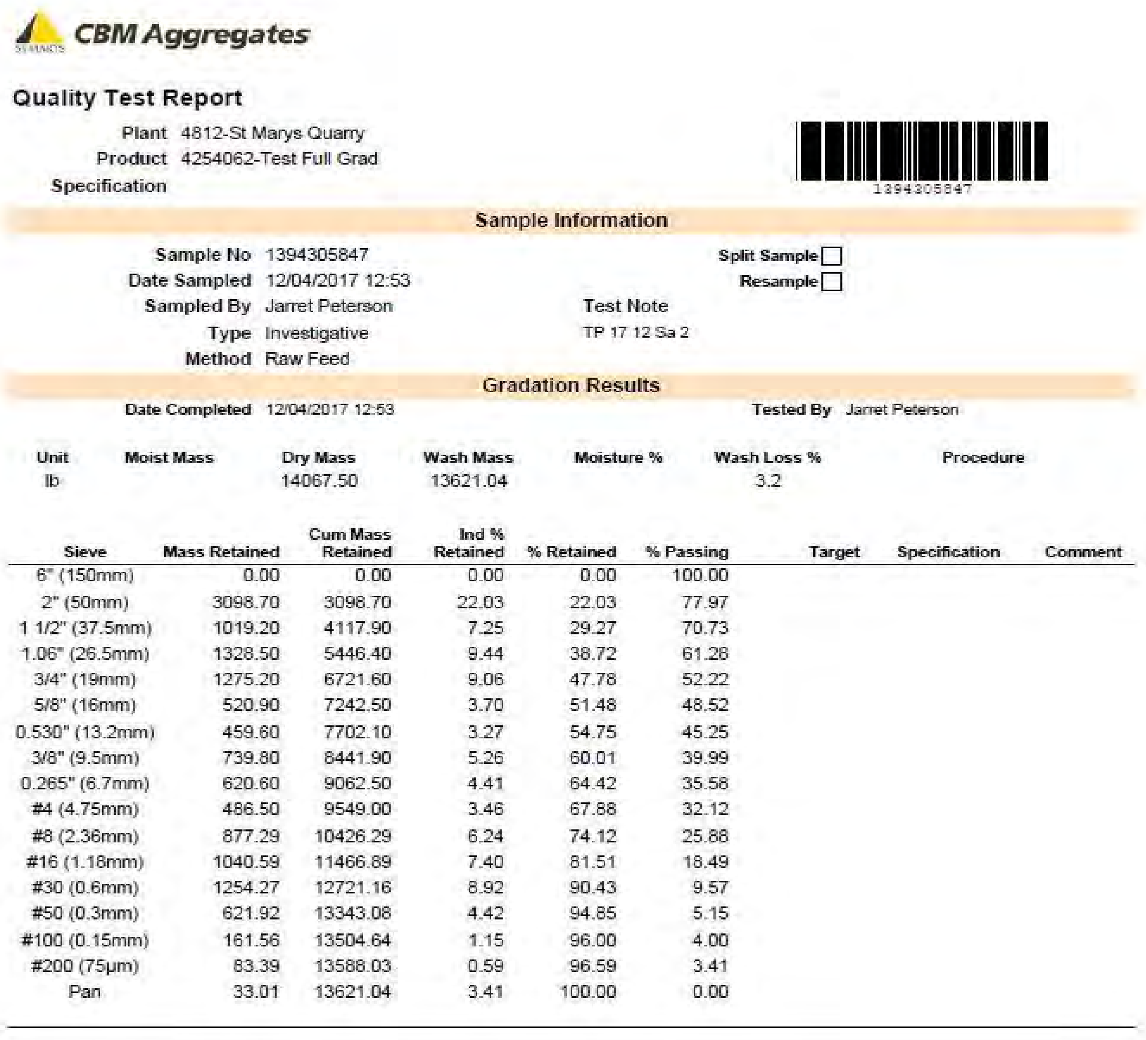
Gradation Results

Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		14338.90	14066.62		1.9	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	6540.40	6540.40	45.61	45.61	54.39			
1 1/2" (37.5mm)	610.80	7151.20	4.26	49.87	50.13			
1.06" (26.5mm)	602.10	7753.30	4.20	54.07	45.93			
3/4" (19mm)	1003.00	8756.30	6.99	61.07	38.93			
5/8" (16mm)	252.20	9008.50	1.76	62.83	37.17			
0.530" (13.2mm)	351.50	9360.00	2.45	65.28	34.72			
3/8" (9.5mm)	633.60	9993.60	4.42	69.70	30.30			
0.265" (6.7mm)	507.10	10500.70	3.54	73.23	26.77			
#4 (4.75mm)	364.50	10865.20	2.54	75.77	24.23			
#8 (2.36mm)	655.01	11520.21	4.57	80.34	19.66			
#16 (1.18mm)	902.10	12422.31	6.29	86.63	13.37			
#30 (0.6mm)	982.52	13404.83	6.85	93.49	6.51			
#50 (0.3mm)	463.16	13867.99	3.23	96.72	3.28			
#100 (0.15mm)	124.03	13992.01	0.86	97.58	2.42			
#200 (75µm)	55.23	14047.25	0.39	97.97	2.03			
Pan	19.38	14066.62	2.03	100.00	0.00			

FM = 3.13



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1394305847

Sample Information

Sample No 1394305847
Date Sampled 12/04/2017 12:53
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 12 Sa 2

Gradation Results

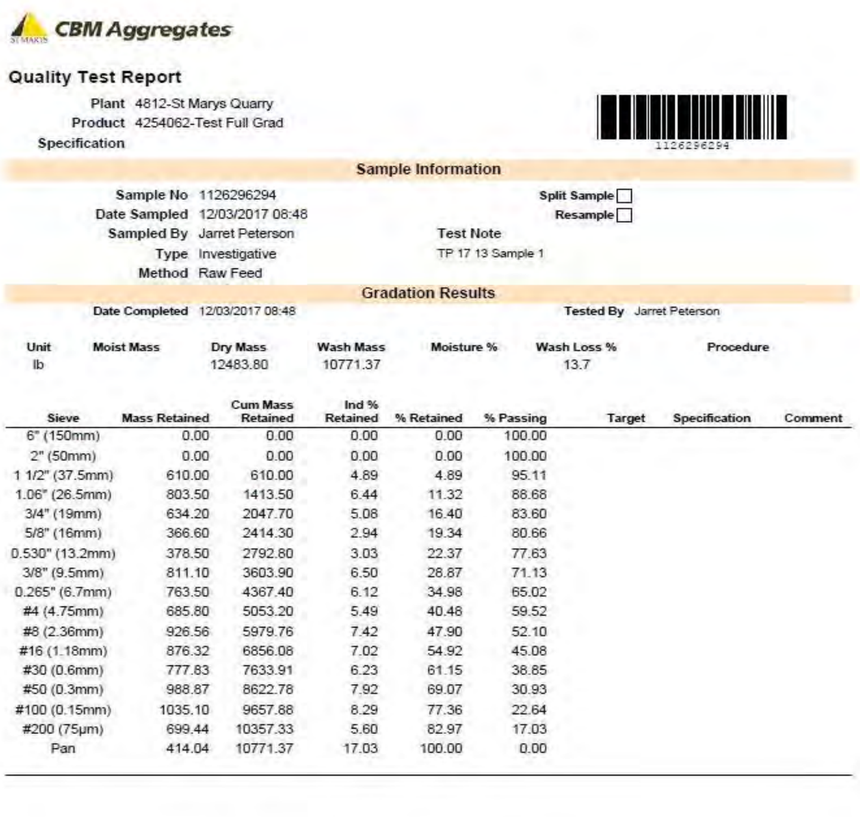
Date Completed 12/04/2017 12:53
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		14067.50	13621.04		3.2	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3098.70	3098.70	22.03	22.03	77.97			
1 1/2" (37.5mm)	1019.20	4117.90	7.25	29.27	70.73			
1.06" (26.5mm)	1328.50	5446.40	9.44	38.72	61.28			
3/4" (19mm)	1275.20	6721.60	9.06	47.78	52.22			
5/8" (16mm)	520.90	7242.50	3.70	51.48	48.52			
0.530" (13.2mm)	459.60	7702.10	3.27	54.75	45.25			
3/8" (9.5mm)	739.80	8441.90	5.26	60.01	39.99			
0.265" (6.7mm)	620.60	9062.50	4.41	64.42	35.58			
#4 (4.75mm)	486.50	9549.00	3.46	67.88	32.12			
#8 (2.36mm)	877.29	10426.29	6.24	74.12	25.88			
#16 (1.18mm)	1040.59	11466.89	7.40	81.51	18.49			
#30 (0.6mm)	1254.27	12721.16	8.92	90.43	9.57			
#50 (0.3mm)	621.92	13343.08	4.42	94.85	5.15			
#100 (0.15mm)	161.56	13504.64	1.15	96.00	4.00			
#200 (75µm)	83.39	13588.03	0.59	96.59	3.41			
Pan	33.01	13621.04	3.41	100.00	0.00			

FM = 3.04

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1126296294

Sample Information

Sample No 1126296294
Date Sampled 12/03/2017 08:48
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 13 Sample 1

Gradation Results

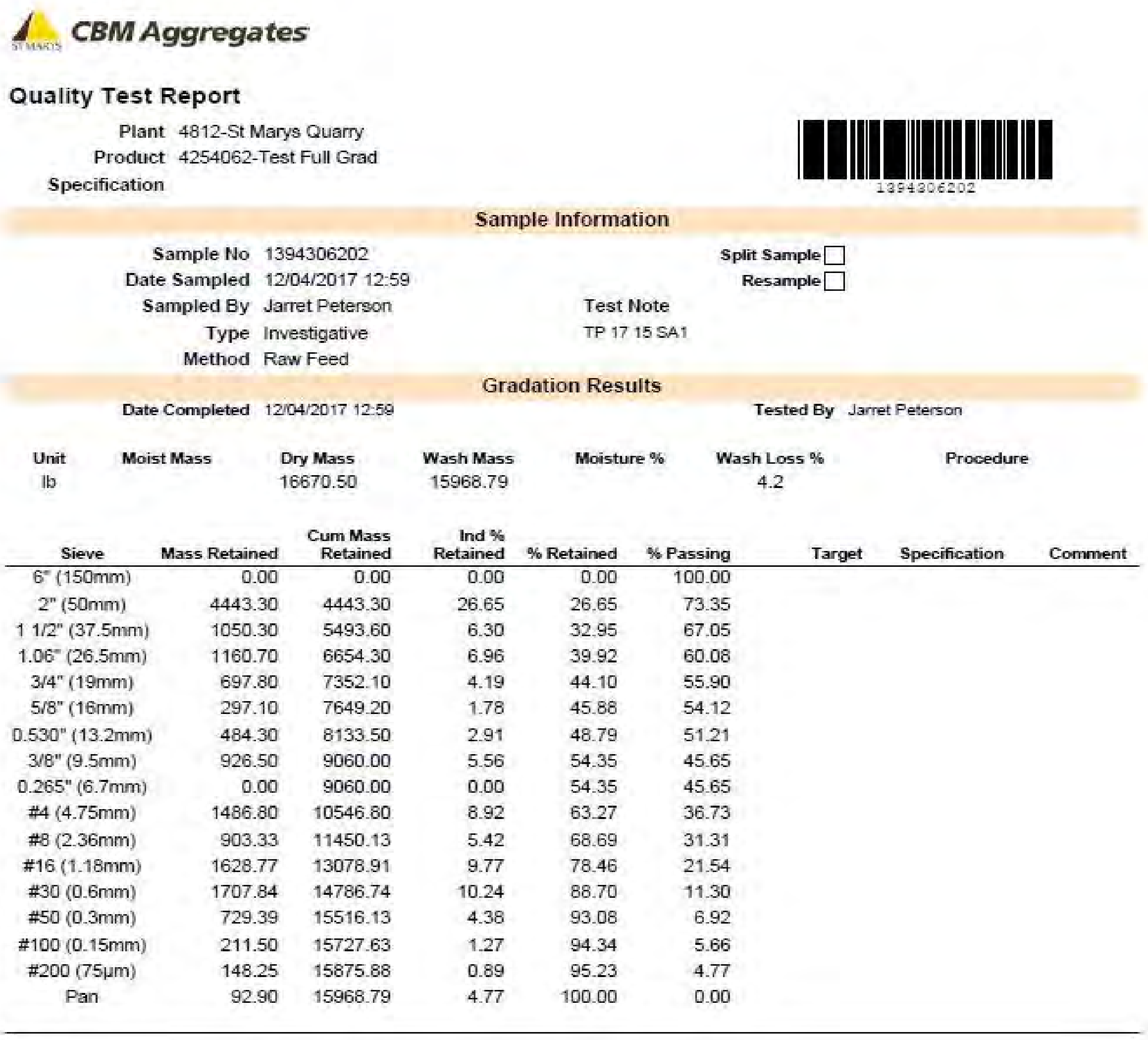
Date Completed 12/03/2017 08:48
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		12483.80	10771.37		13.7	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	0.00	0.00	0.00	0.00	100.00			
1 1/2" (37.5mm)	610.00	610.00	4.89	4.89	95.11			
1.06" (26.5mm)	803.50	1413.50	6.44	11.32	88.68			
3/4" (19mm)	634.20	2047.70	5.08	16.40	83.60			
5/8" (16mm)	366.60	2414.30	2.94	19.34	80.66			
0.530" (13.2mm)	378.50	2792.80	3.03	22.37	77.63			
3/8" (9.5mm)	811.10	3603.90	6.50	28.87	71.13			
0.265" (6.7mm)	763.50	4367.40	6.12	34.98	65.02			
#4 (4.75mm)	685.80	5053.20	5.49	40.48	59.52			
#8 (2.36mm)	926.56	5979.76	7.42	47.90	52.10			
#16 (1.18mm)	876.32	6856.08	7.02	54.92	45.08			
#30 (0.6mm)	777.83	7633.91	6.23	61.15	38.85			
#50 (0.3mm)	988.87	8622.78	7.92	69.07	30.93			
#100 (0.15mm)	1035.10	9657.88	8.29	77.36	22.64			
#200 (75µm)	699.44	10357.33	5.60	82.97	17.03			
Pan	414.04	10771.37	17.03	100.00	0.00			

FM = 1.82

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1394306202

Sample Information

Sample No 1394306202
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 15 SA1

Gradation Results

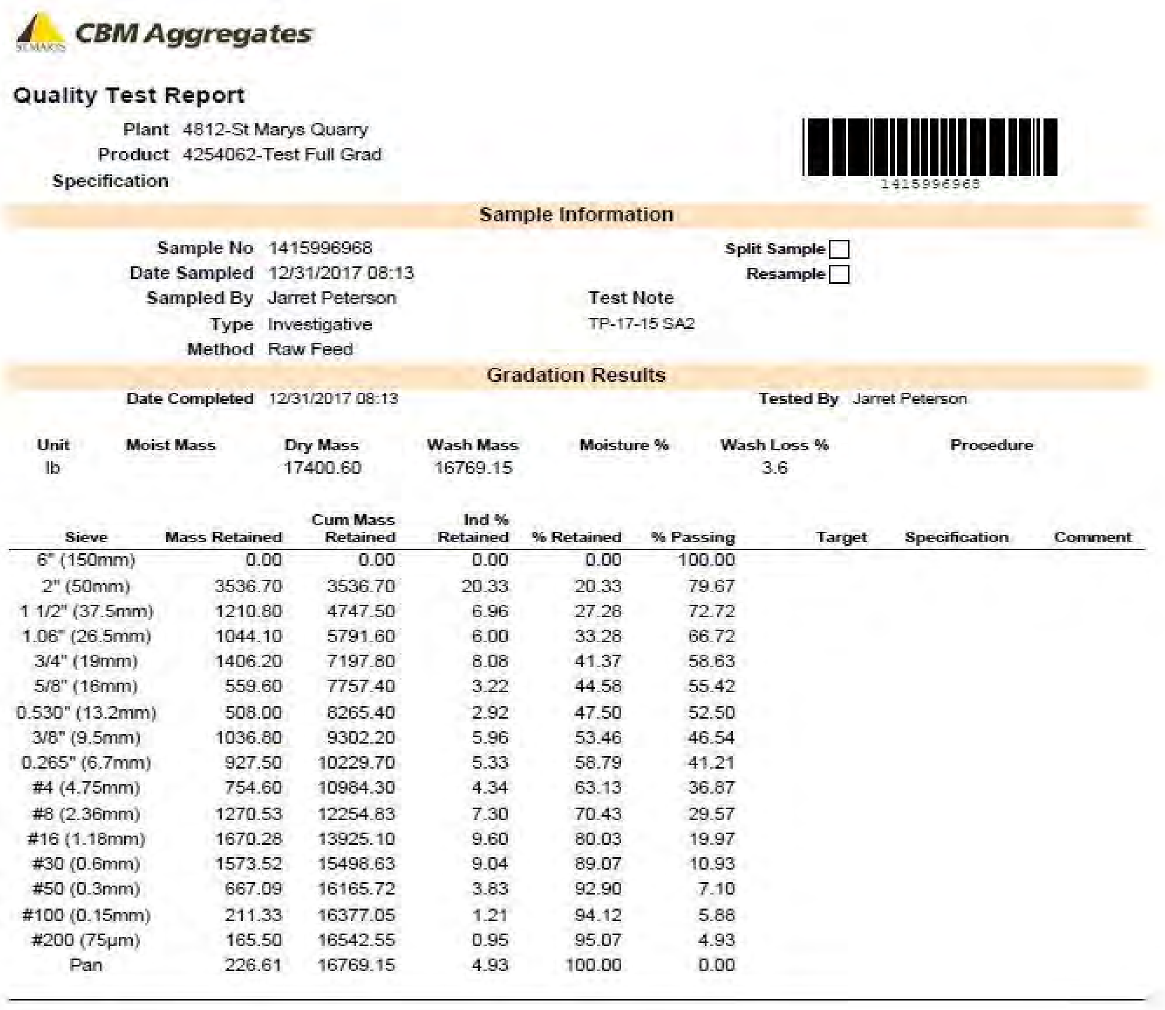
Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		16670.50	15968.79		4.2	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	4443.30	4443.30	26.65	26.65	73.35			
1 1/2" (37.5mm)	1050.30	5493.60	6.30	32.95	67.05			
1.06" (26.5mm)	1160.70	6654.30	6.96	39.92	60.08			
3/4" (19mm)	697.80	7352.10	4.19	44.10	55.90			
5/8" (16mm)	297.10	7649.20	1.78	45.88	54.12			
0.530" (13.2mm)	484.30	8133.50	2.91	48.79	51.21			
3/8" (9.5mm)	926.50	9060.00	5.56	54.35	45.65			
0.265" (6.7mm)	0.00	9060.00	0.00	54.35	45.65			
#4 (4.75mm)	1486.80	10546.80	8.92	63.27	36.73			
#8 (2.36mm)	903.33	11450.13	5.42	68.69	31.31			
#16 (1.18mm)	1628.77	13078.91	9.77	78.46	21.54			
#30 (0.6mm)	1707.84	14786.74	10.24	88.70	11.30			
#50 (0.3mm)	729.39	15516.13	4.38	93.08	6.92			
#100 (0.15mm)	211.50	15727.63	1.27	94.34	5.66			
#200 (75µm)	148.25	15875.88	0.89	95.23	4.77			
Pan	92.90	15968.79	4.77	100.00	0.00			

FM = 2.91

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415996968

Sample Information

Sample No 1415996968
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP-17-15 SA2

Gradation Results

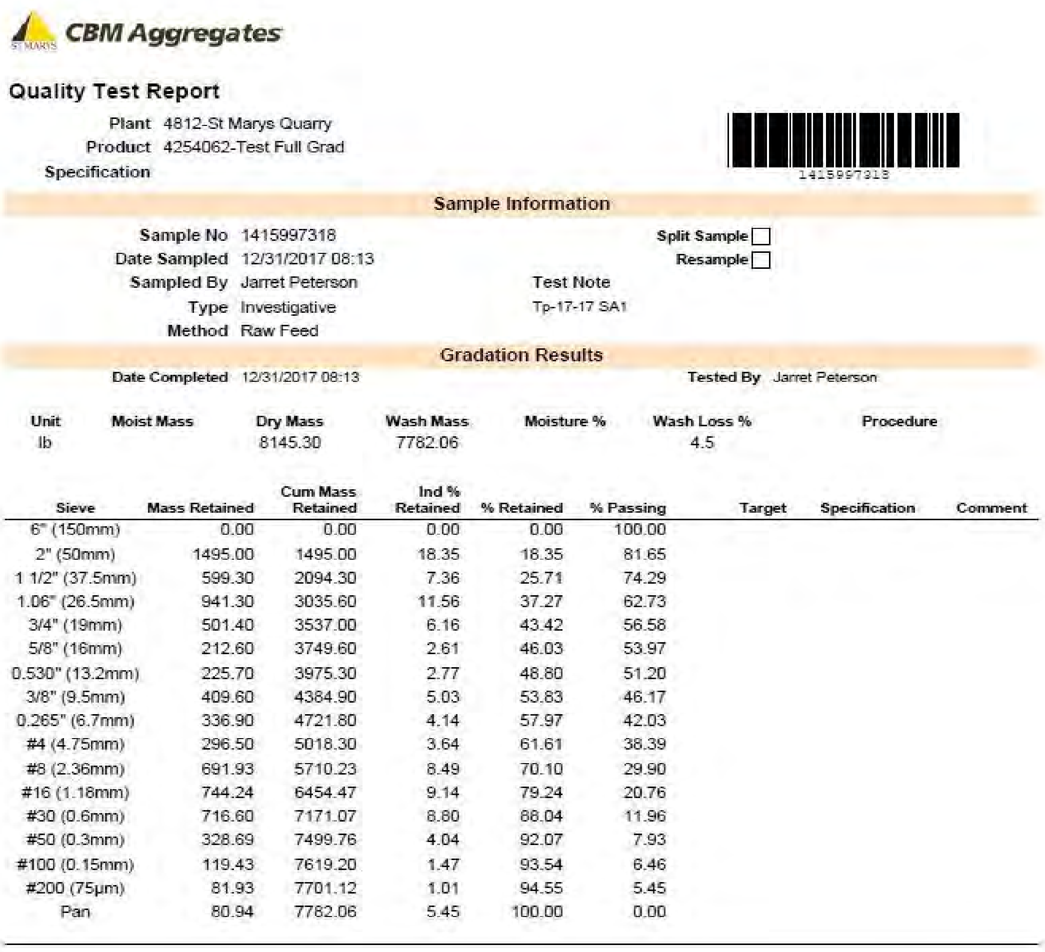
Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		17400.60	16769.15		3.6	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3536.70	3536.70	20.33	20.33	79.67			
1 1/2" (37.5mm)	1210.80	4747.50	6.96	27.28	72.72			
1.06" (26.5mm)	1044.10	5791.60	6.00	33.28	66.72			
3/4" (19mm)	1406.20	7197.80	8.08	41.37	58.63			
5/8" (16mm)	559.60	7757.40	3.22	44.58	55.42			
0.530" (13.2mm)	508.00	8265.40	2.92	47.50	52.50			
3/8" (9.5mm)	1036.80	9302.20	5.96	53.46	46.54			
0.265" (6.7mm)	927.50	10229.70	5.33	58.79	41.21			
#4 (4.75mm)	754.60	10984.30	4.34	63.13	36.87			
#8 (2.36mm)	1270.53	12254.83	7.30	70.43	29.57			
#16 (1.18mm)	1670.28	13925.10	9.60	80.03	19.97			
#30 (0.6mm)	1573.52	15498.63	9.04	89.07	10.93			
#50 (0.3mm)	667.09	16165.72	3.83	92.90	7.10			
#100 (0.15mm)	211.33	16377.05	1.21	94.12	5.88			
#200 (75μm)	165.50	16542.55	0.95	95.07	4.93			
Pan	226.61	16769.15	4.93	100.00	0.00			

FM = 3.01

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1415997318

Sample Information

Sample No 1415997318
Date Sampled 12/31/2017 08:13
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
Tp-17-17 SA1

Gradation Results

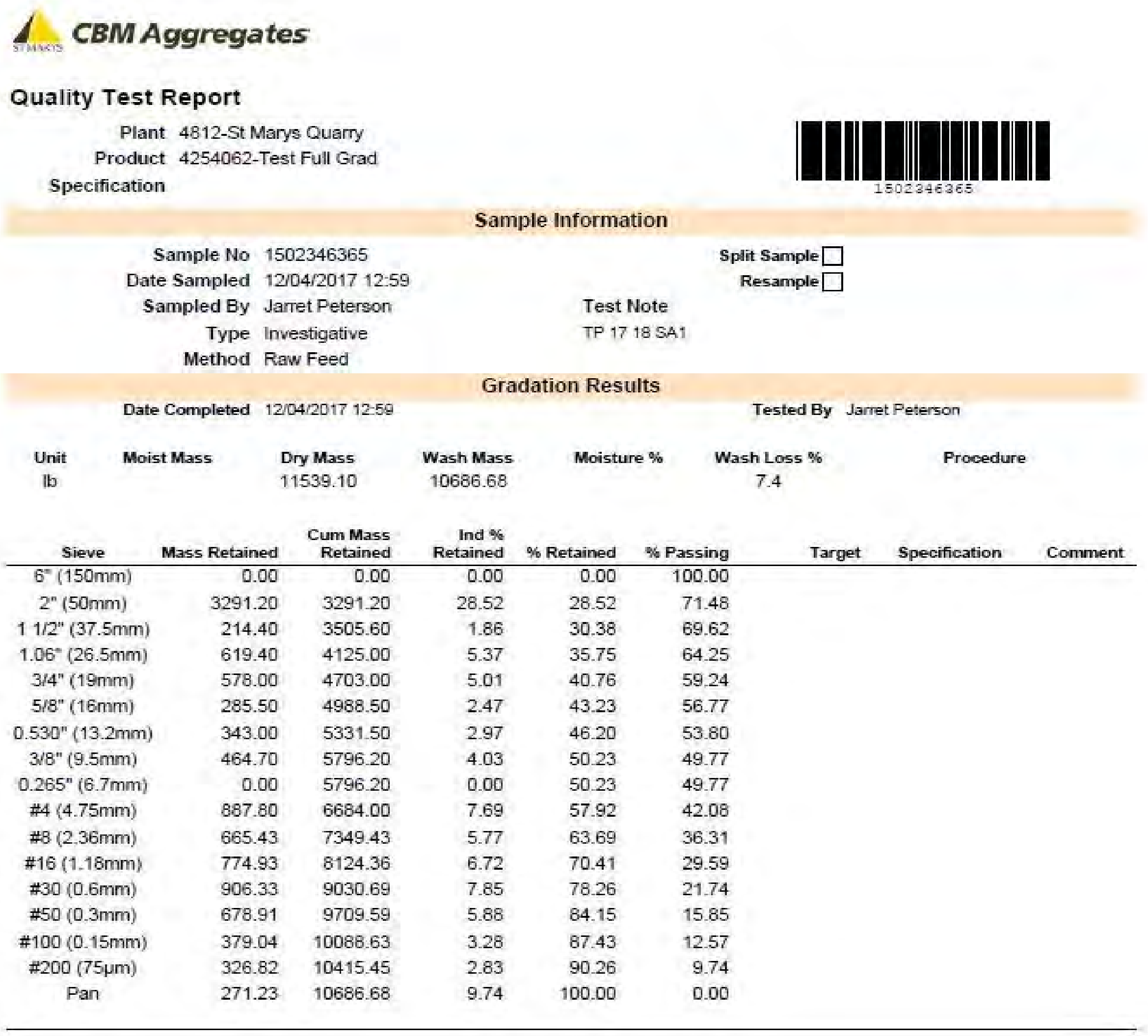
Date Completed 12/31/2017 08:13
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		8145.30	7782.06		4.5	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	1495.00	1495.00	18.35	18.35	81.65			
1 1/2" (37.5mm)	599.30	2094.30	7.36	25.71	74.29			
1.06" (26.5mm)	941.30	3035.60	11.56	37.27	62.73			
3/4" (19mm)	501.40	3537.00	6.16	43.42	56.58			
5/8" (16mm)	212.60	3749.60	2.61	46.03	53.97			
0.530" (13.2mm)	225.70	3975.30	2.77	48.80	51.20			
3/8" (9.5mm)	409.60	4384.90	5.03	53.83	46.17			
0.265" (6.7mm)	336.90	4721.80	4.14	57.97	42.03			
#4 (4.75mm)	296.50	5018.30	3.64	61.61	38.39			
#8 (2.36mm)	691.93	5710.23	8.49	70.10	29.90			
#16 (1.18mm)	744.24	6454.47	9.14	79.24	20.76			
#30 (0.6mm)	716.60	7171.07	8.80	88.04	11.96			
#50 (0.3mm)	328.69	7499.76	4.04	92.07	7.93			
#100 (0.15mm)	119.43	7619.20	1.47	93.54	6.46			
#200 (75µm)	81.93	7701.12	1.01	94.55	5.45			
Pan	80.94	7782.06	5.45	100.00	0.00			

FM = 2.99

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1502346365

Sample Information

Sample No 1502346365
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 18 SA1

Gradation Results

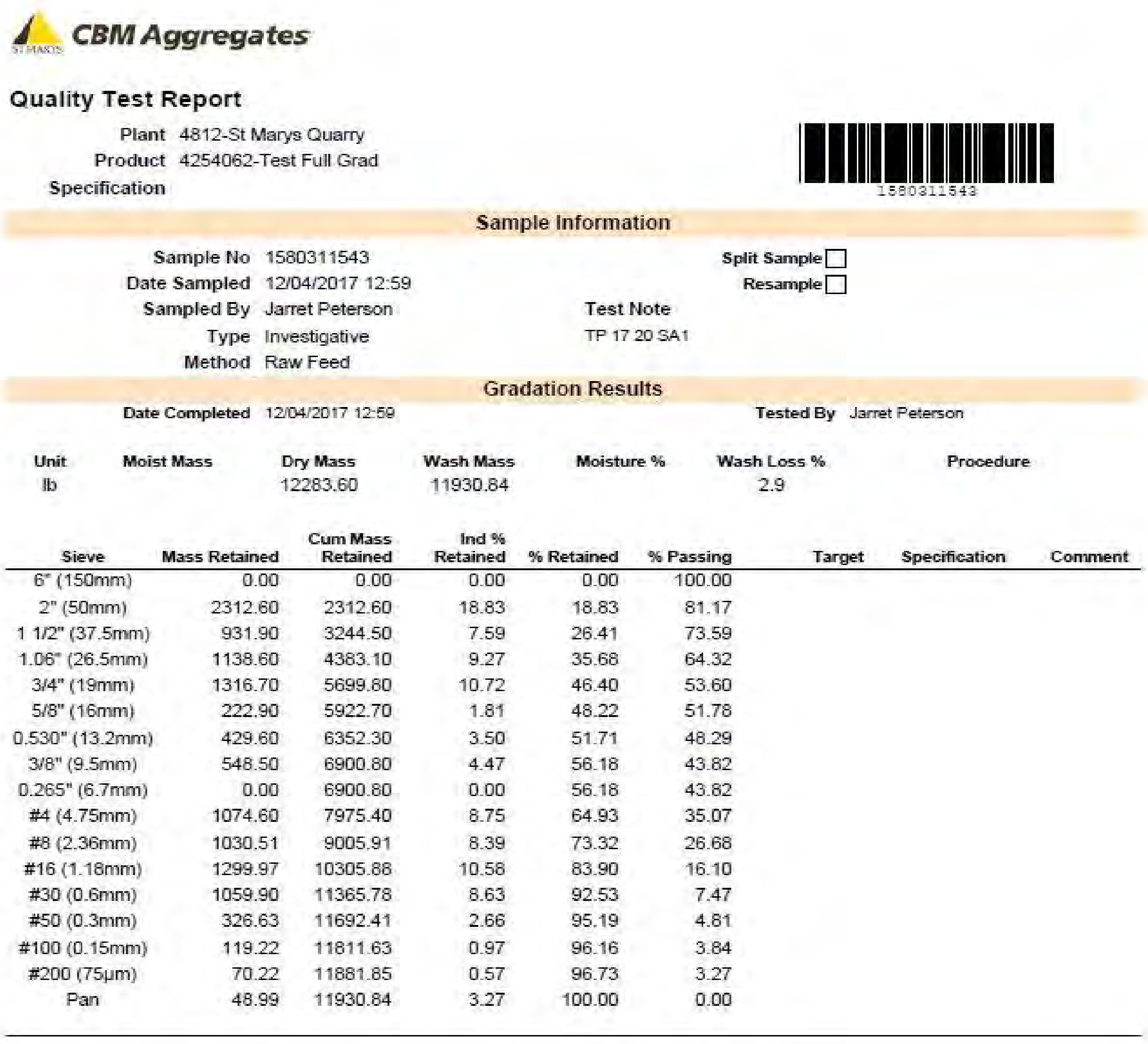
Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		11539.10	10686.68		7.4	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3291.20	3291.20	28.52	28.52	71.48			
1 1/2" (37.5mm)	214.40	3505.60	1.86	30.38	69.62			
1.06" (26.5mm)	619.40	4125.00	5.37	35.75	64.25			
3/4" (19mm)	578.00	4703.00	5.01	40.76	59.24			
5/8" (16mm)	285.50	4988.50	2.47	43.23	56.77			
0.530" (13.2mm)	343.00	5331.50	2.97	46.20	53.80			
3/8" (9.5mm)	464.70	5796.20	4.03	50.23	49.77			
0.265" (6.7mm)	0.00	5796.20	0.00	50.23	49.77			
#4 (4.75mm)	887.80	6684.00	7.69	57.92	42.08			
#8 (2.36mm)	665.43	7349.43	5.77	63.69	36.31			
#16 (1.18mm)	774.93	8124.36	6.72	70.41	29.59			
#30 (0.6mm)	906.33	9030.69	7.85	78.26	21.74			
#50 (0.3mm)	678.91	9709.59	5.88	84.15	15.85			
#100 (0.15mm)	379.04	10088.63	3.28	87.43	12.57			
#200 (75µm)	326.82	10415.45	2.83	90.26	9.74			
Pan	271.23	10686.68	9.74	100.00	0.00			

FM = 2.24

Sample 1



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1580311543

Sample Information

Sample No 1580311543
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 20 SA1

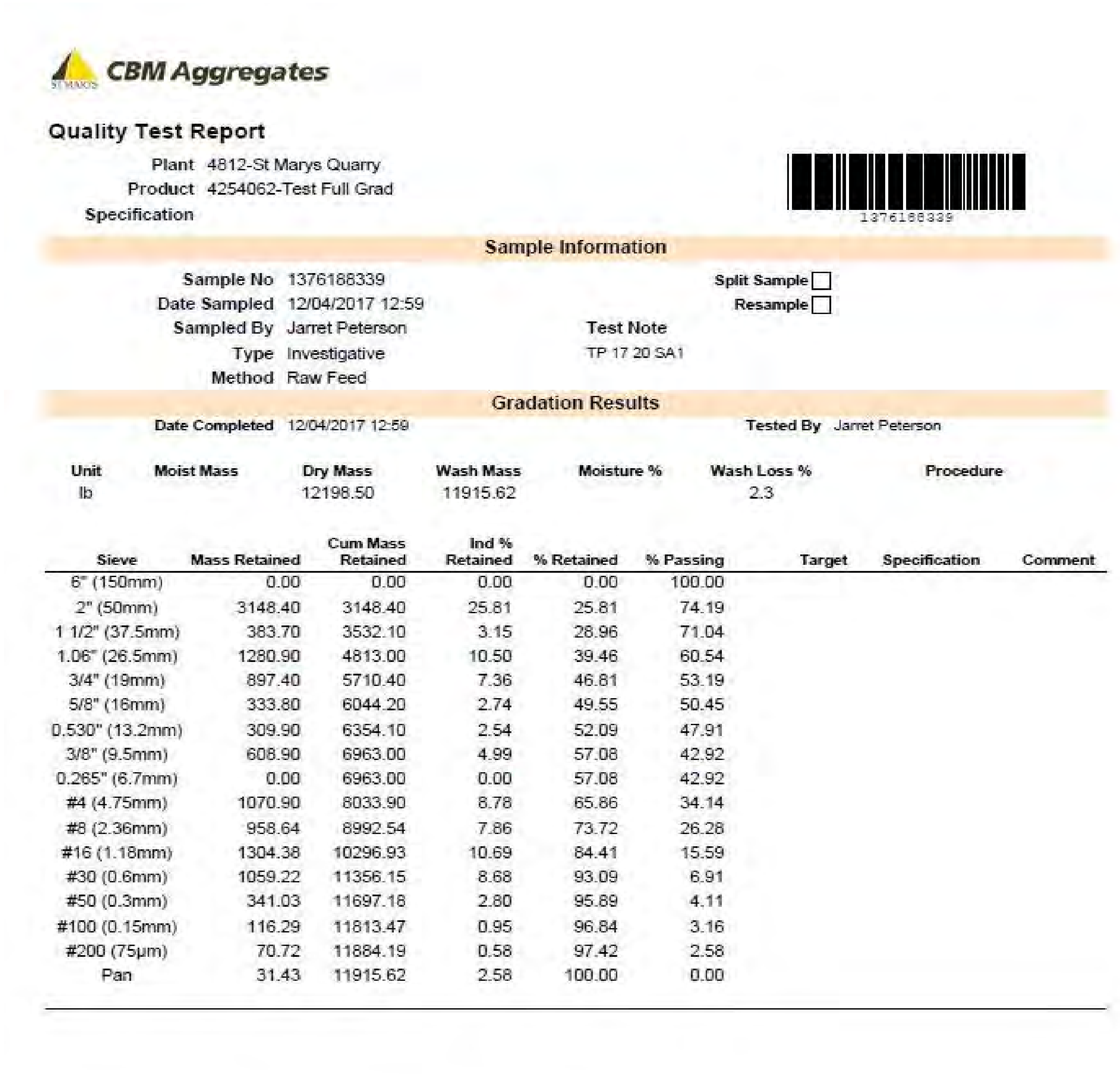
Gradation Results

Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		12283.60	11930.84		2.9	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	2312.60	2312.60	18.83	18.83	81.17			
1 1/2" (37.5mm)	931.90	3244.50	7.59	26.41	73.59			
1.06" (26.5mm)	1138.60	4383.10	9.27	35.68	64.32			
3/4" (19mm)	1316.70	5699.80	10.72	46.40	53.60			
5/8" (16mm)	222.90	5922.70	1.81	48.22	51.78			
0.530" (13.2mm)	429.60	6352.30	3.50	51.71	48.29			
3/8" (9.5mm)	548.50	6900.80	4.47	56.18	43.82			
0.265" (6.7mm)	0.00	6900.80	0.00	56.18	43.82			
#4 (4.75mm)	1074.60	7975.40	8.75	64.93	35.07			
#8 (2.36mm)	1030.51	9005.91	8.39	73.32	26.68			
#16 (1.18mm)	1299.97	10305.88	10.58	83.90	16.10			
#30 (0.6mm)	1059.90	11365.78	8.63	92.53	7.47			
#50 (0.3mm)	326.63	11692.41	2.66	95.19	4.81			
#100 (0.15mm)	119.22	11811.63	0.97	96.16	3.84			
#200 (75µm)	70.22	11881.85	0.57	96.73	3.27			
Pan	48.99	11930.84	3.27	100.00	0.00			

FM = 3.32



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1376188339

Sample Information

Sample No 1376188339
Date Sampled 12/04/2017 12:59
Sampled By Jarret Peterson
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 20 SA1

Gradation Results

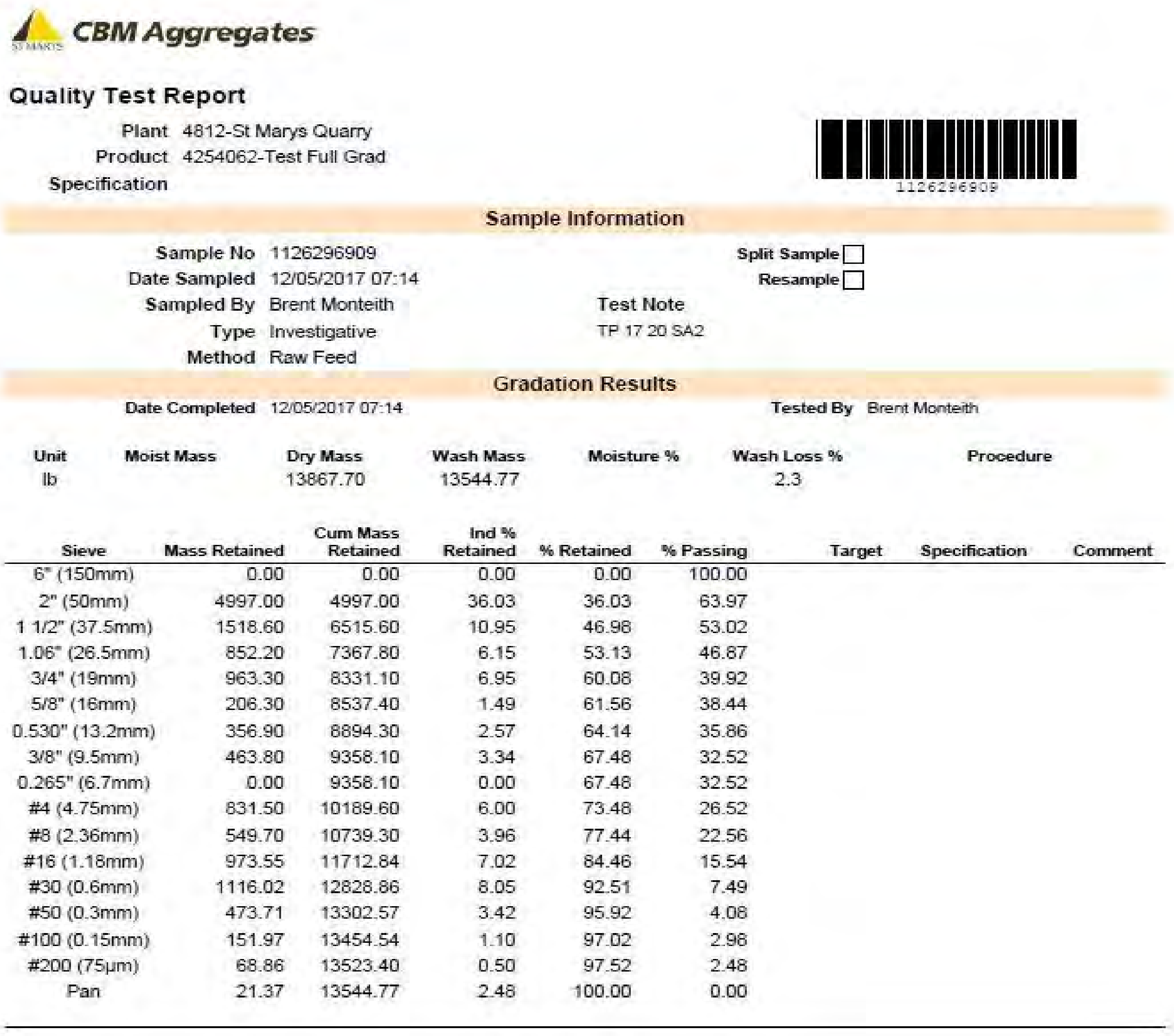
Date Completed 12/04/2017 12:59
Tested By Jarret Peterson

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		12198.50	11915.62		2.3	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	3148.40	3148.40	25.81	25.81	74.19			
1 1/2" (37.5mm)	383.70	3532.10	3.15	28.96	71.04			
1.06" (26.5mm)	1280.90	4813.00	10.50	39.46	60.54			
3/4" (19mm)	897.40	5710.40	7.36	46.81	53.19			
5/8" (16mm)	333.80	6044.20	2.74	49.55	50.45			
0.530" (13.2mm)	309.90	6354.10	2.54	52.09	47.91			
3/8" (9.5mm)	608.90	6963.00	4.99	57.08	42.92			
0.265" (6.7mm)	0.00	6963.00	0.00	57.08	42.92			
#4 (4.75mm)	1070.90	8033.90	8.78	65.86	34.14			
#8 (2.36mm)	958.64	8992.54	7.86	73.72	26.28			
#16 (1.18mm)	1304.38	10296.93	10.69	84.41	15.59			
#30 (0.6mm)	1059.22	11356.15	8.68	93.09	6.91			
#50 (0.3mm)	341.03	11697.18	2.80	95.89	4.11			
#100 (0.15mm)	116.29	11813.47	0.95	96.84	3.16			
#200 (75µm)	70.72	11884.19	0.58	97.42	2.58			
Pan	31.43	11915.62	2.58	100.00	0.00			

FM = 3.36

Sample 2



CBM Aggregates

Quality Test Report

Plant 4812-St Marys Quarry
Product 4254062-Test Full Grad
Specification

1126296909

Sample Information

Sample No 1126296909
Date Sampled 12/05/2017 07:14
Sampled By Brent Monteith
Type Investigative
Method Raw Feed

Split Sample ☐
Resample ☐

Test Note
TP 17 20 SA2

Gradation Results

Date Completed 12/05/2017 07:14
Tested By Brent Monteith

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		13867.70	13544.77		2.3	

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
6" (150mm)	0.00	0.00	0.00	0.00	100.00			
2" (50mm)	4997.00	4997.00	36.03	36.03	63.97			
1 1/2" (37.5mm)	1518.60	6515.60	10.95	46.98	53.02			
1.06" (26.5mm)	852.20	7367.80	6.15	53.13	46.87			
3/4" (19mm)	963.30	8331.10	6.95	60.08	39.92			
5/8" (16mm)	206.30	8537.40	1.49	61.56	38.44			
0.530" (13.2mm)	356.90	8894.30	2.57	64.14	35.86			
3/8" (9.5mm)	463.80	9358.10	3.34	67.48	32.52			
0.265" (6.7mm)	0.00	9358.10	0.00	67.48	32.52			
#4 (4.75mm)	831.50	10189.60	6.00	73.48	26.52			
#8 (2.36mm)	549.70	10739.30	3.96	77.44	22.56			
#16 (1.18mm)	973.55	11712.84	7.02	84.46	15.54			
#30 (0.6mm)	1116.02	12828.86	8.05	92.51	7.49			
#50 (0.3mm)	473.71	13302.57	3.42	95.92	4.08			
#100 (0.15mm)	151.97	13454.54	1.10	97.02	2.98			
#200 (75µm)	68.86	13523.40	0.50	97.52	2.48			
Pan	21.37	13544.77	2.48	100.00	0.00			

FM = 3.02

APPENDIX C

Geophysical Results

Borehole Geophysical Logging

Following are descriptions of some of the borehole geophysical techniques utilized by Golder Geophysics.

Mechanical Caliper

This measurement records the borehole diameter as indicated by the average deflection of three spring-loaded arms pressed against the wall of the borehole. Abrupt shifts to larger diameter (kicks) can indicate the locations where fractures intersect the borehole wall. However, the thickness of the caliper arms and the mechanical enlargement of fractures that can occur during drilling result in an approximate, qualitative relation between fracture aperture and the size of the caliper deflection. Changes in borehole diameter indicated by the caliper log complement other geophysical logs – e.g. accurate changes in borehole diameter are needed for interpretation of structure from acoustic and optical televiewer logs.

Optical Televiewer

This measurement produces a continuous oriented 360° image of the borehole wall using an optical imaging system as the logging probe is slowly pulled upwards. The televiewer probe is magnetically orientated so that the azimuth of the scan and the deviation of the borehole can be measured during logging.

The example below (unwrapped image of the inside of a borehole) shows televiewer data acquired by Golder Associates at 0.002 m (2 mm) and 0.003 m (3 mm) intervals for the optical and acoustic televiewers respectively

Natural Gamma

The natural gamma log provides a measurement (recorded in counts per second – cps) that is proportional to the natural radioactivity of the formation. The sample volume for the gamma log is typically a 25 to 30 cm radius. The log is used principally for lithologic identification and stratigraphic correlation.

The tool used for logging employs a scintillation sodium iodide (NaI) detector. The gamma-emitting radio-isotopes that naturally occur in geologic materials are Potassium 40 and nuclides in the Uranium 238 and Thorium 232 decay series. Potassium 40 occurs with all potassium minerals including potassium feldspars. Uranium 238 is typically associated with dark shales and uranium mineralization. Thorium 232 is typically associated with biotite, sphene, zircon and other heavy minerals.

The usual interpretation of the gamma log is that measured counts are proportional to the quantity of clay minerals present. This assumes that the natural radioisotopes of potassium, uranium and thorium occur as exchange ions attached to the clay particles, so that the correlation is between gamma counts and the cation exchange capacity (CEC).

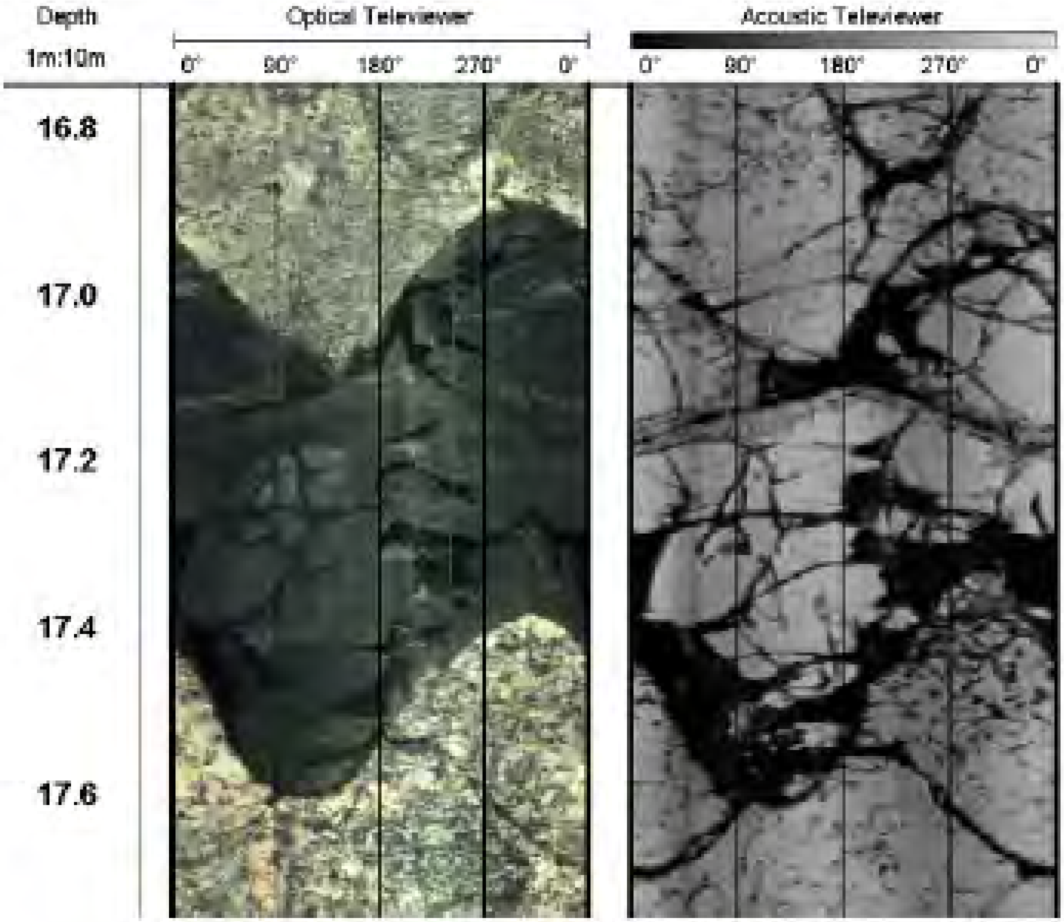
Apparent Conductivity

Apparent conductivity is a measure of the bulk apparent electrical conductivity of the subsurface, which is primarily a function of interconnected porosity, clay content, moisture content and the dissolved ion concentration in the pore fluid. Temperature, phase state of the pore water and the amount and composition of any suspended colloids in the pore water also contribute to conductivity but to a lesser degree. An increase in any of these properties would result in an elevated apparent conductivity response.

However, changes in clay content can also significantly alter instrument response. Clay particles have a relatively large number of ions adsorbed to their surface. When clays are saturated, these adsorbed ions can become partially dissociated and available for ionic conductivity. Since clay particles have a relatively large surface area, the presence of small amounts of clay can significantly increase bulk apparent conductivity.

Typically, the apparent conductivity of saturated sediments will vary proportionally with the natural gamma signature, as the clay content changes. However, when the pore fluid contains far higher concentrations of ions not normally present in ground water, as in the case of a contaminant plume, the apparent conductivity will increase irrespective of the natural gamma background signature.

Metal objects, such as steel casing in the borehole, will show as an anomalous response in the apparent conductivity log, either as large positive or negative deflections.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Acoustic Televiewer
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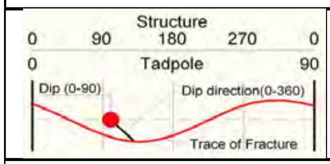
90°
180°
270°
0°
16.8
17.0
17.2
17.4
17.6

GEOPHYSICAL RECORD OF BOREHOLE: BH17-01

Project Number: 1781508
Client:
Date: January 2018

Datum:
Easting:
Northing:
Elevation:
Depth Reference:
Drilled Depth:
Borehole Diameter:
Casing Diameter:
Casing Depth:
Water Level:
Borehole Inclination:
Borehole Azimuth:
Location: St. Mary's
Log Date: 18-Jan-18
Logged By: PG



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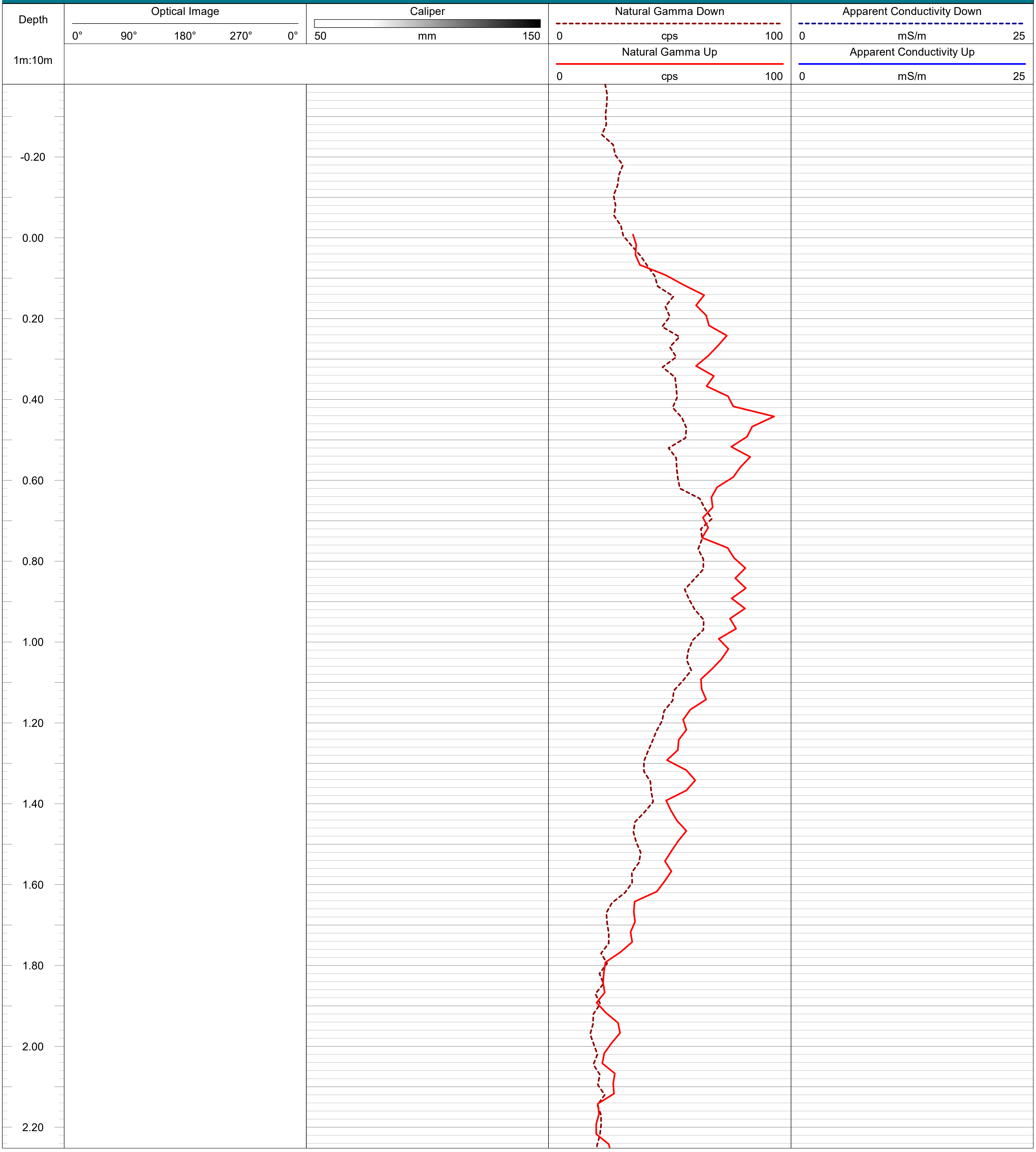

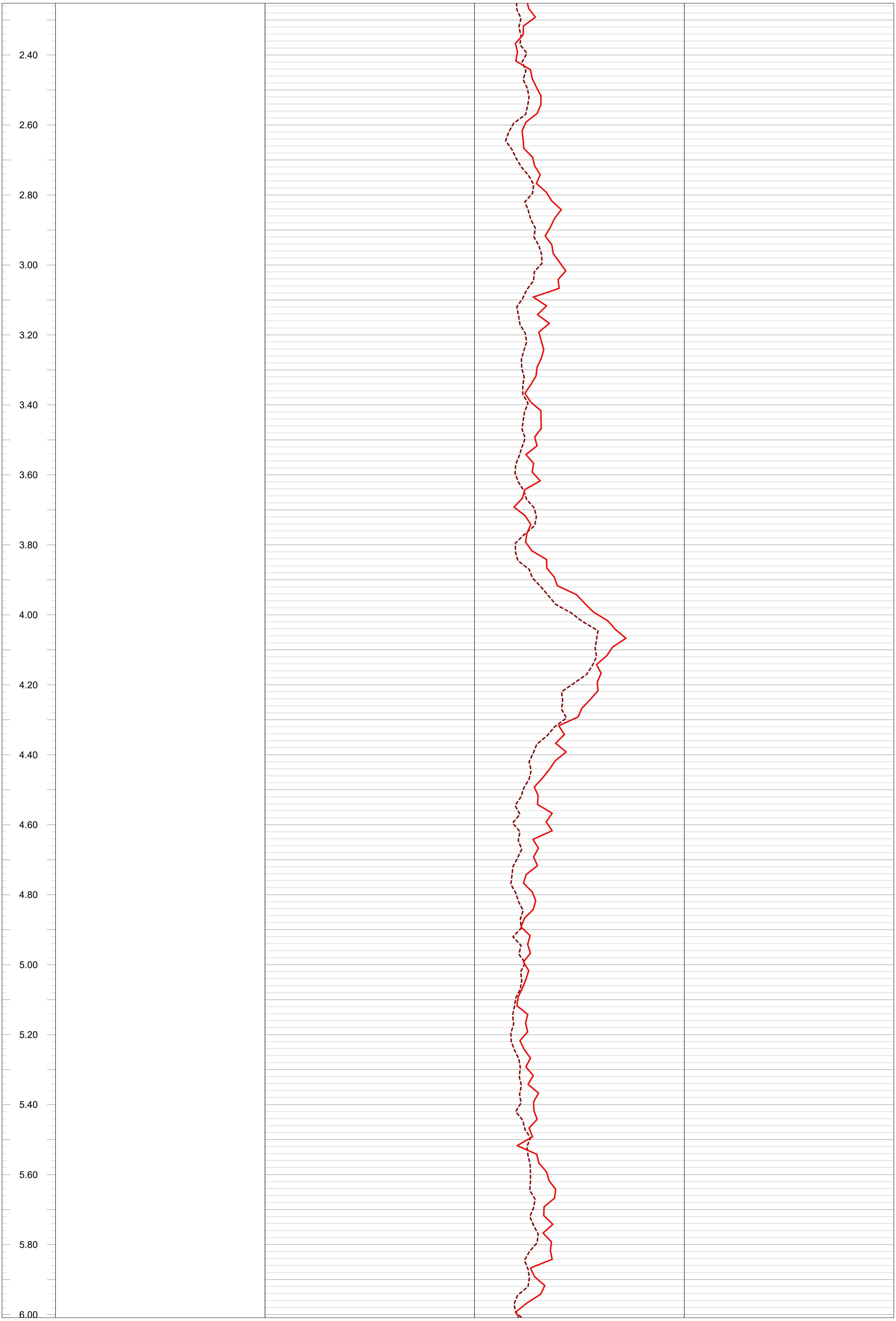
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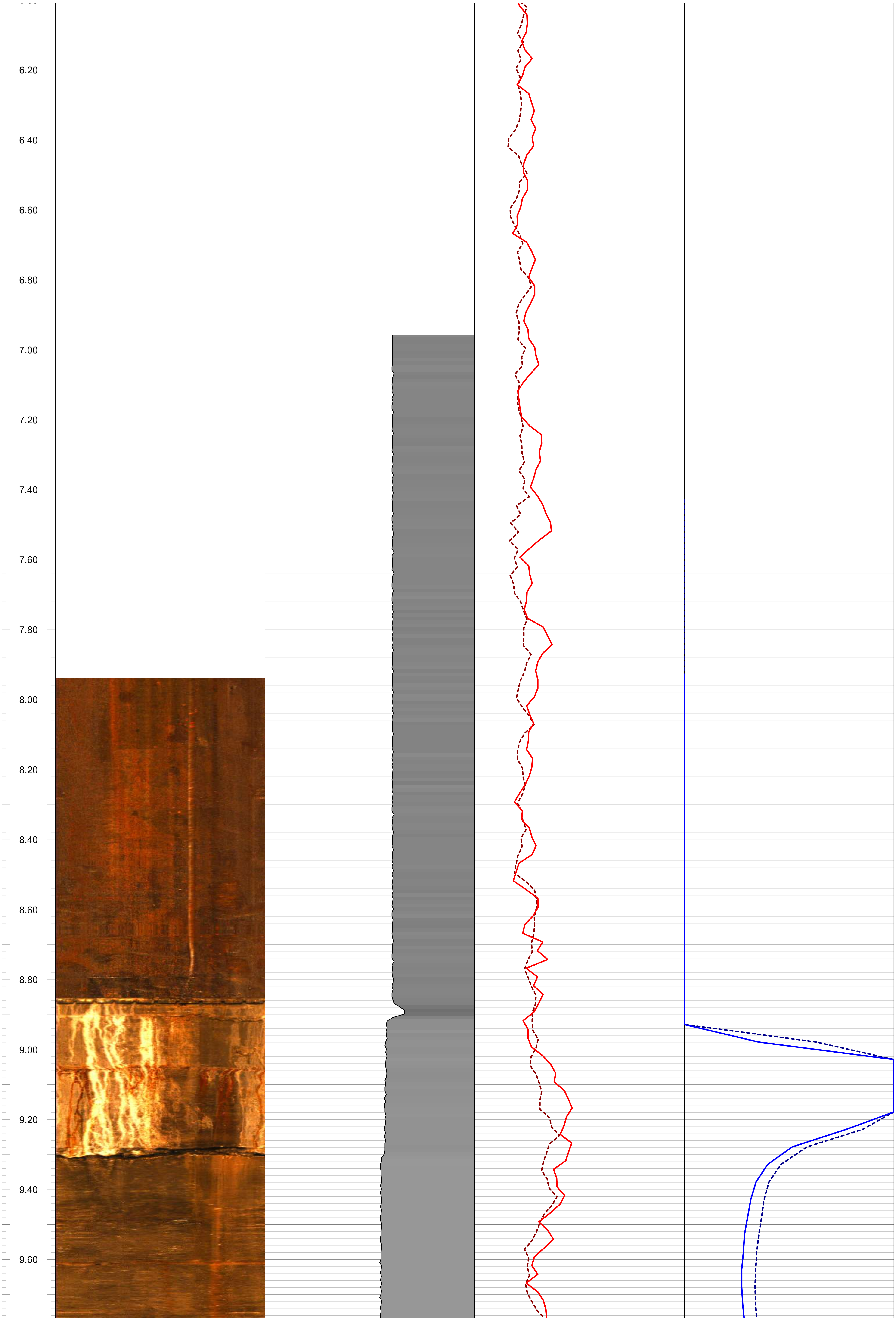
6.00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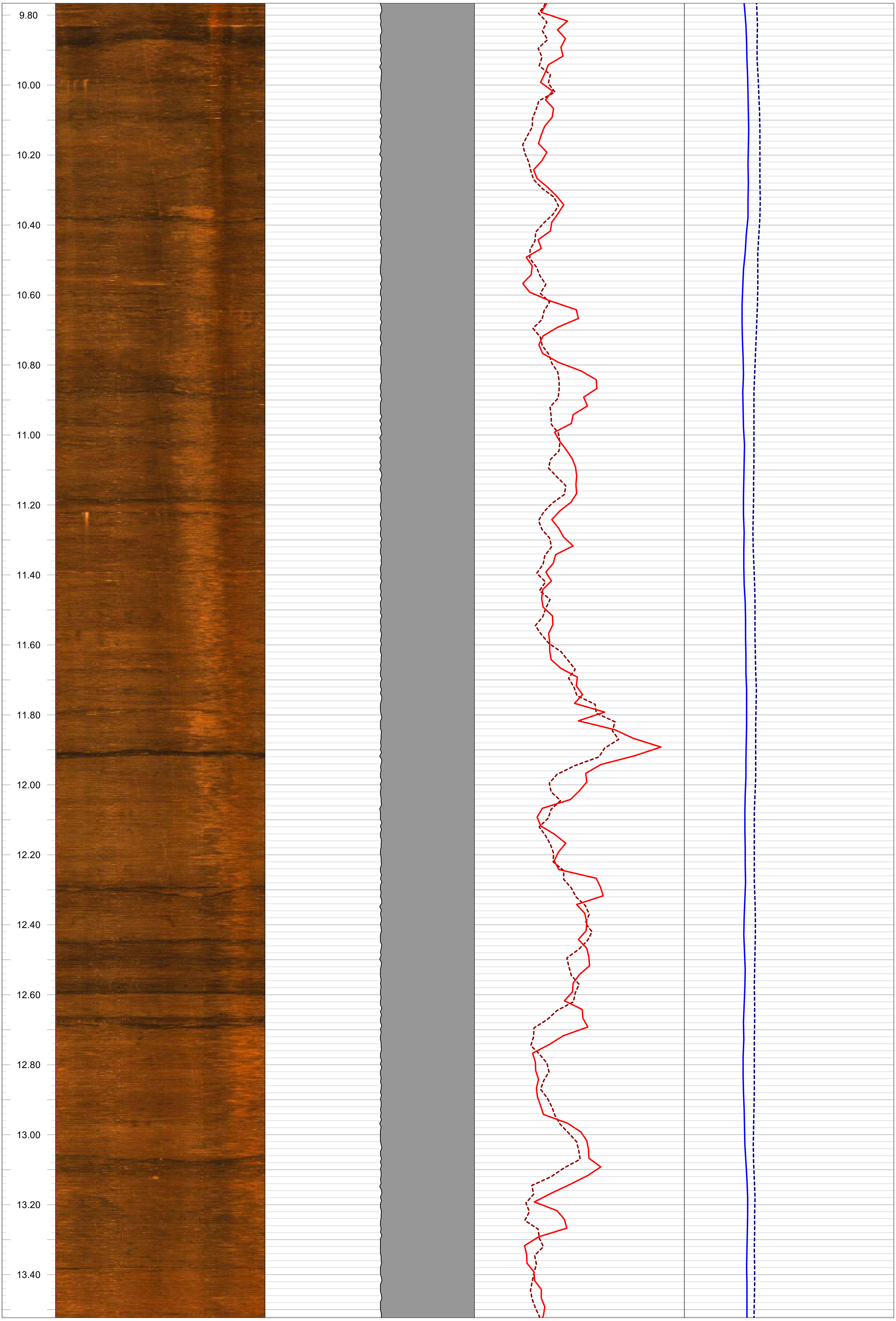
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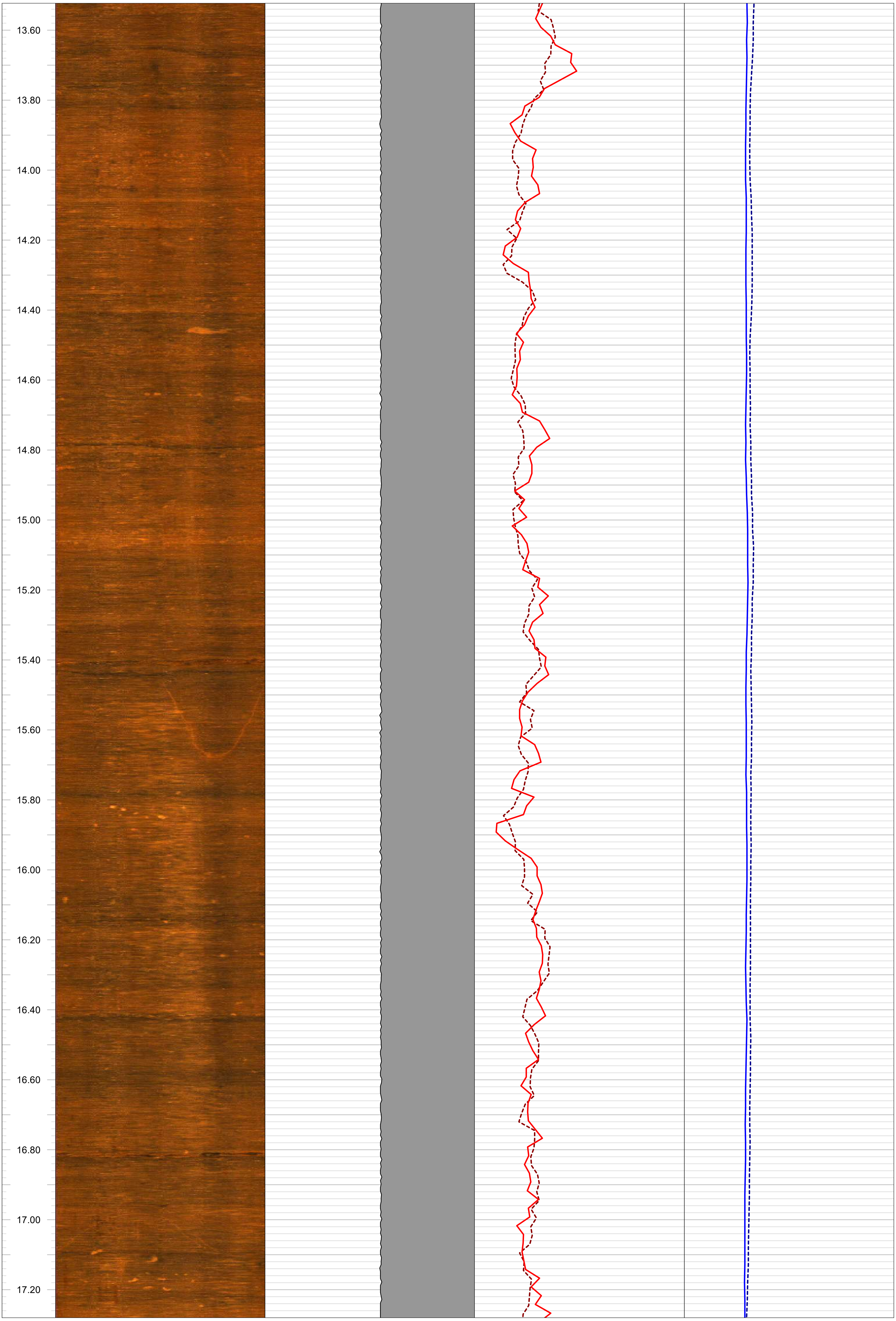
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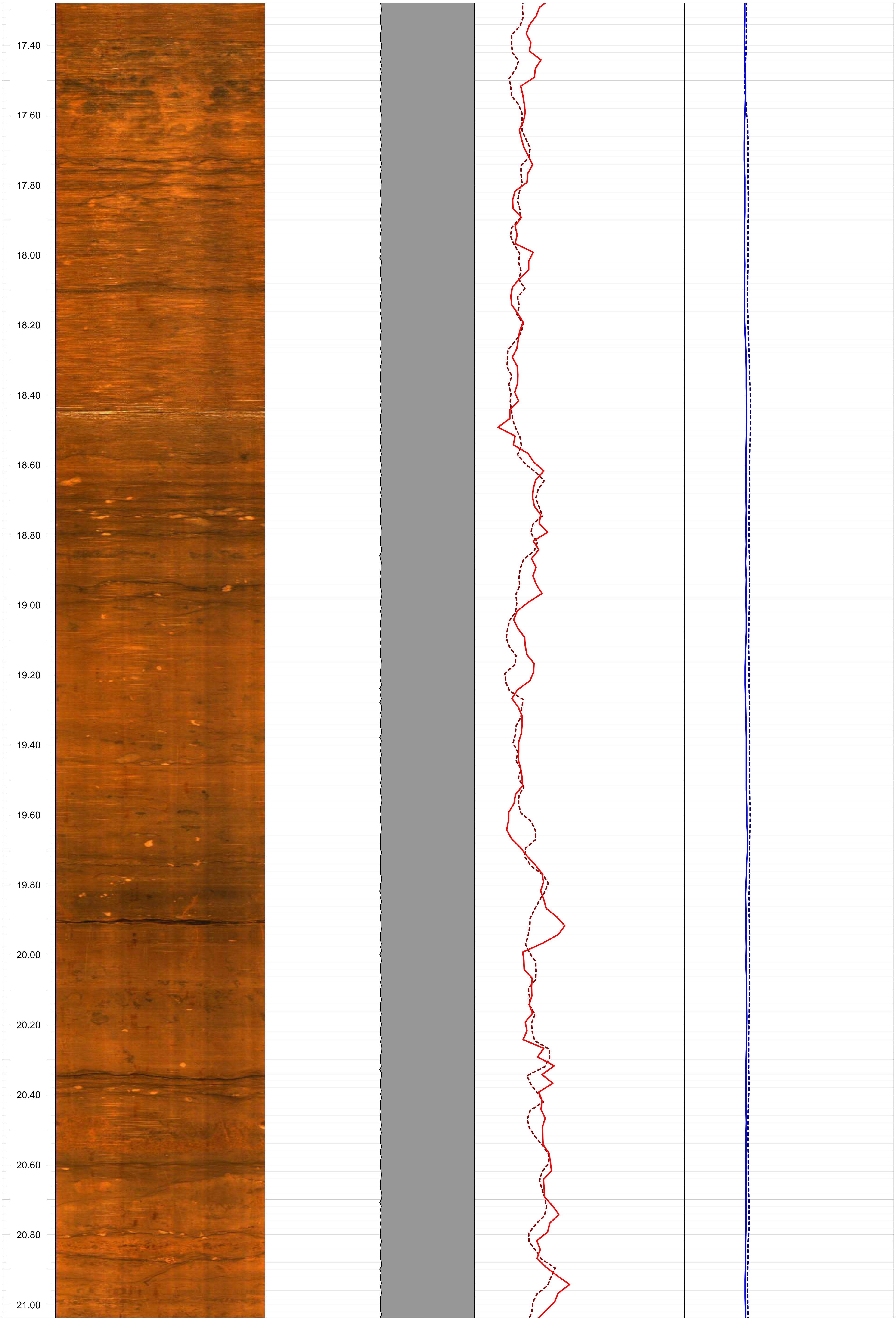
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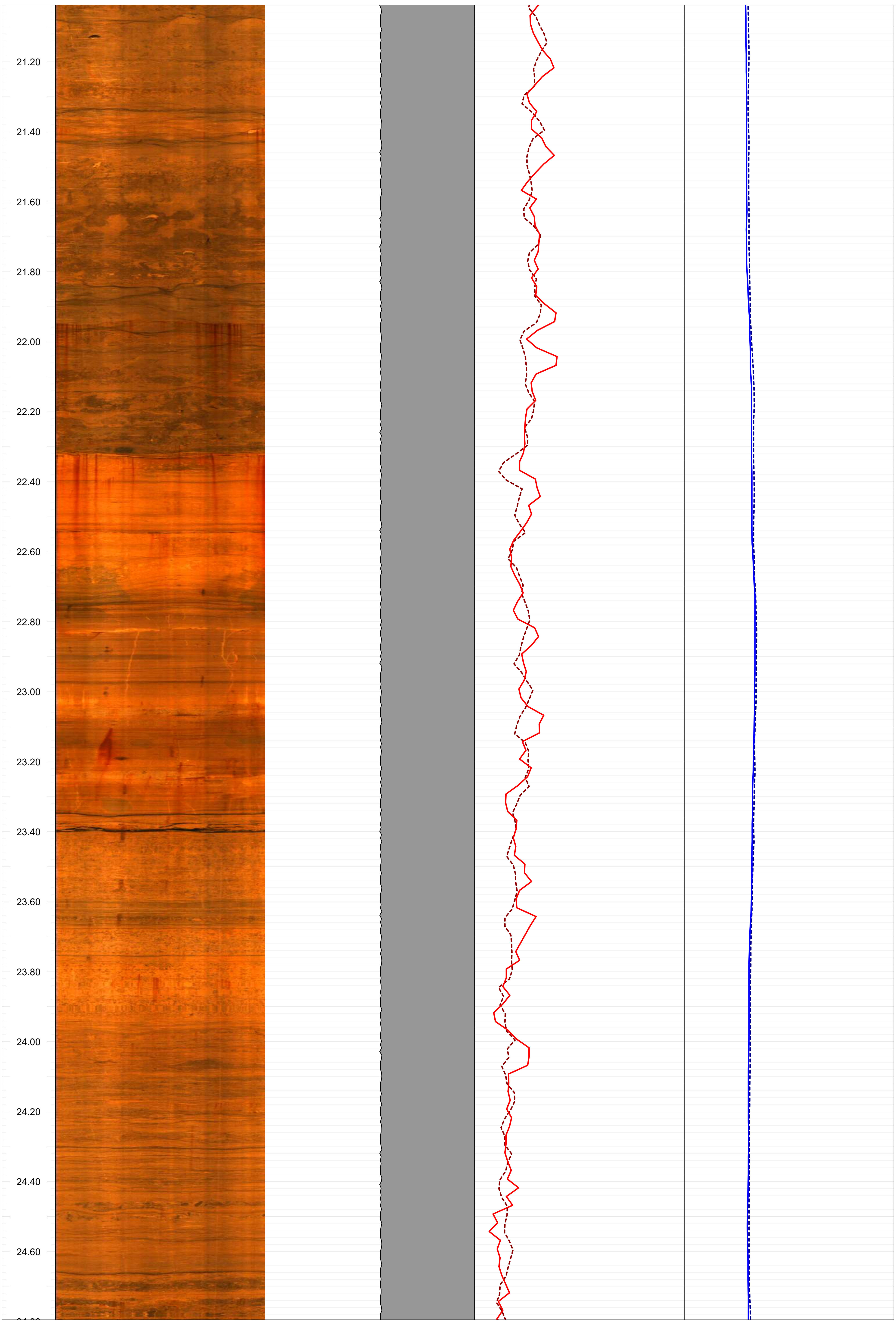
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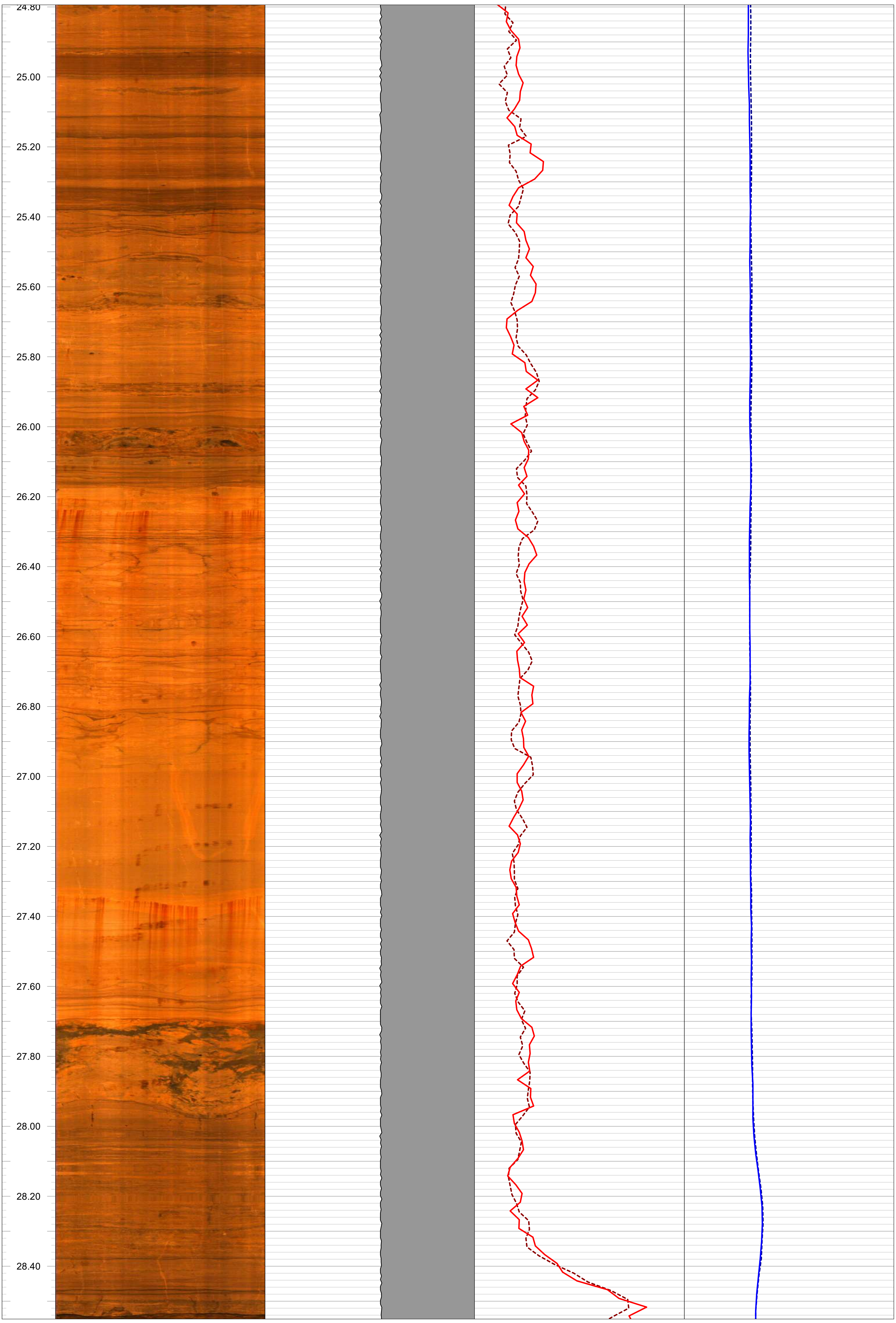
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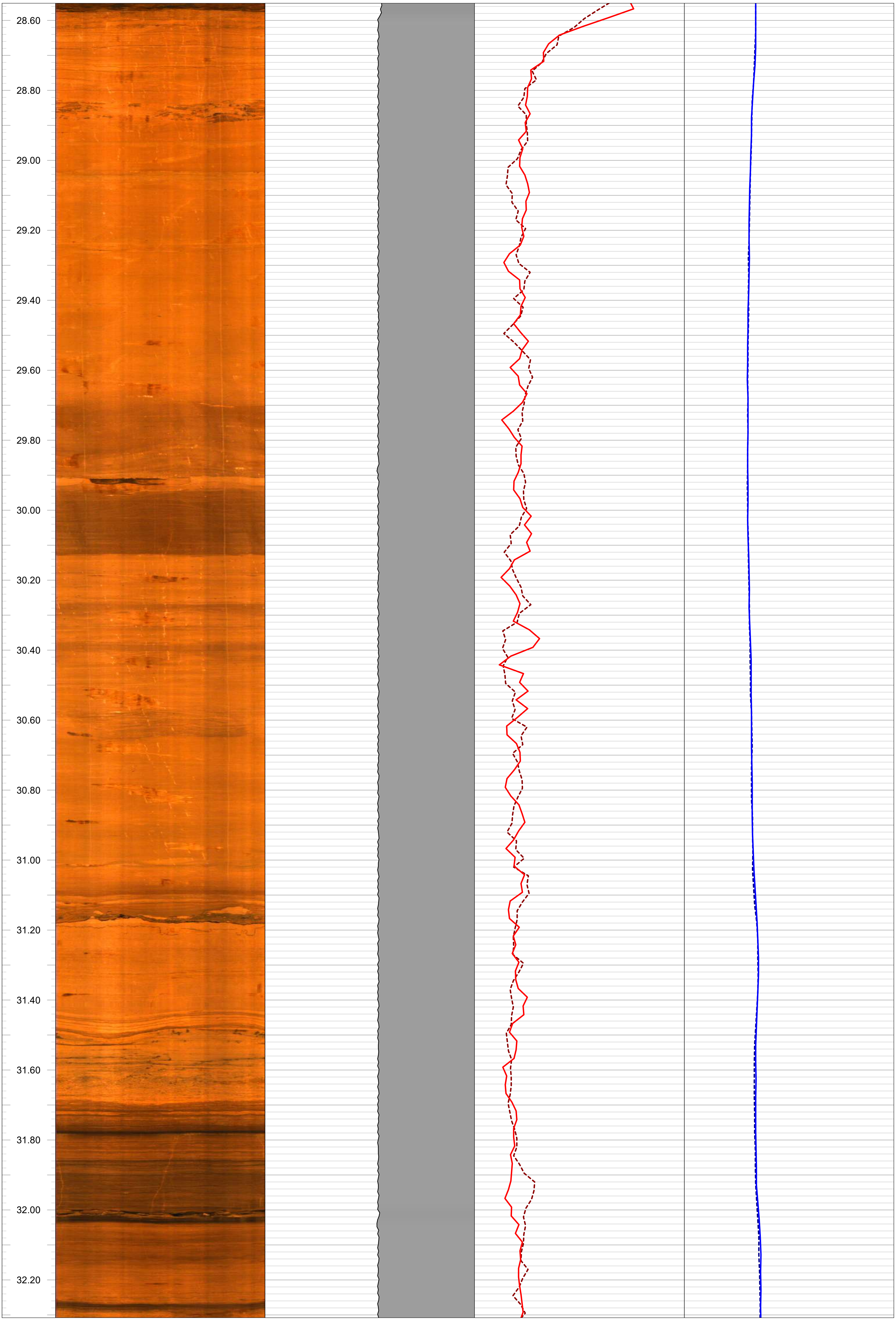
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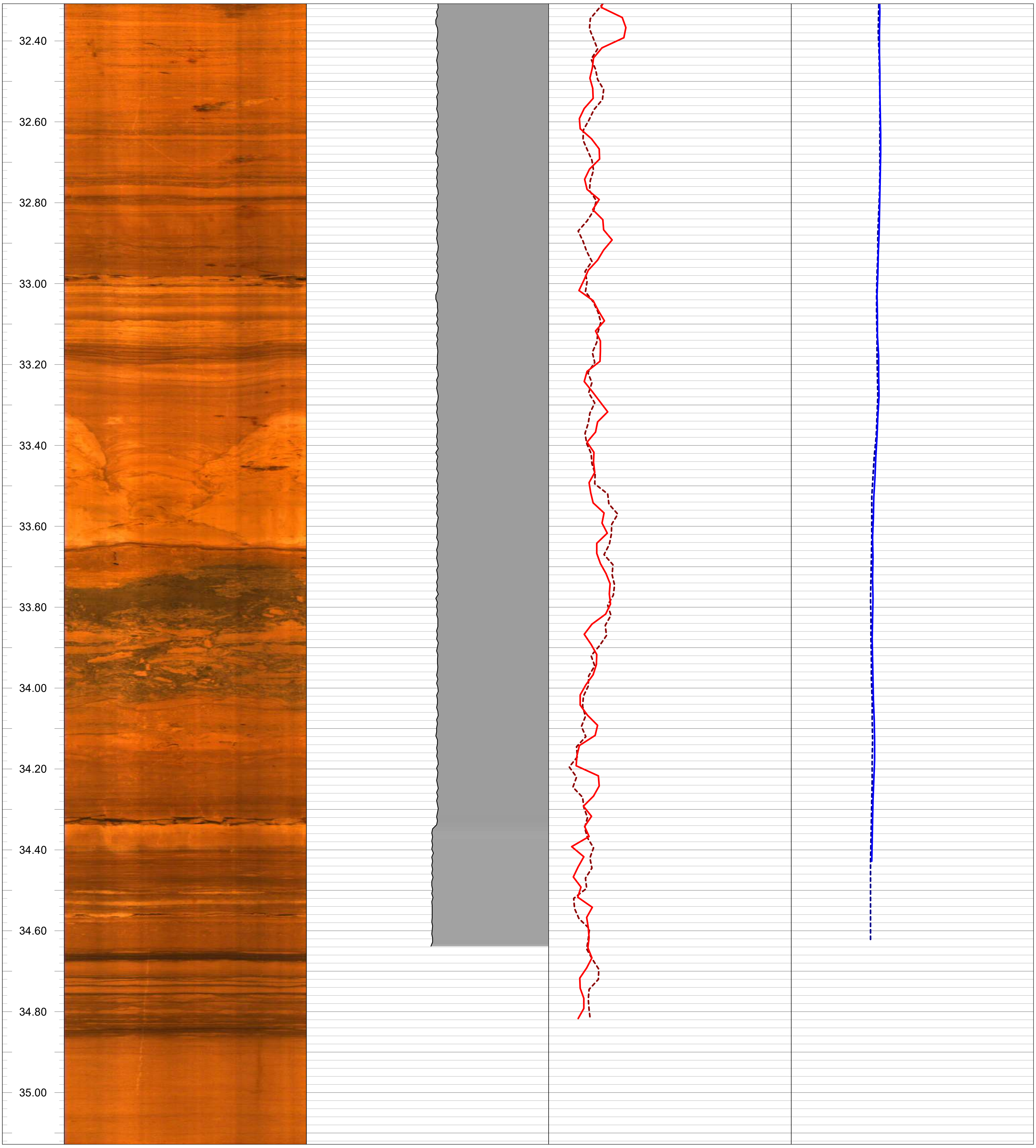
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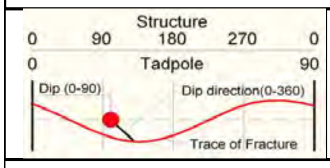
GEOPHYSICAL RECORD OF BOREHOLE: BH17-02
Project Number: 1781508
Client:
Date: January 2018

Datum:		**Elevation:**		**Borehole Diameter:**		**Water Level:**		**Location:**	St. Mary's
Easting:		**Depth Reference:**		**Casing Diameter:**		**Borehole Inclination:**		**Log Date:**	18-Jan-2018
Northing:		**Drilled Depth:**		**Casing Depth:**		**Borehole Azimuth:**		**Logged By:**	PG



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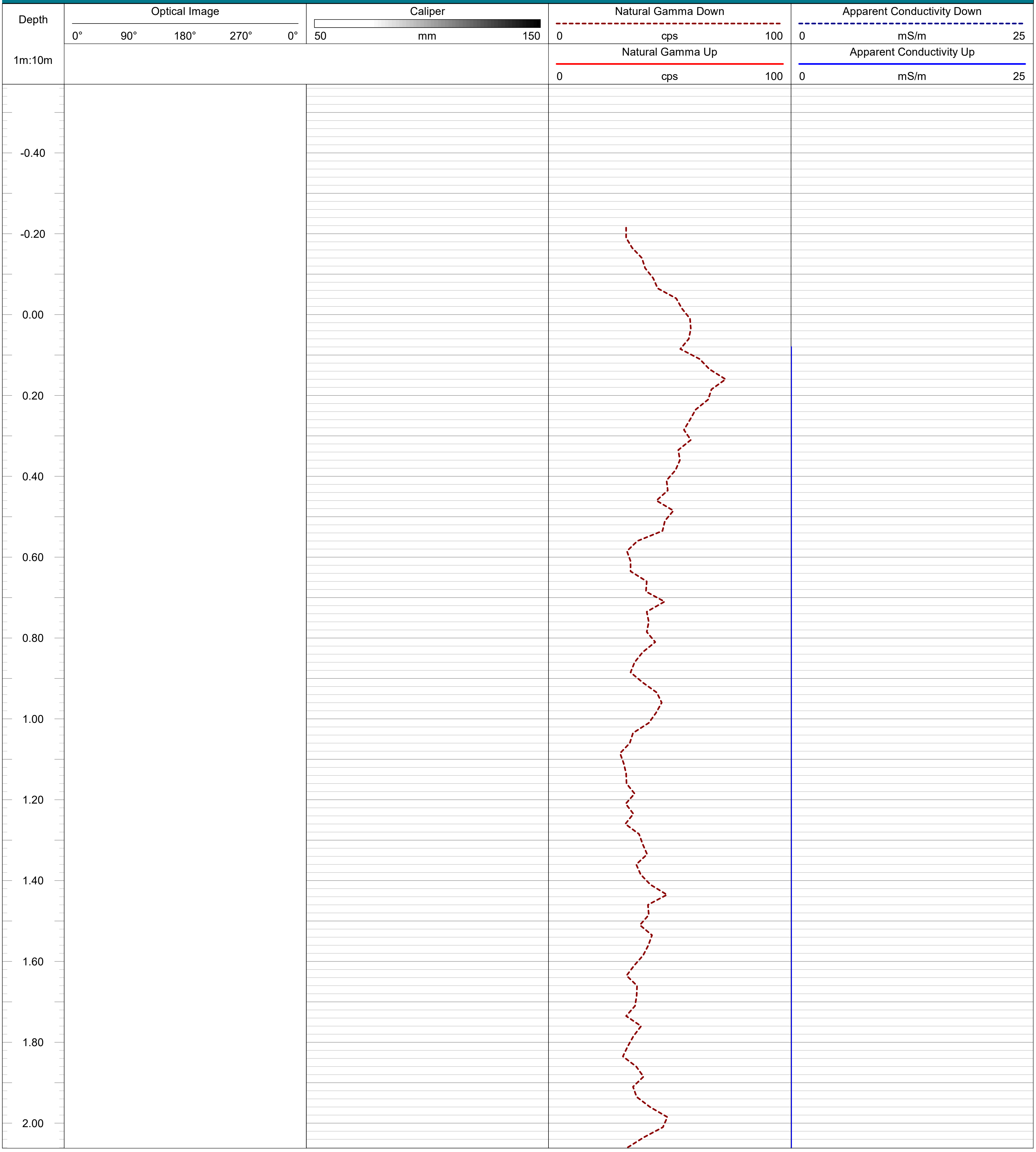

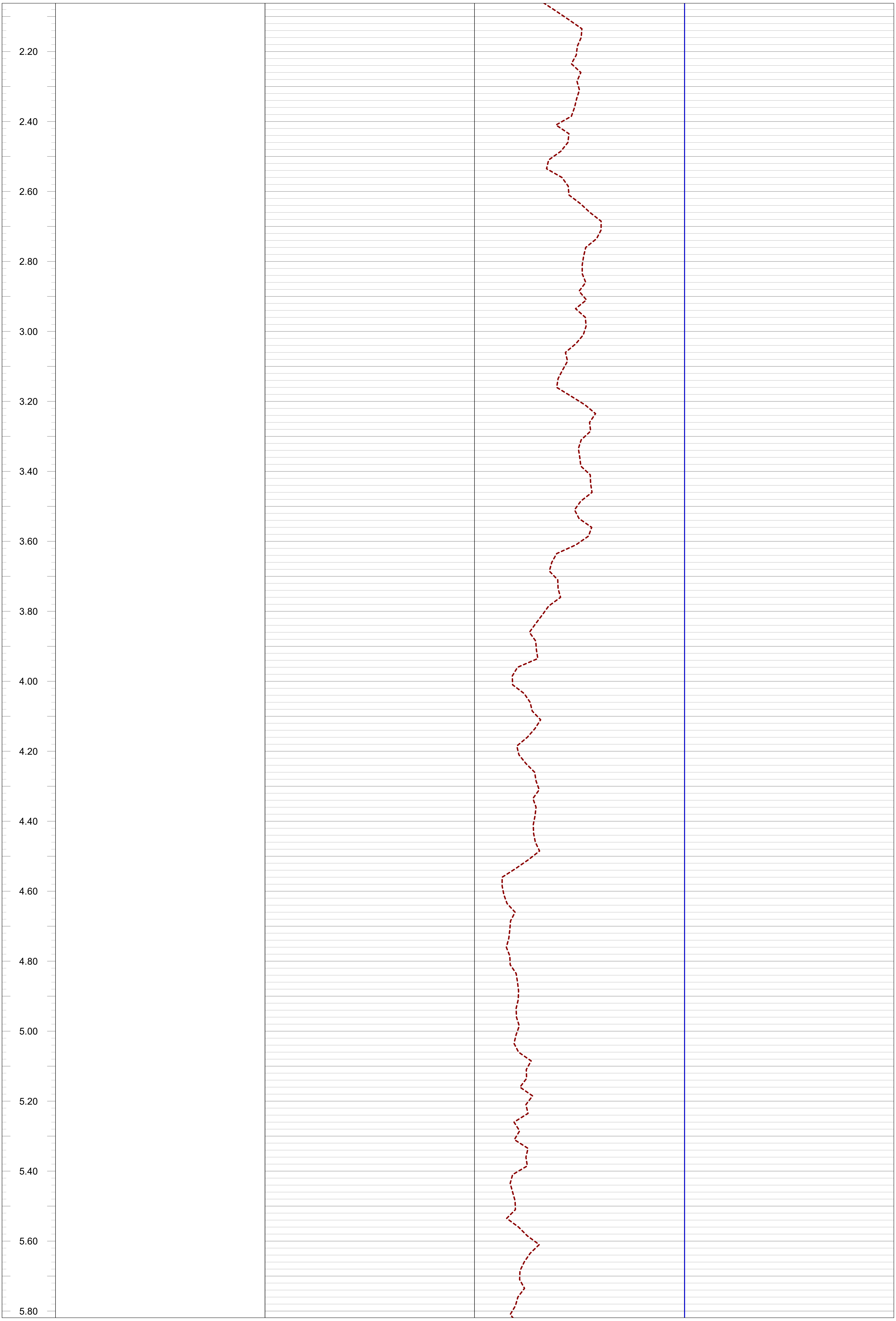
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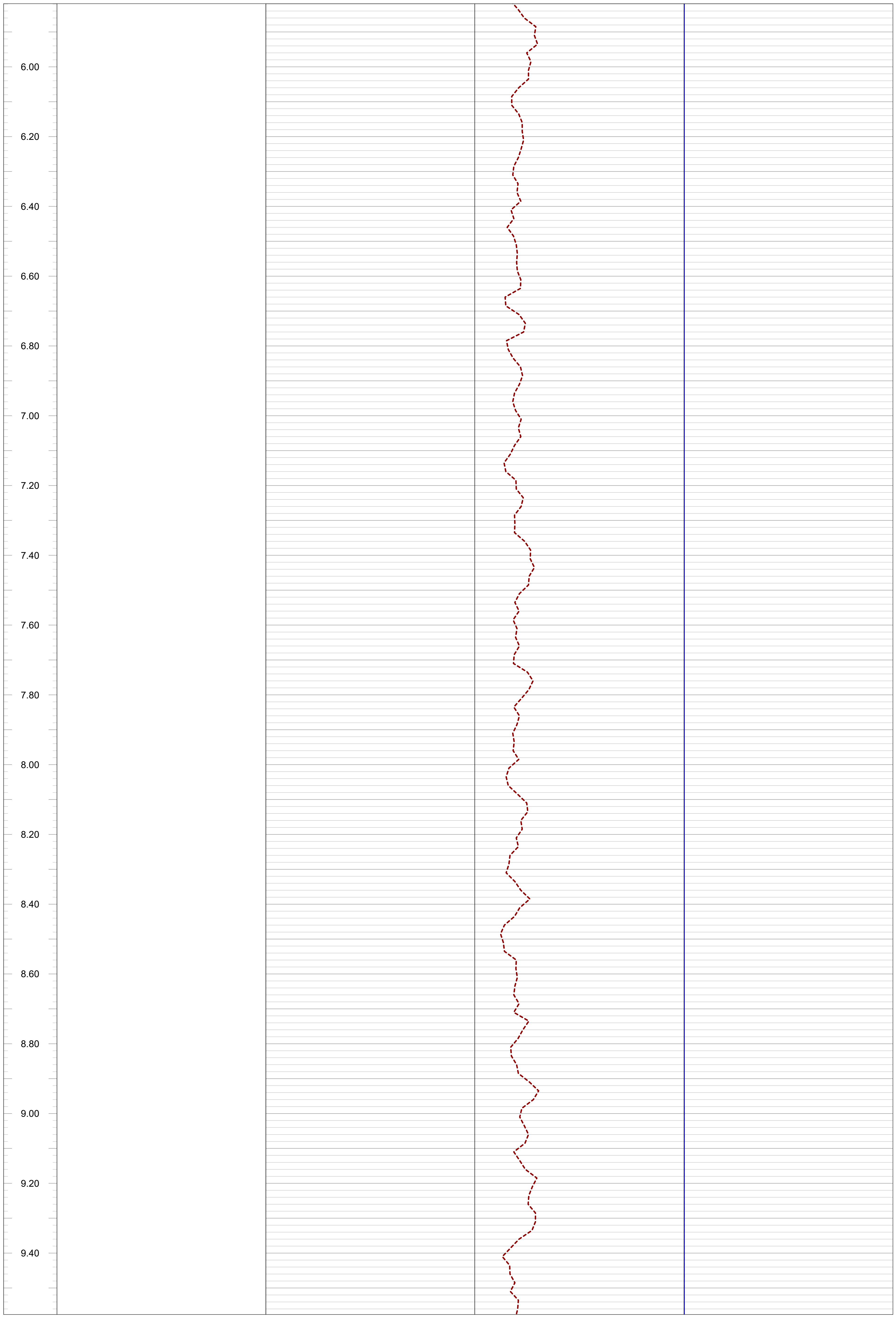
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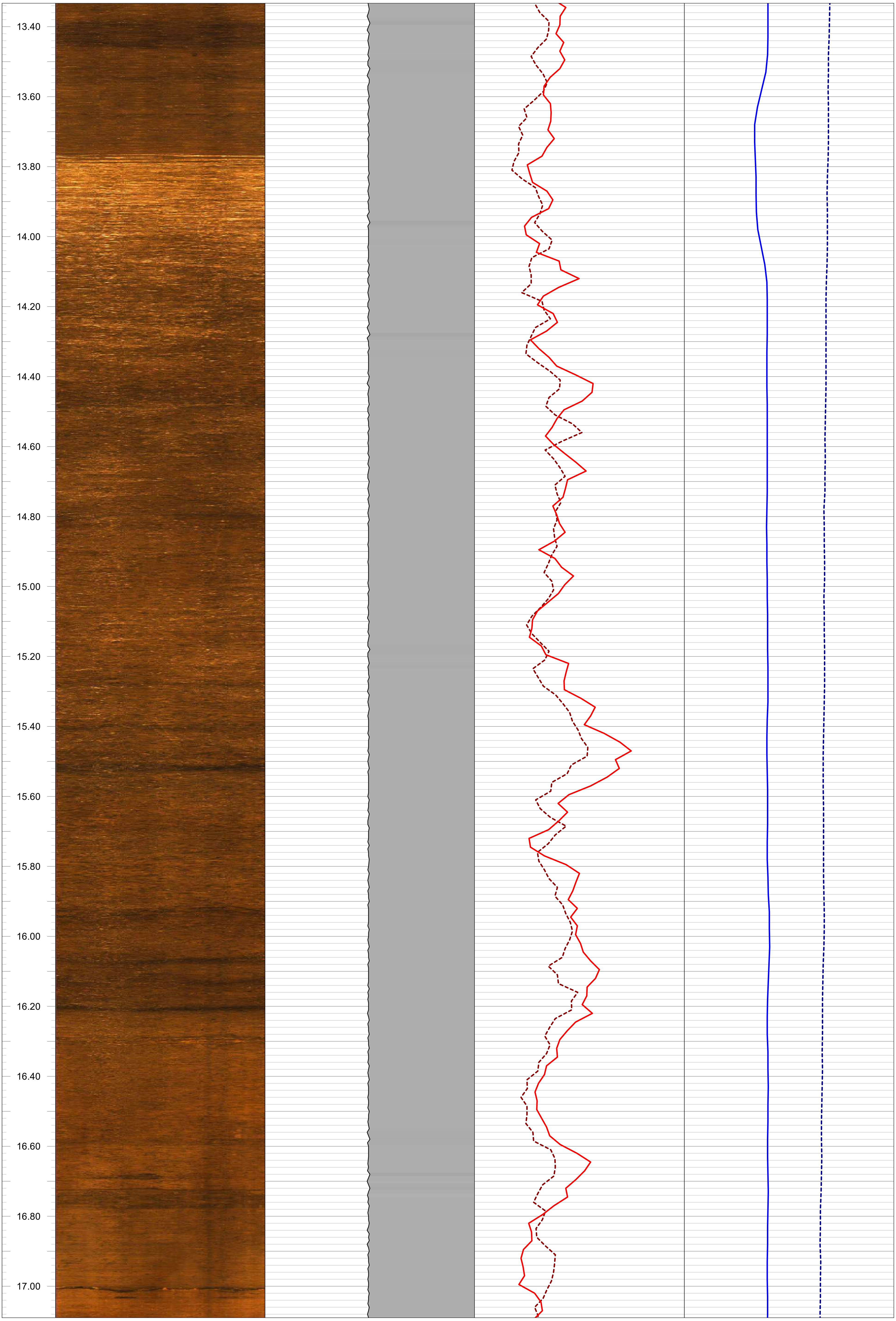
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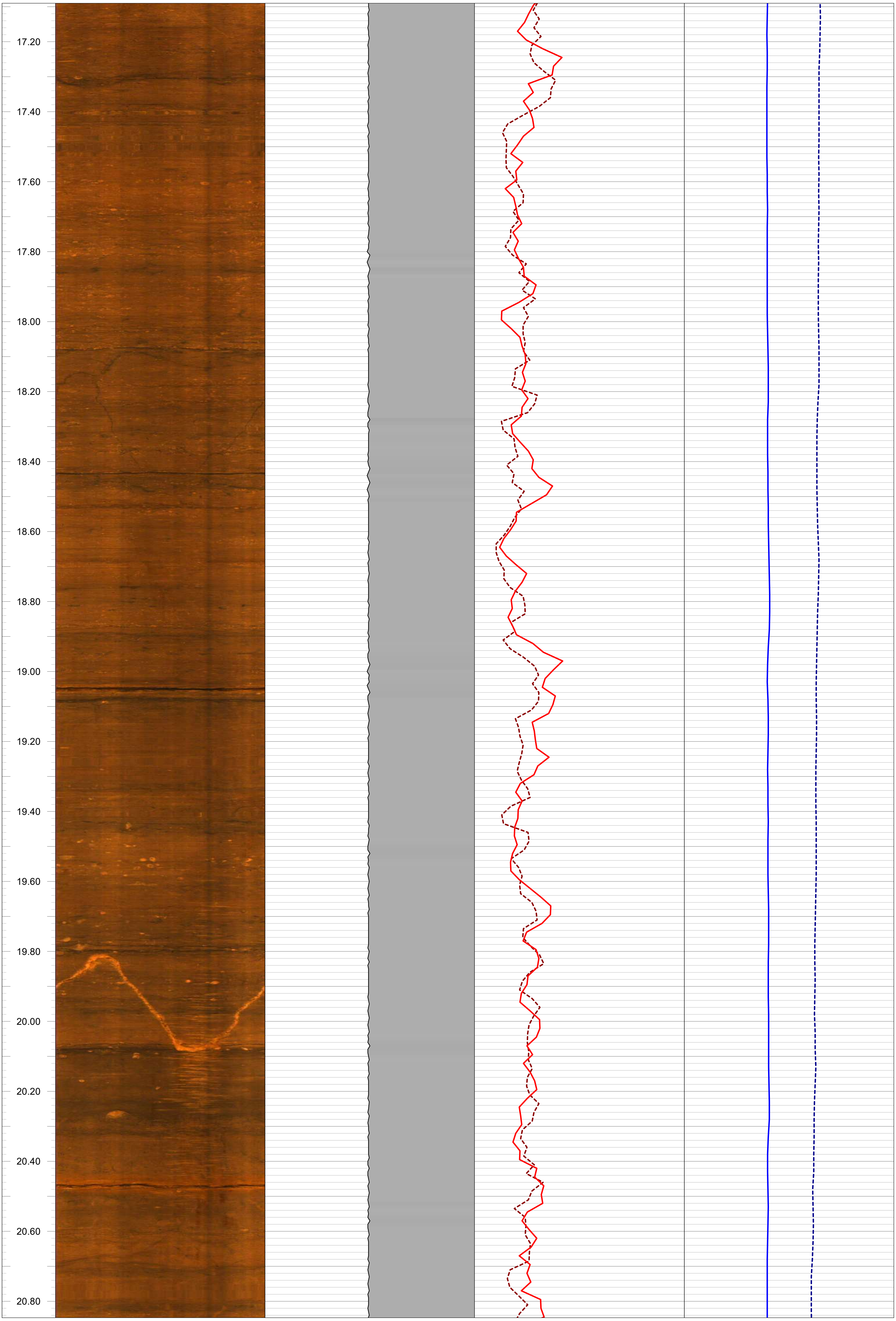
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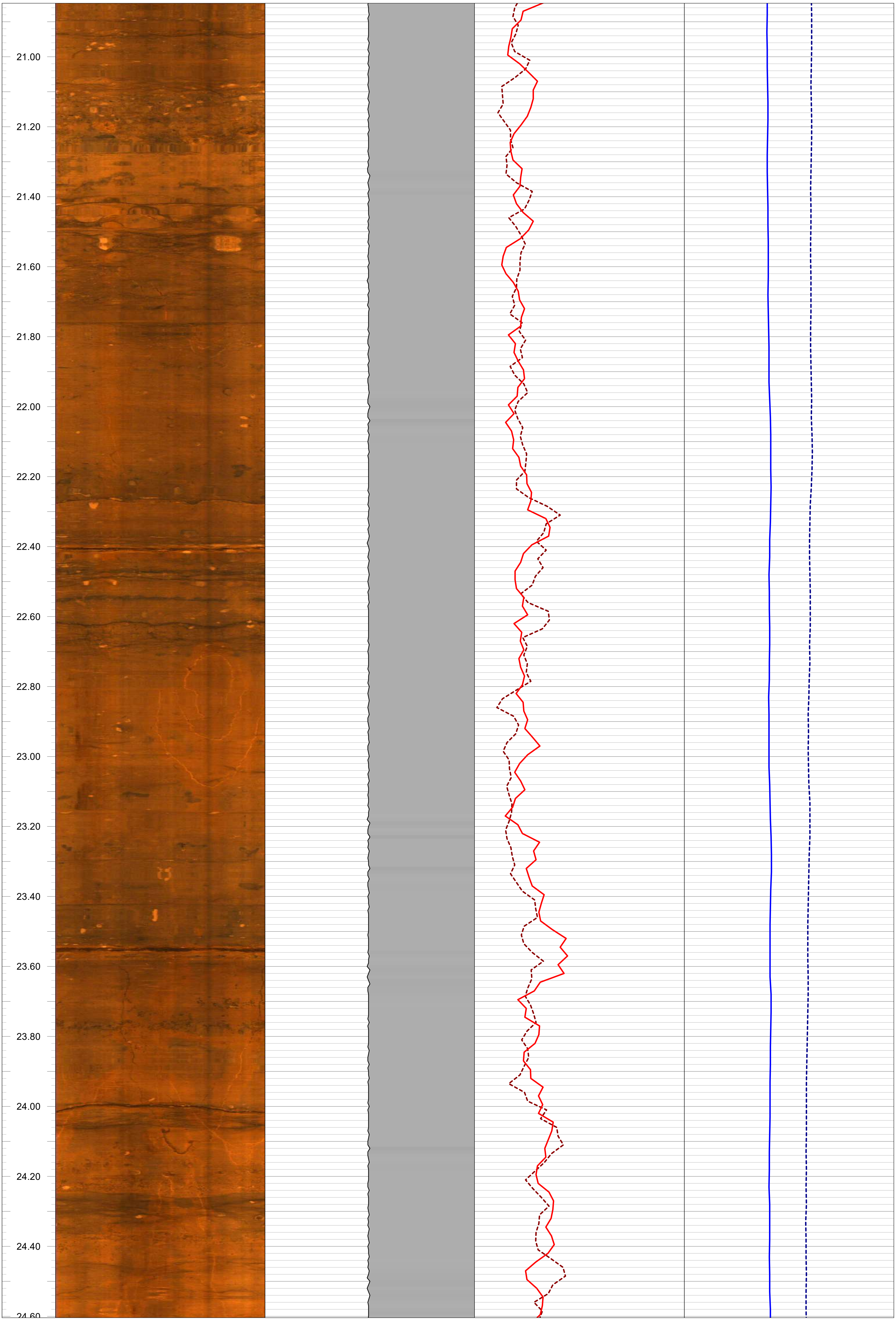
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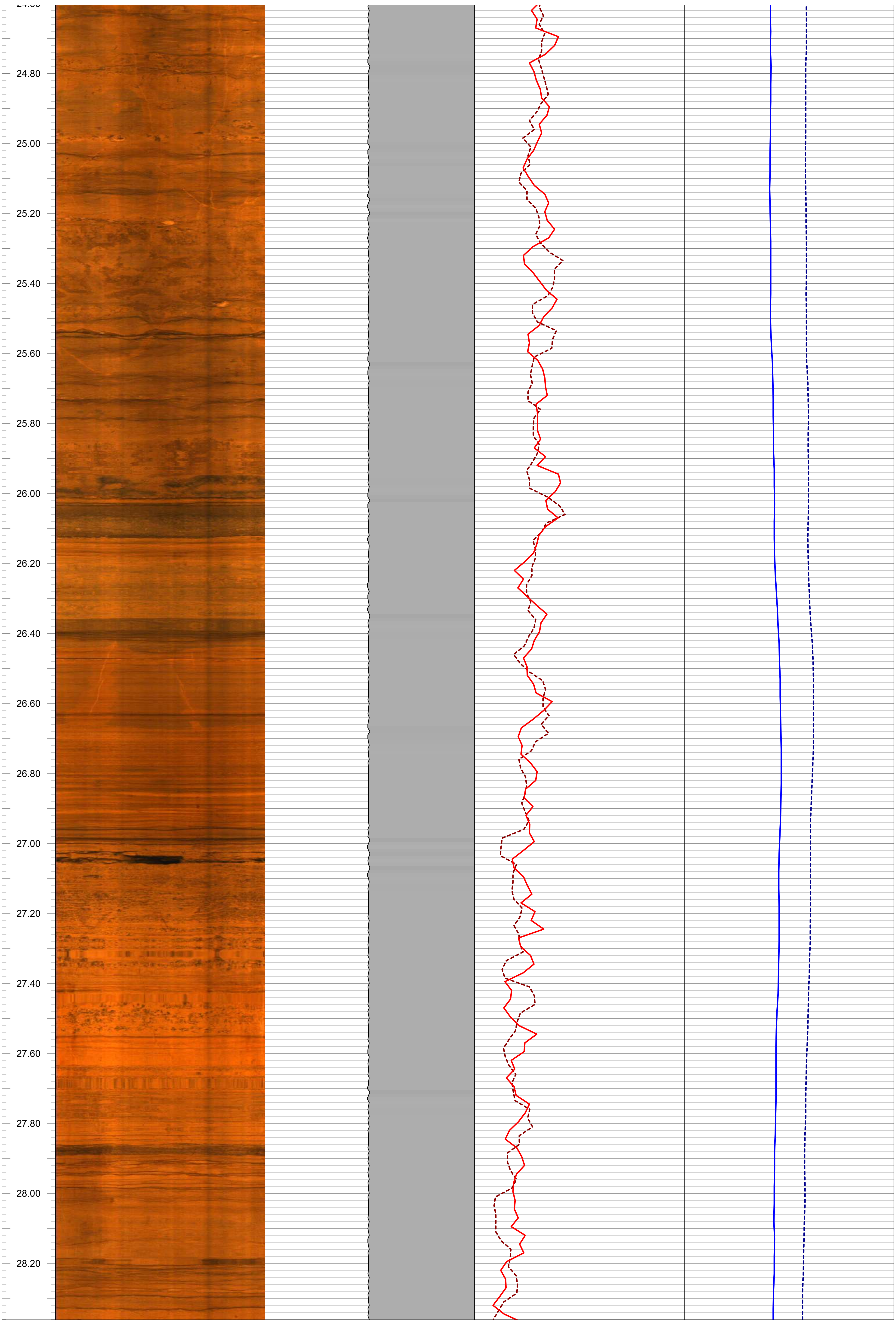
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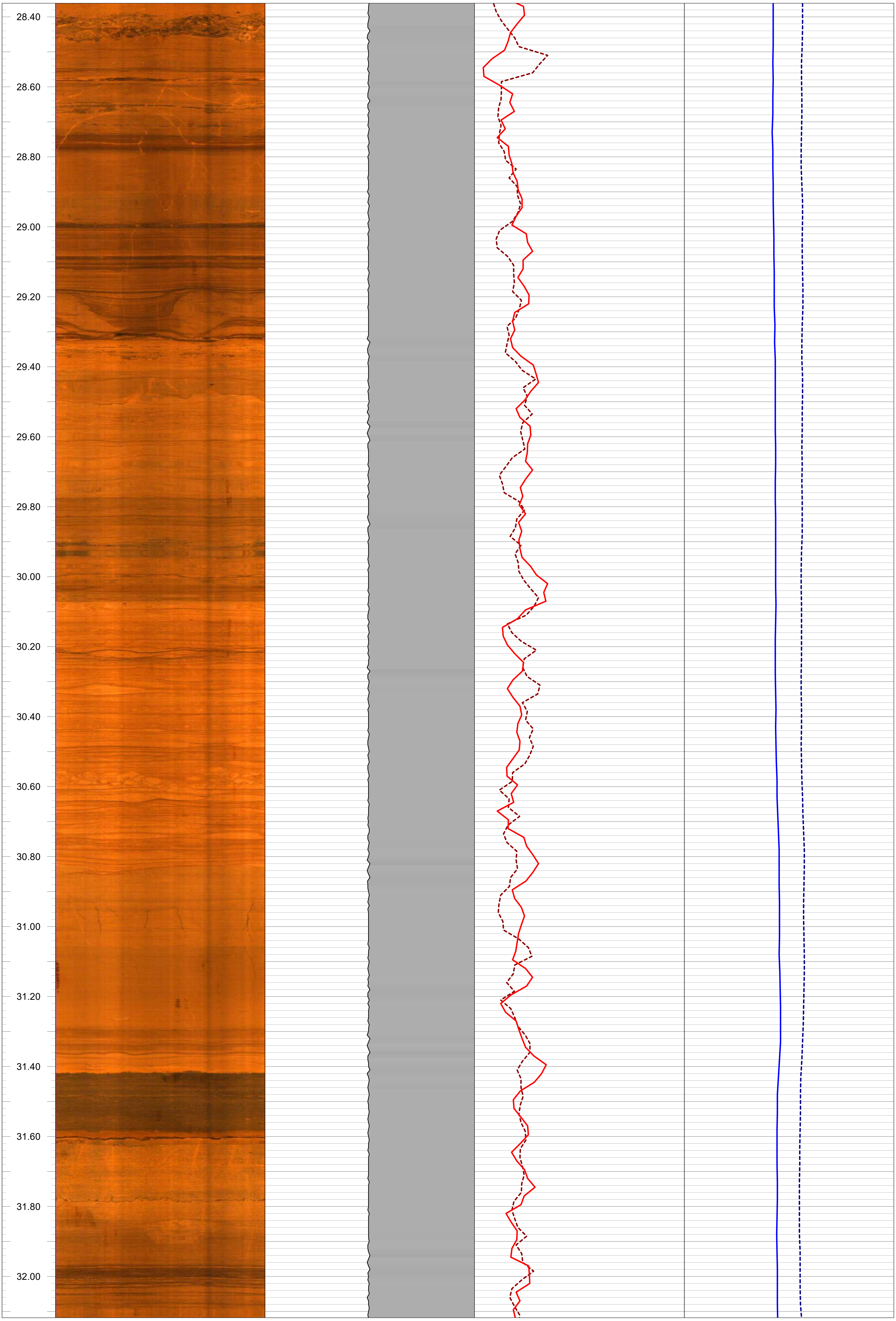
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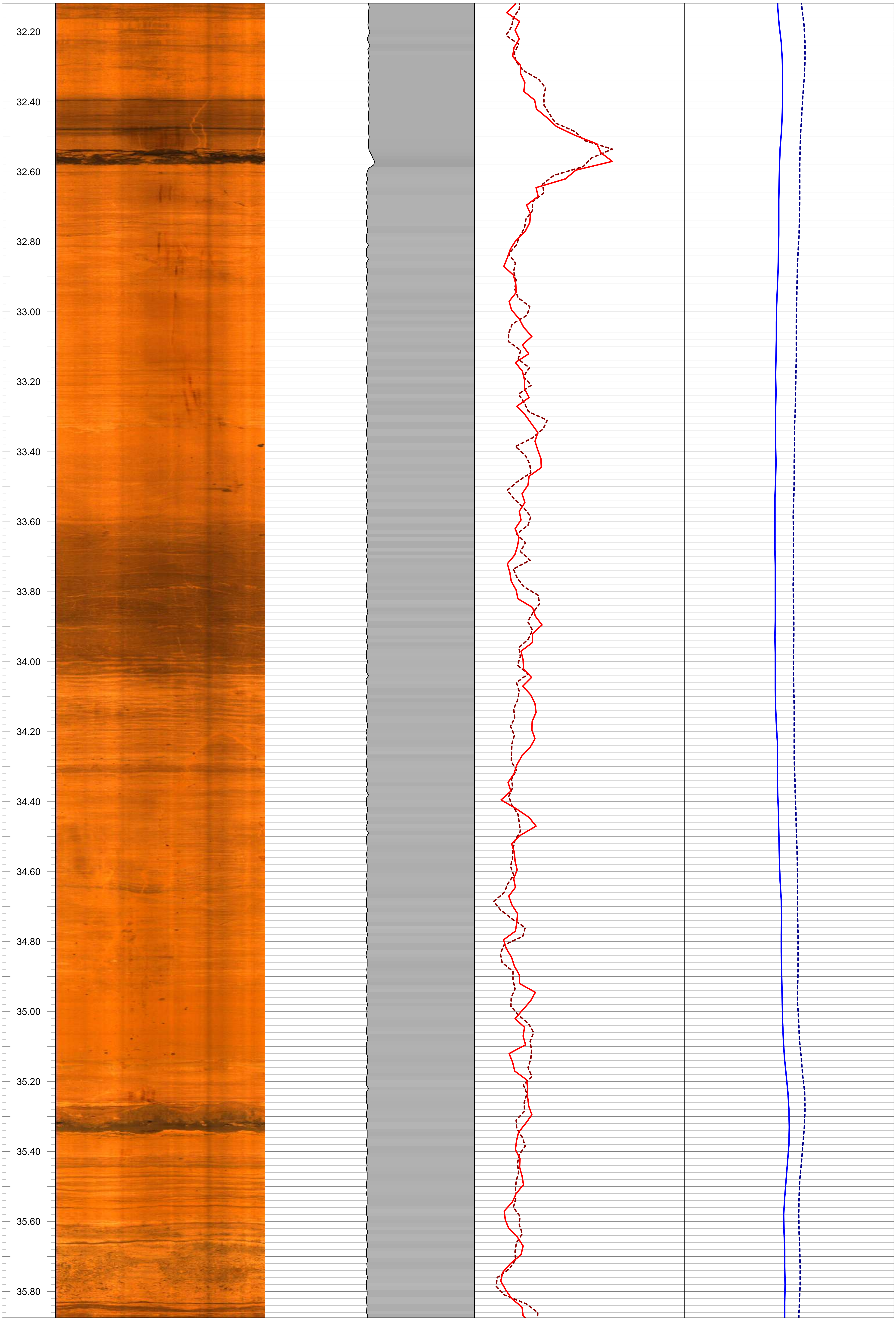
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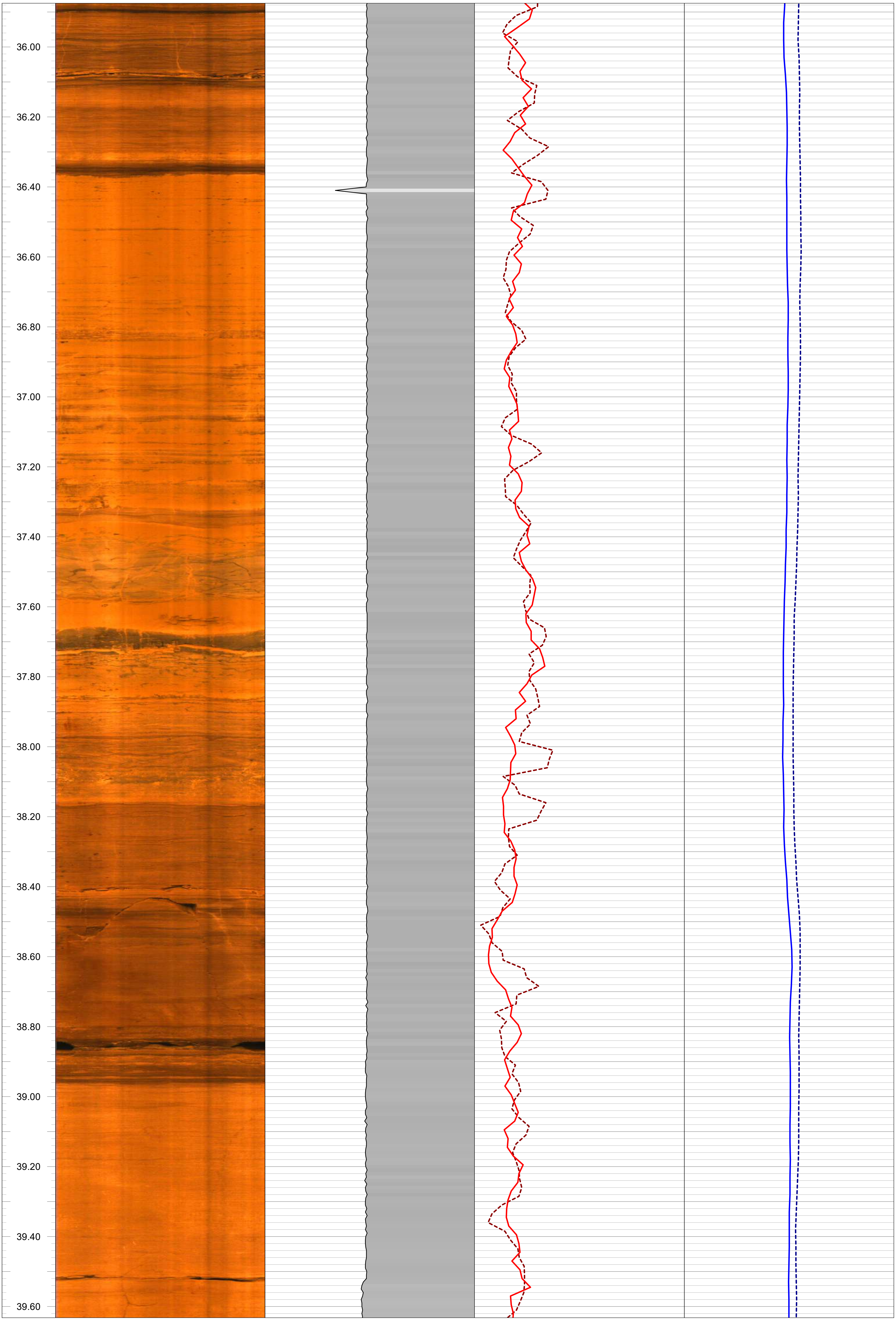
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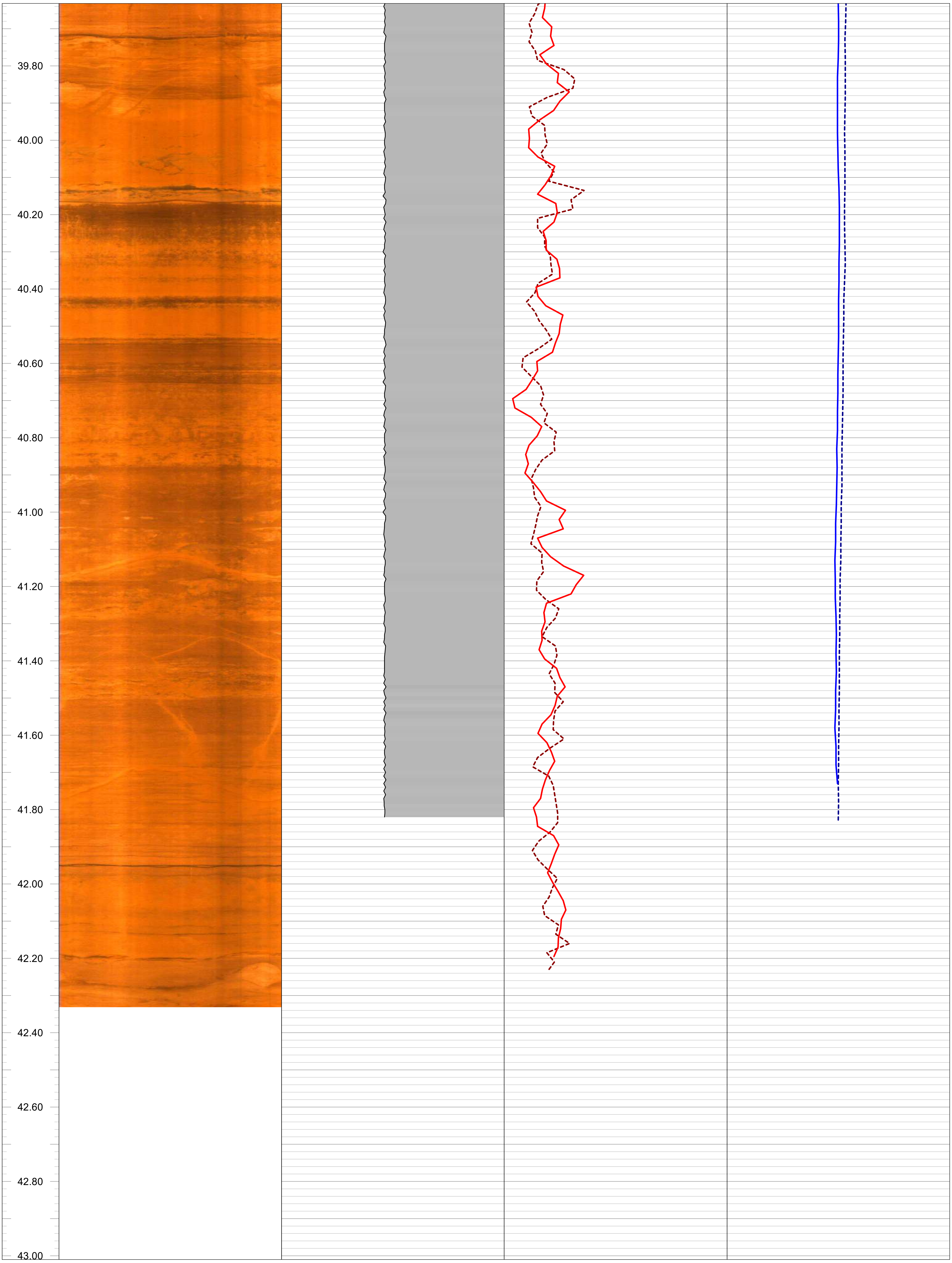
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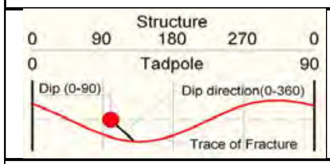
GEOPHYSICAL RECORD OF BOREHOLE: BH17-03
Project Number: 1781508
Client:
Date: January 2018

Datum:	**Elevation:**	**Borehole Diameter:**	**Water Level:**	**Location:**	St. Mary's
Easting:	**Depth Reference:**	**Casing Diameter:**	**Borehole Inclination:**	**Log Date:**	17-Jan-2018
Northing:	**Drilled Depth:**	**Casing Depth:**	**Borehole Azimuth:**	**Logged By:**	PG



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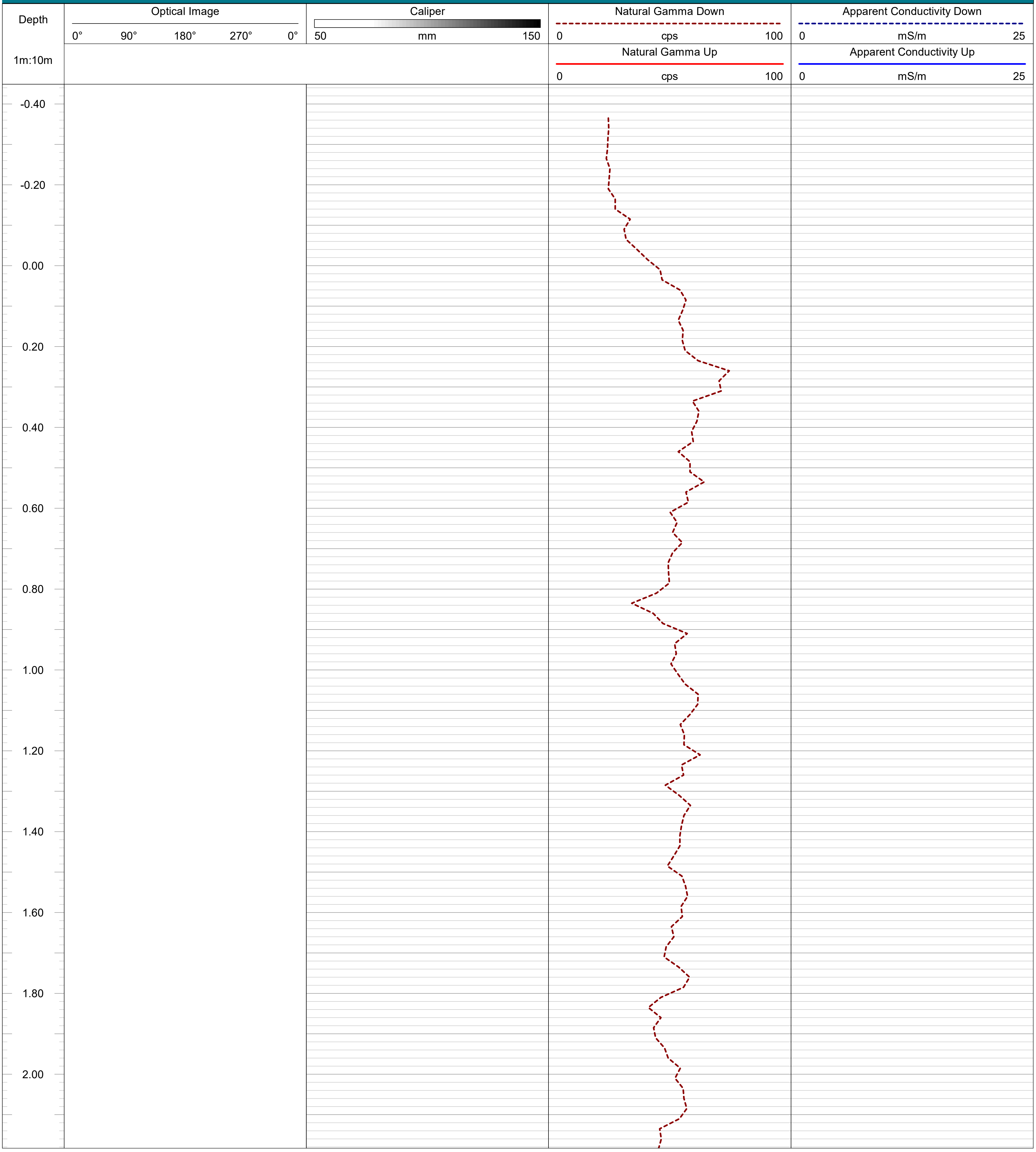

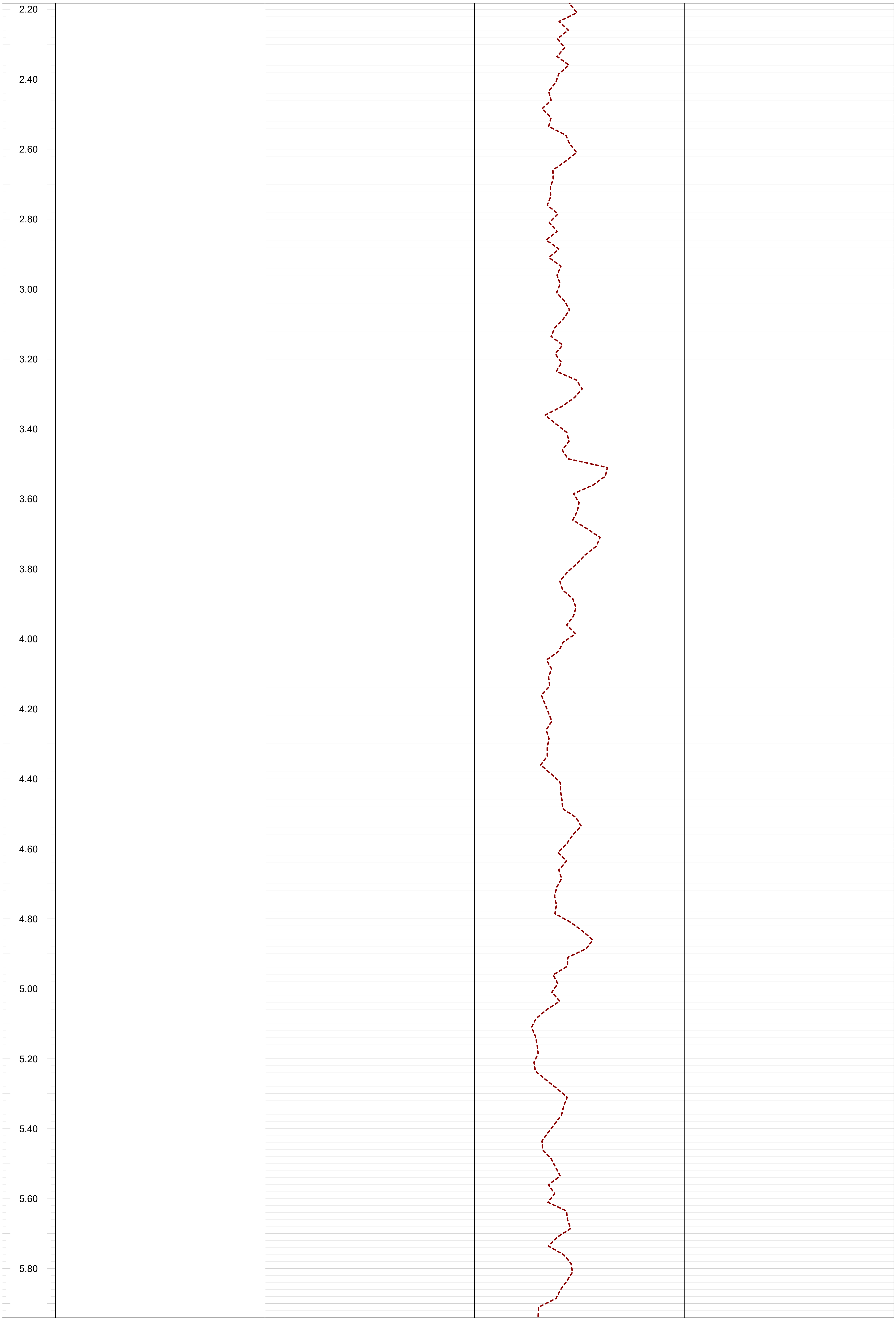
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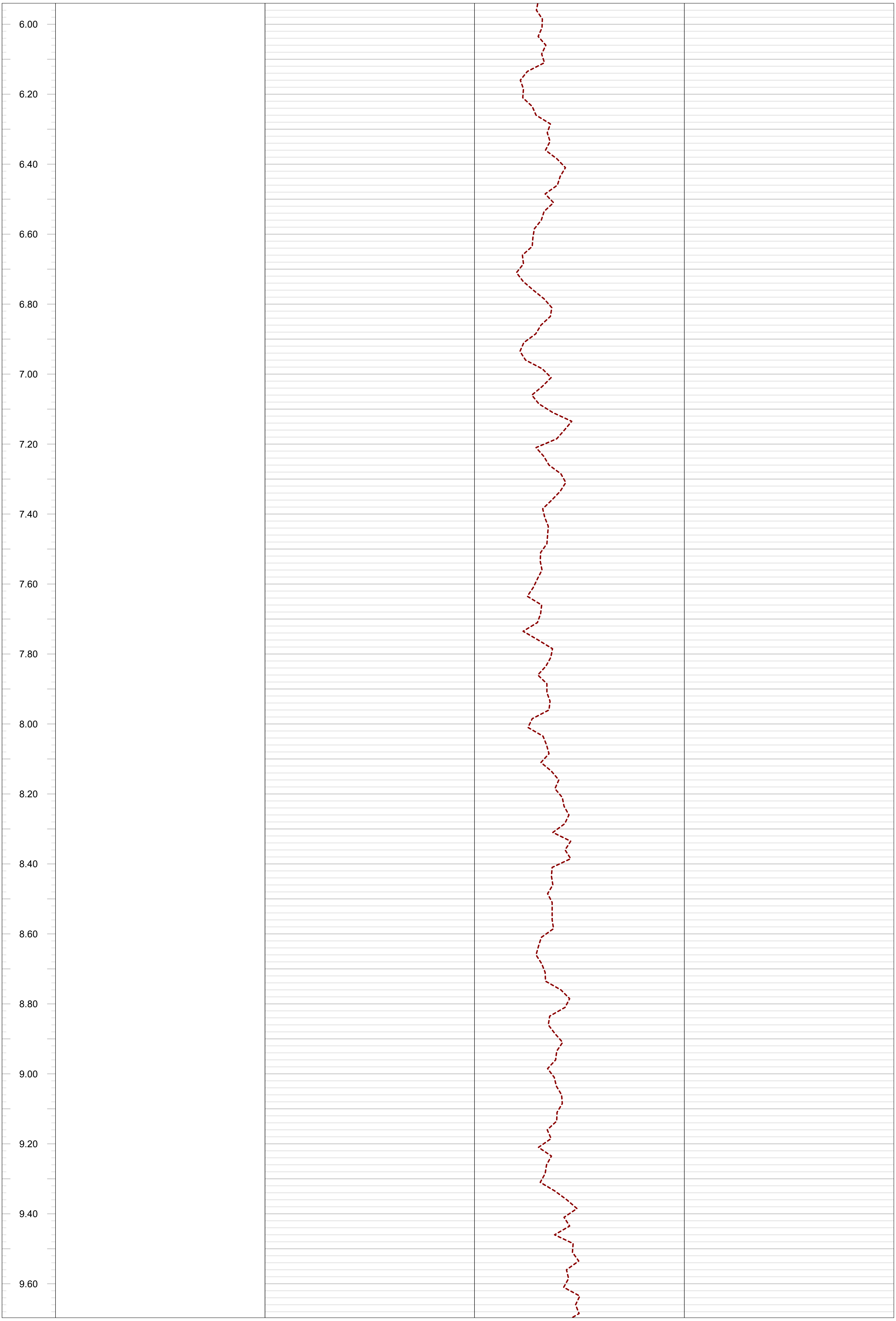
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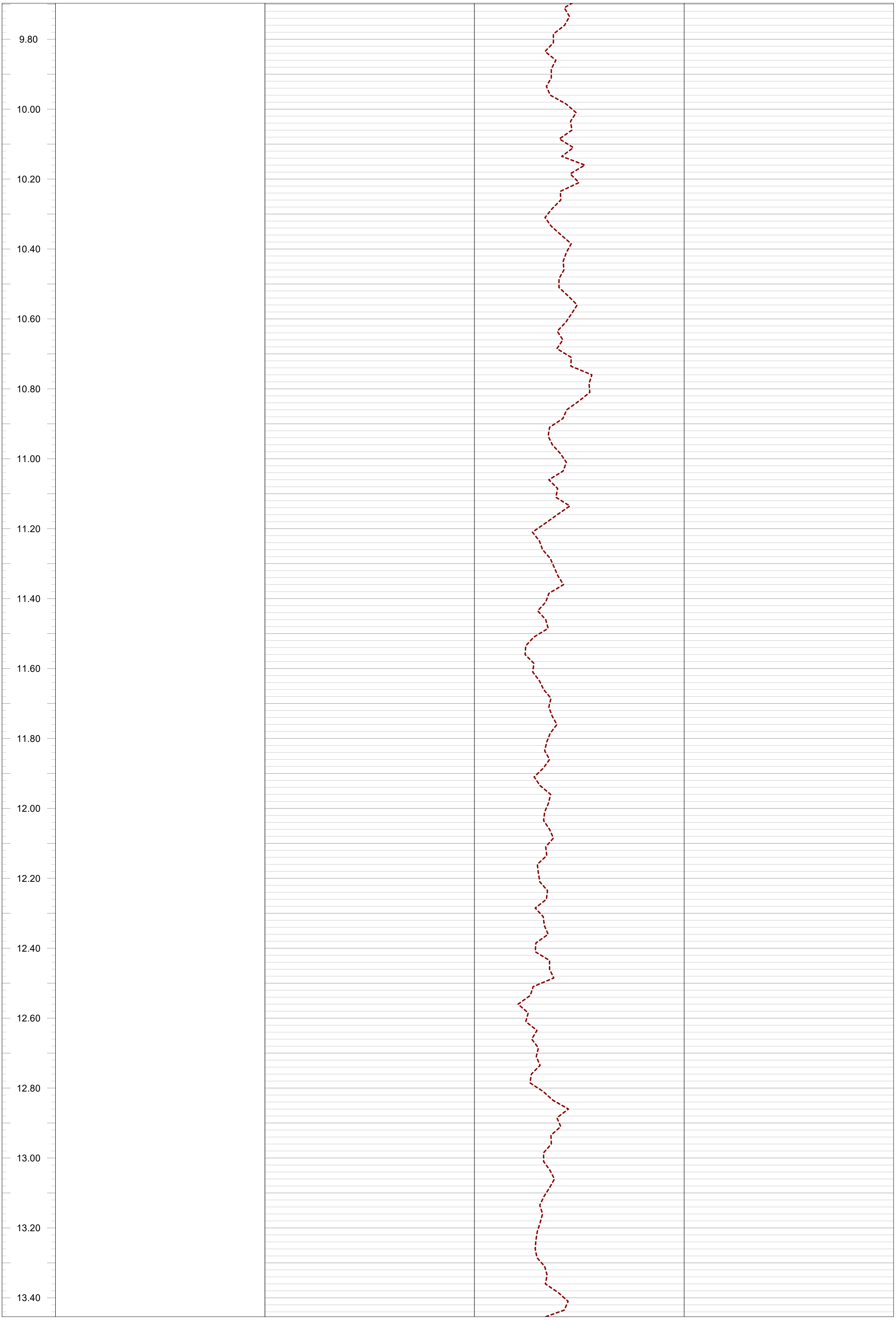
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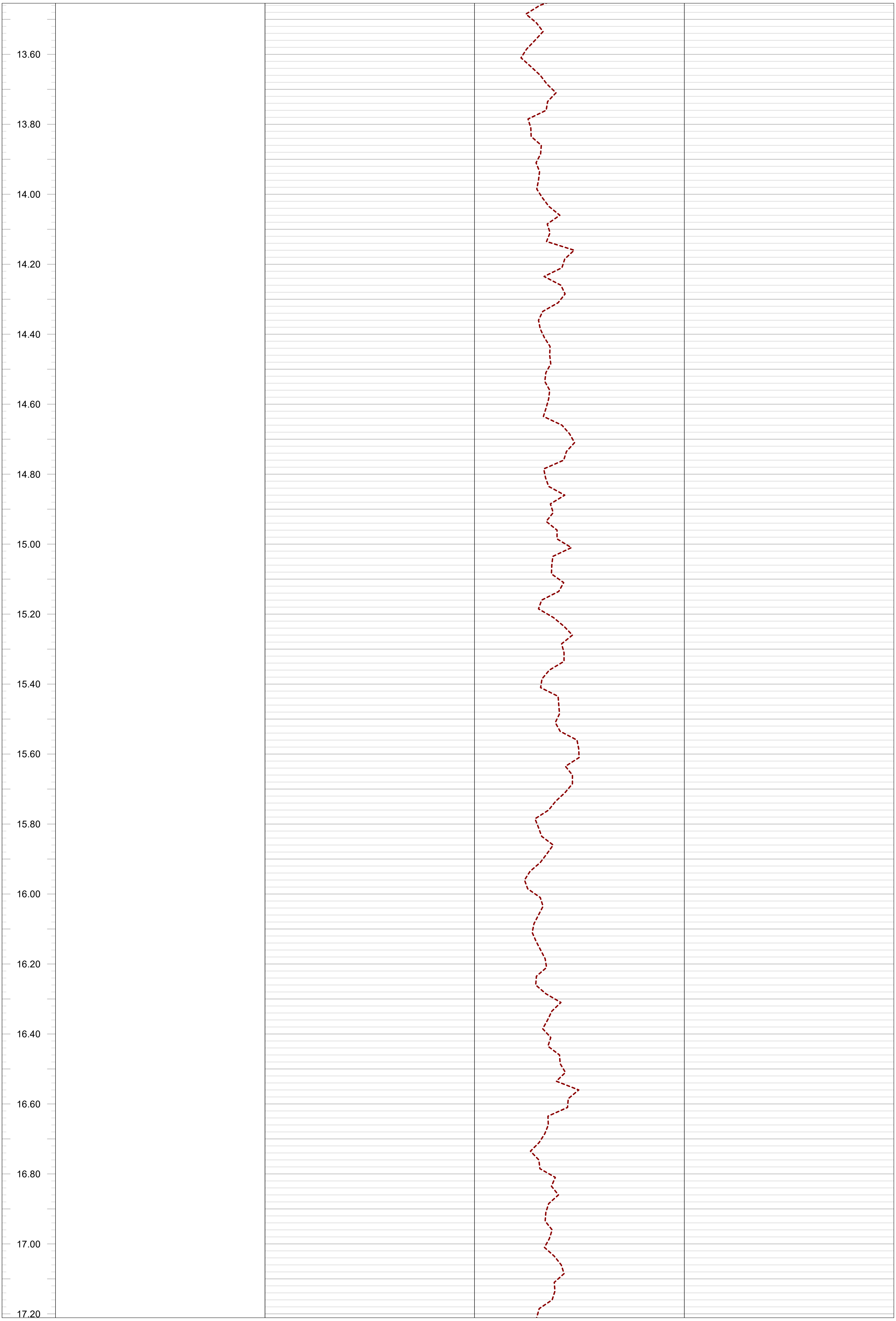

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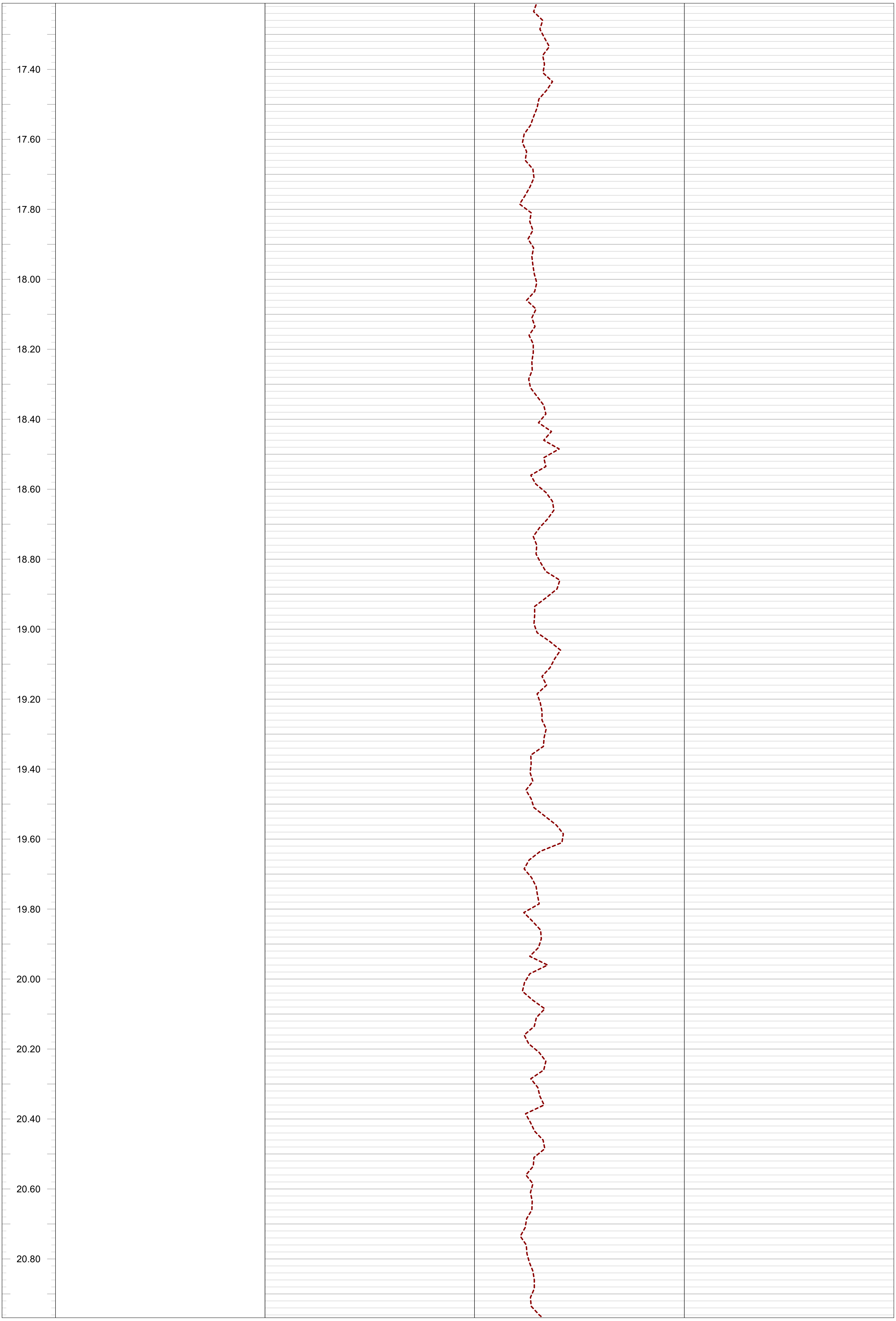
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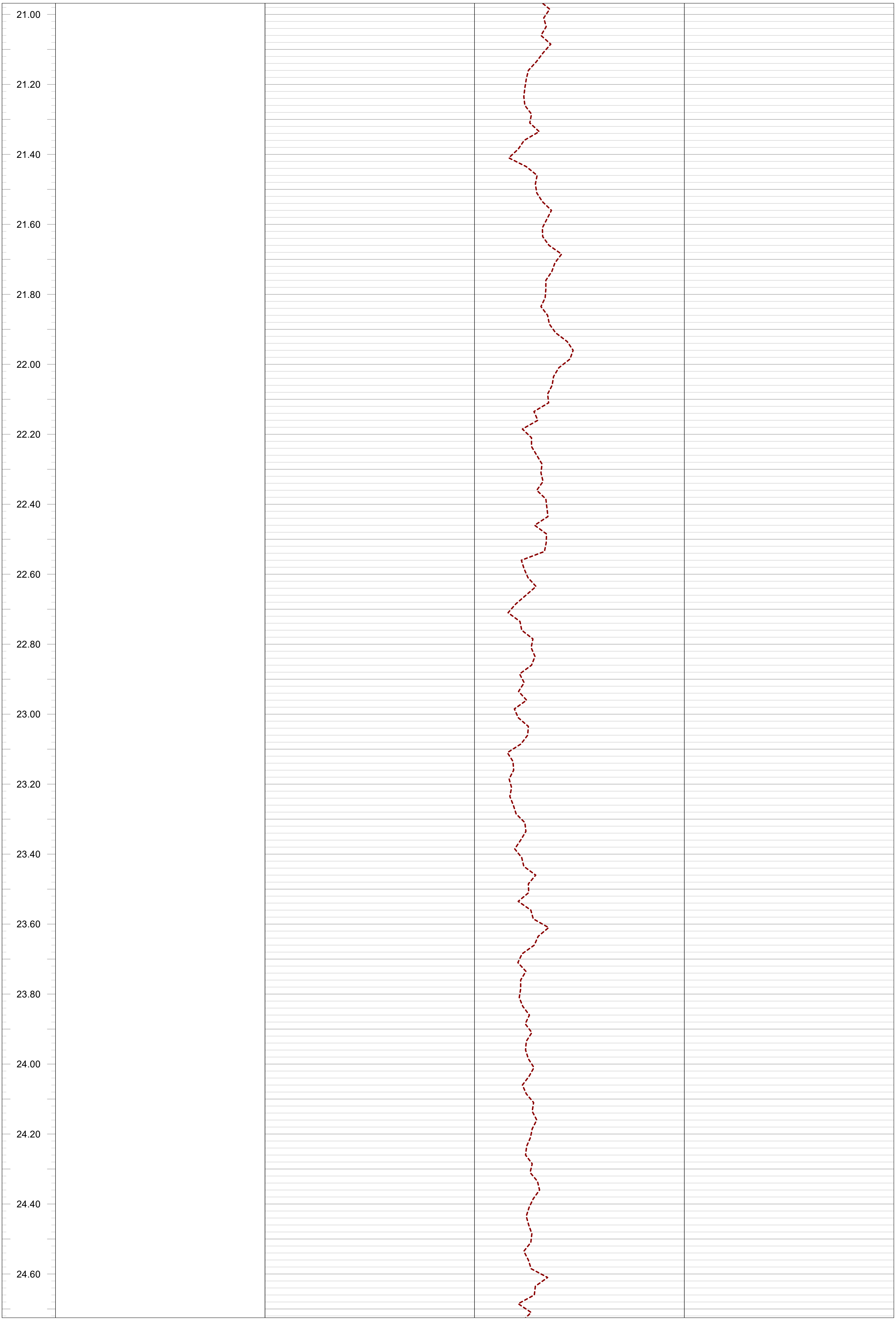
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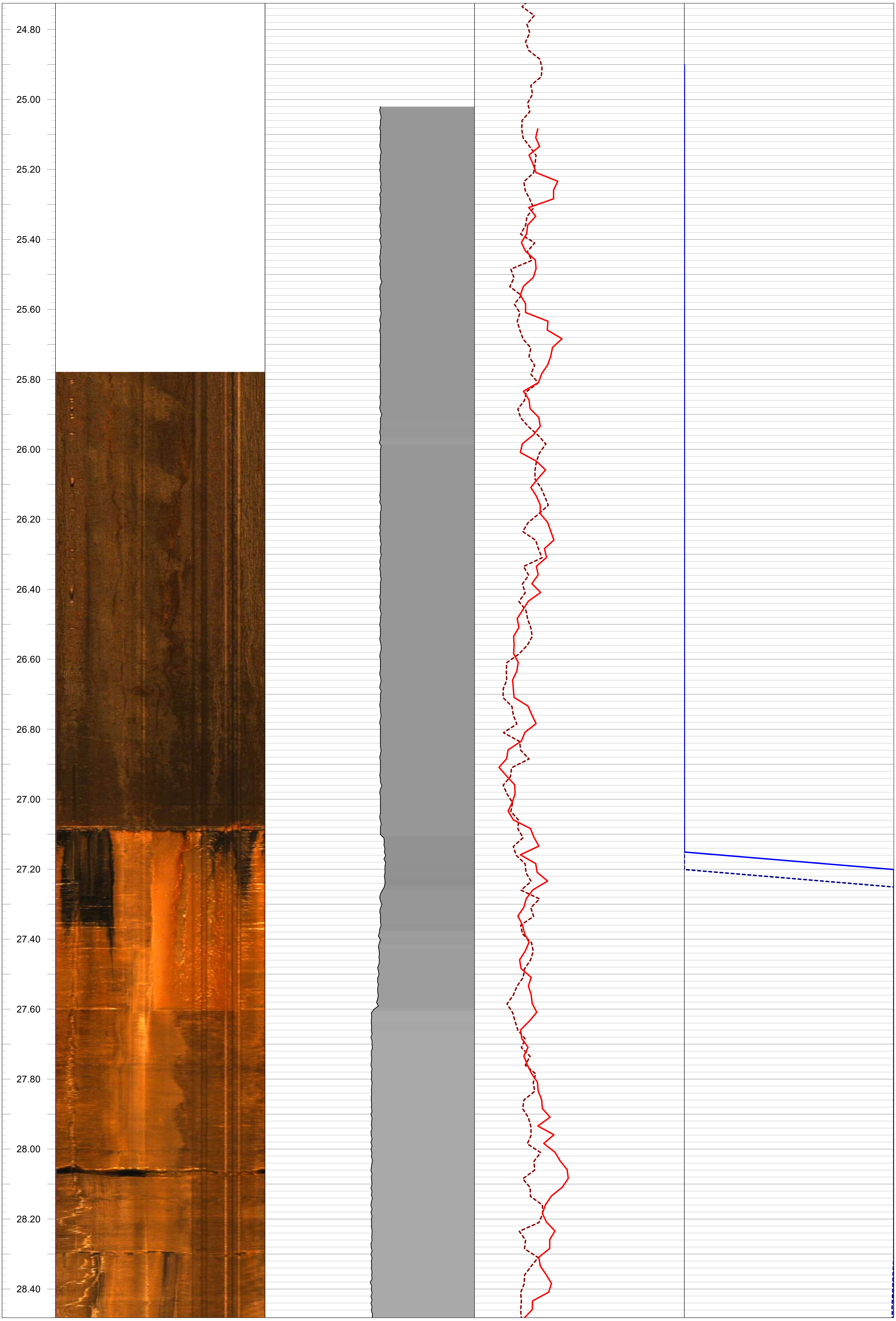
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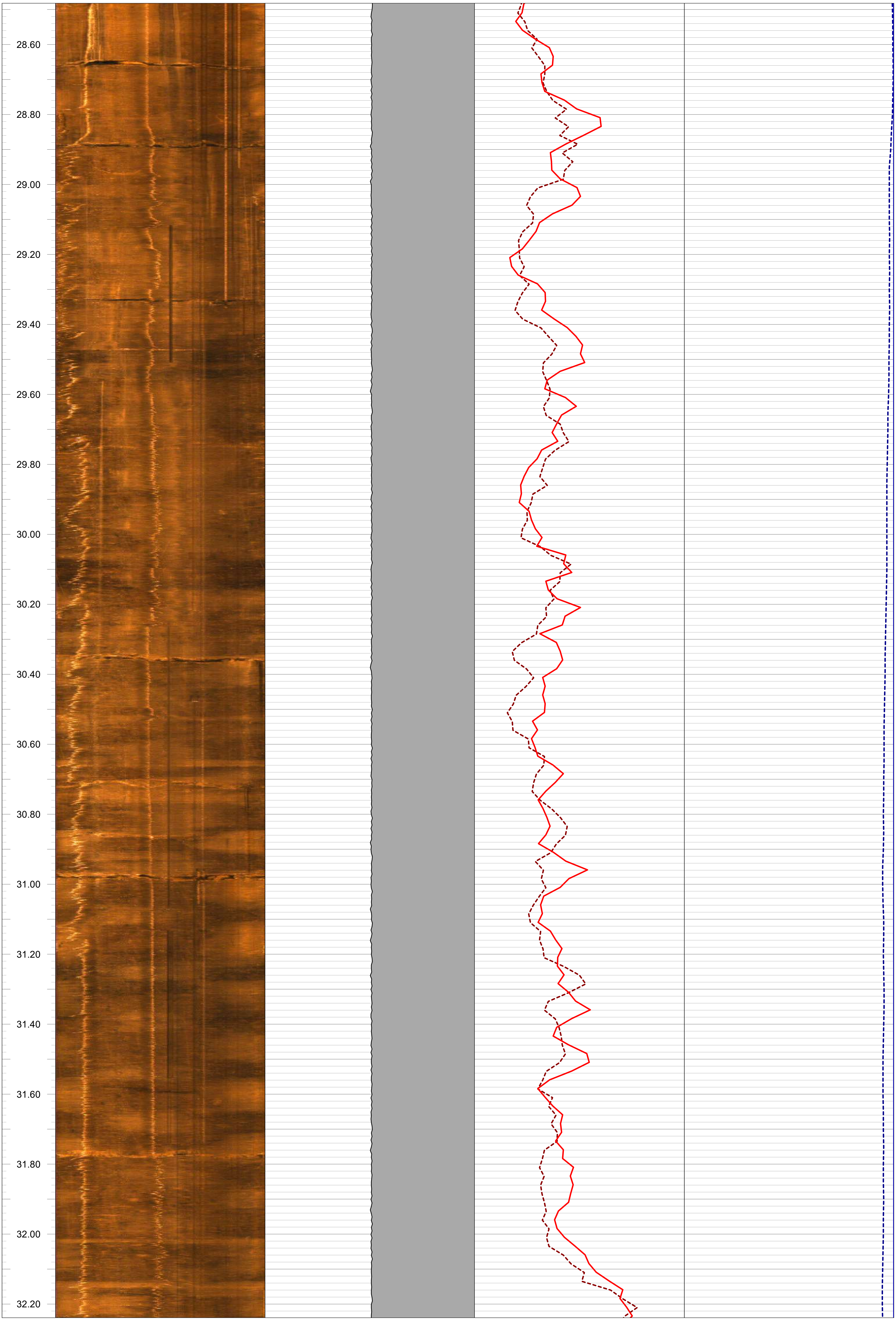
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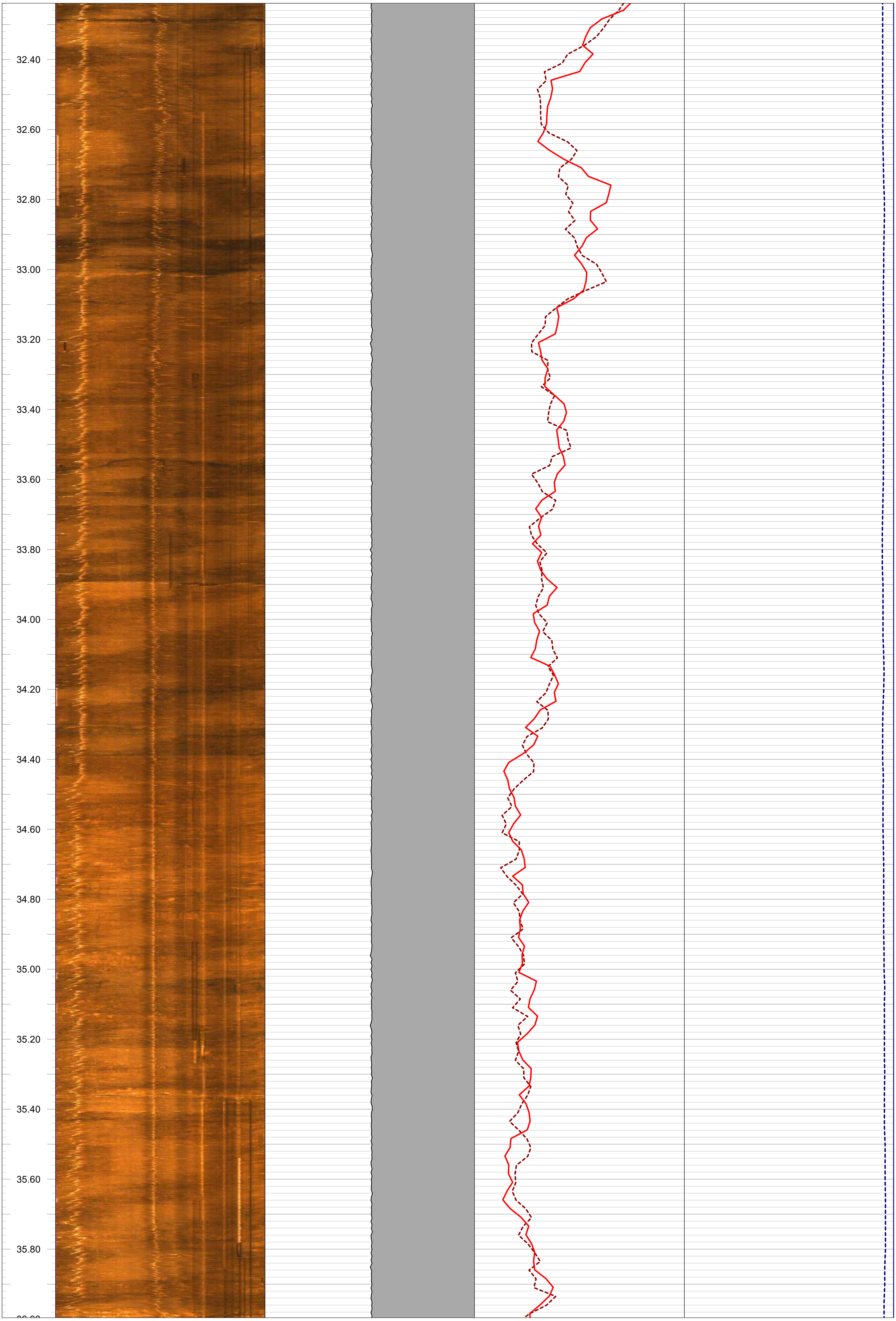
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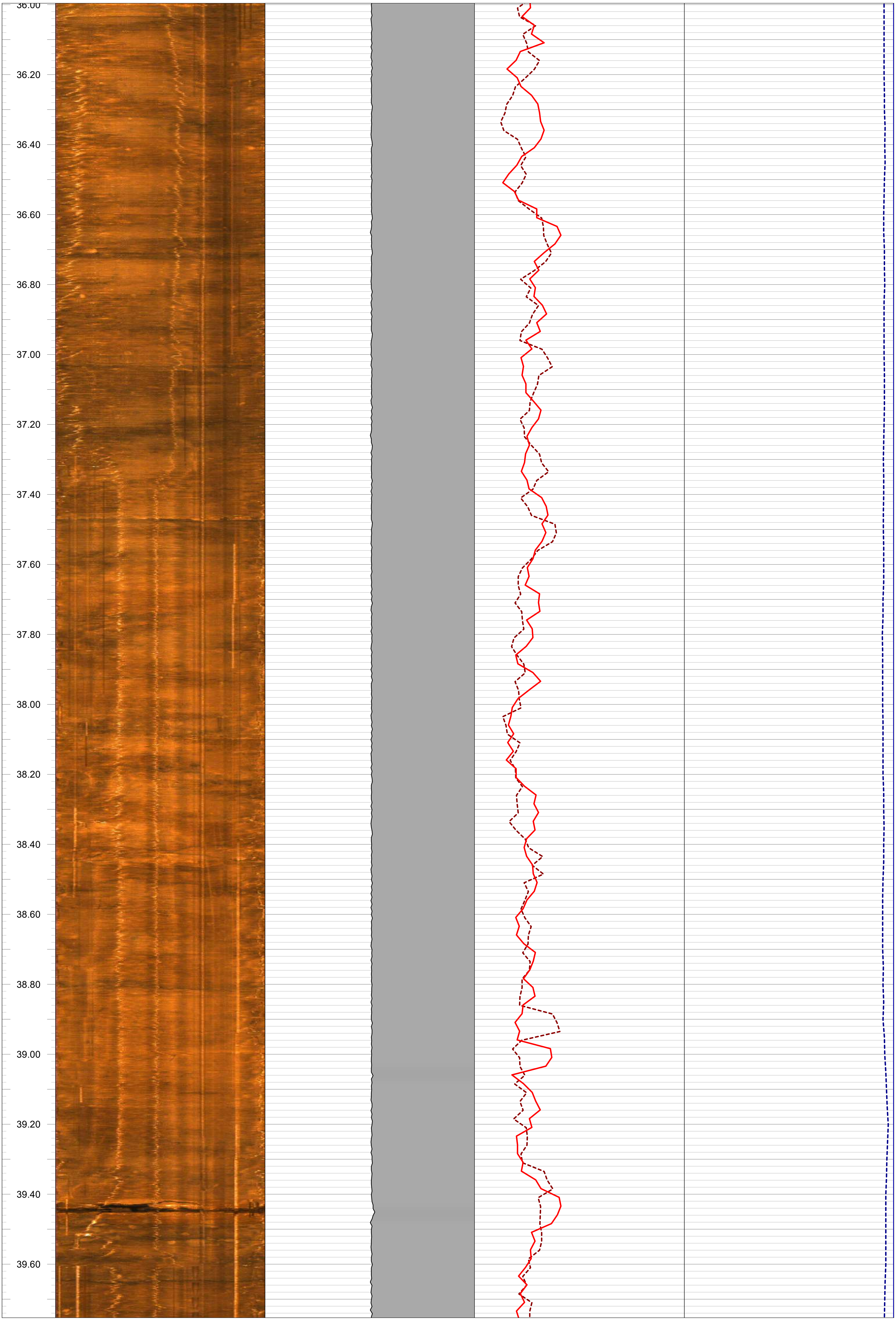
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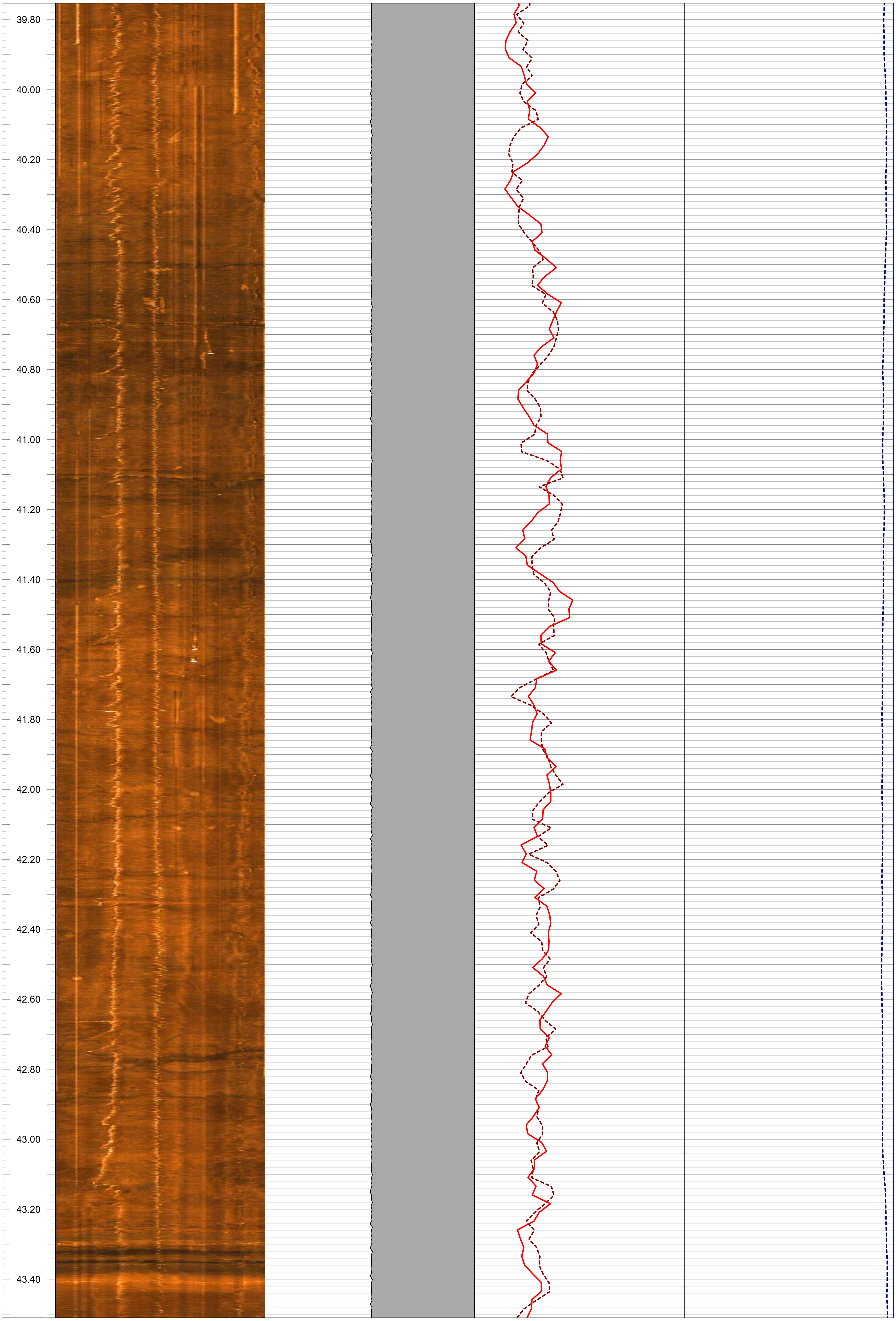
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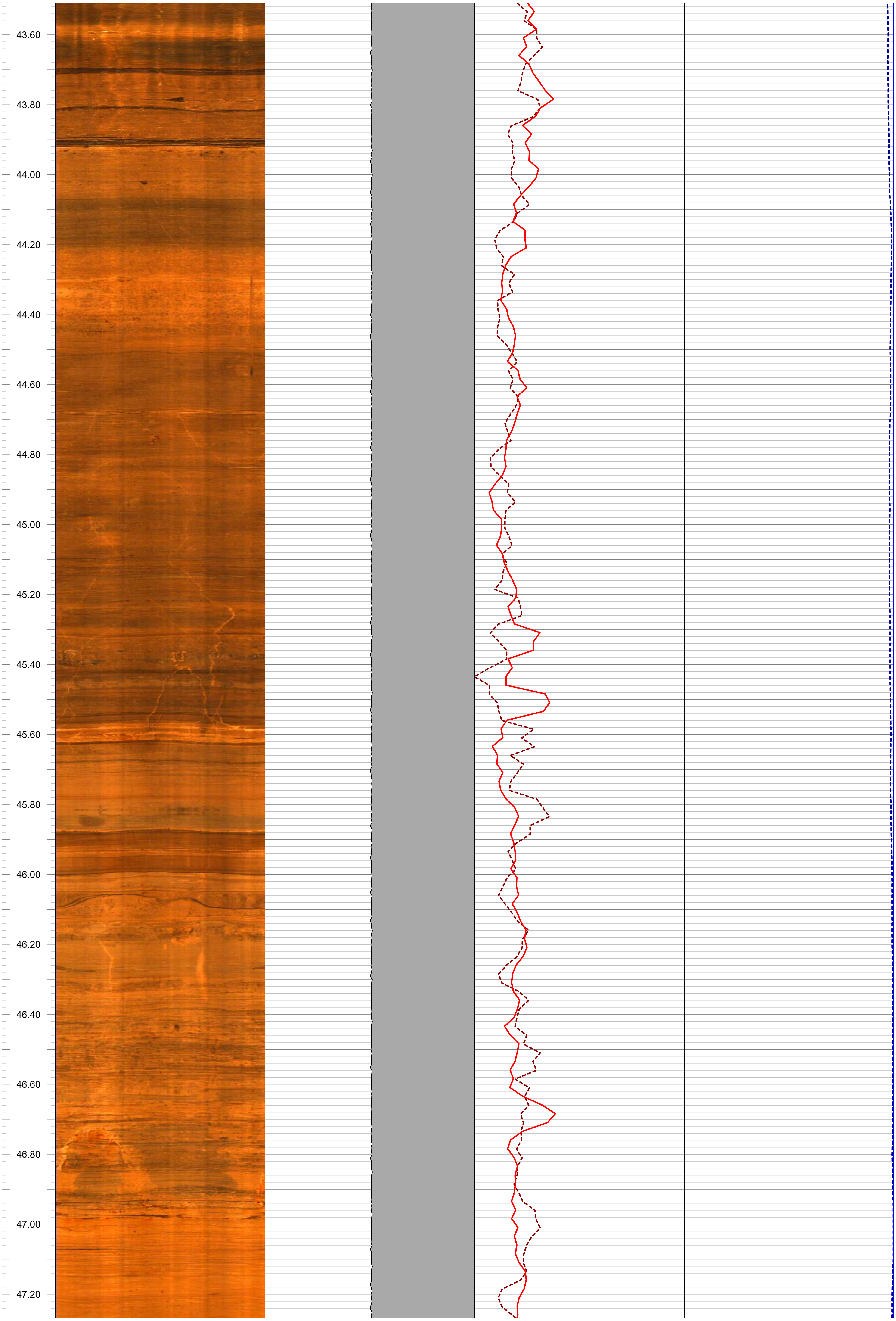
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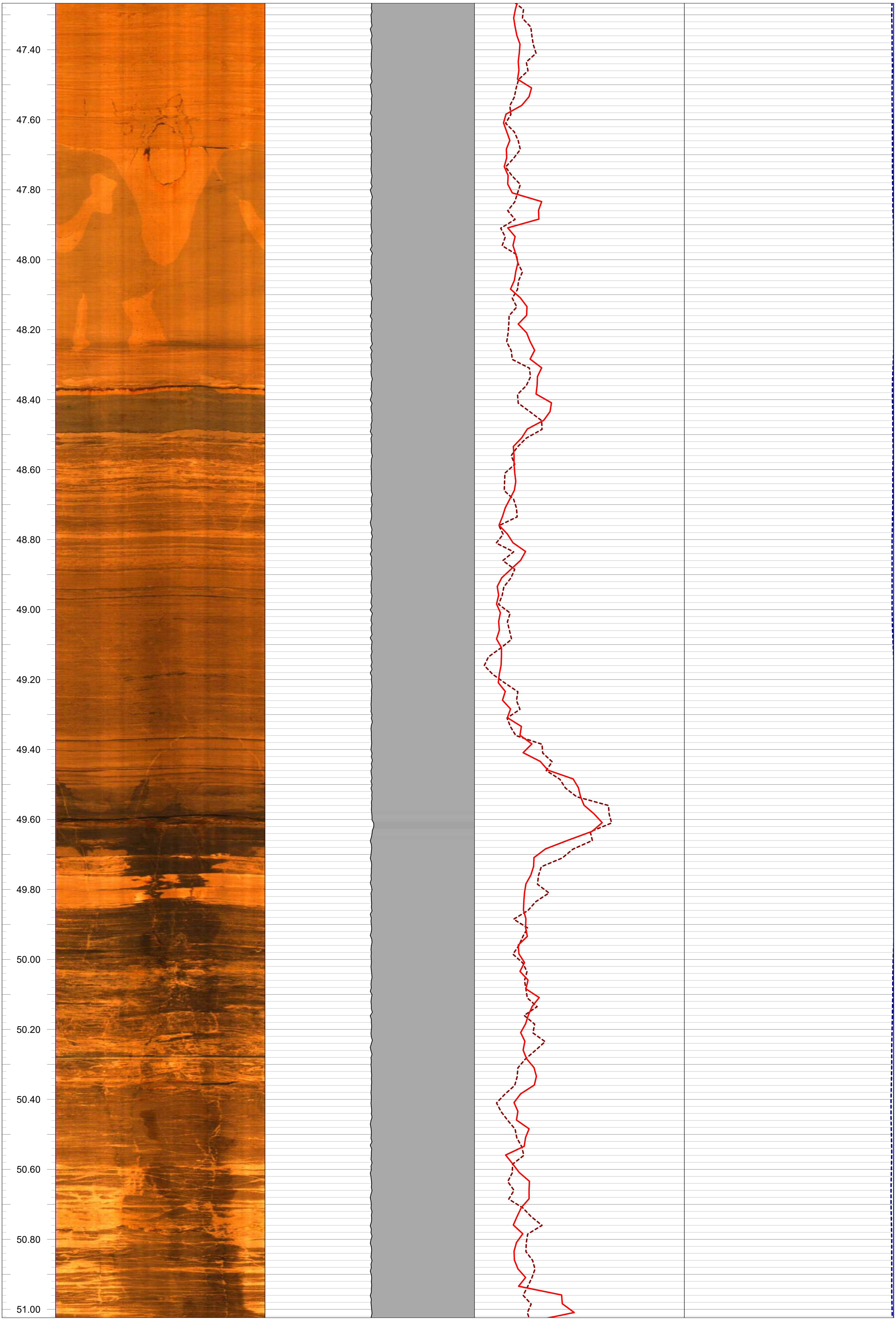
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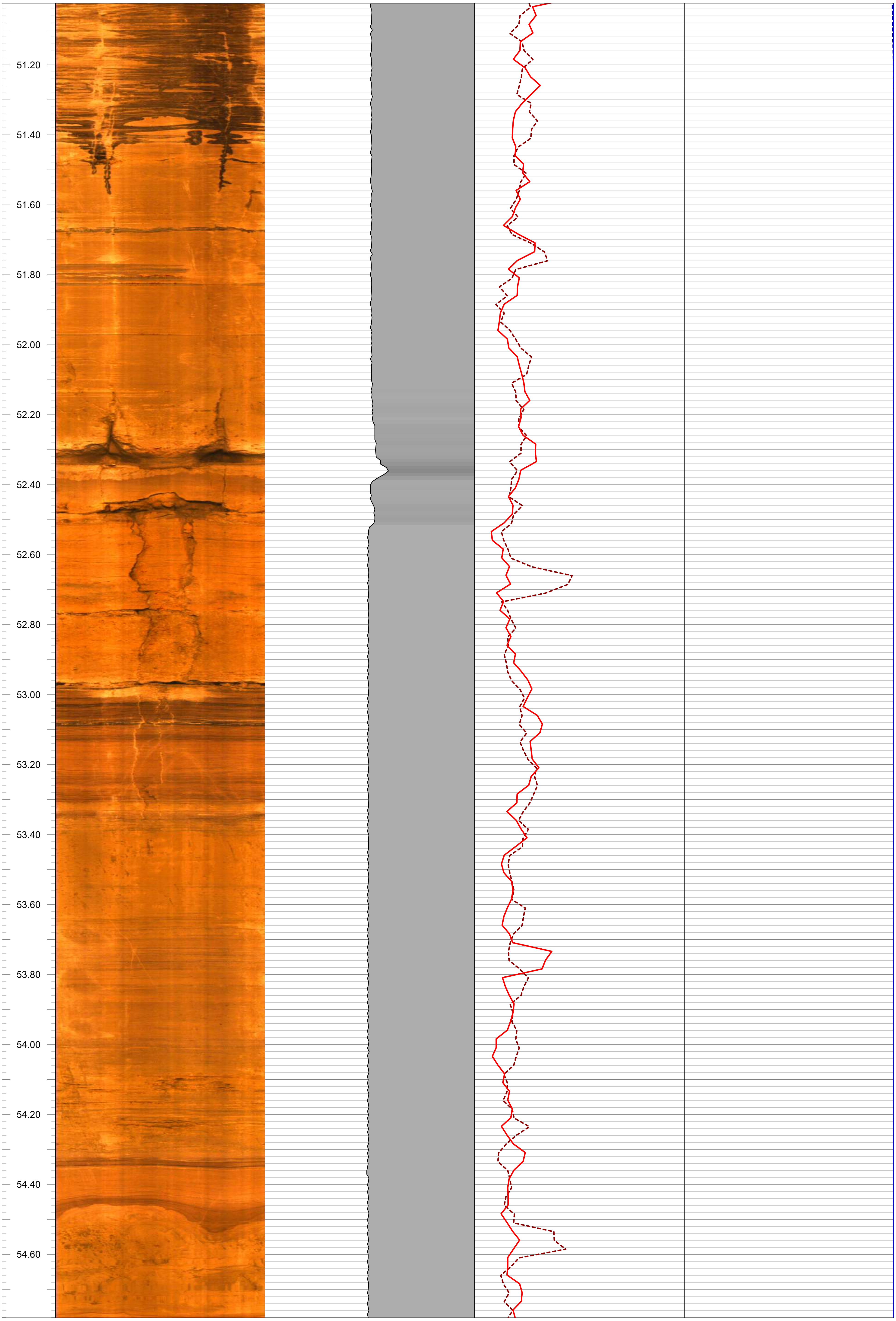
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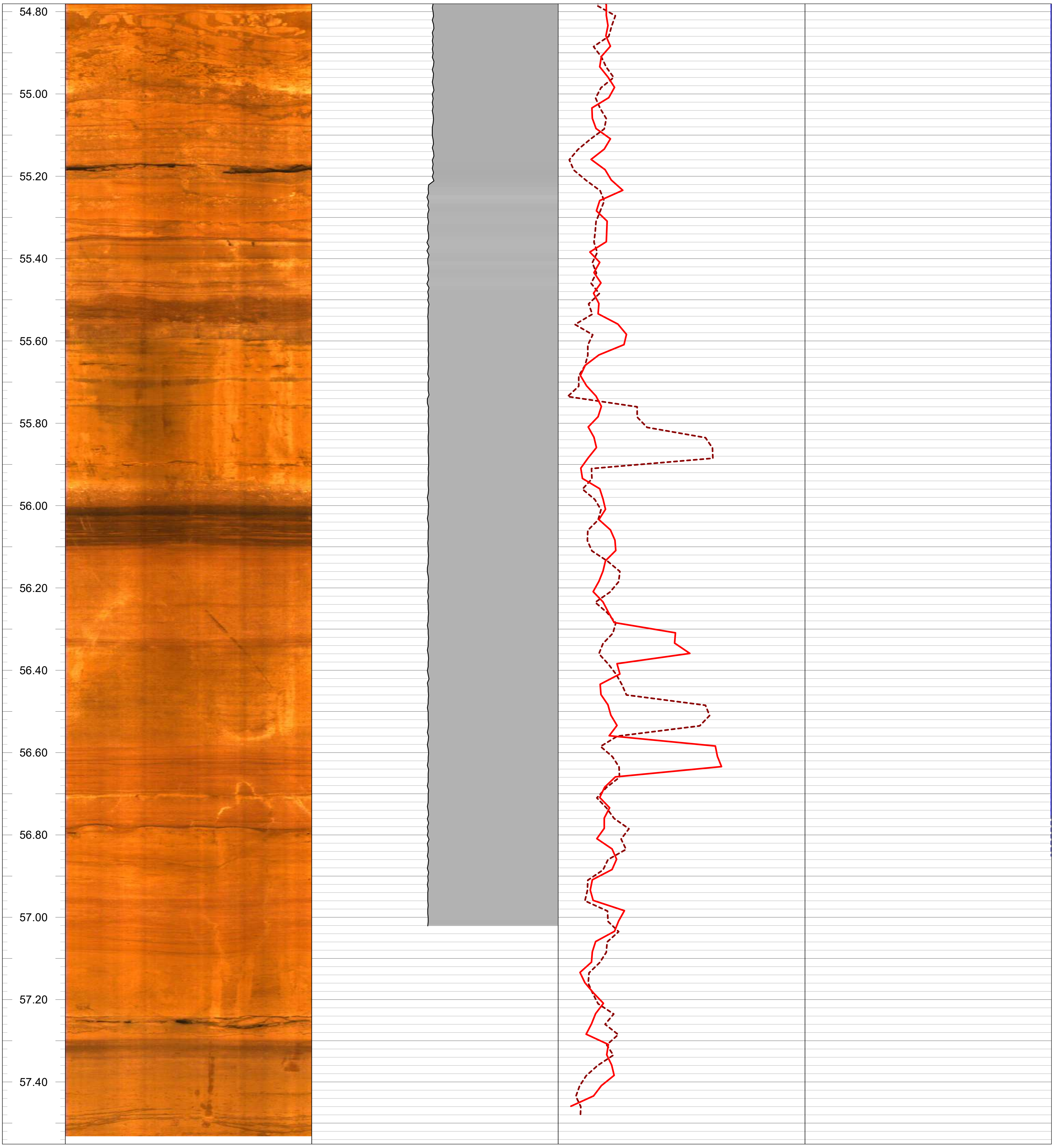
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GEOPHYSICAL RECORD OF BOREHOLE: BH17-04

Project Number: 1781508

Client:

Date: January 2018

Datum:

Easting:

Northing:

Elevation:

Depth Reference:

Drilled Depth:

Borehole Diameter:

Casing Diameter:

Casing Depth:

Water Level:

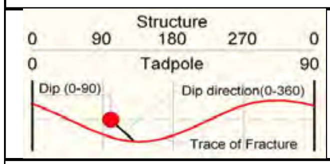
Borehole Inclination:

Borehole Azimuth:

Location: St. Mary's

Log Date: 17-Jan-2018

Logged By: PG



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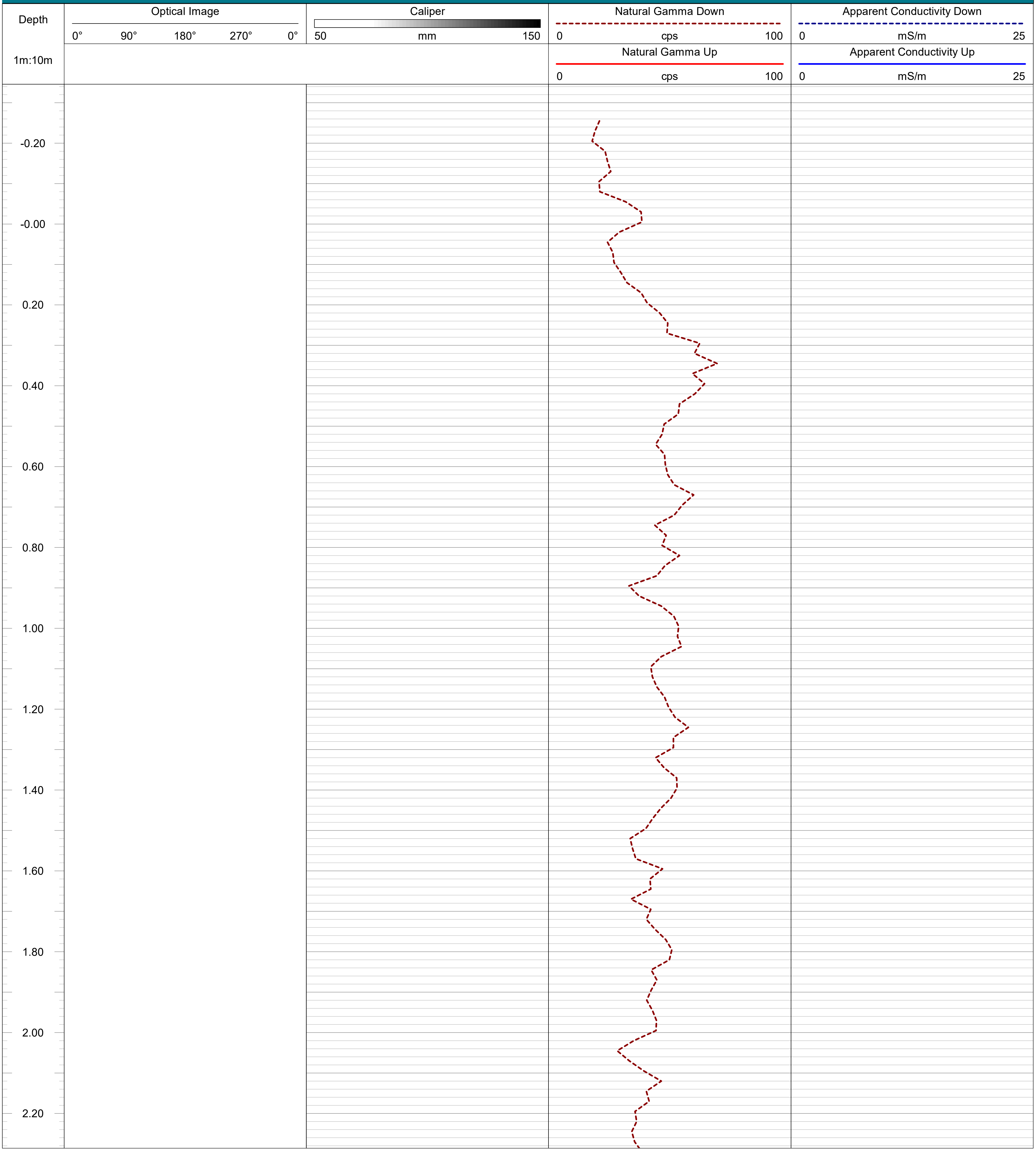

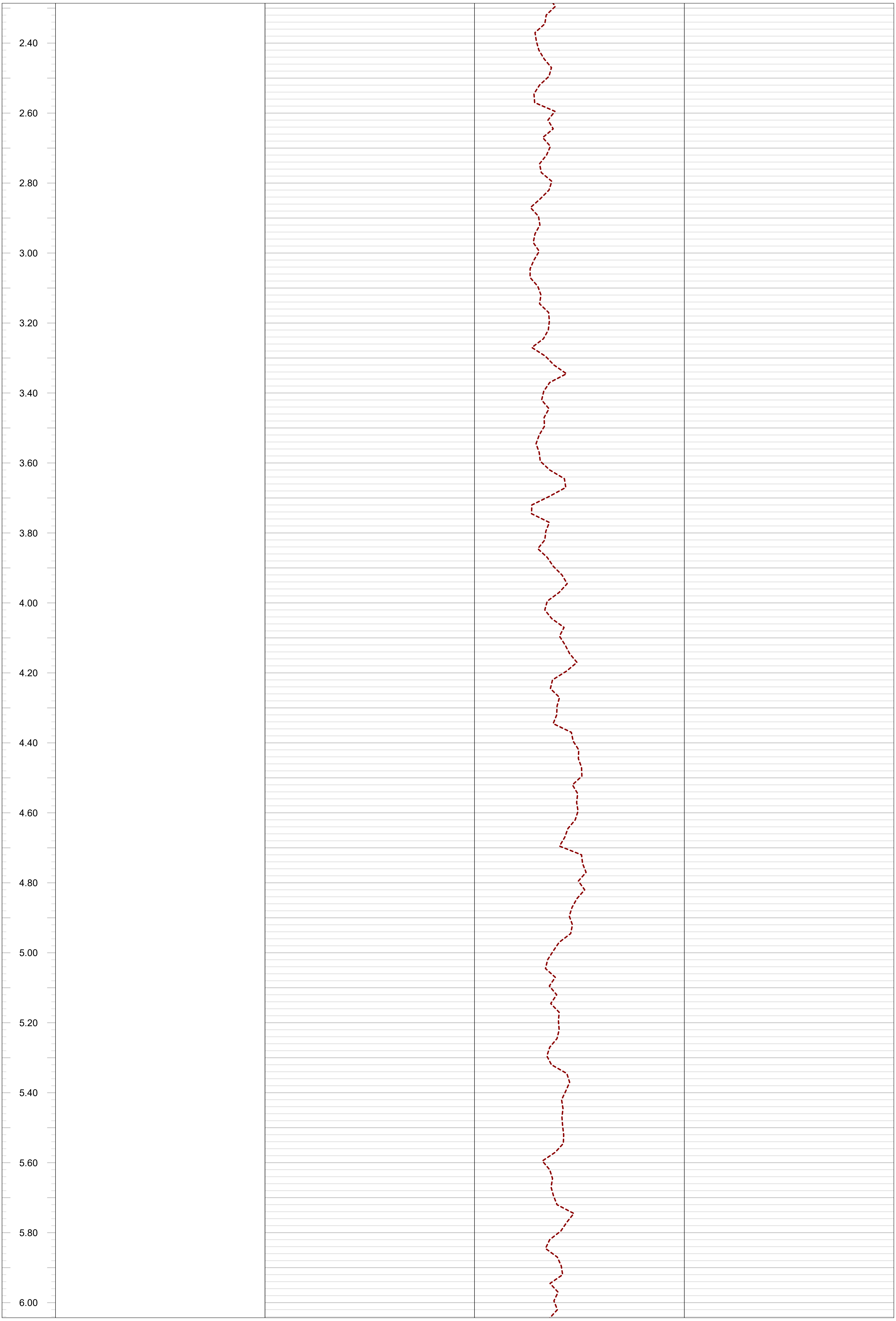
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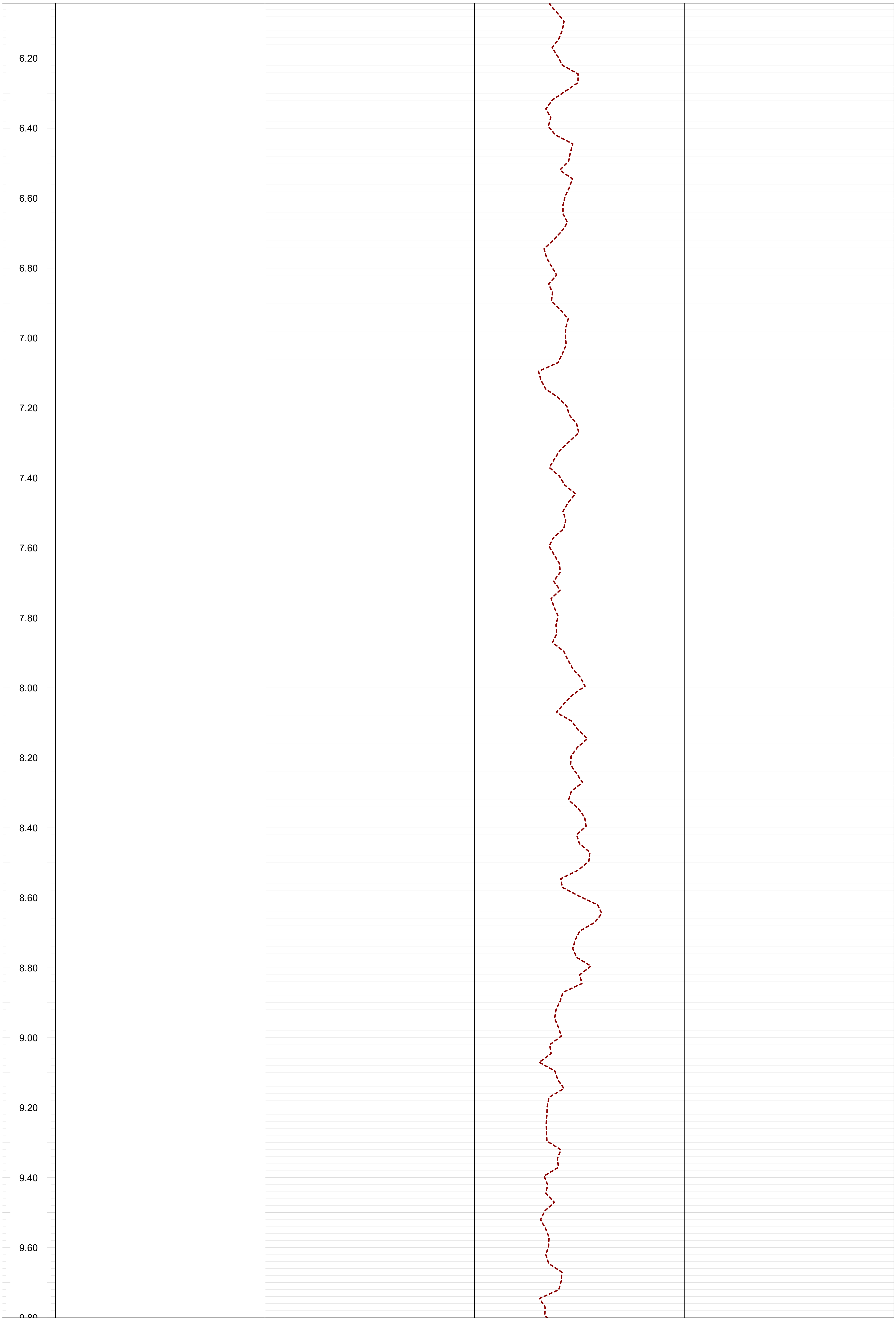
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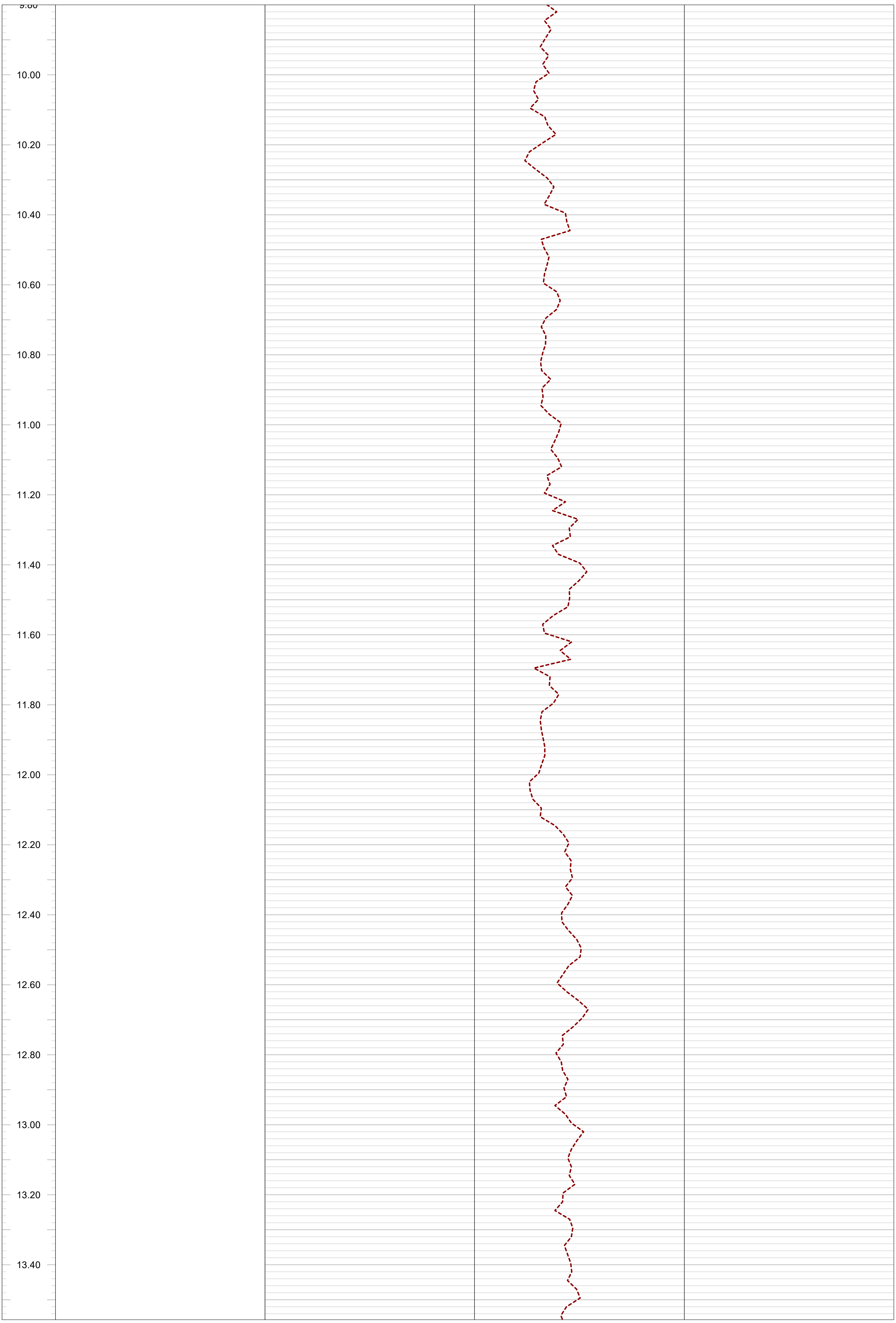
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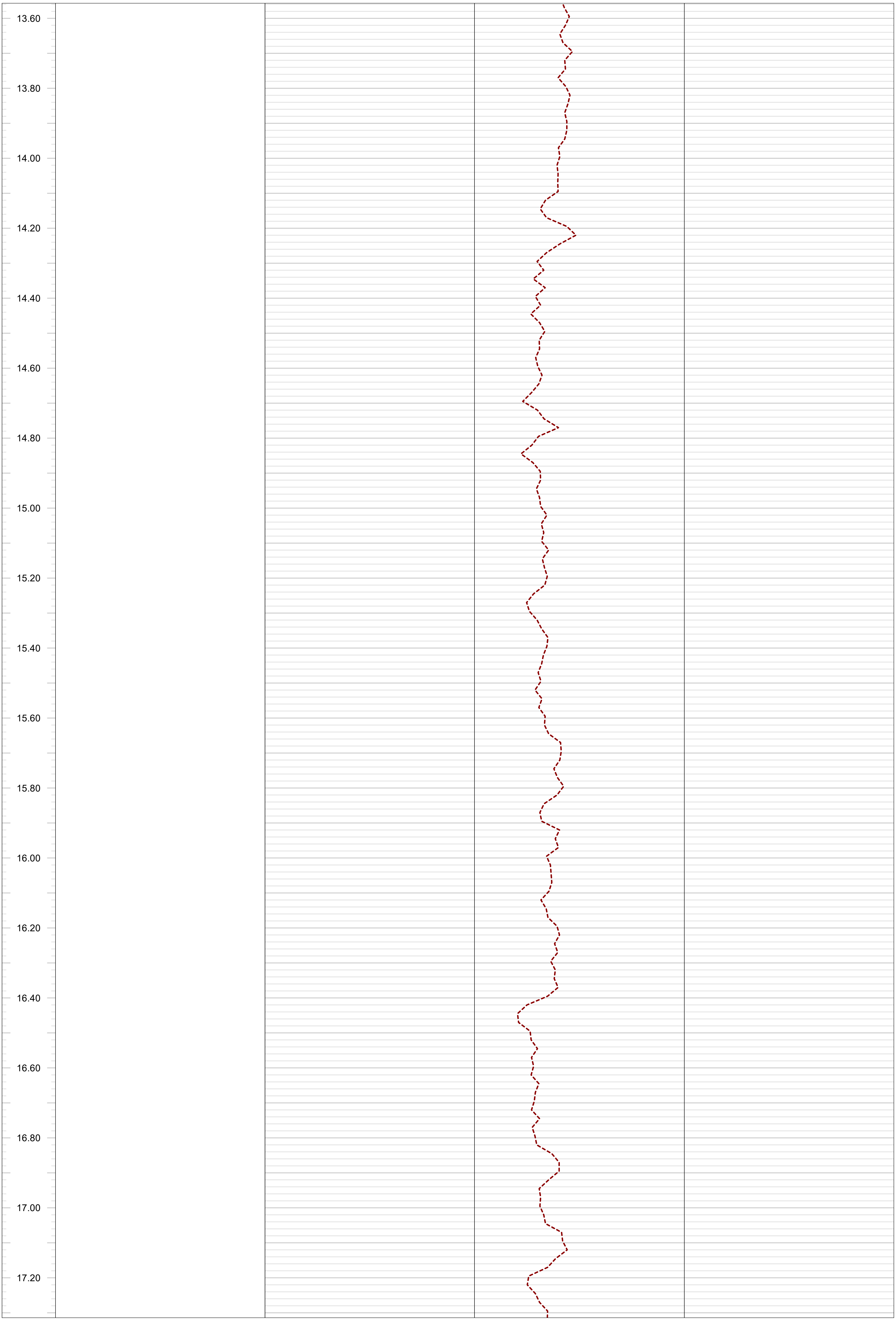
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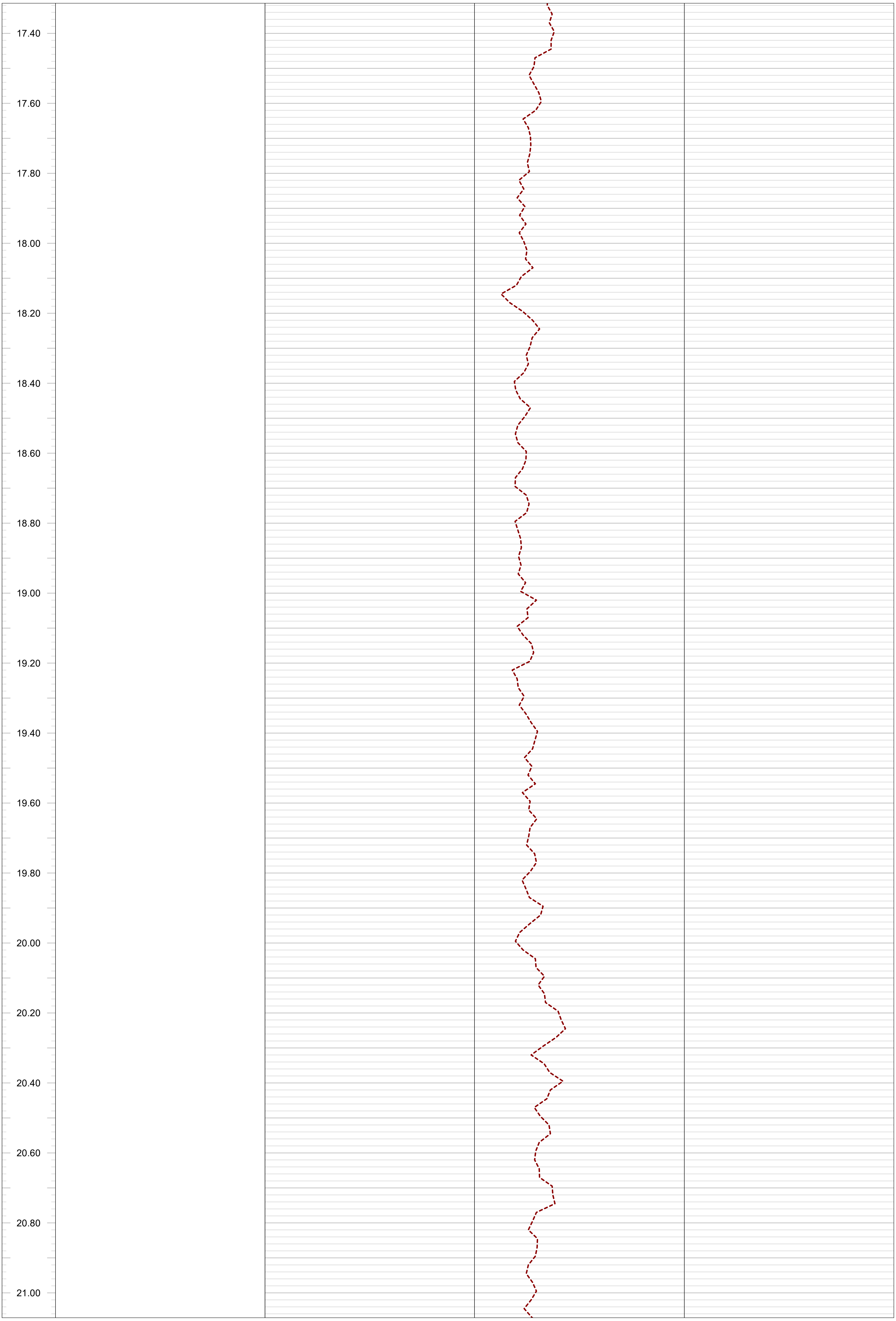
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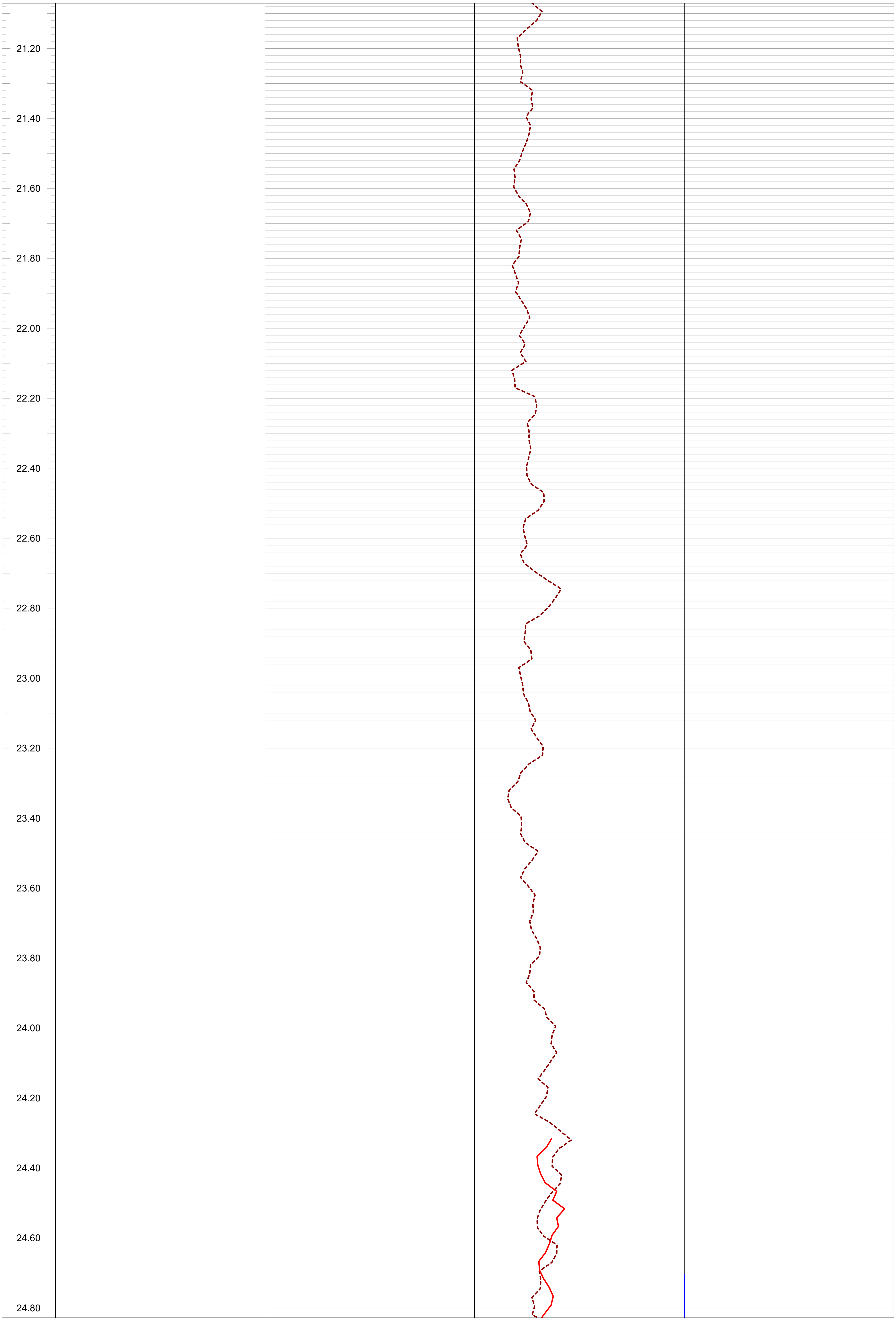
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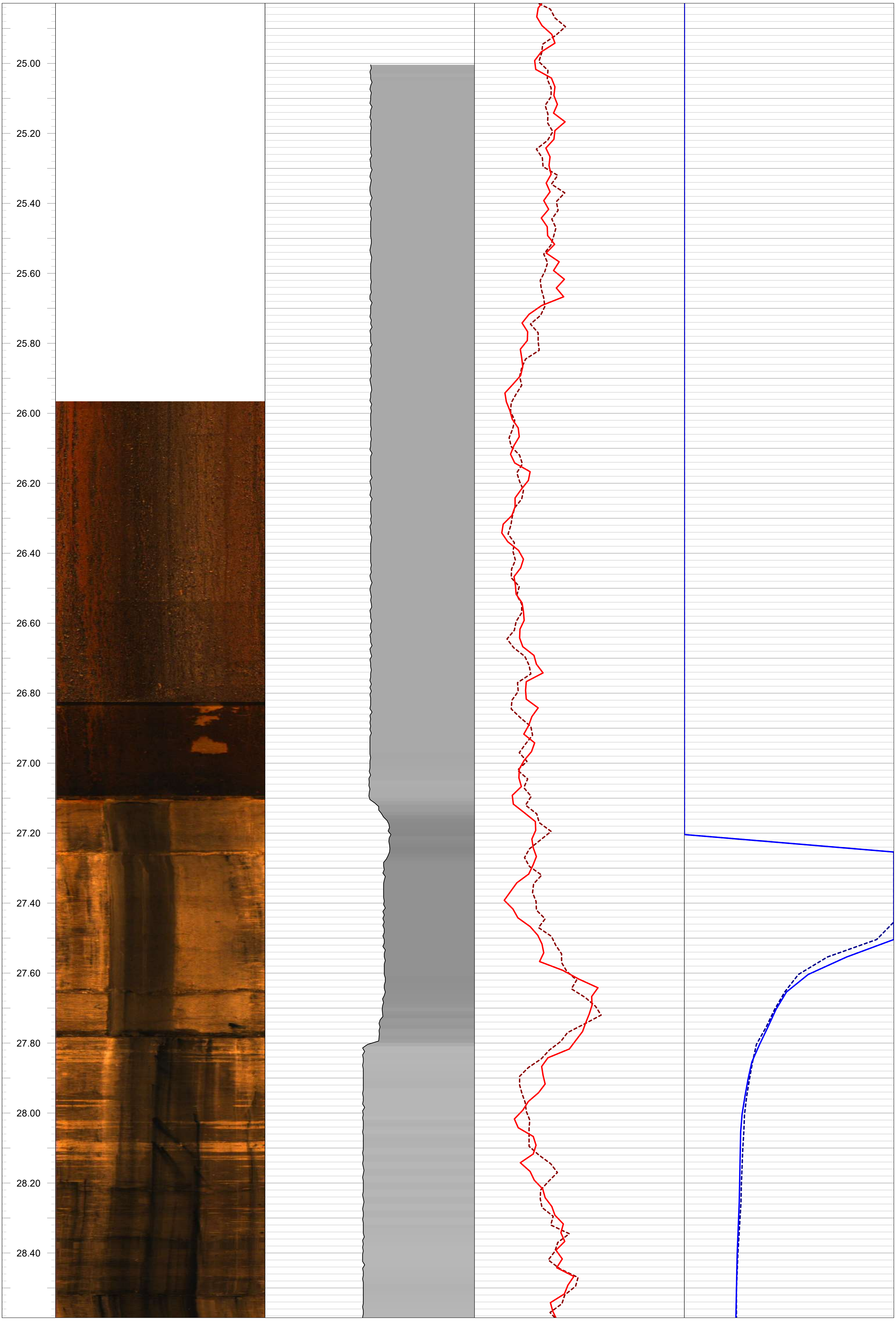
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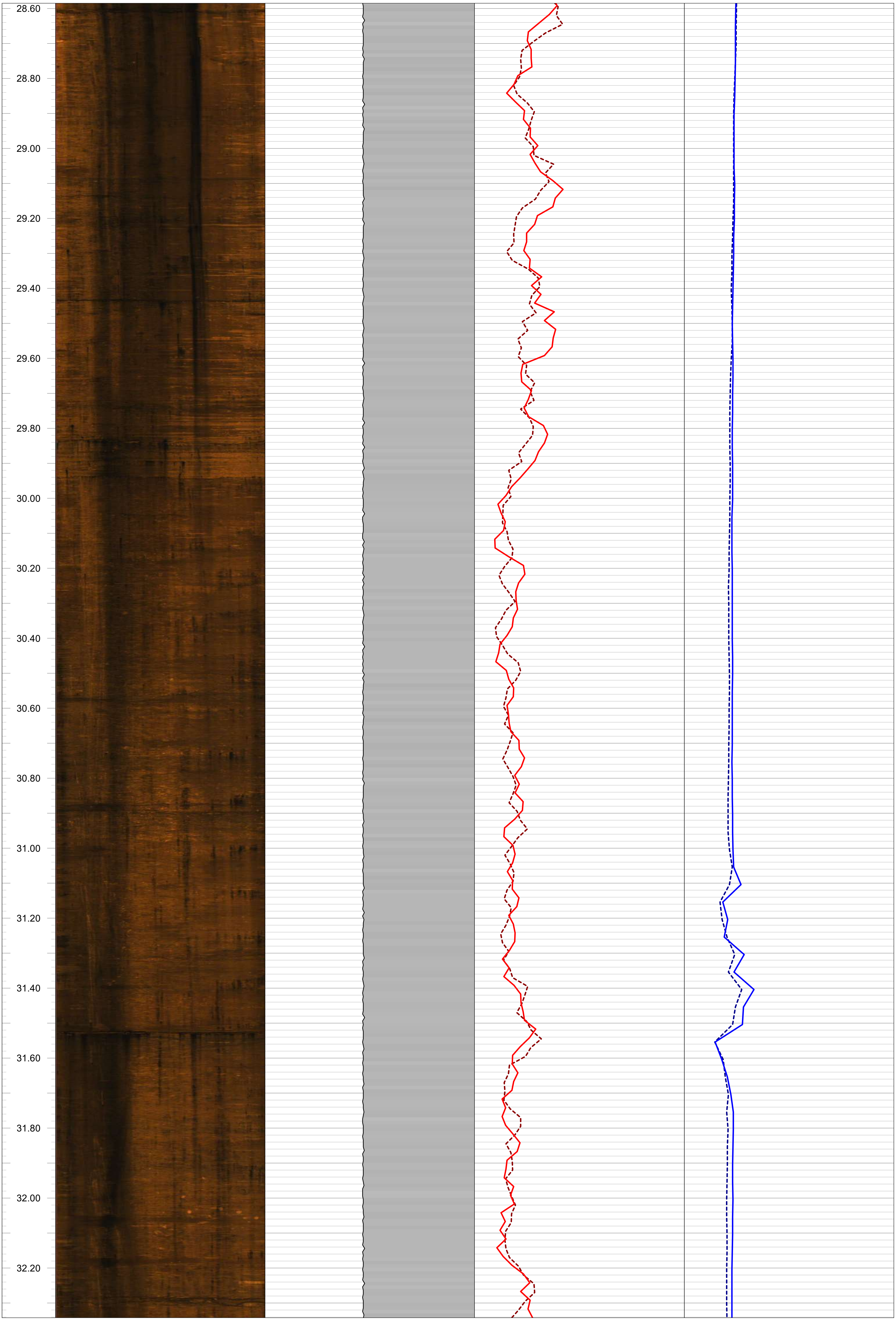
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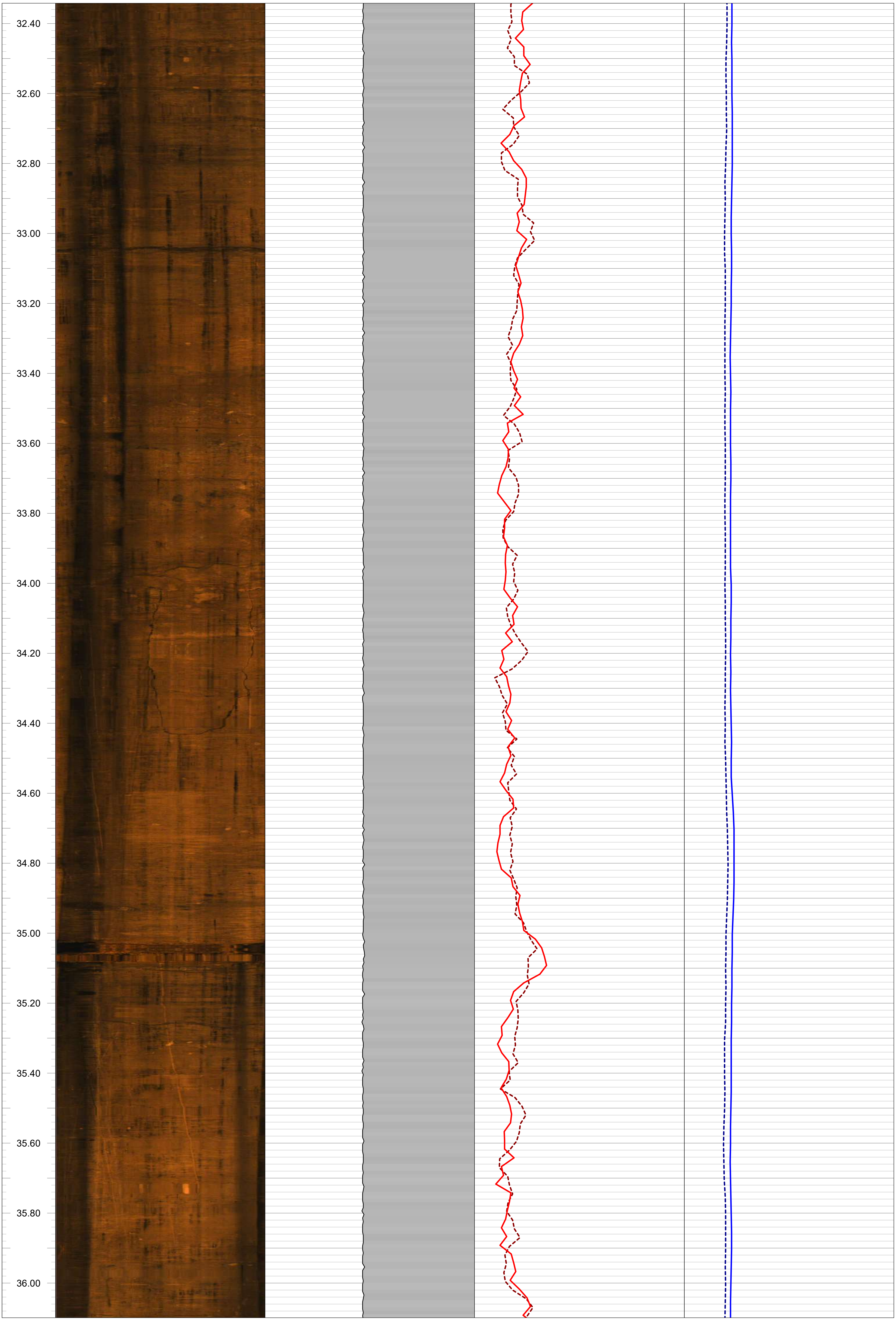
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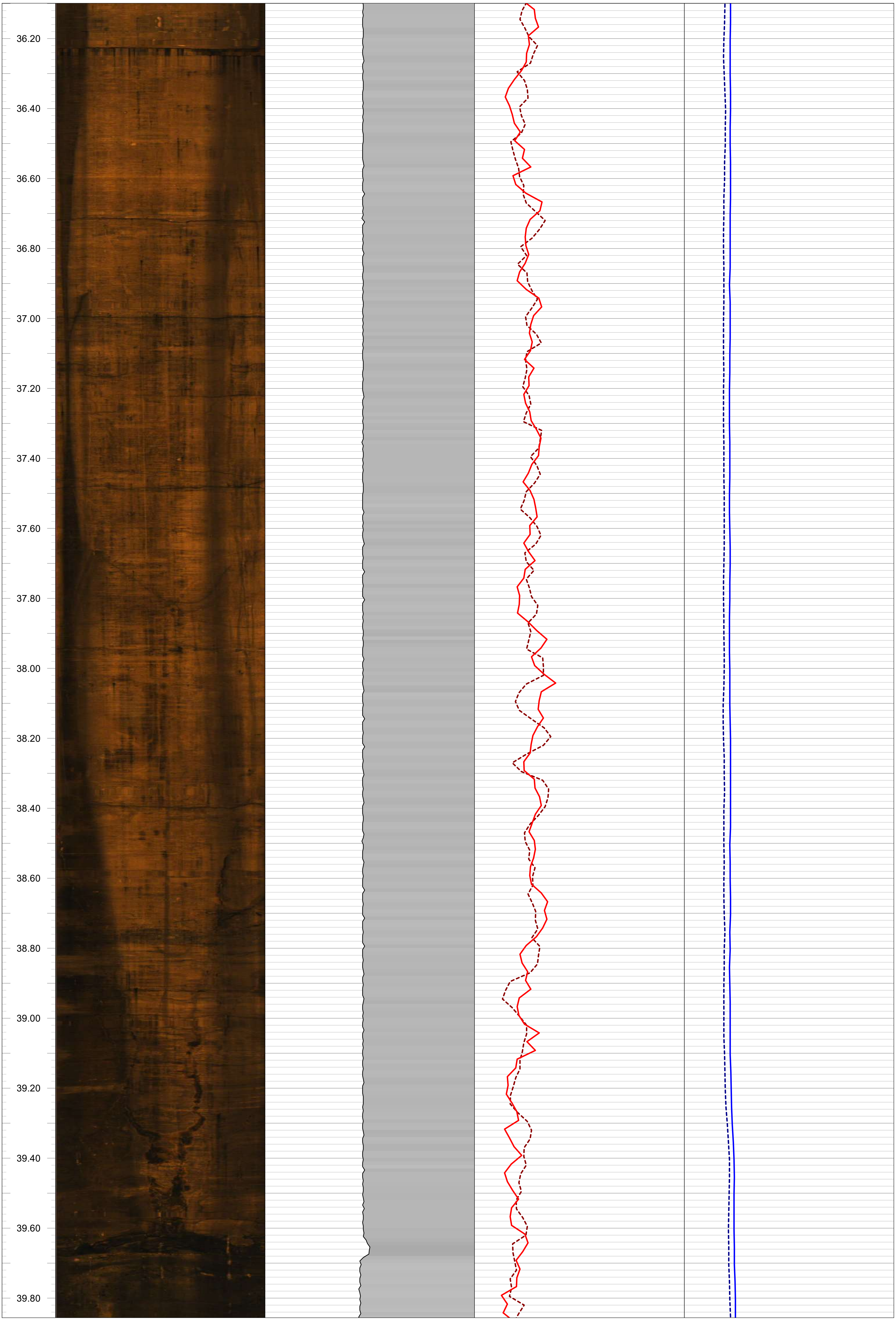
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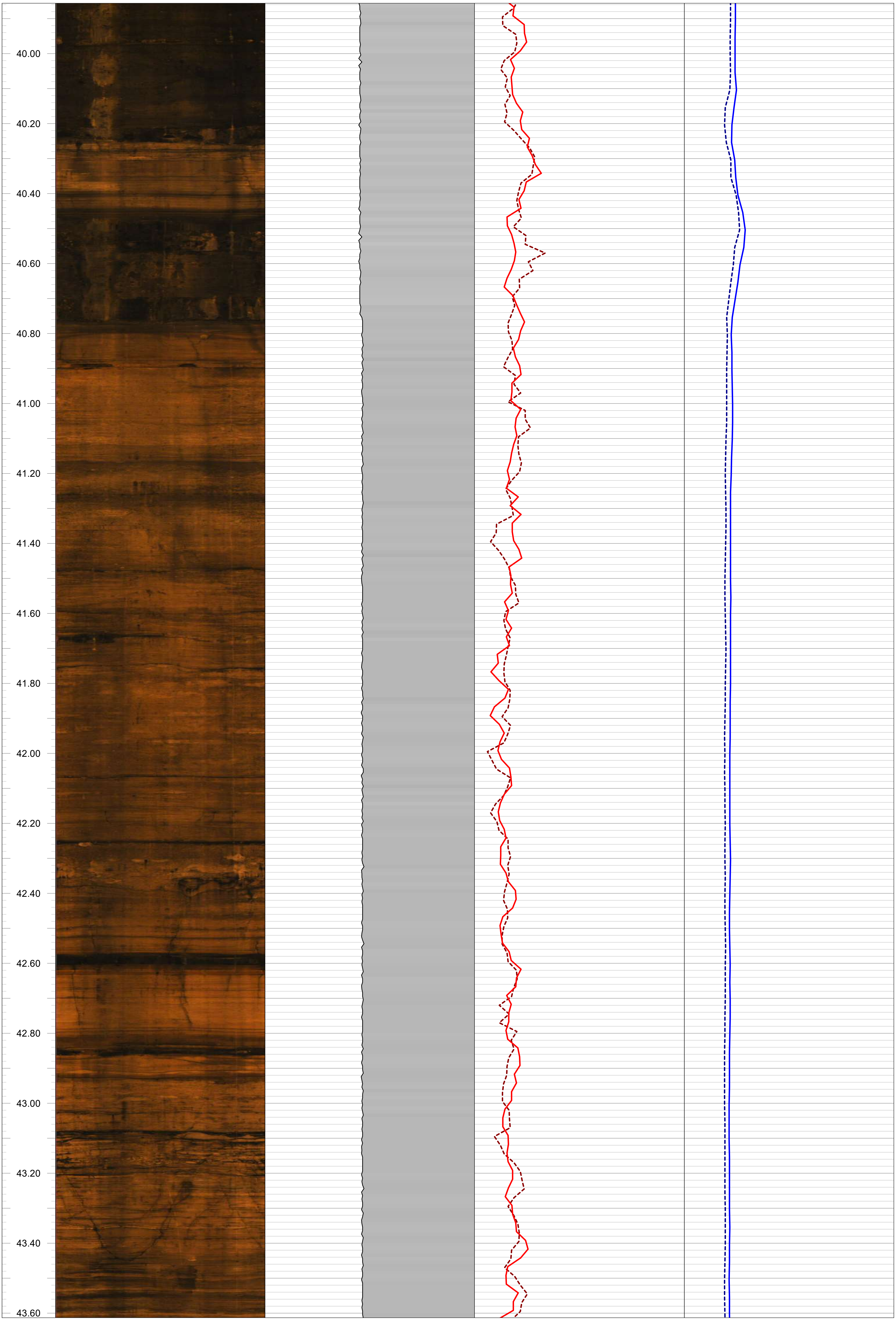
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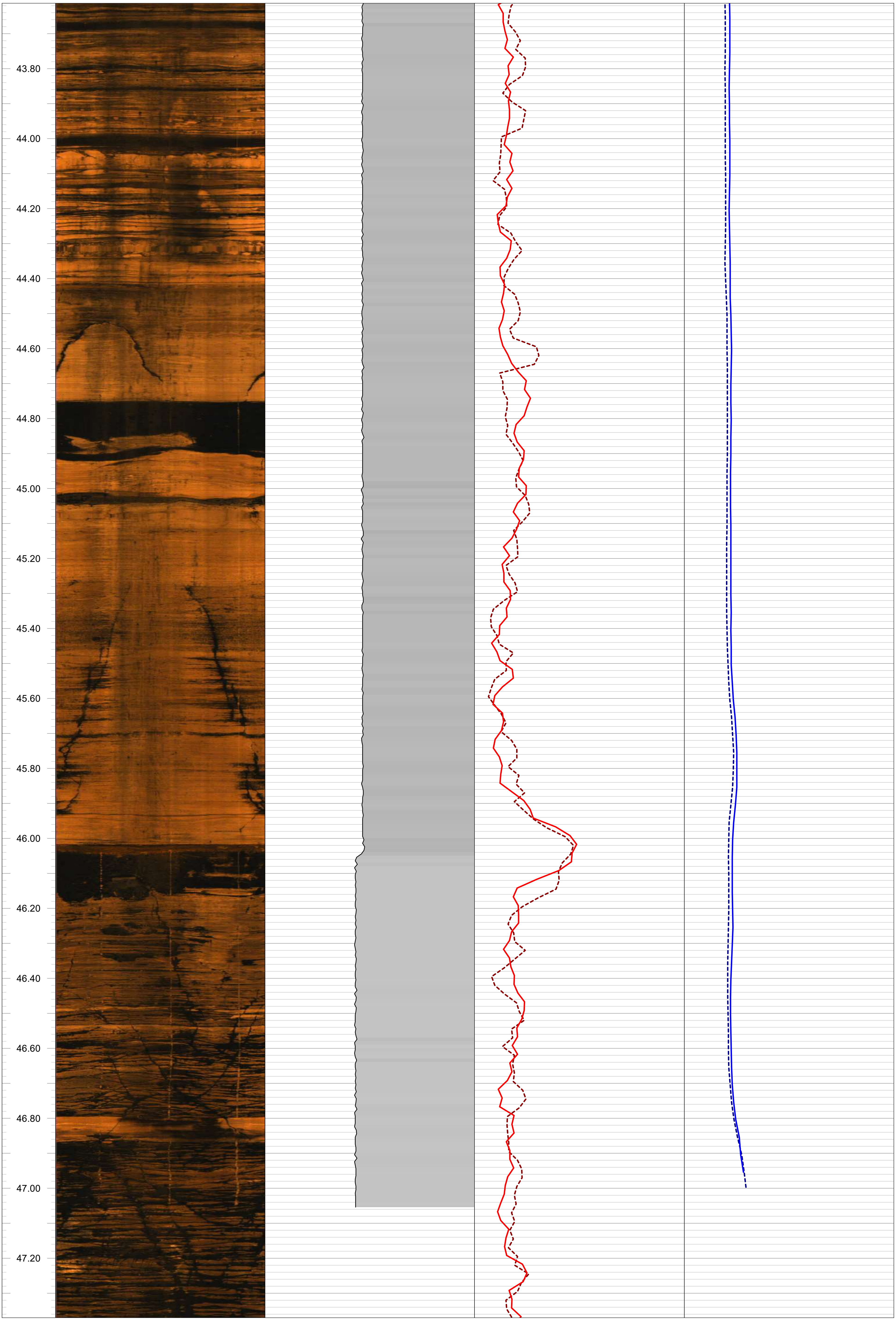
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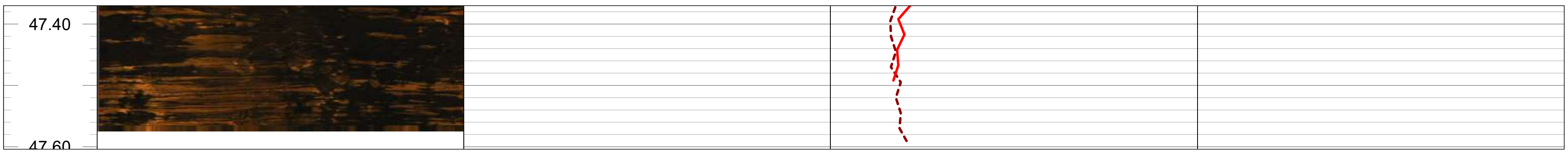
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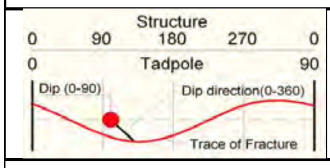
GEOPHYSICAL RECORD OF BOREHOLE: BH17-05

Project Number: 1781508
Client:
Date: January 2018

Datum:	**Elevation:**	**Borehole Diameter:**	**Water Level:**	**Location:** St. Mary's
Easting:	**Depth Reference:**	**Casing Diameter:**	**Borehole Inclination:**	**Log Date:** 17-Jan-2018
Northing:	**Drilled Depth:**	**Casing Depth:**	**Borehole Azimuth:**	**Logged By:** PG



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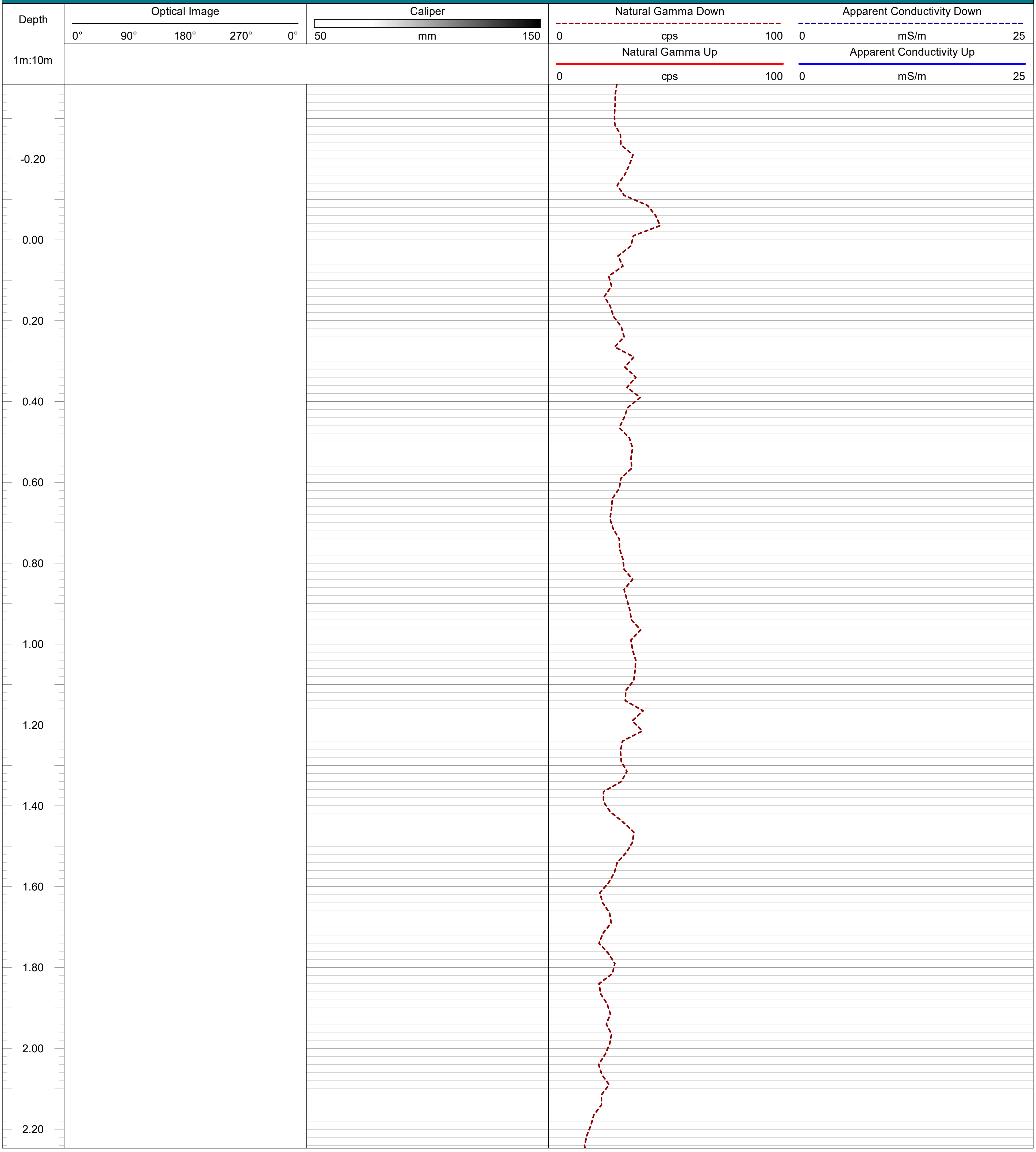

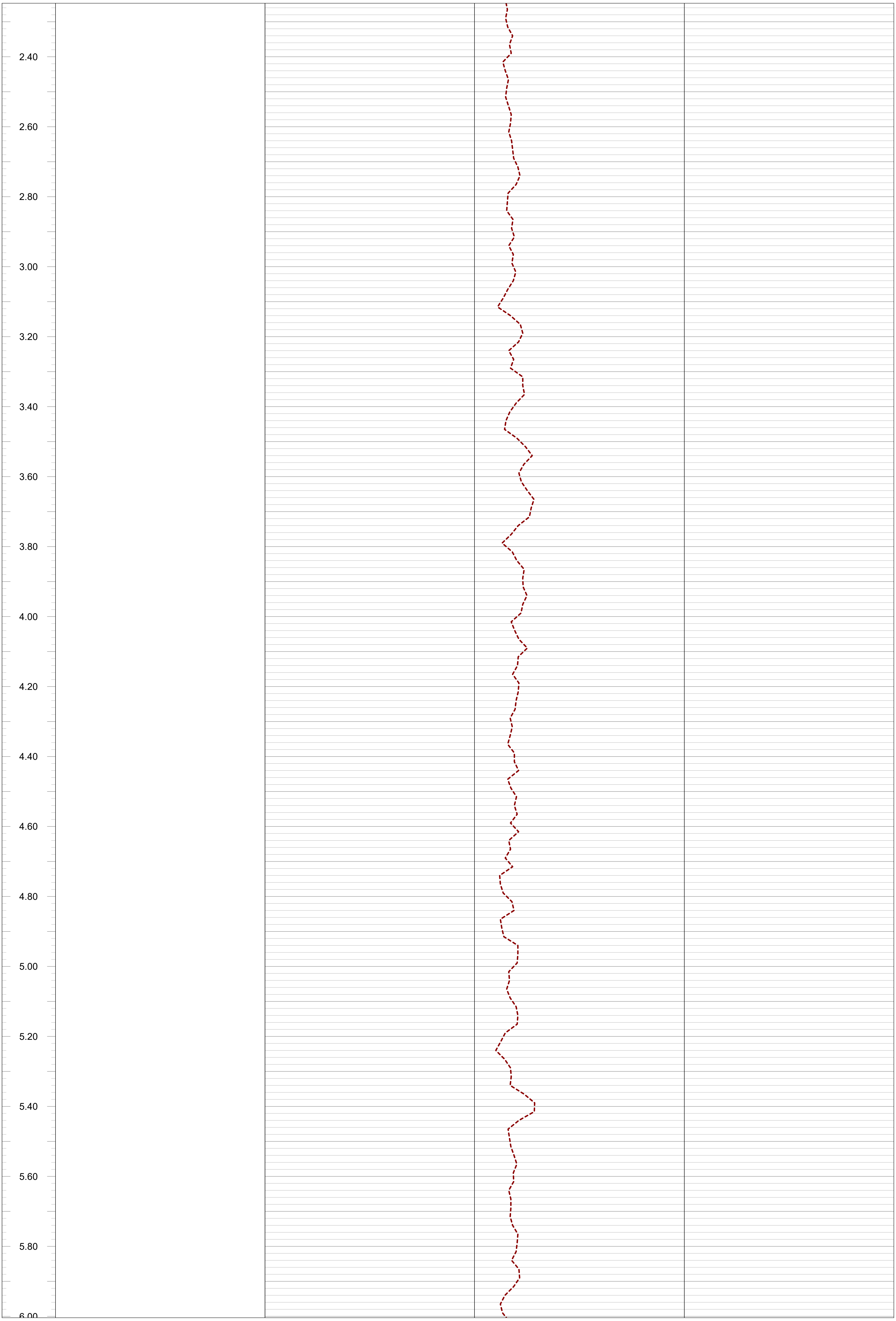
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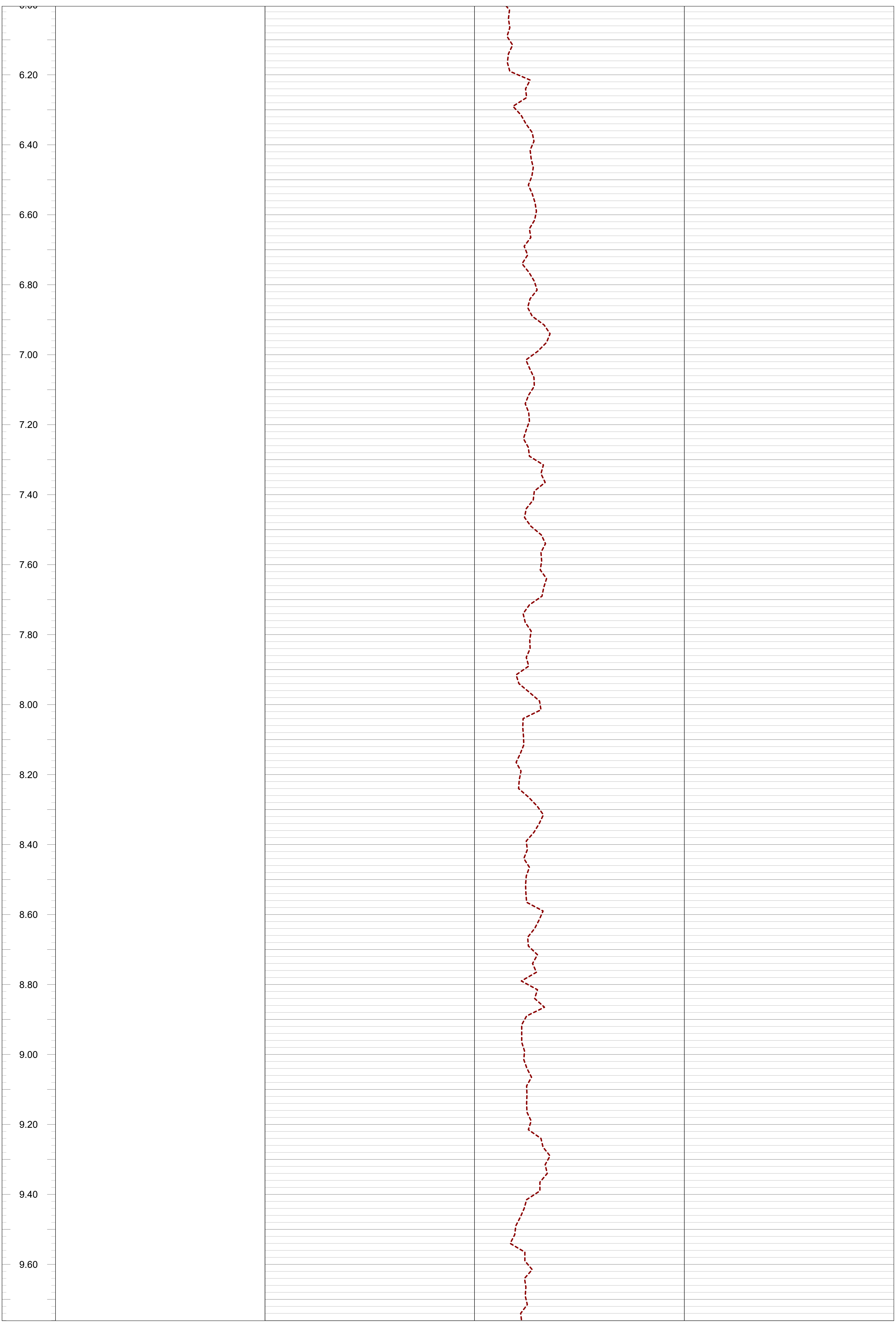
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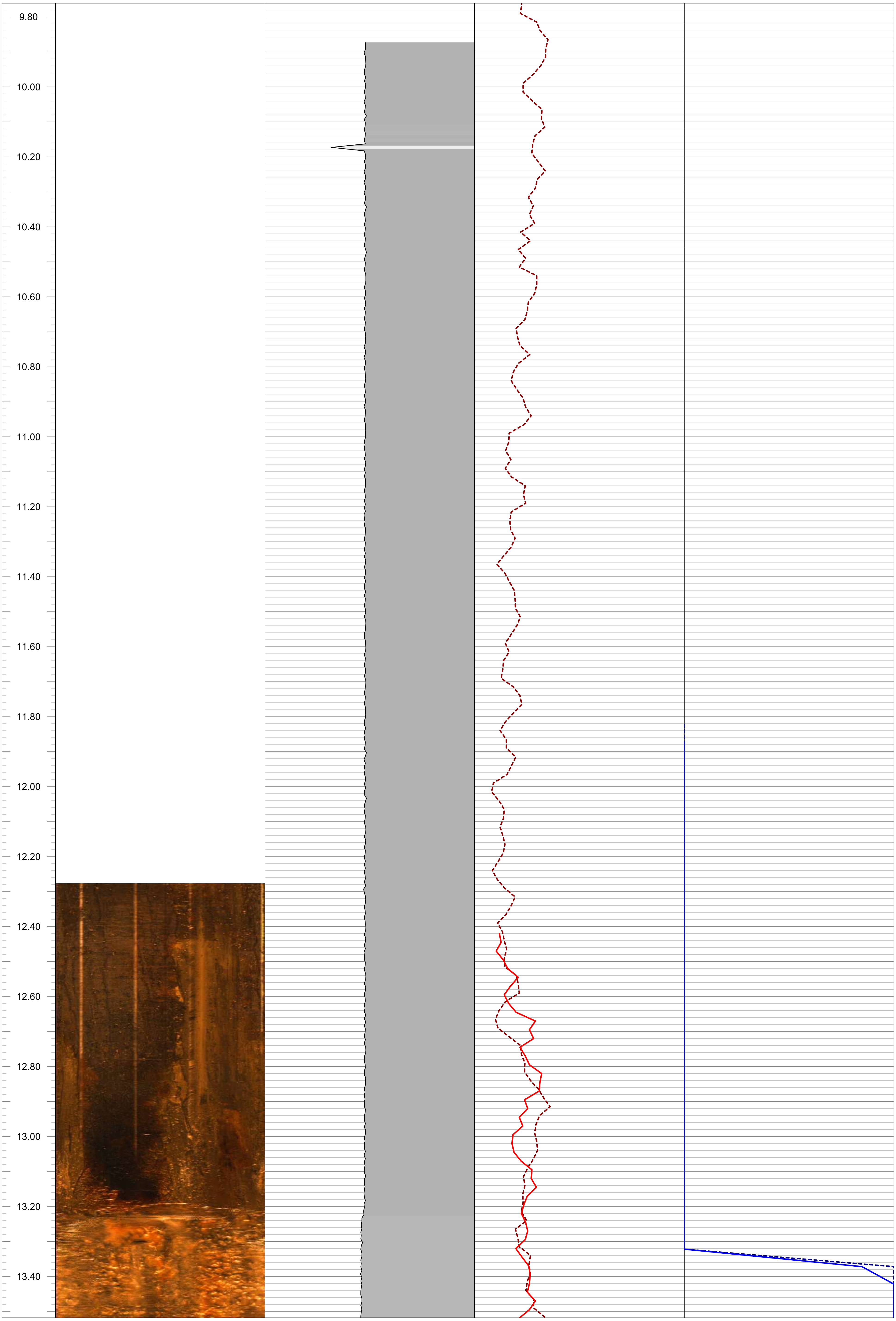
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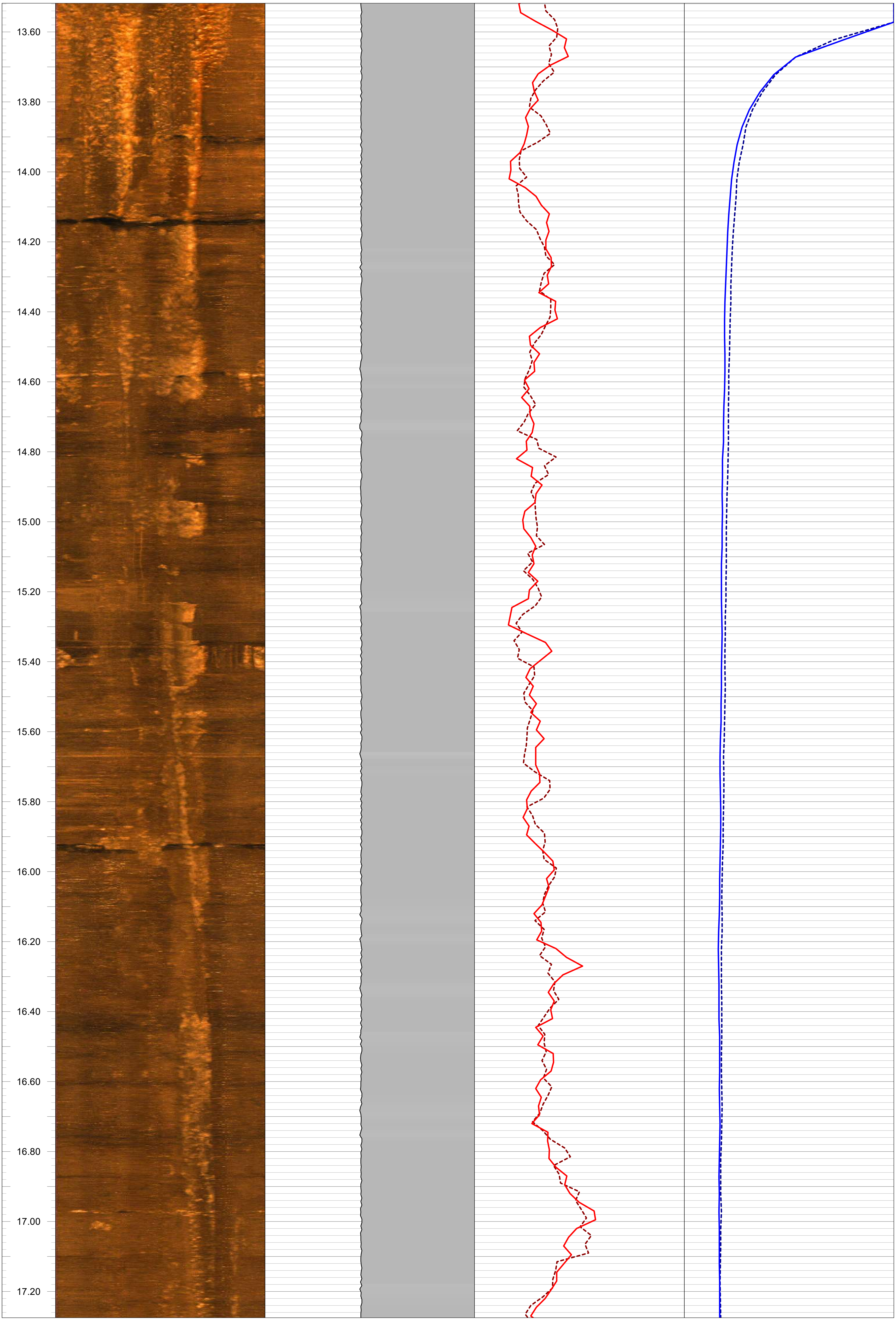
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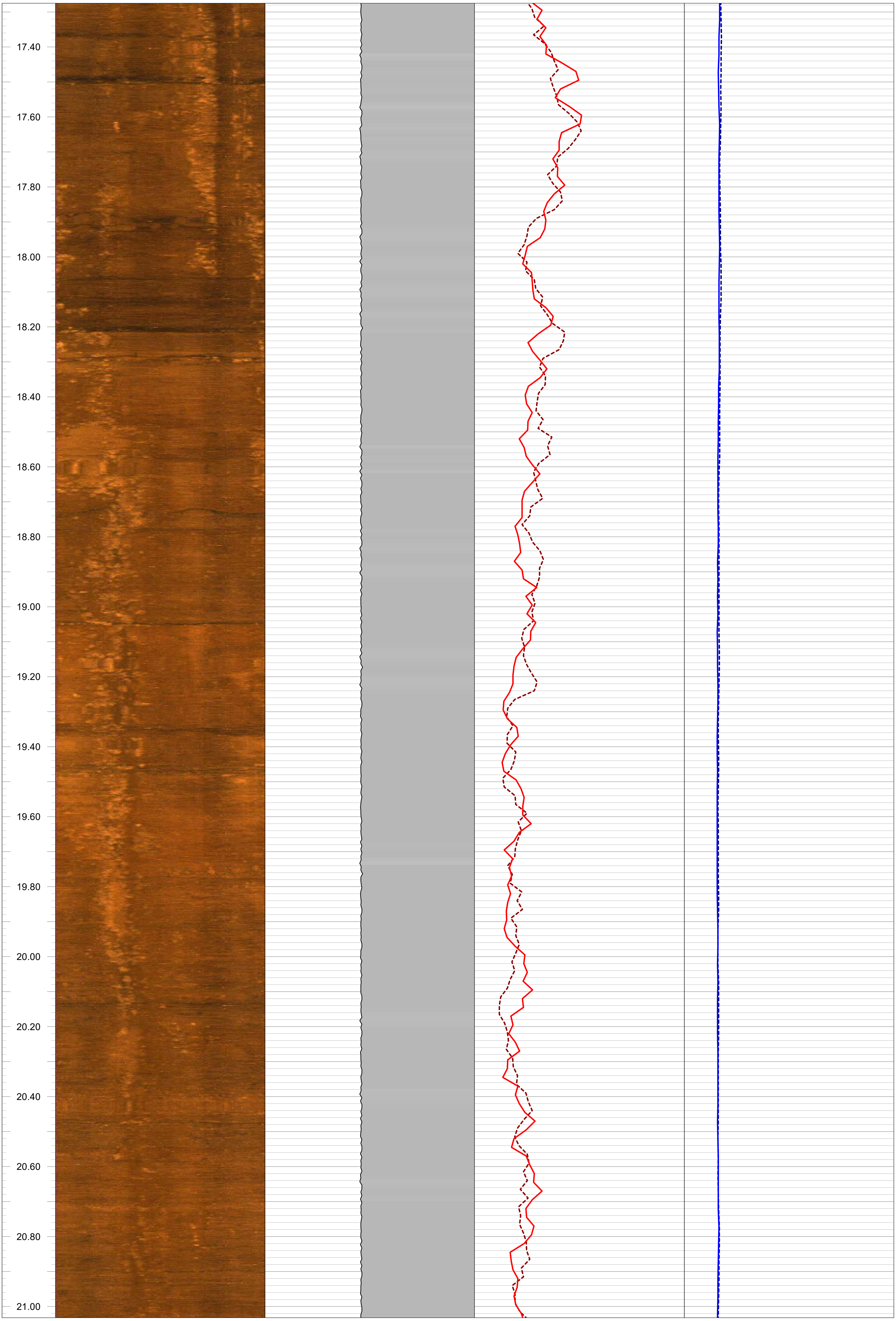
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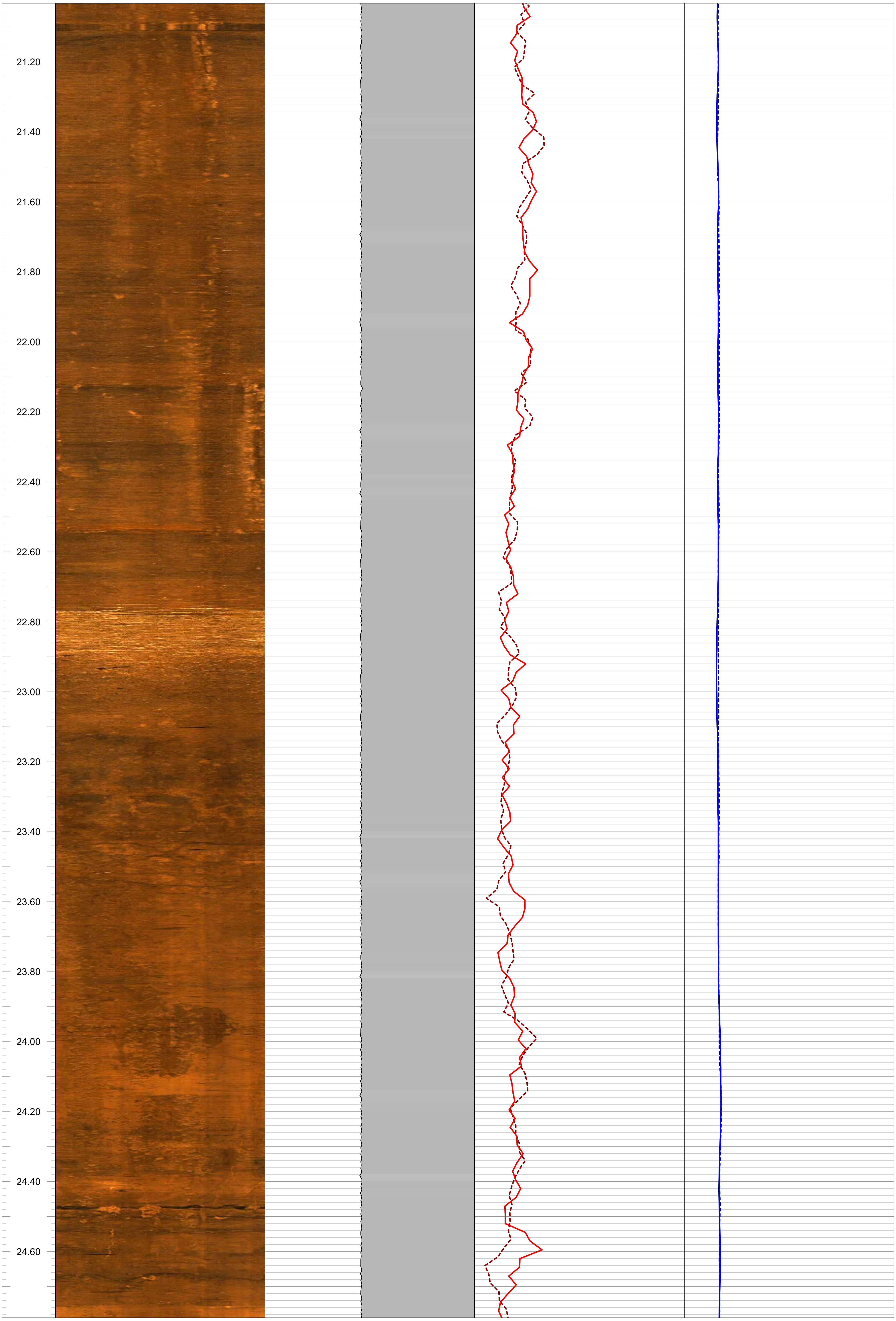
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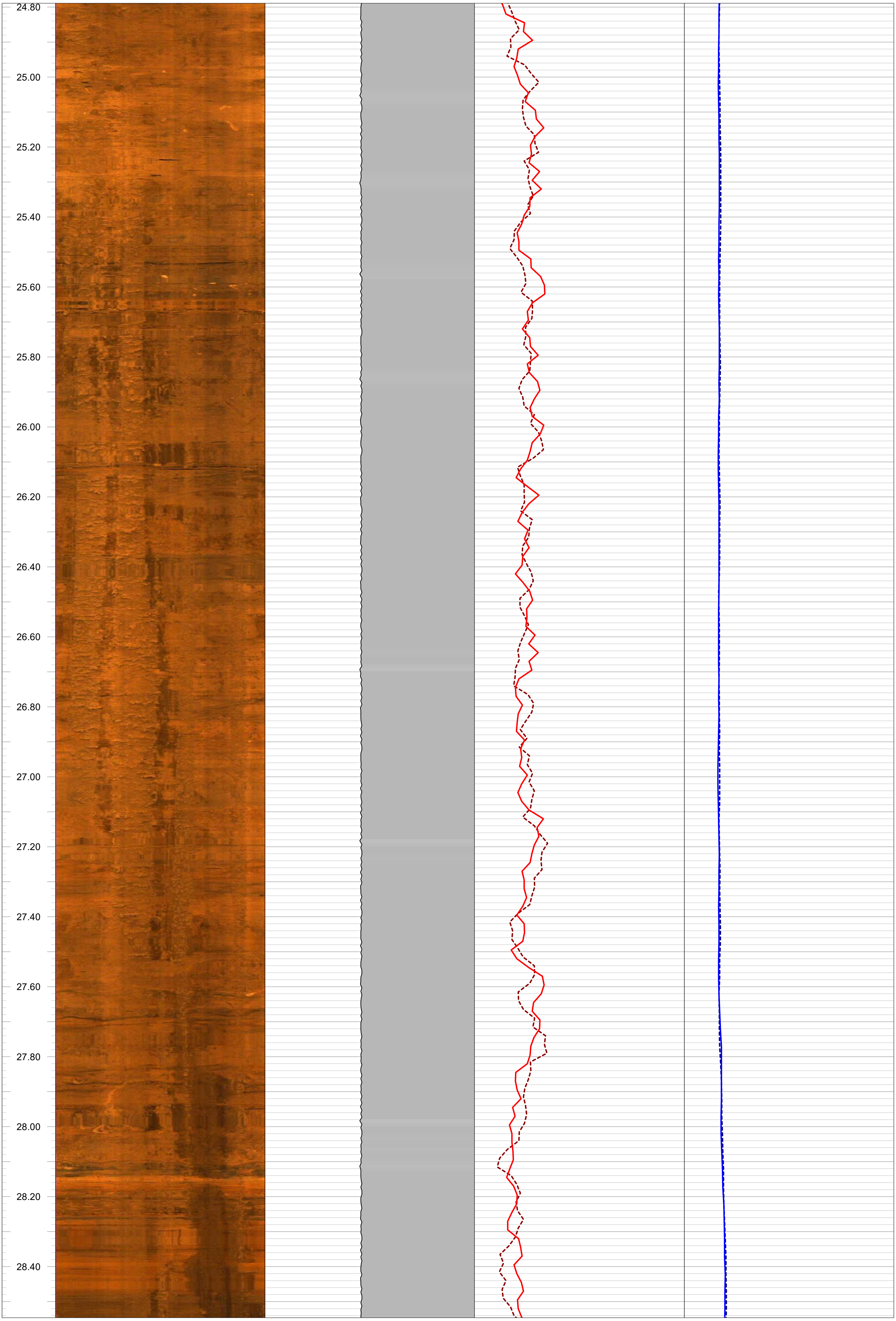
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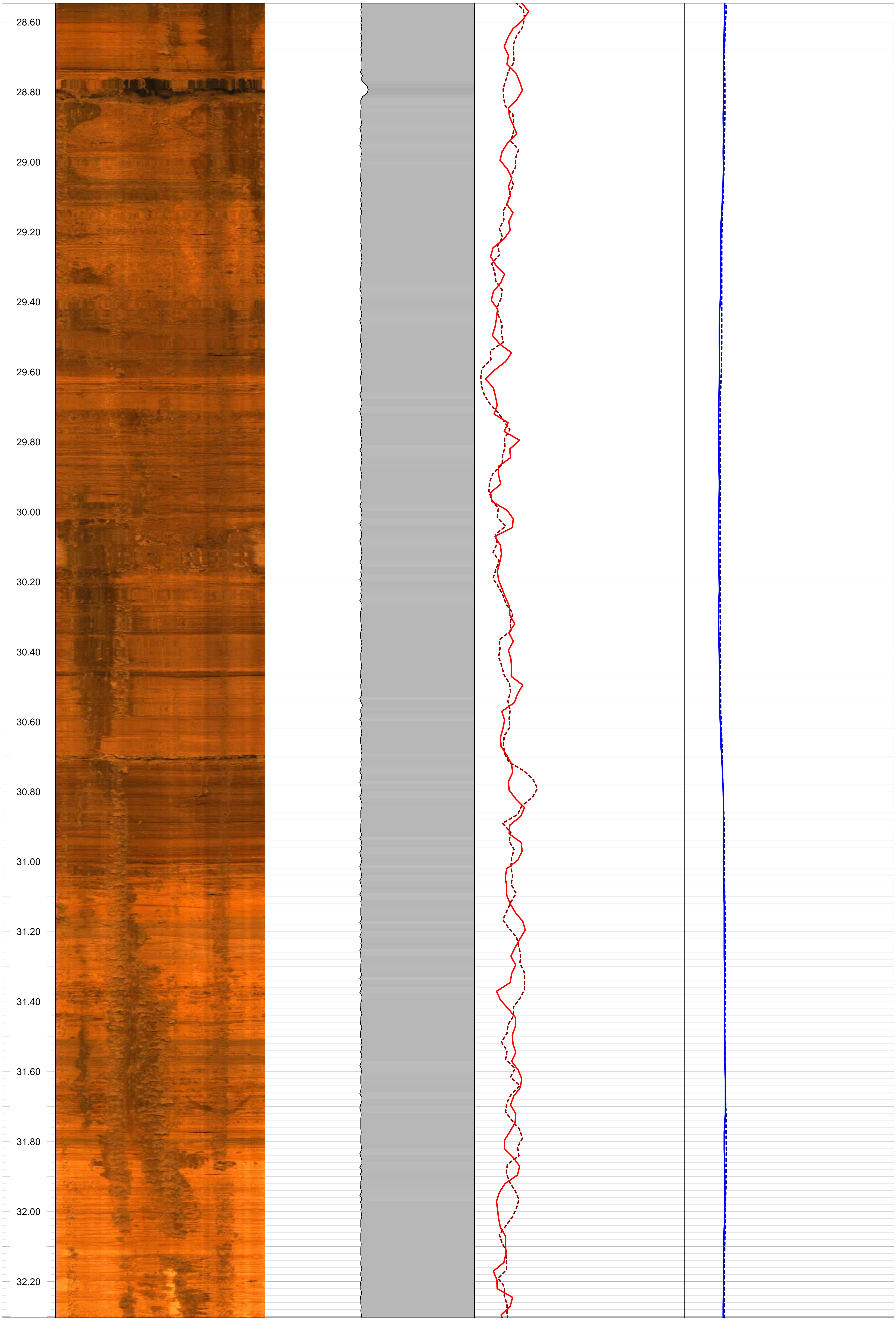
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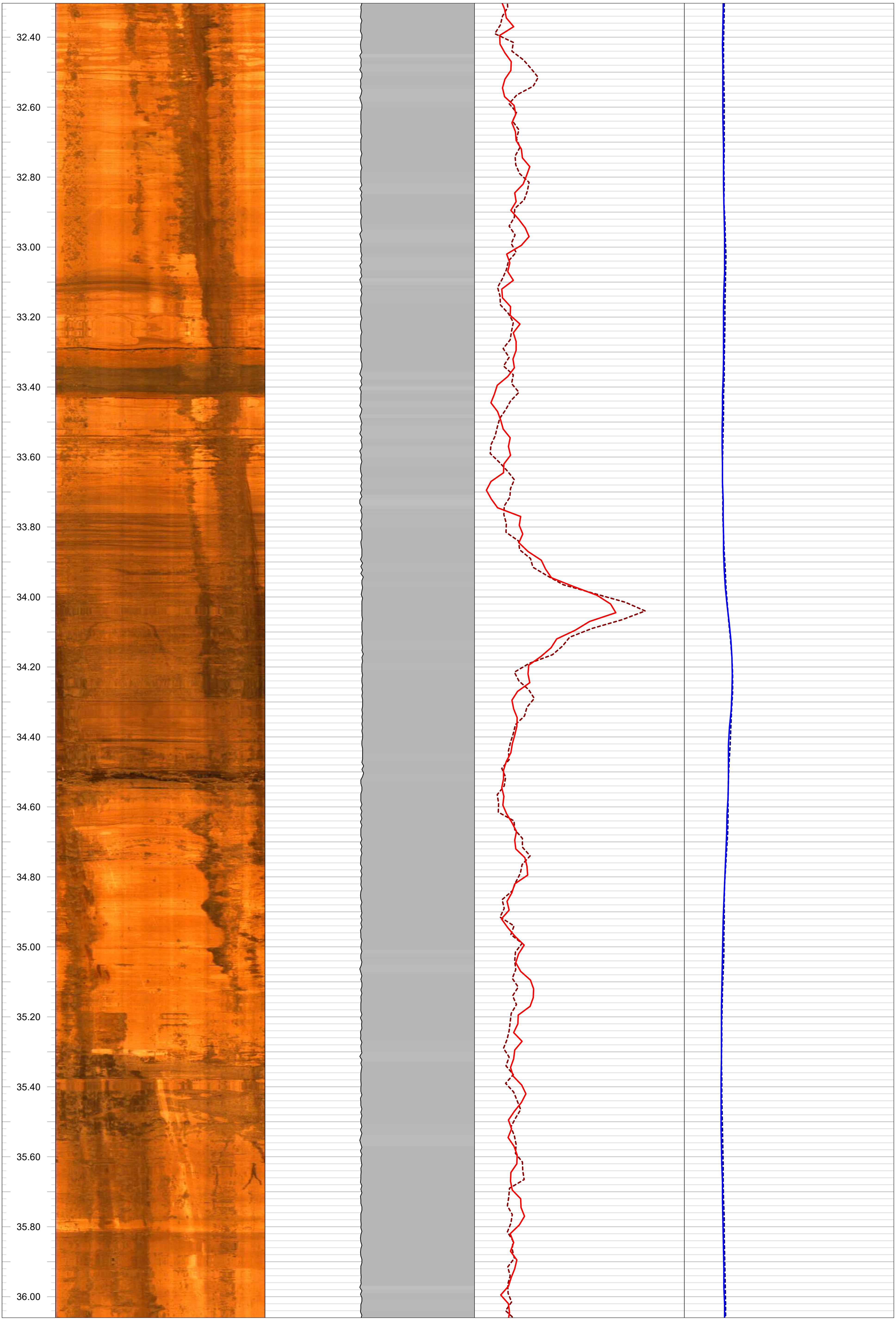
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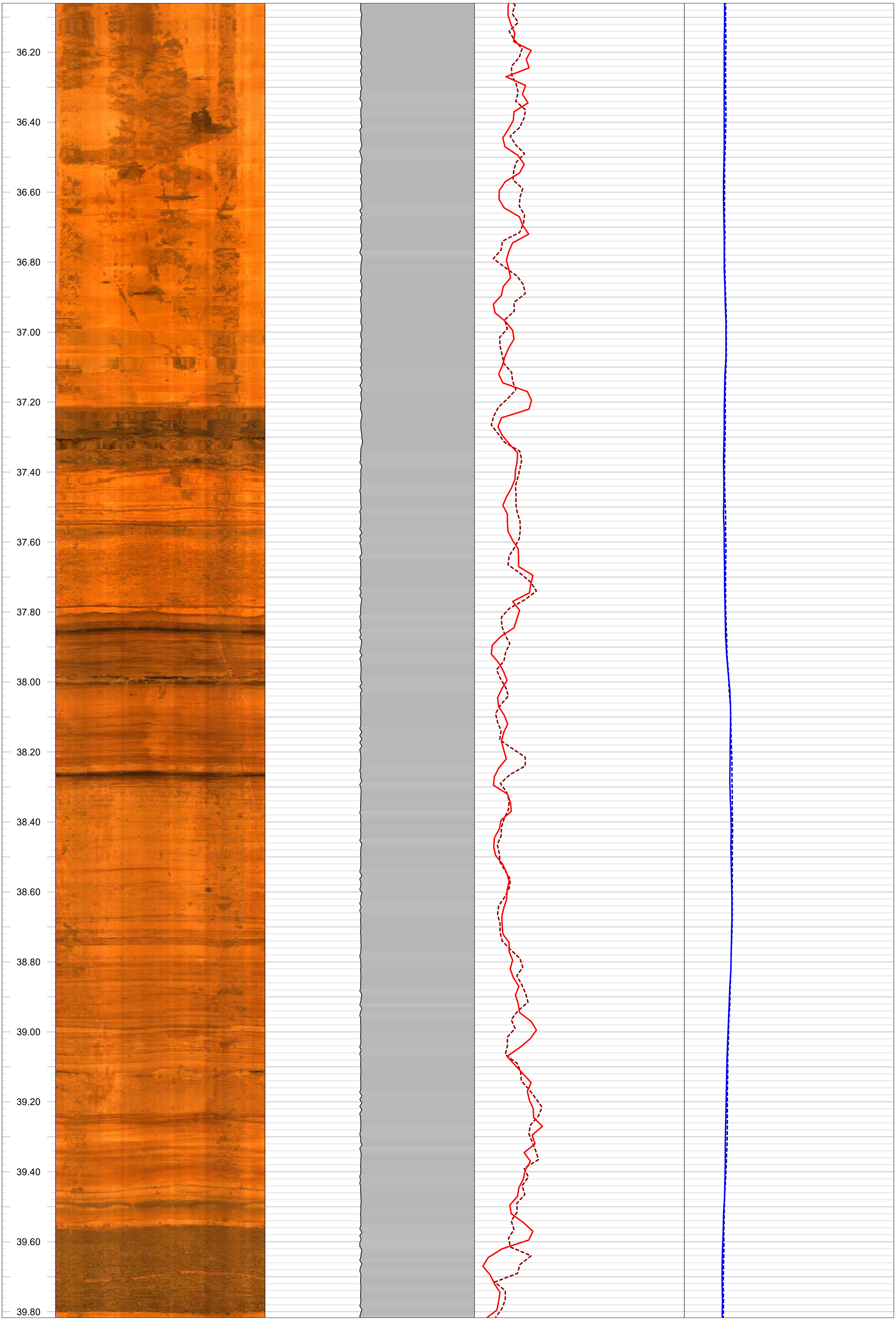
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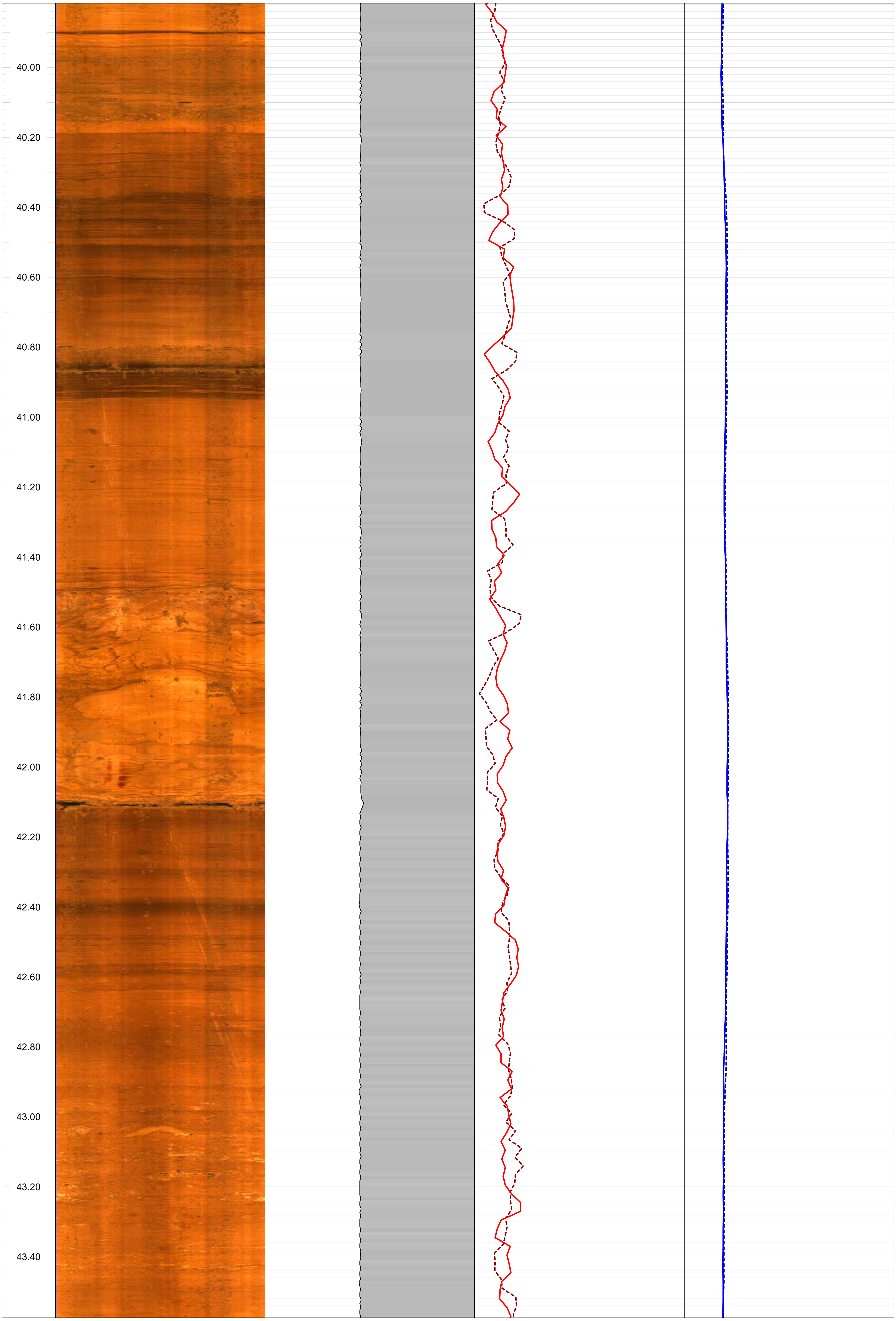
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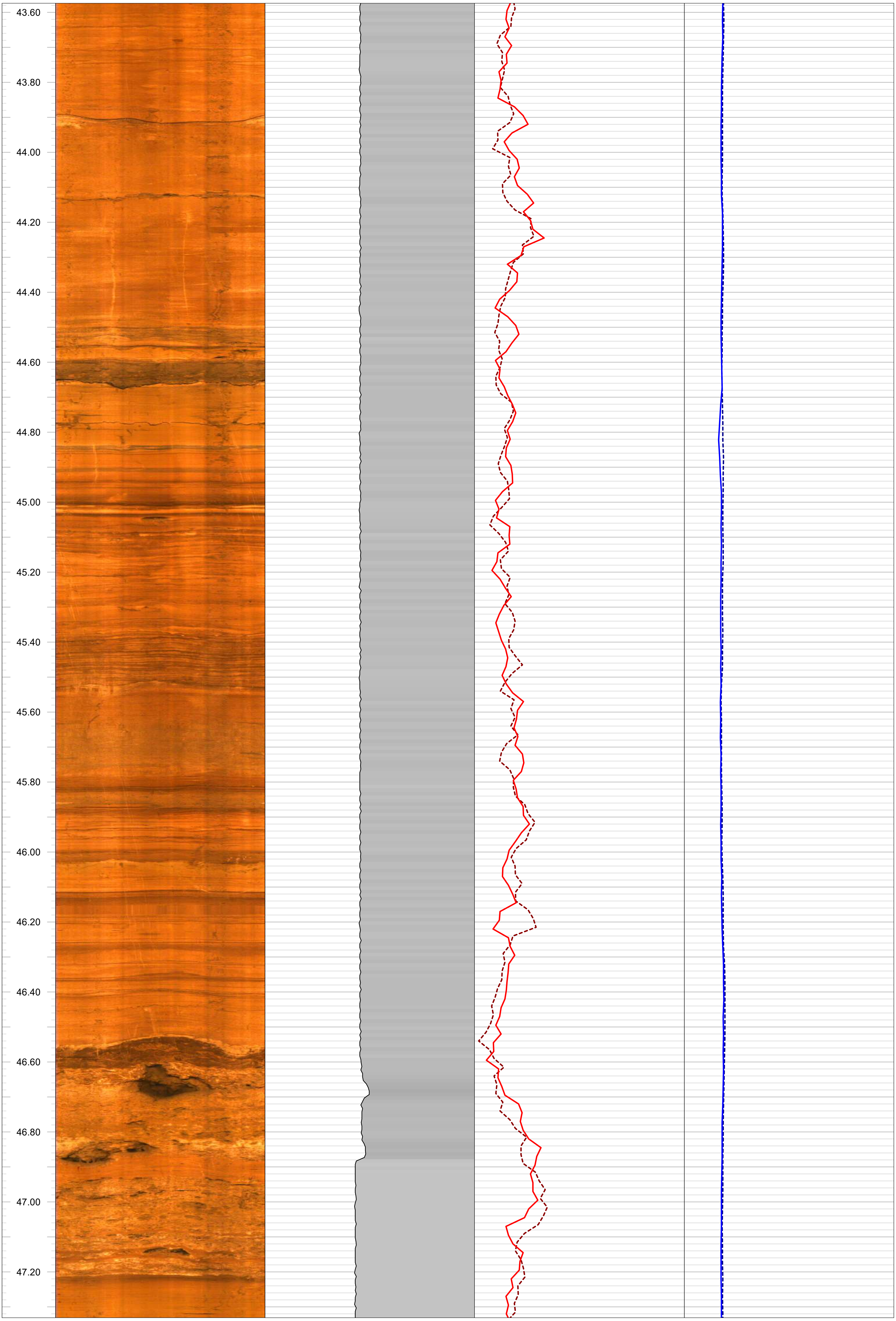
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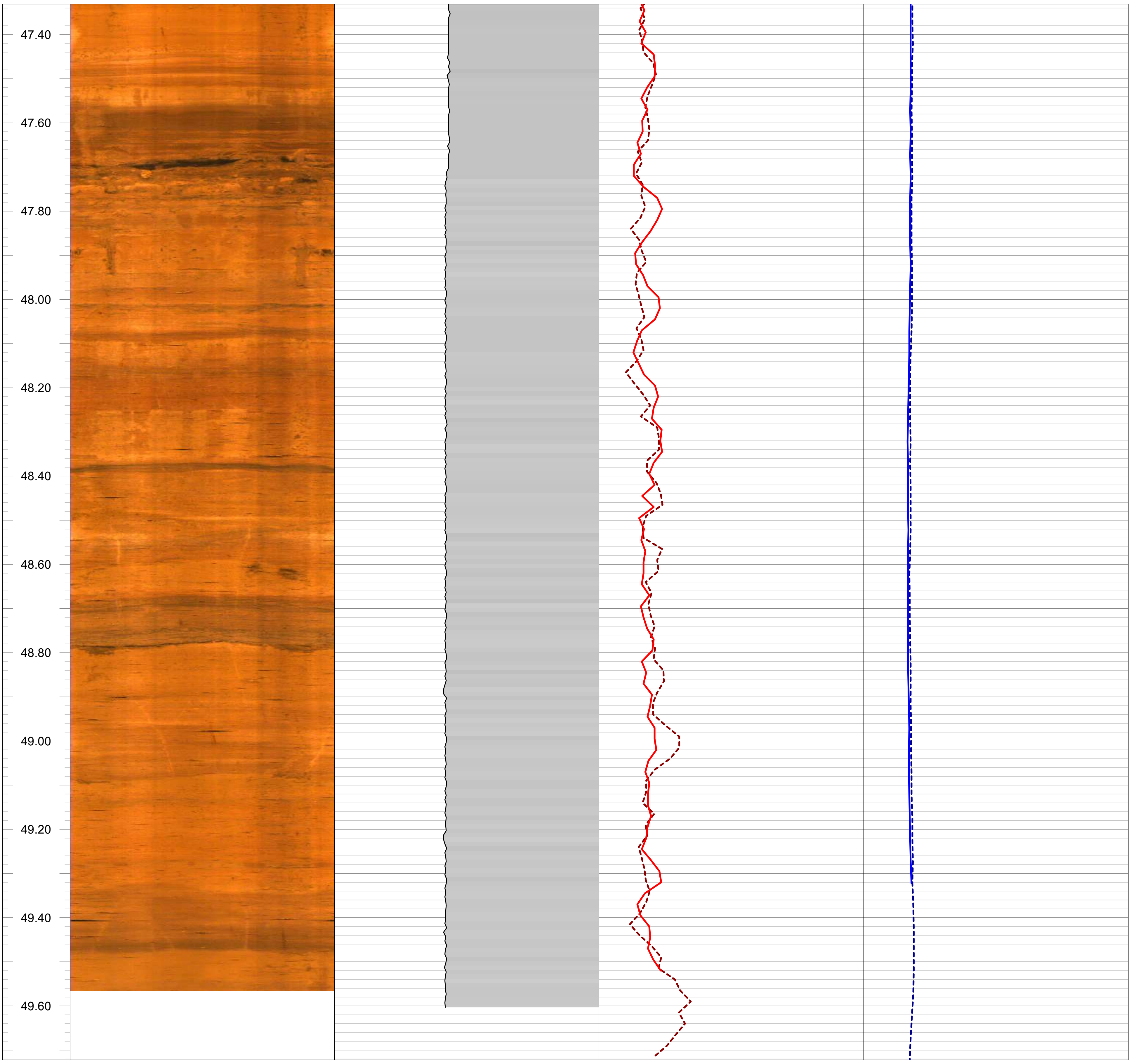
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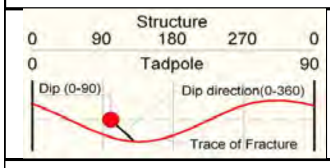
GEOPHYSICAL RECORD OF BOREHOLE: MW17-01
Project Number: 1781508
Client:
Date: January 2018

Datum:		**Elevation:**		**Borehole Diameter:**		**Water Level:**		**Location:**	St. Mary's
Easting:		**Depth Reference:**		**Casing Diameter:**		**Borehole Inclination:**		**Log Date:**	16-Jan-2018
Northing:		**Drilled Depth:**		**Casing Depth:**		**Borehole Azimuth:**		**Logged By:**	PG



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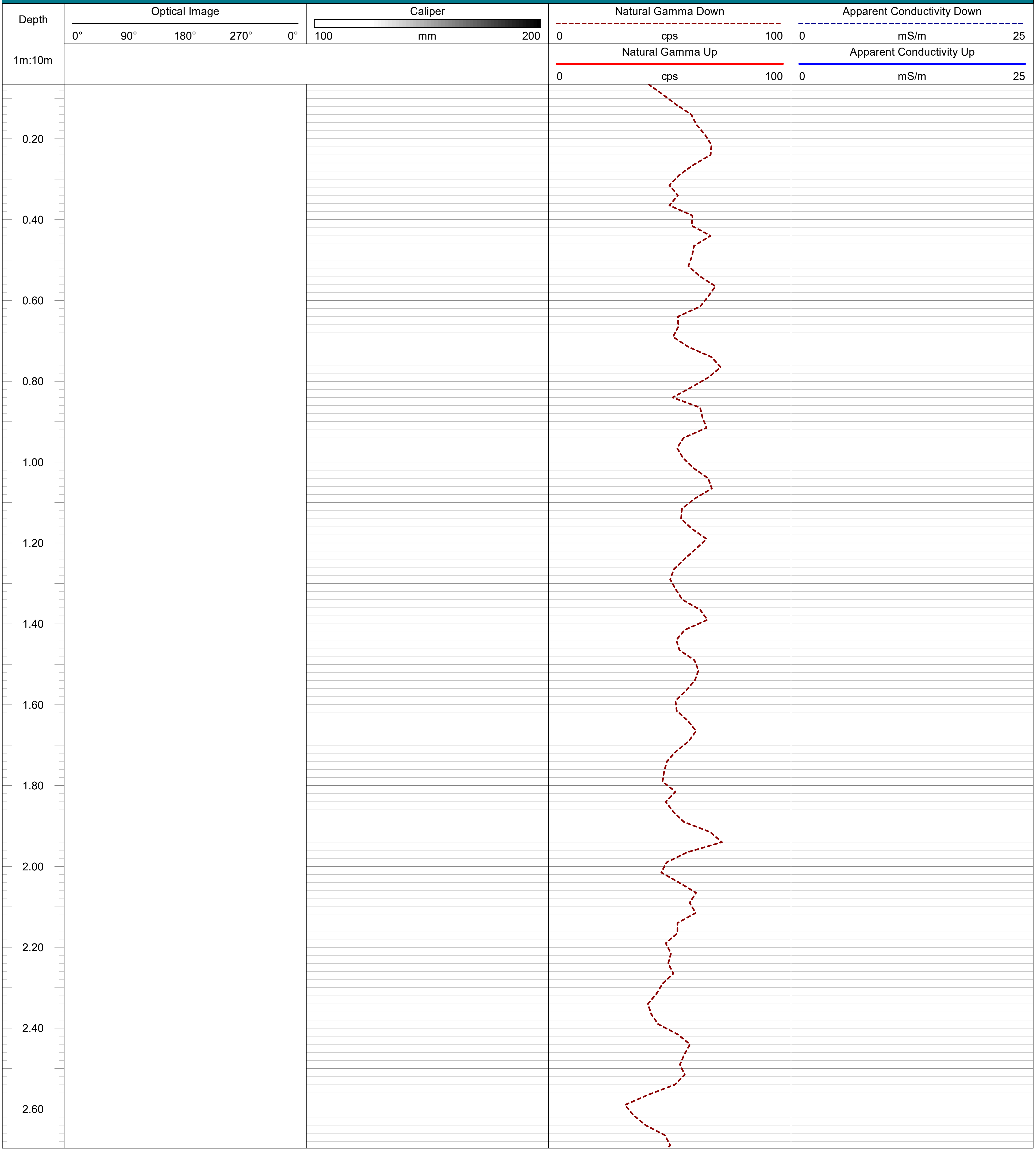

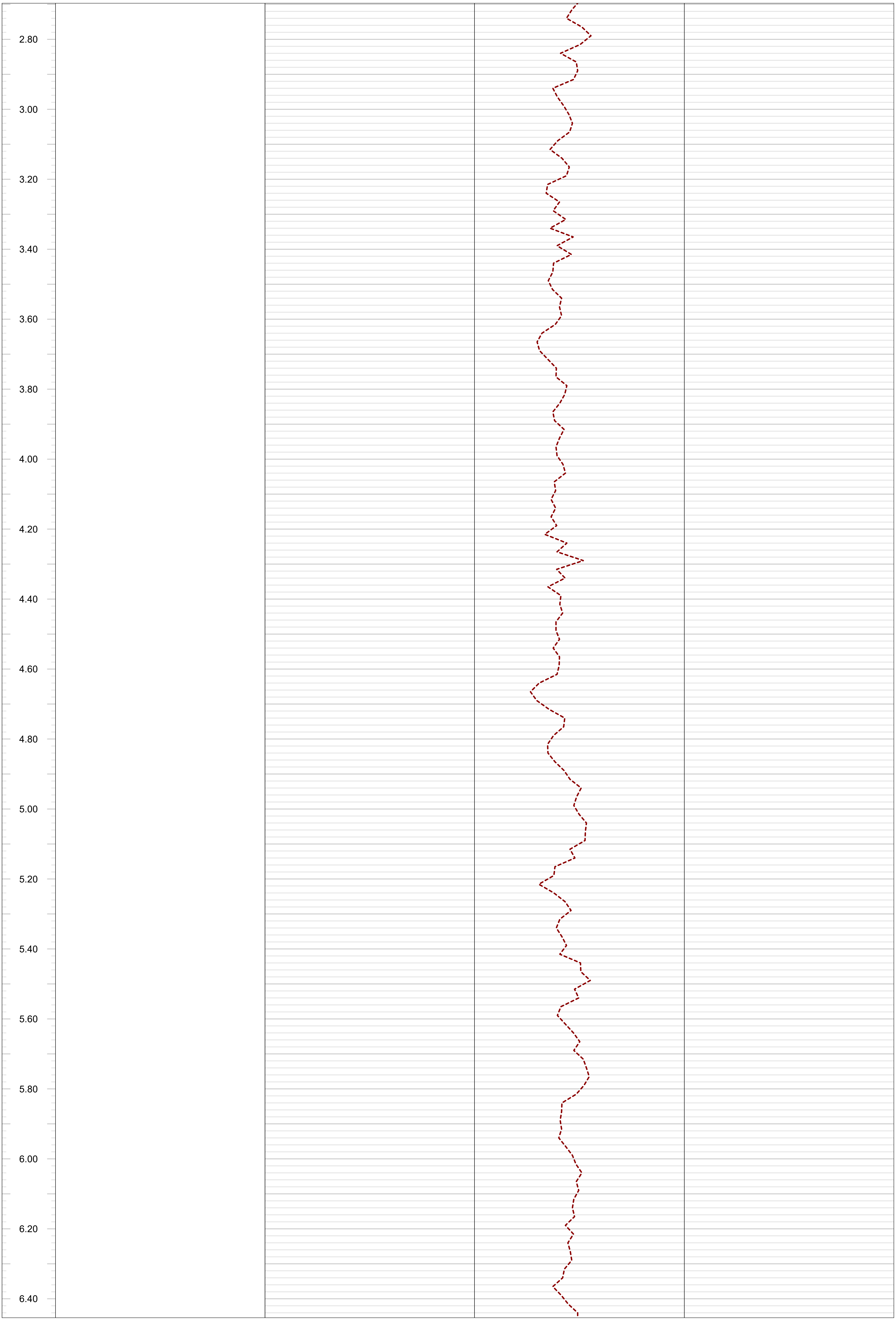
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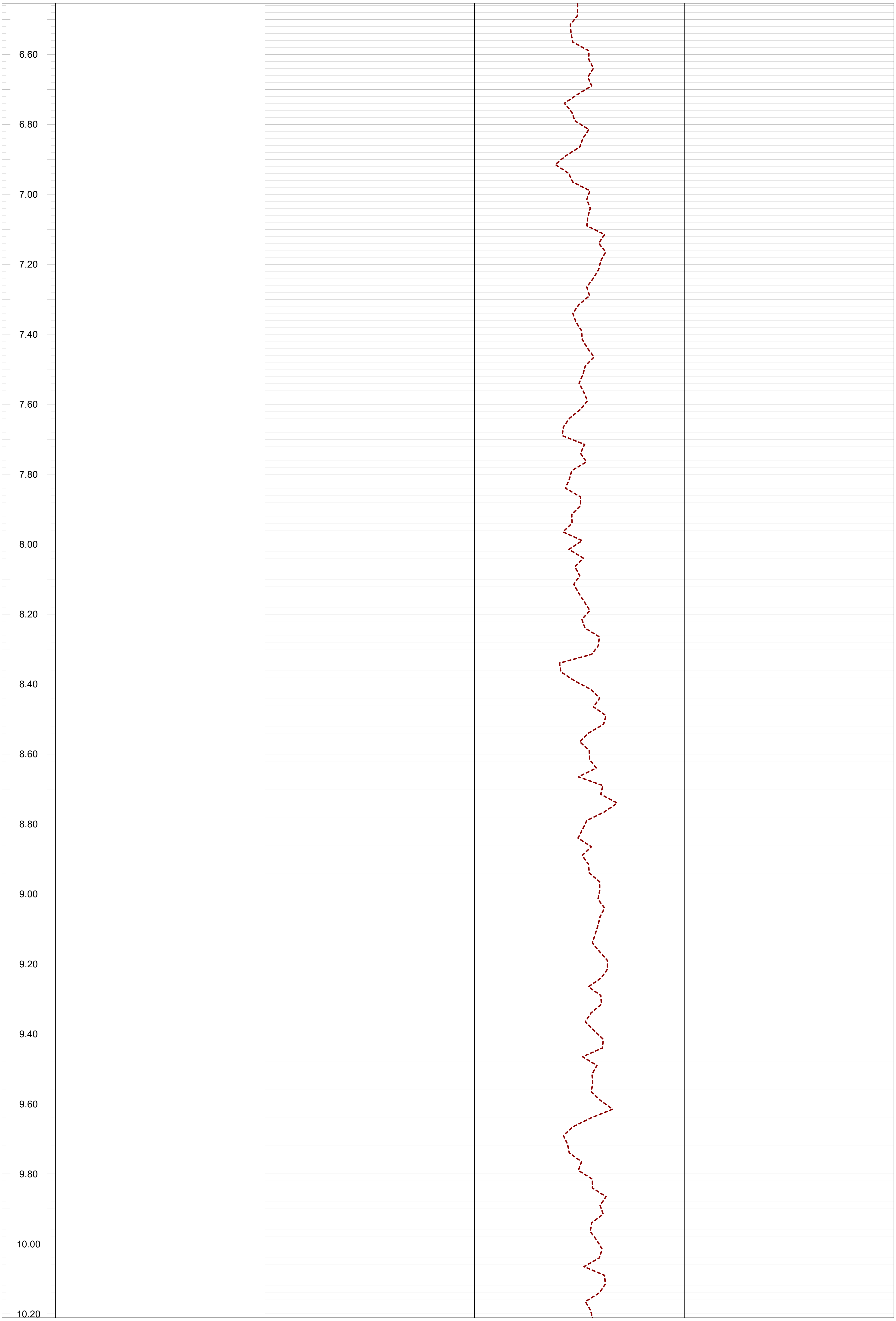
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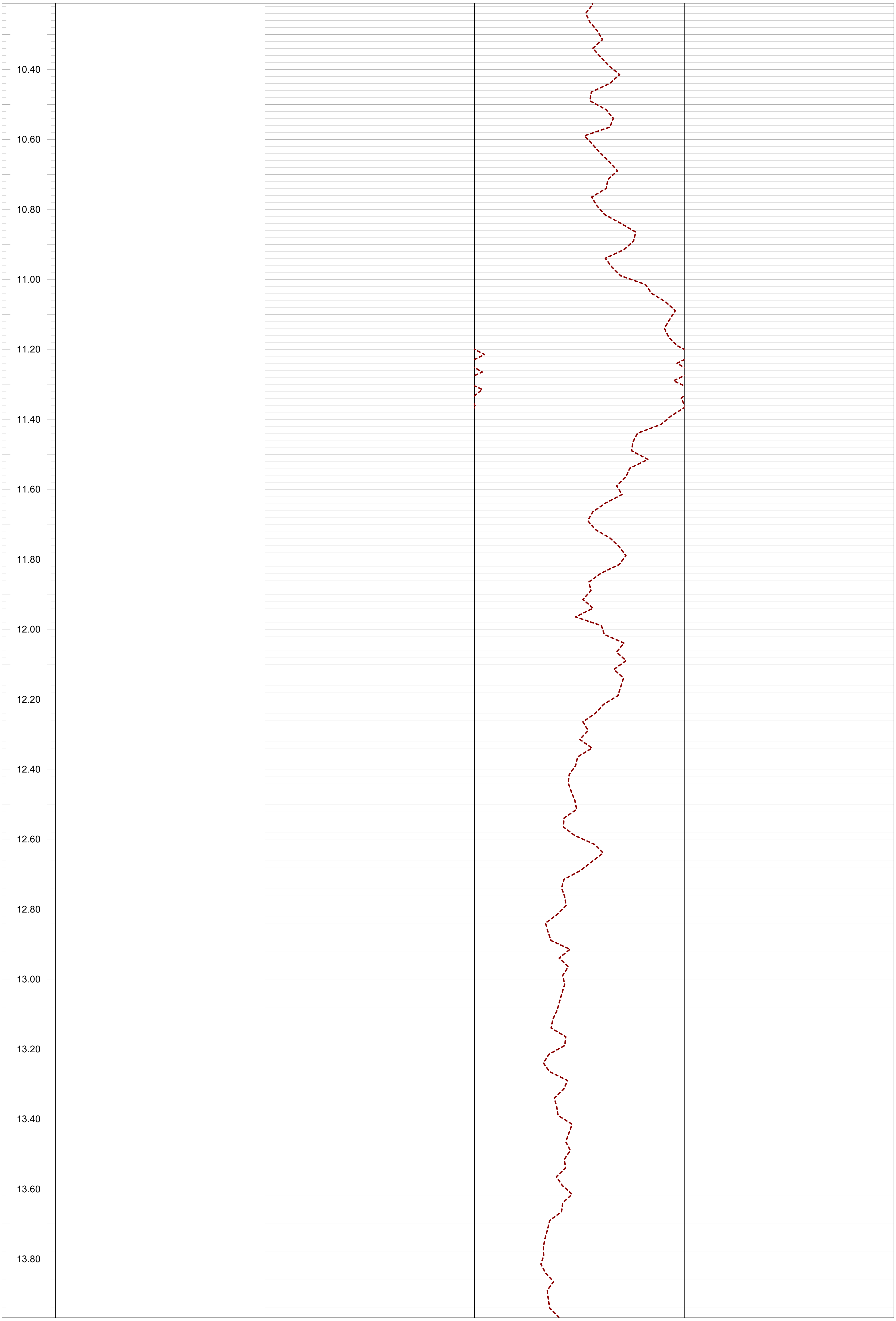
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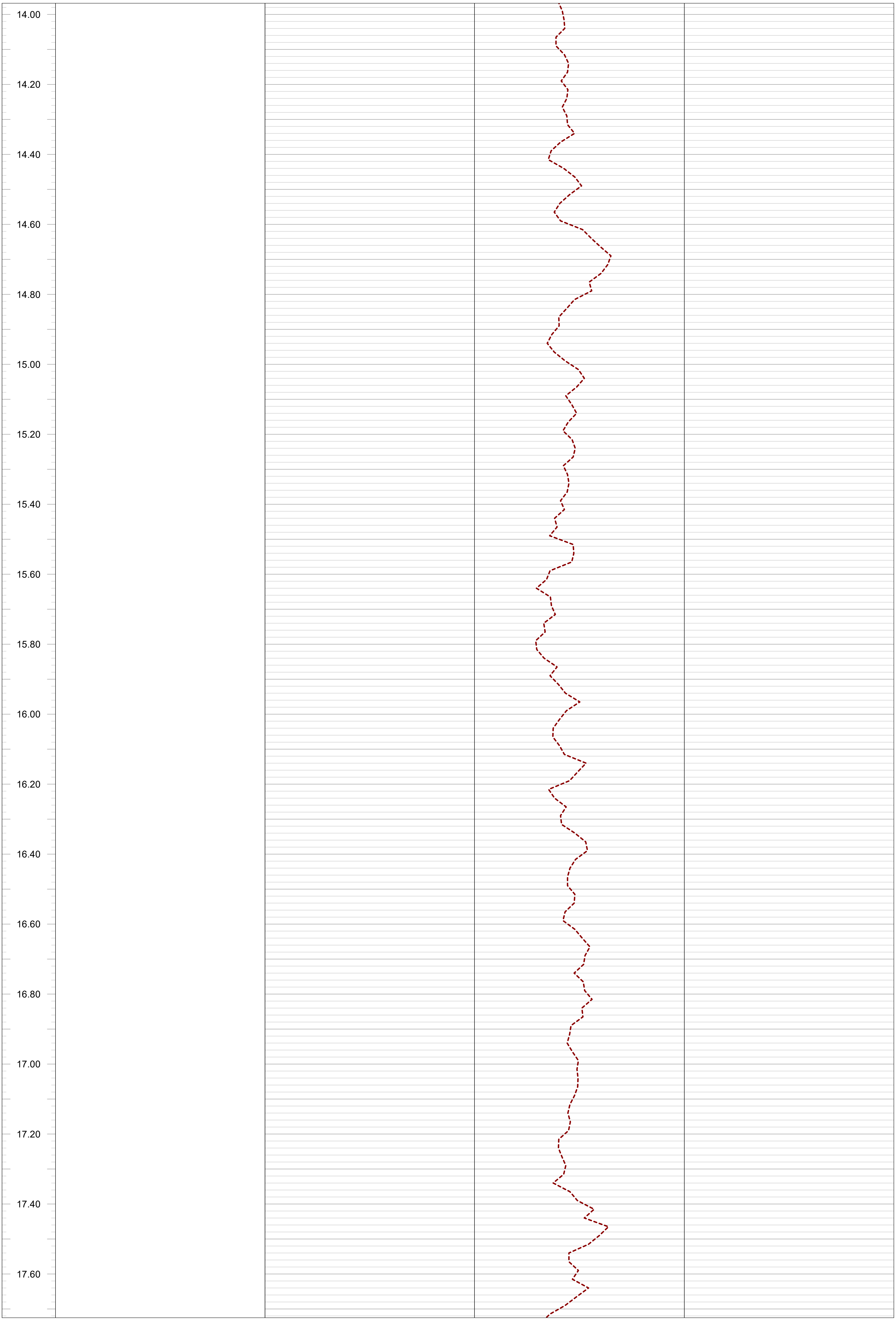
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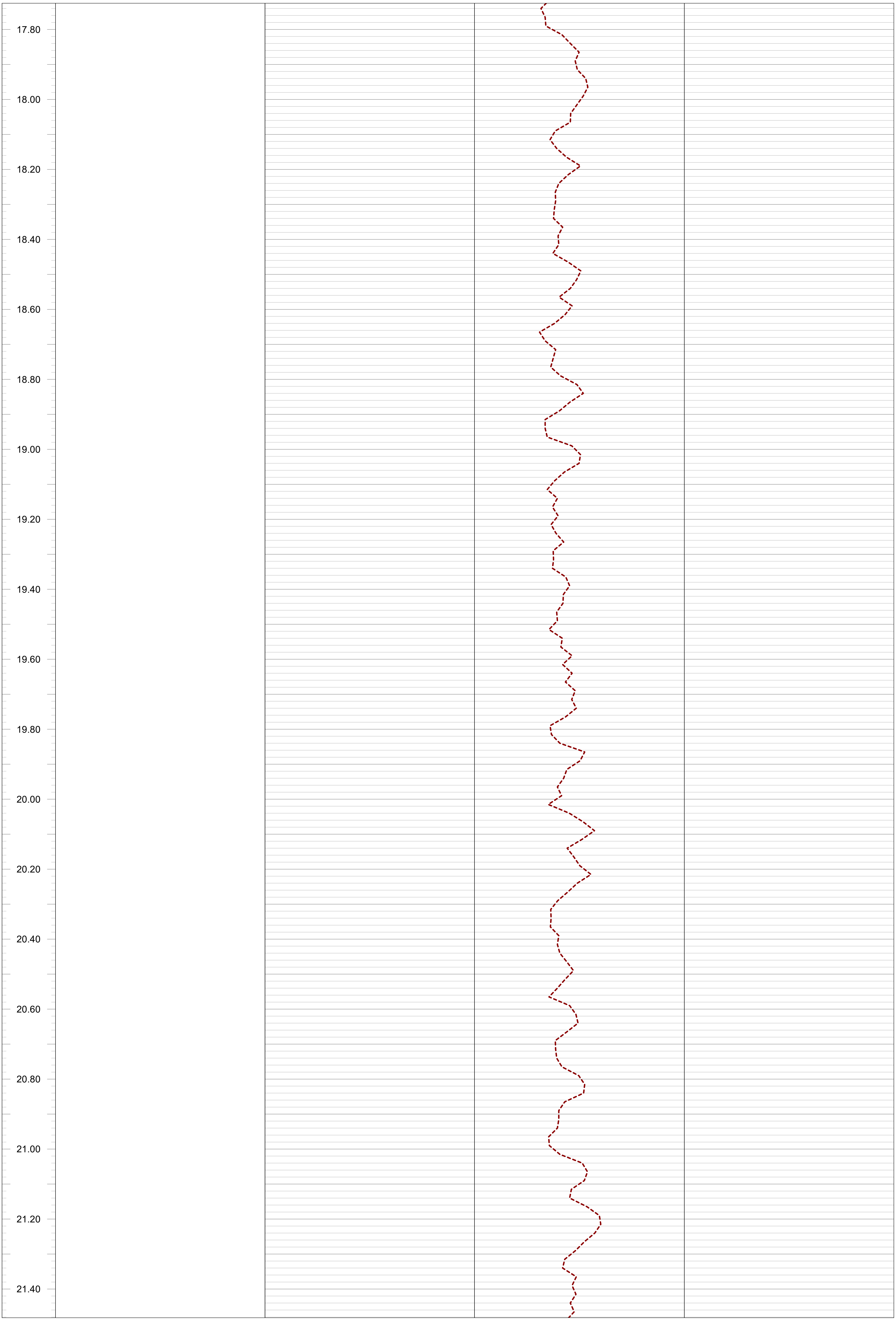
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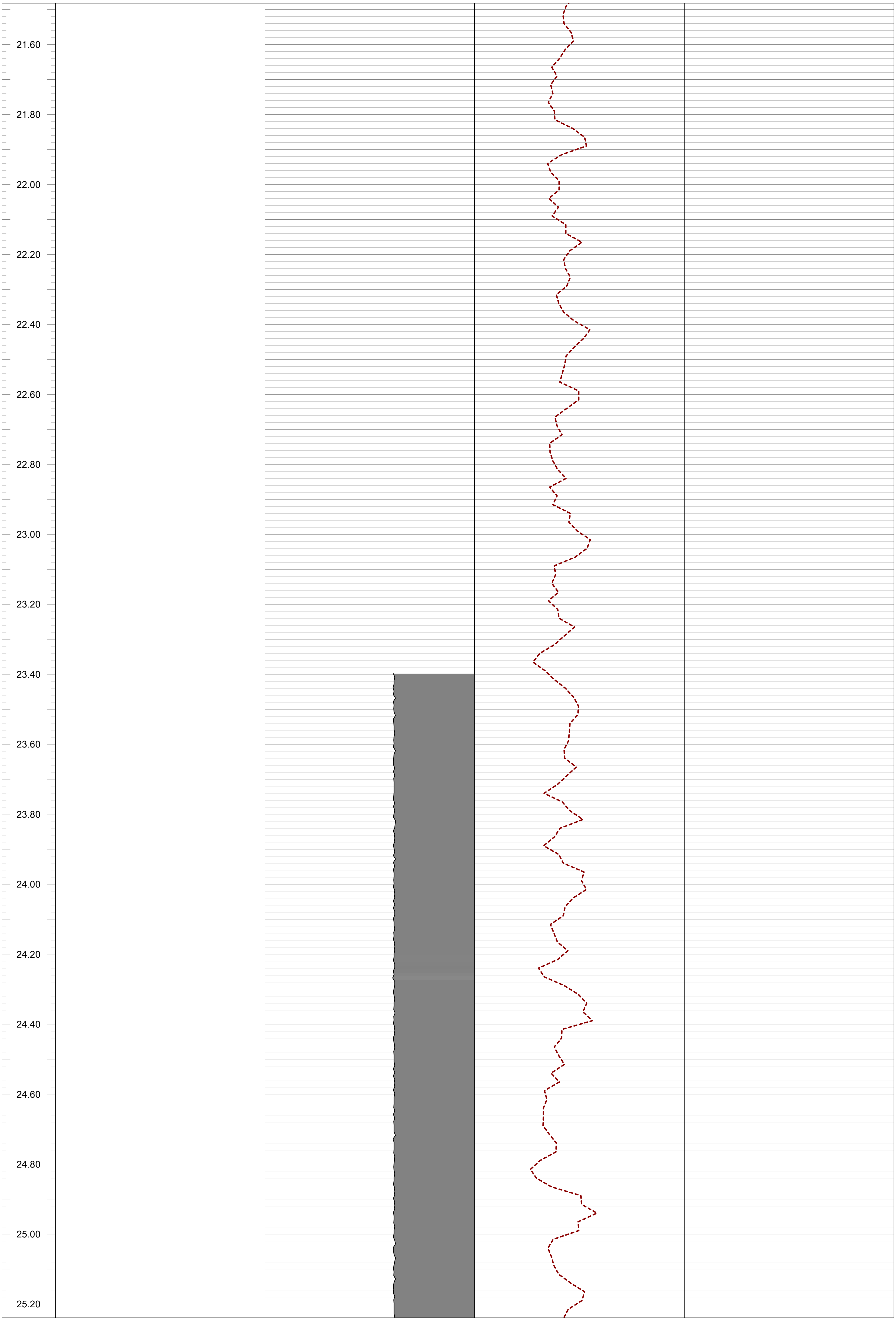
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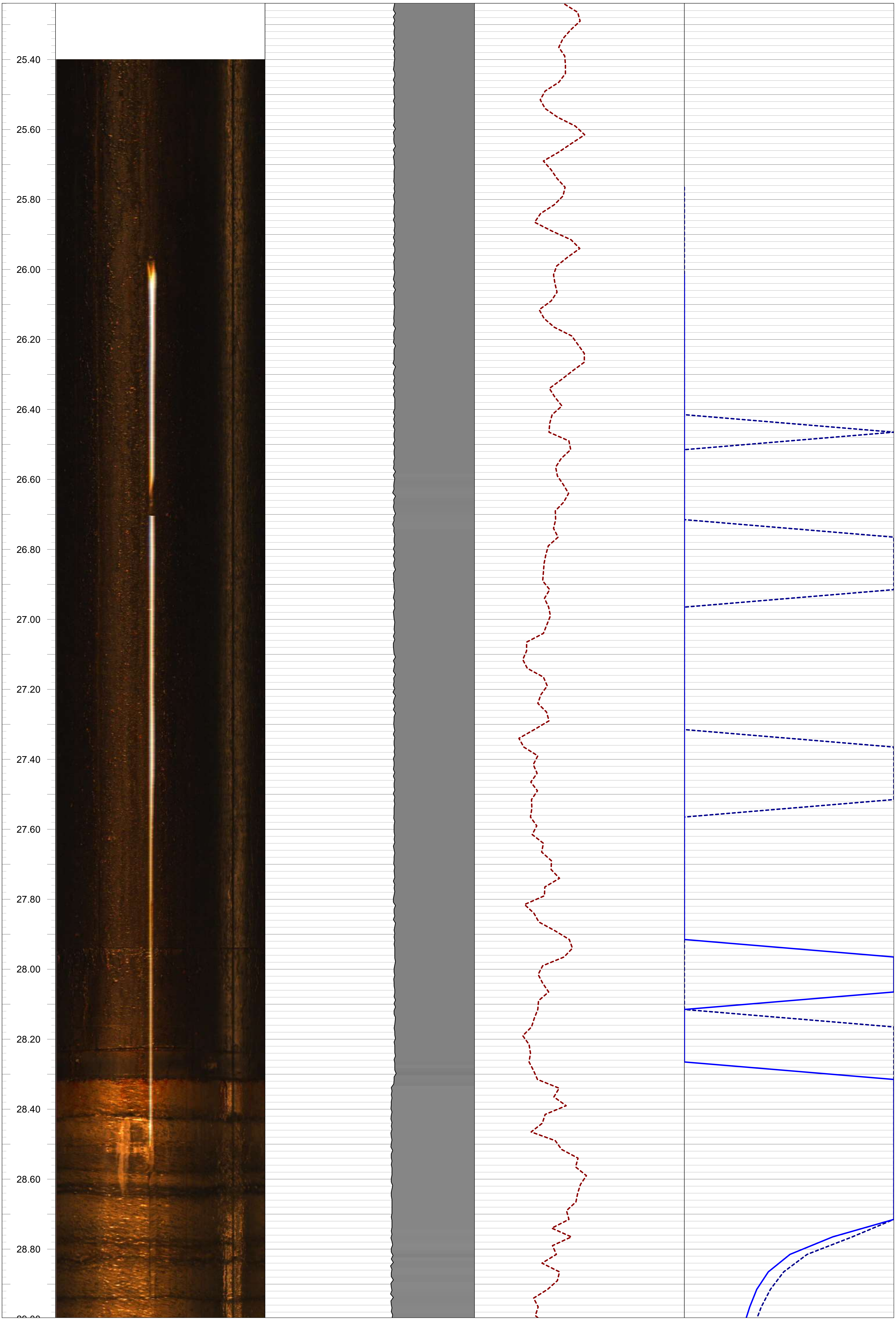
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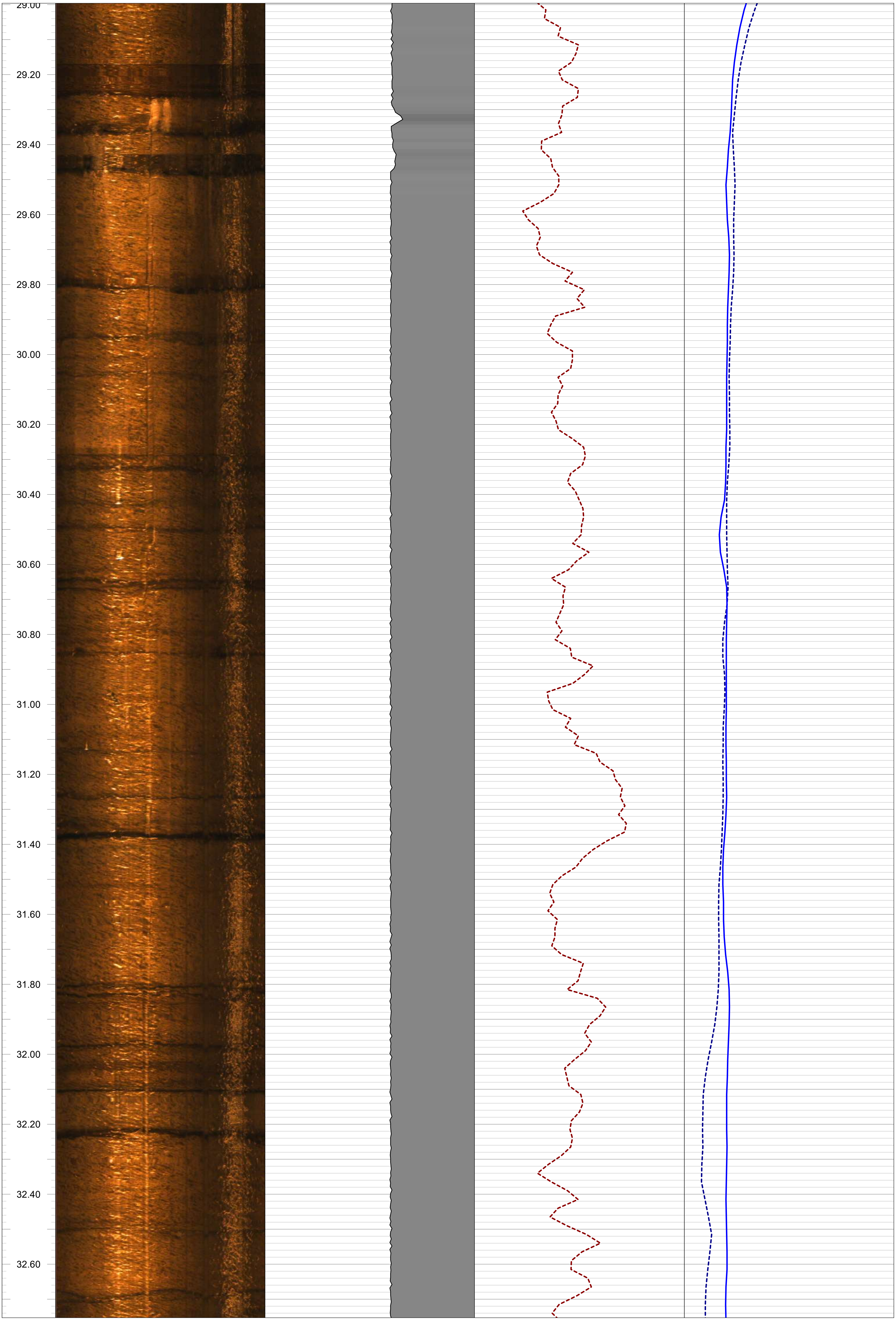
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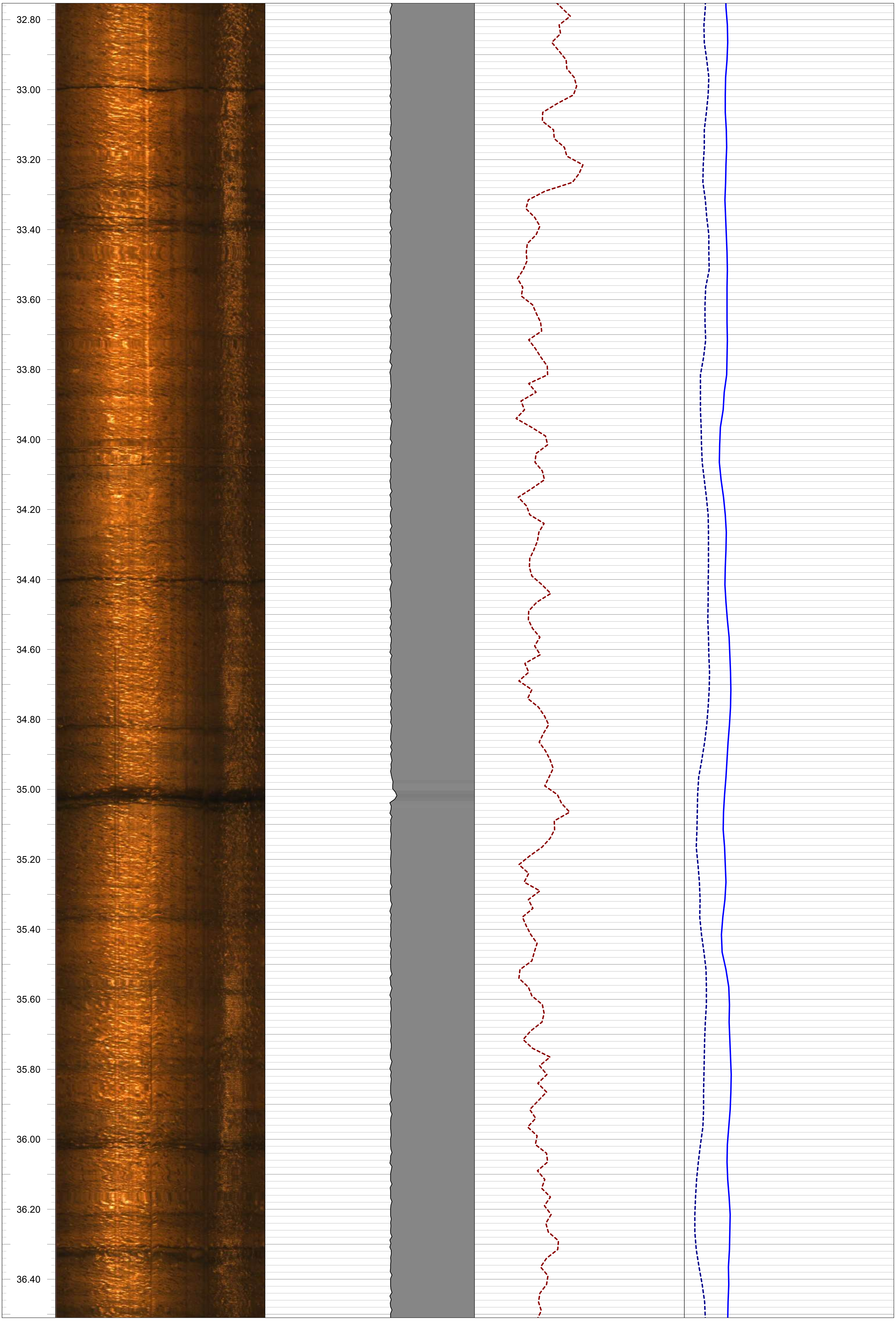
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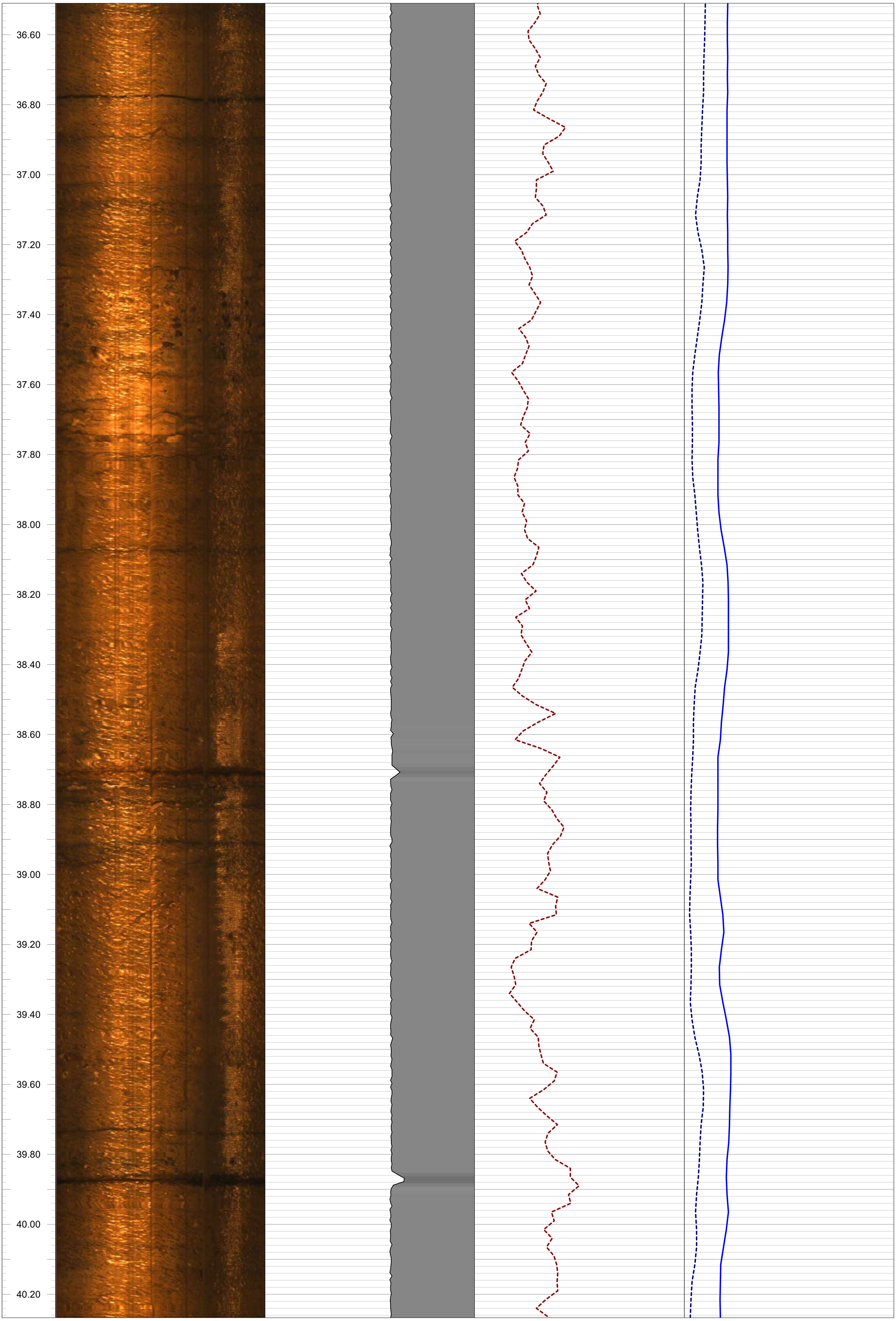
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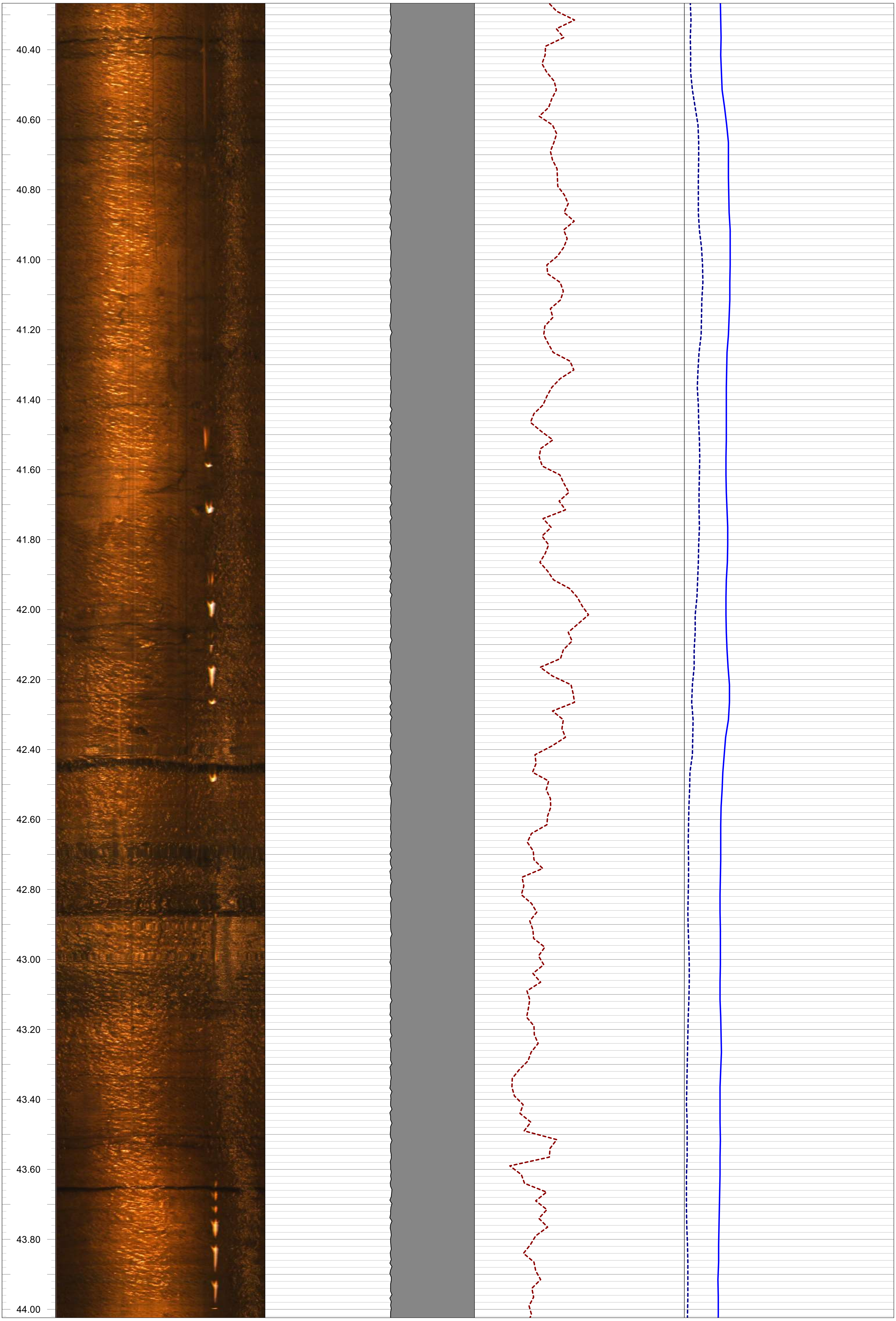
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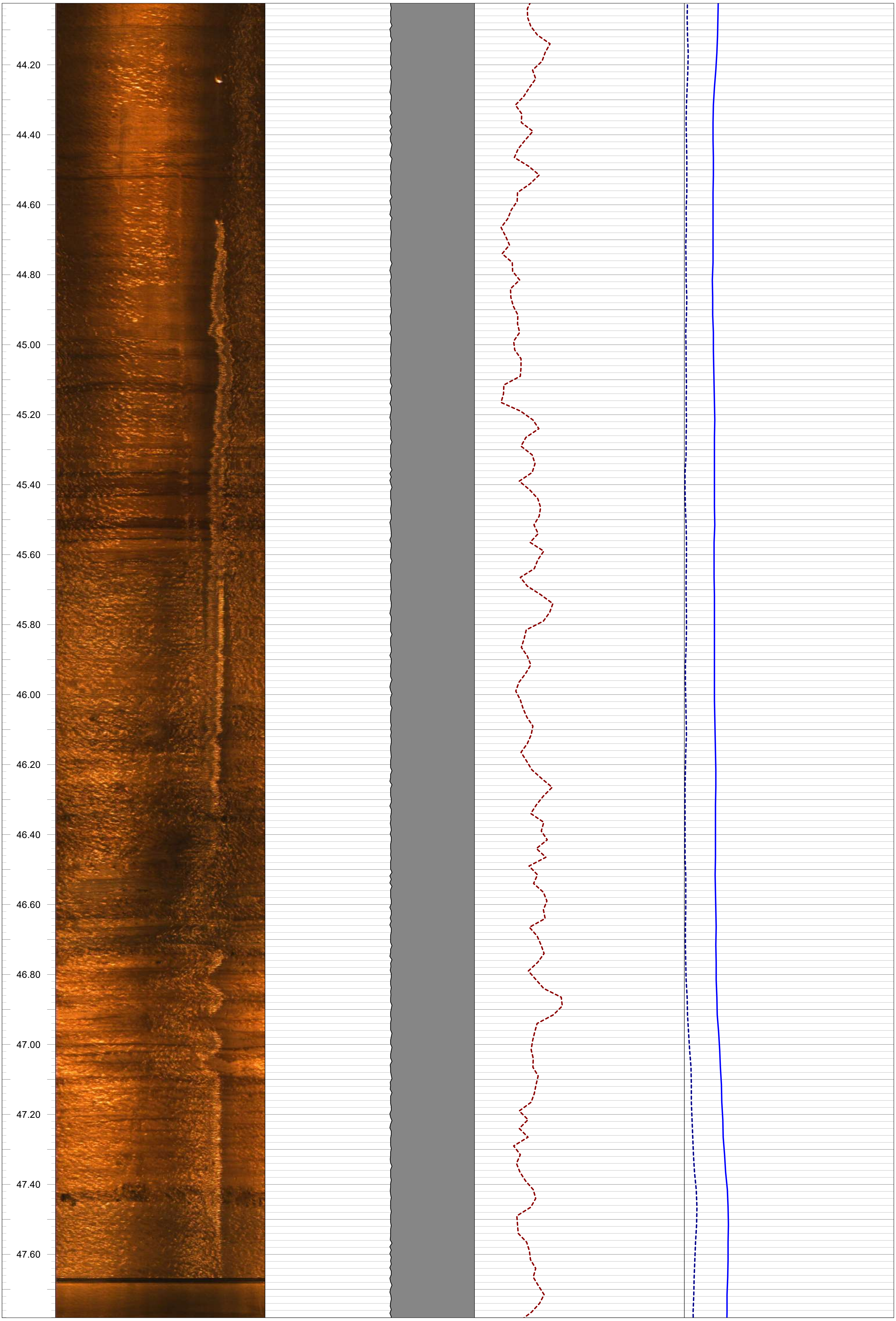
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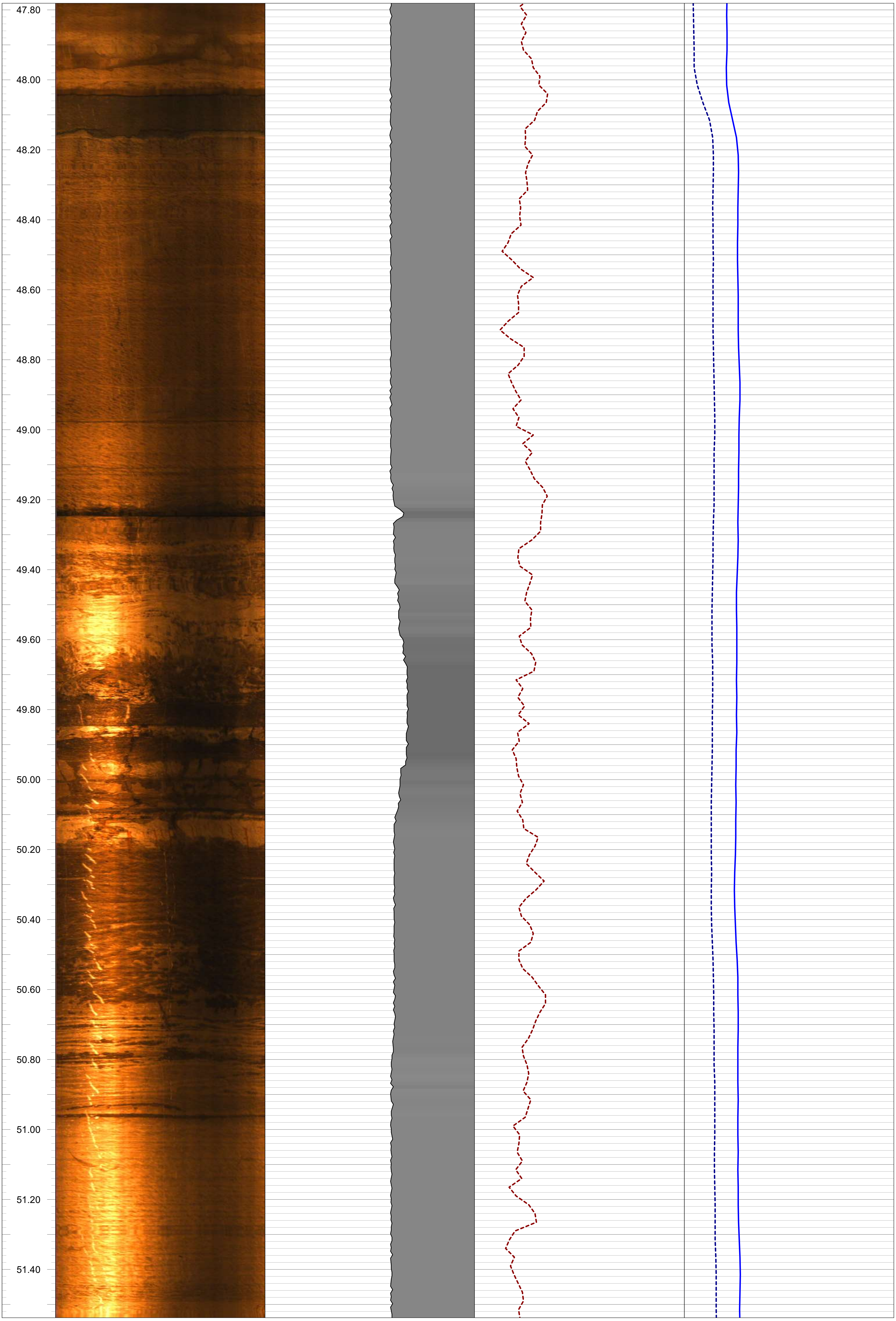
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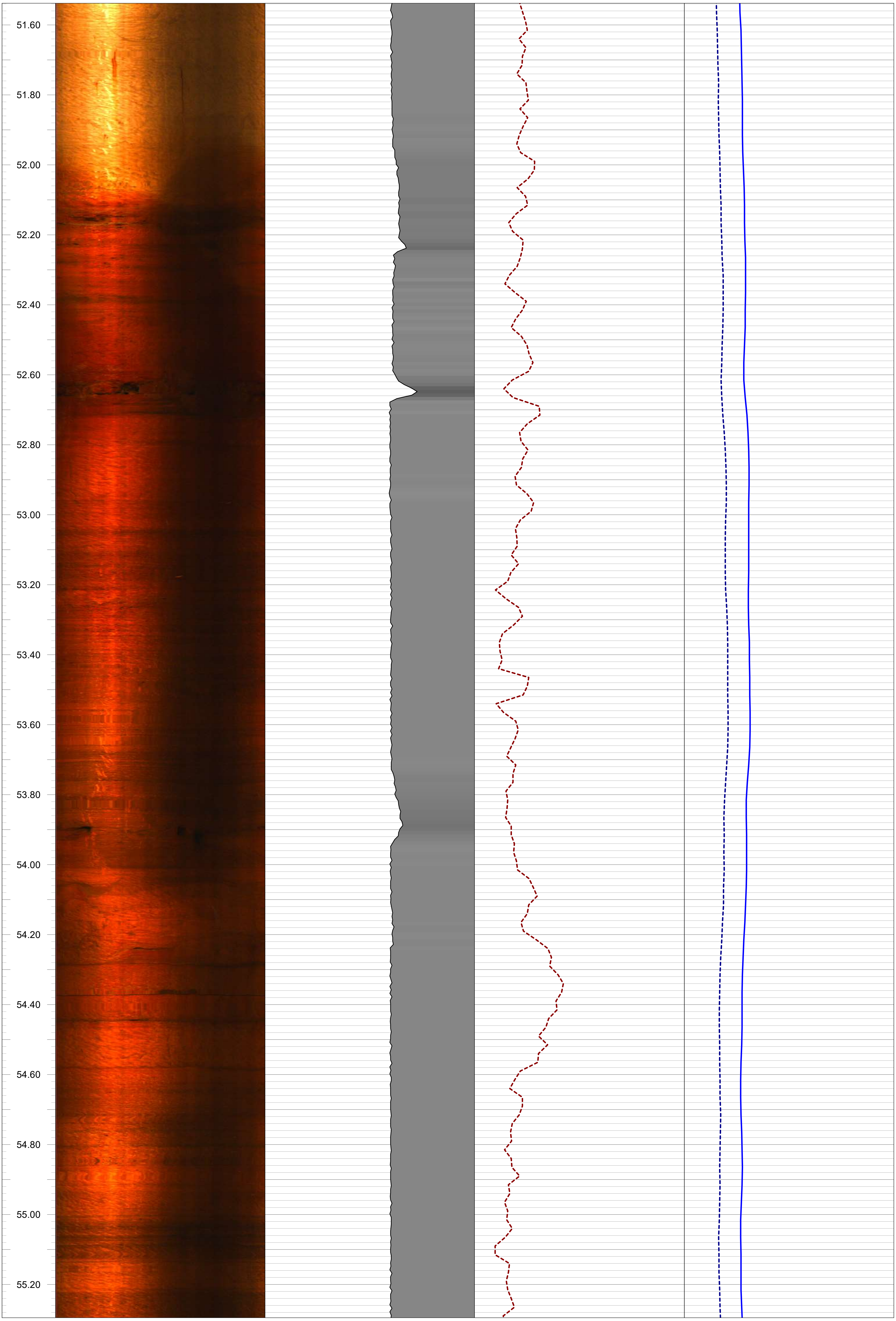
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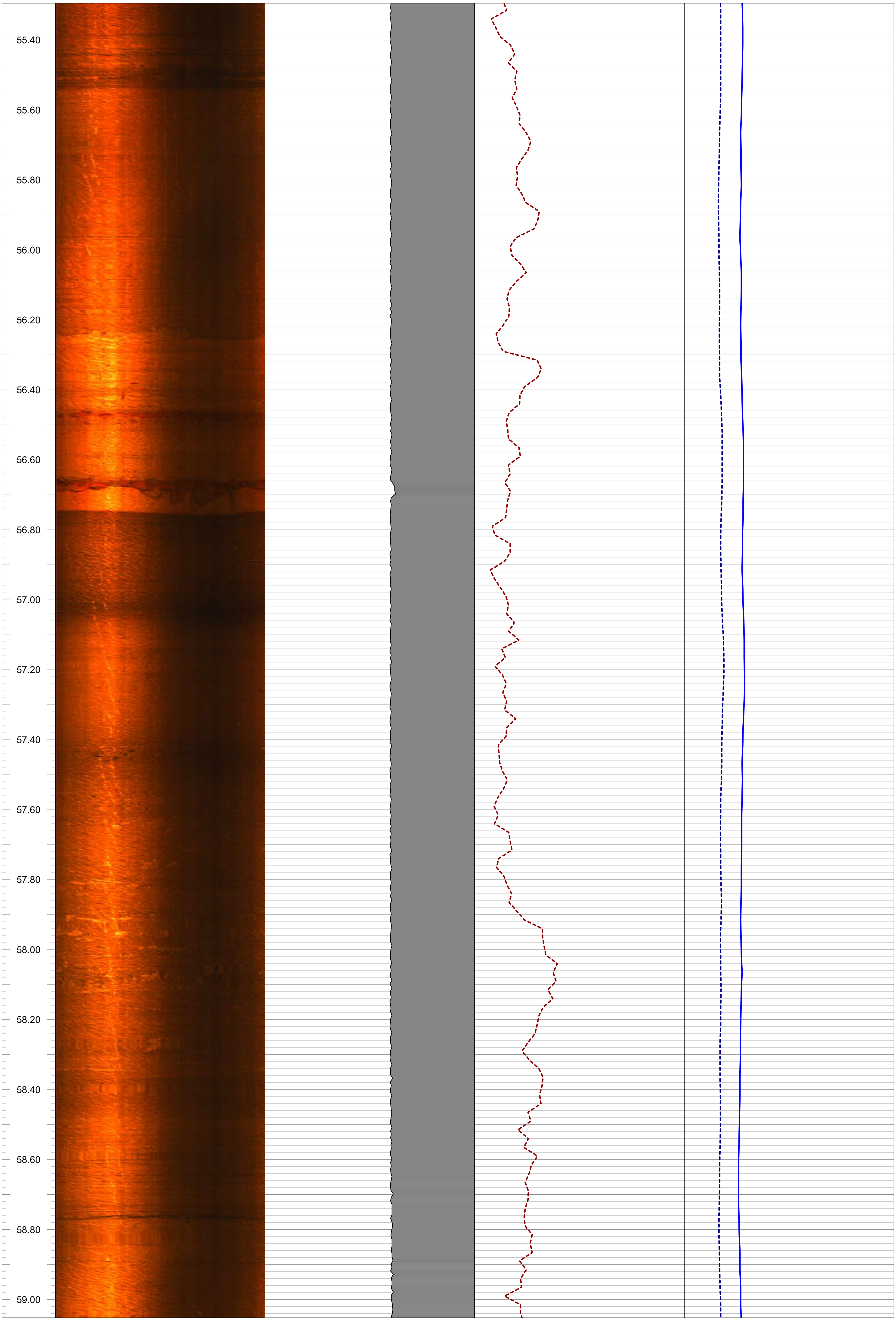
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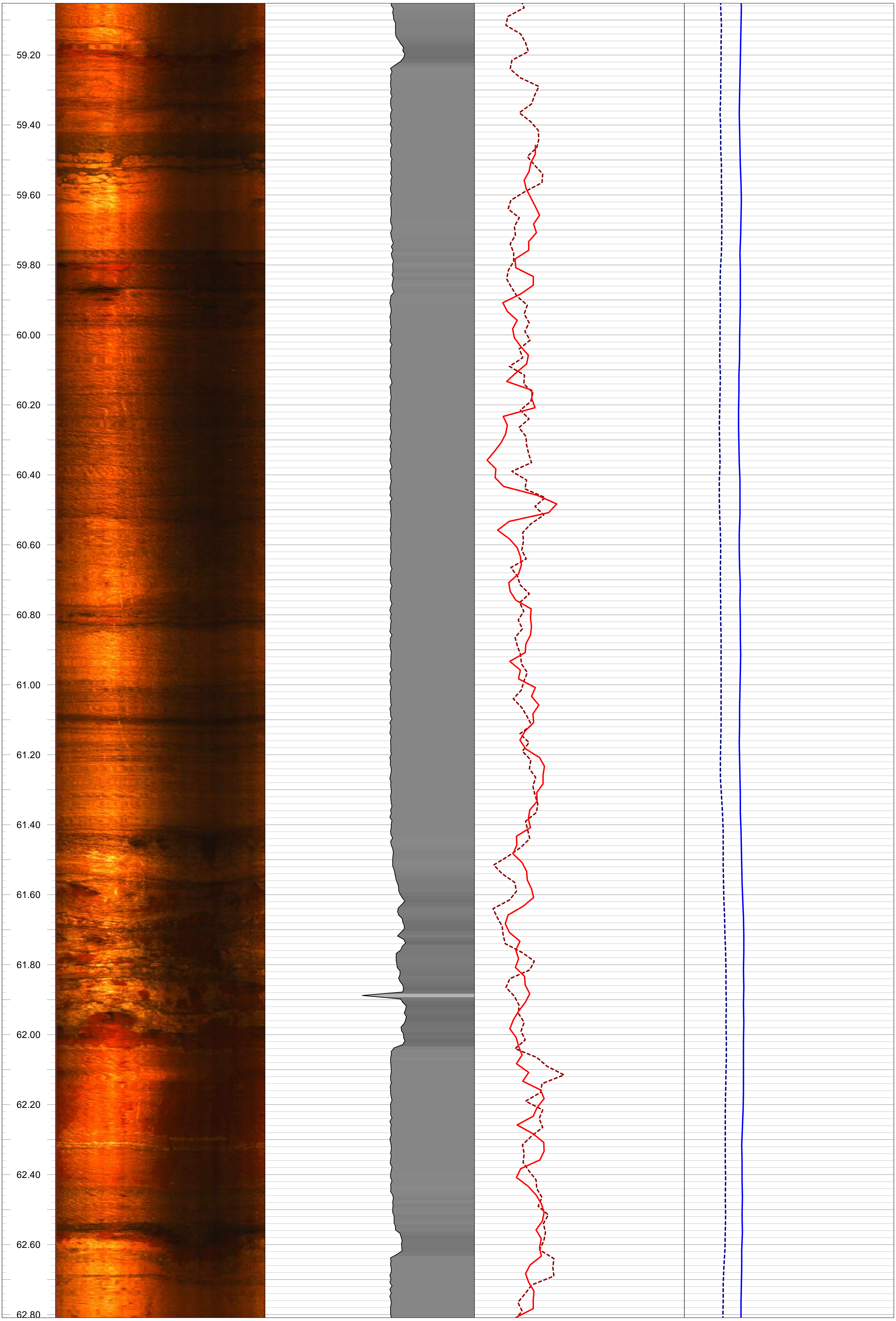
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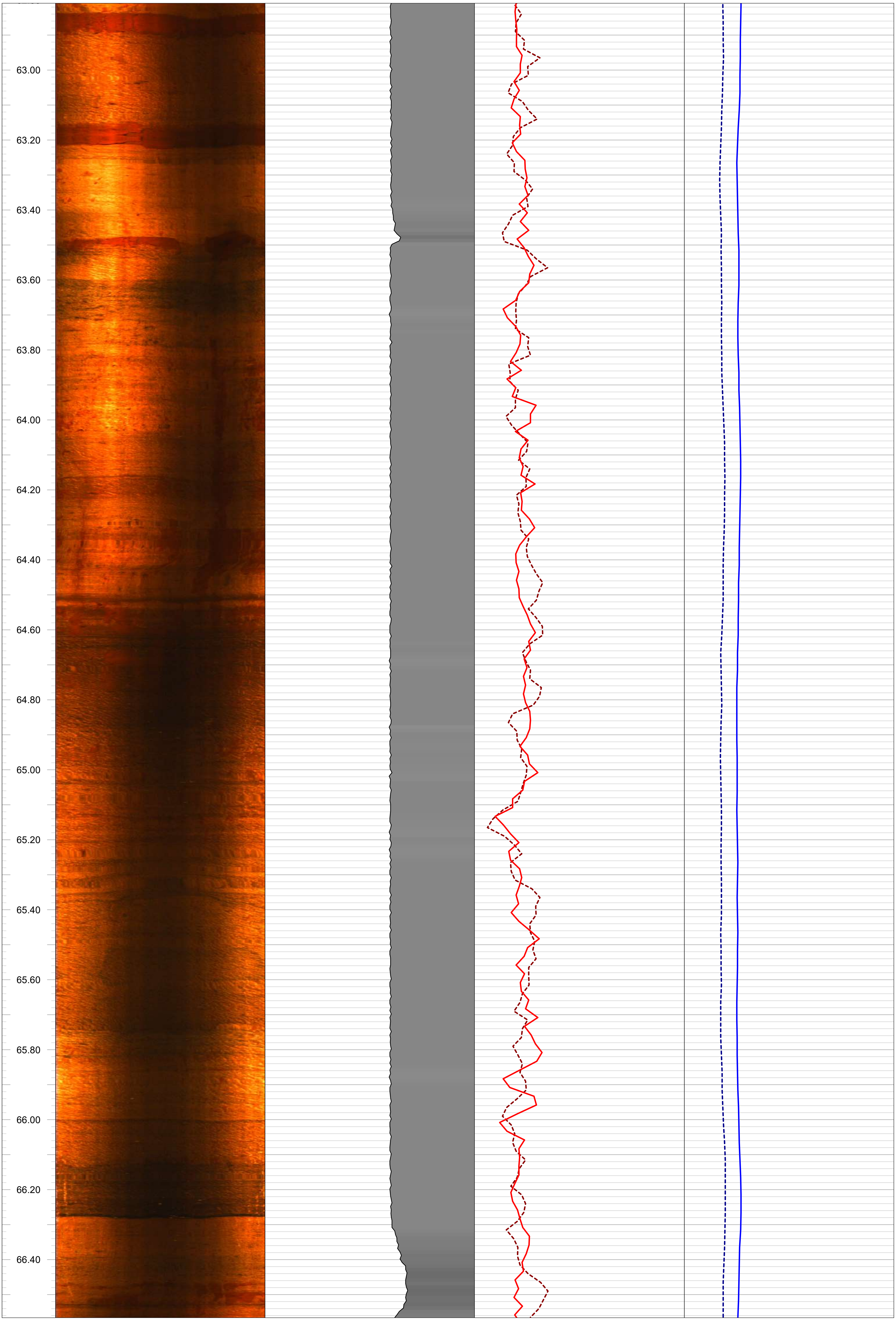
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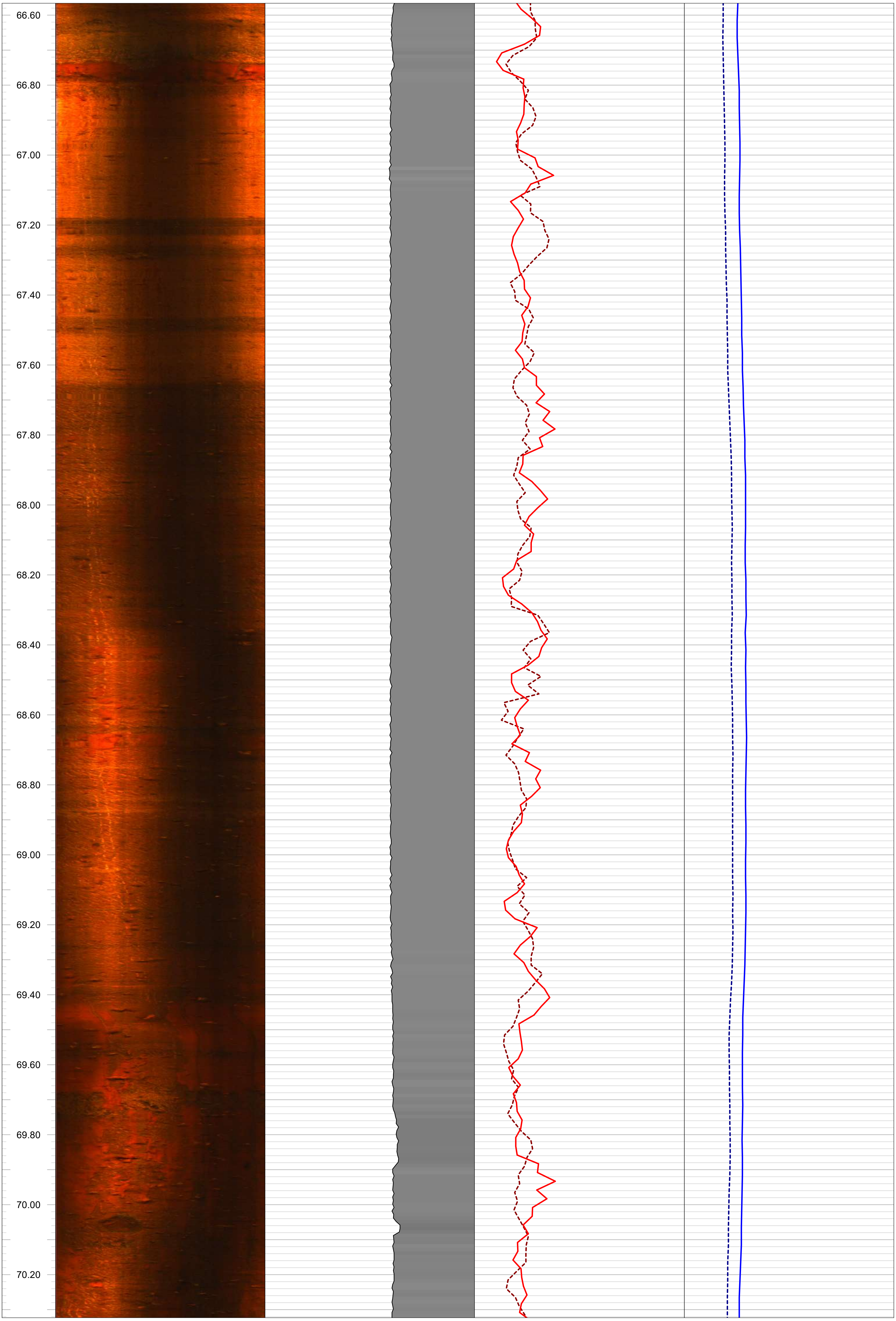
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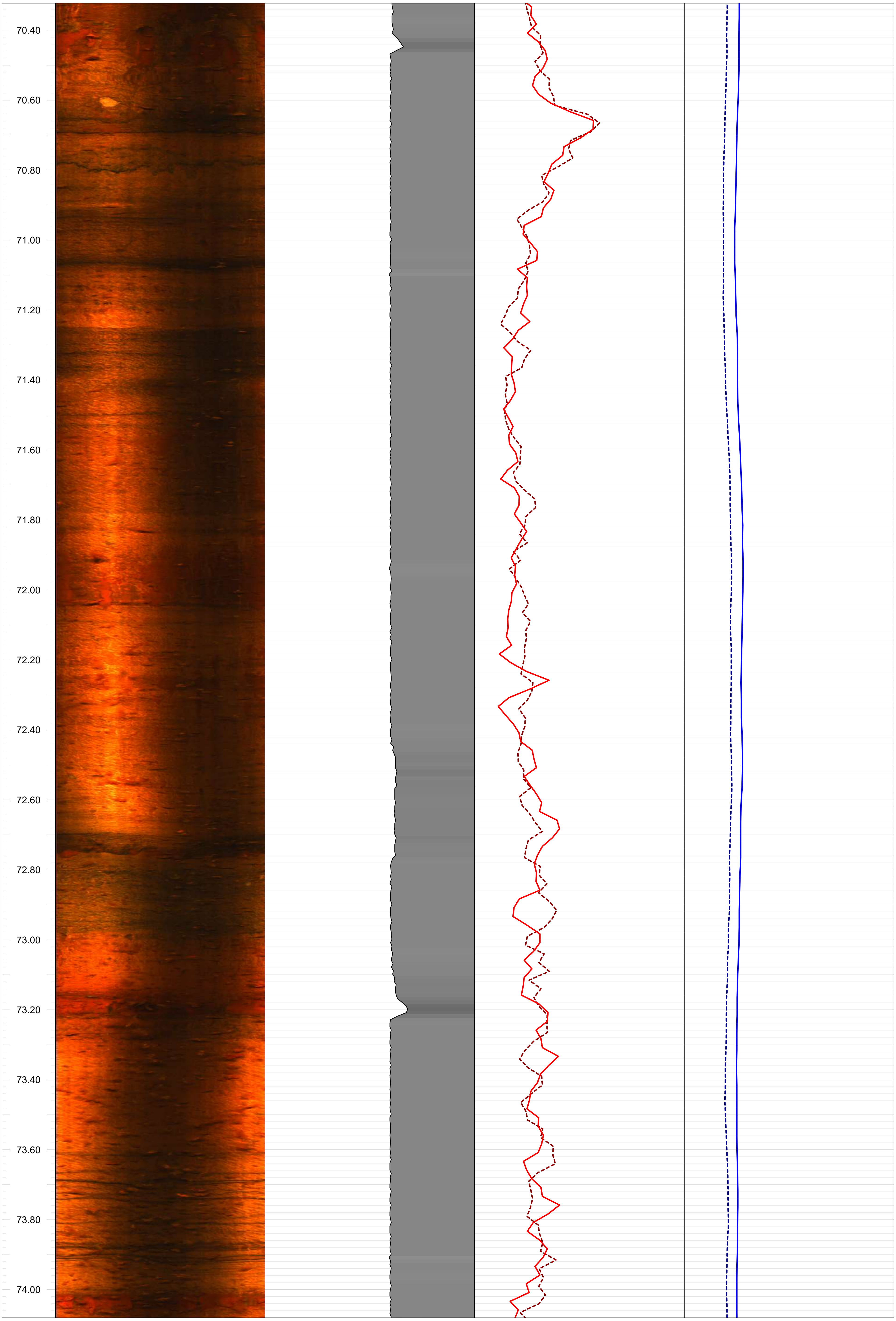
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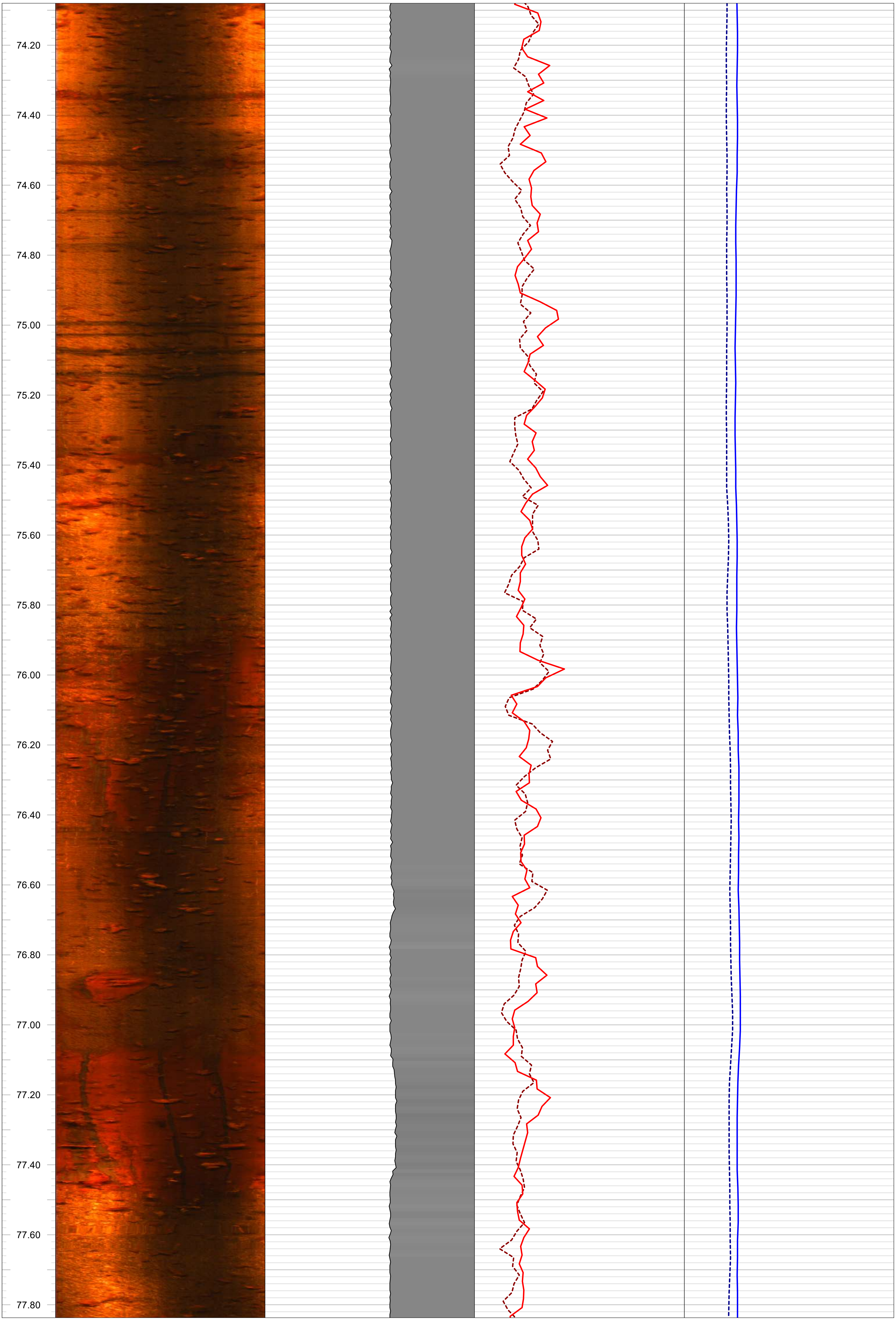
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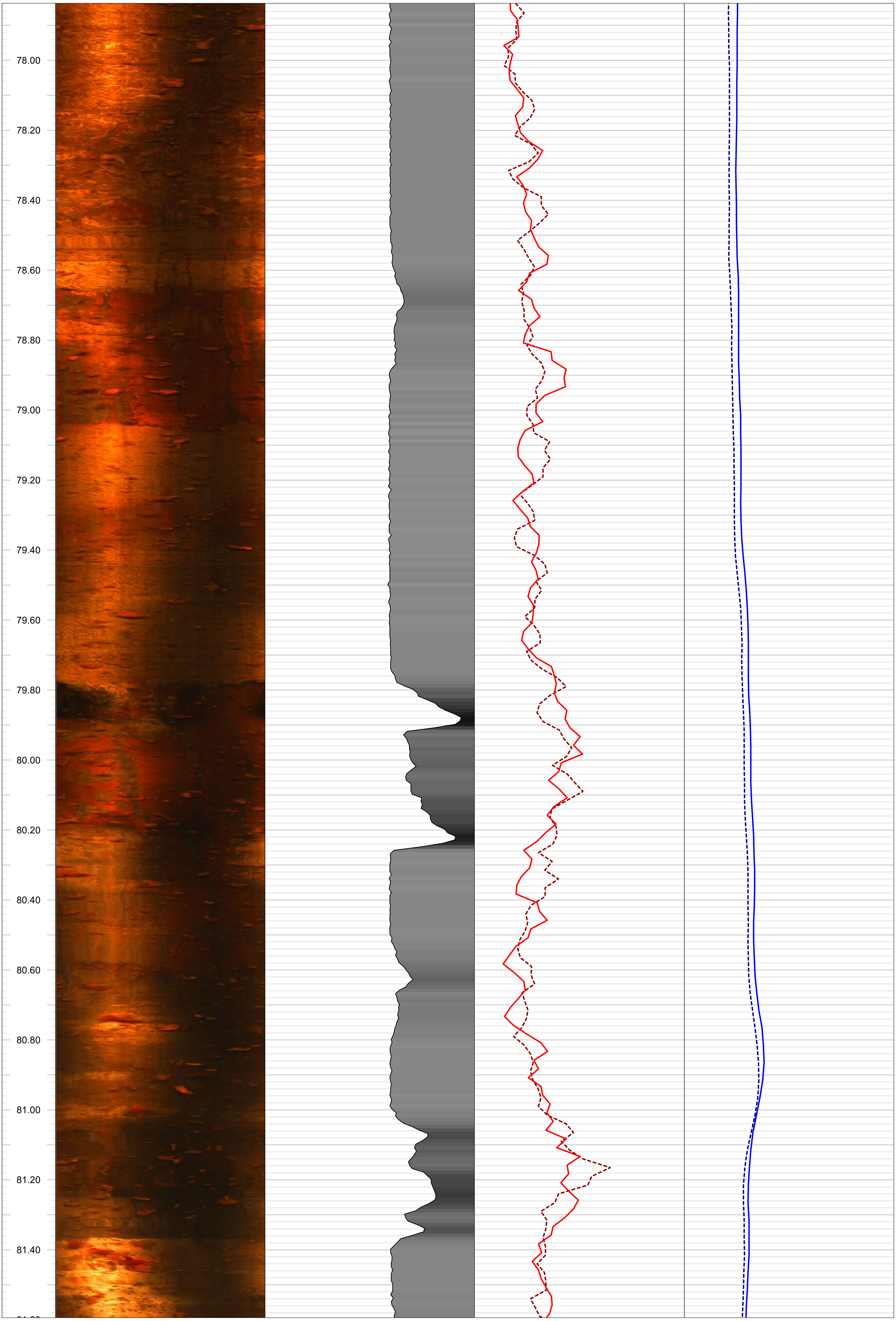
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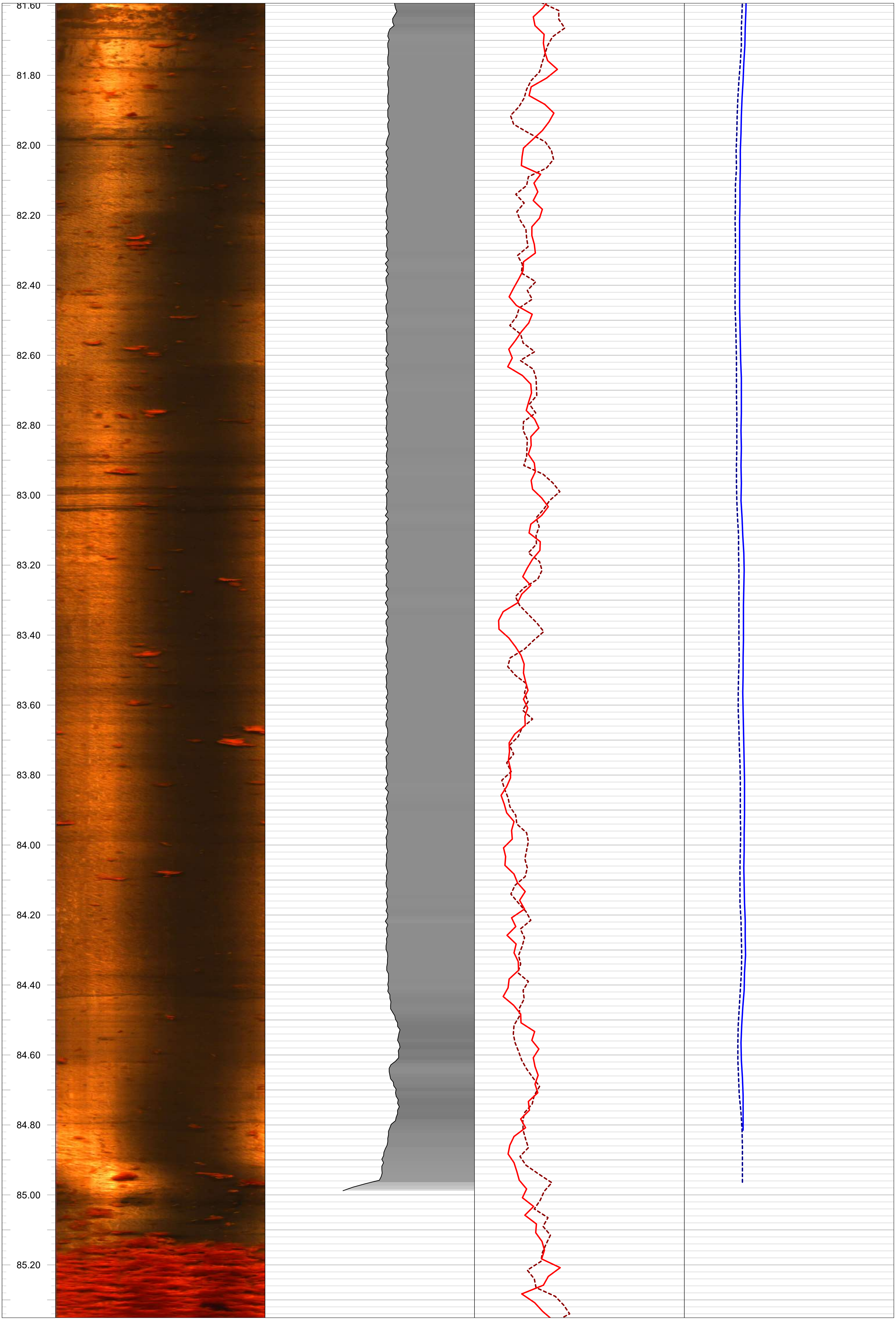
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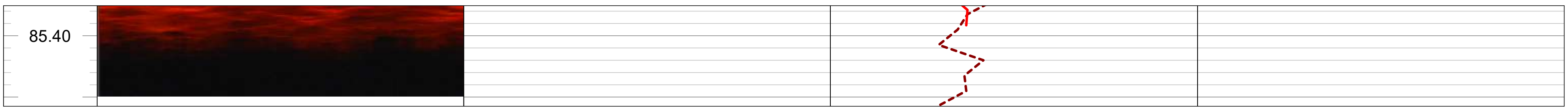
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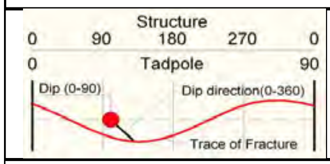
GEOPHYSICAL RECORD OF BOREHOLE: MW17-02

Project Number: 1781508

Client:

Date: January 2018

Datum:	**Elevation:**	**Borehole Diameter:**	**Water Level:**	**Location:**	St. Mary's
Easting:	**Depth Reference:**	**Casing Diameter:**	**Borehole Inclination:**	**Log Date:**	18-Jan-2018
Northing:	**Drilled Depth:**	**Casing Depth:**	**Borehole Azimuth:**	**Logged By:**	PG



Notes:

Depth	Optical Image	Caliper	Natural Gamma Down	Apparent Conductivity Down
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1m:10m			Natural Gamma Up	Apparent Conductivity Up
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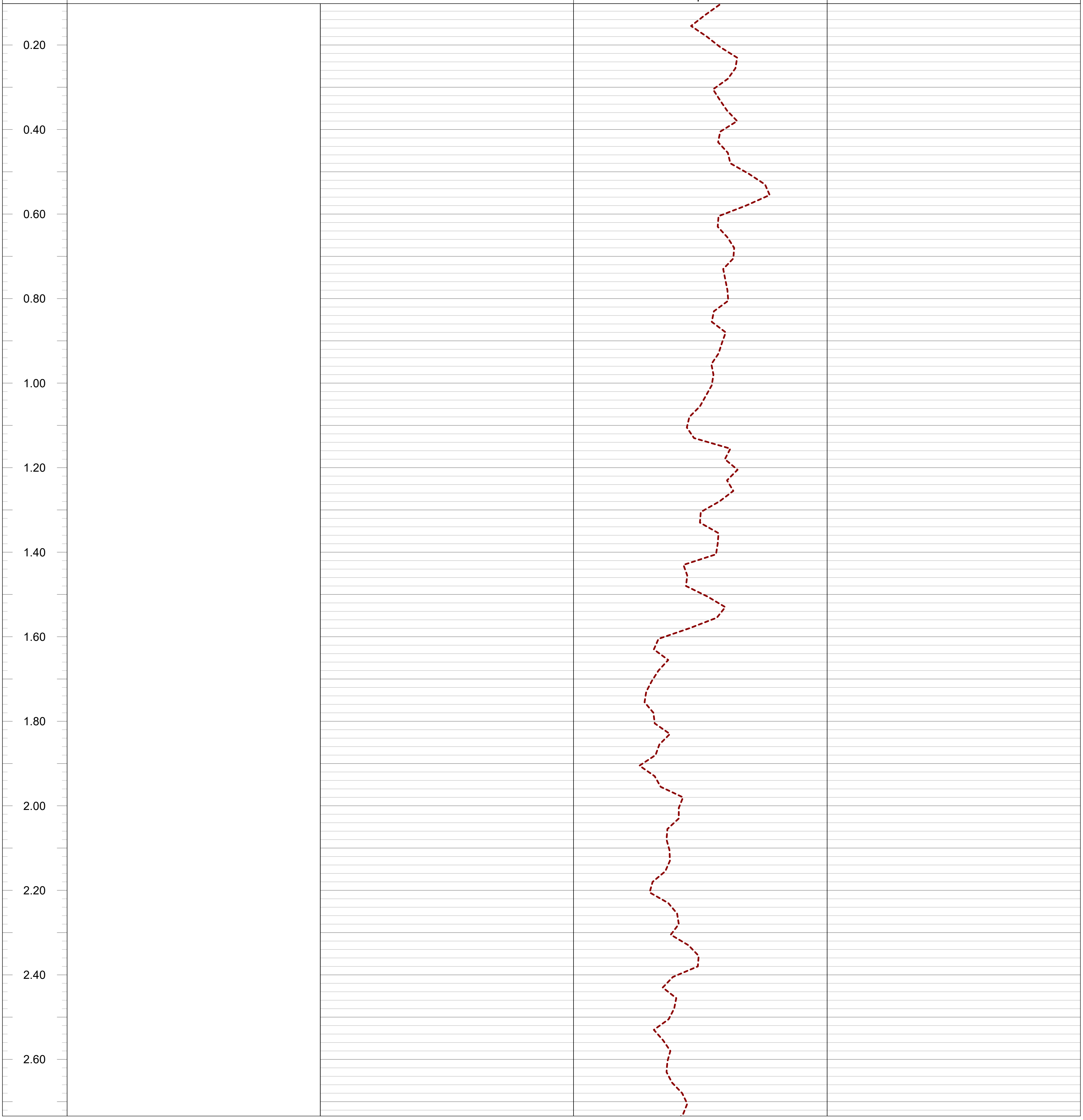

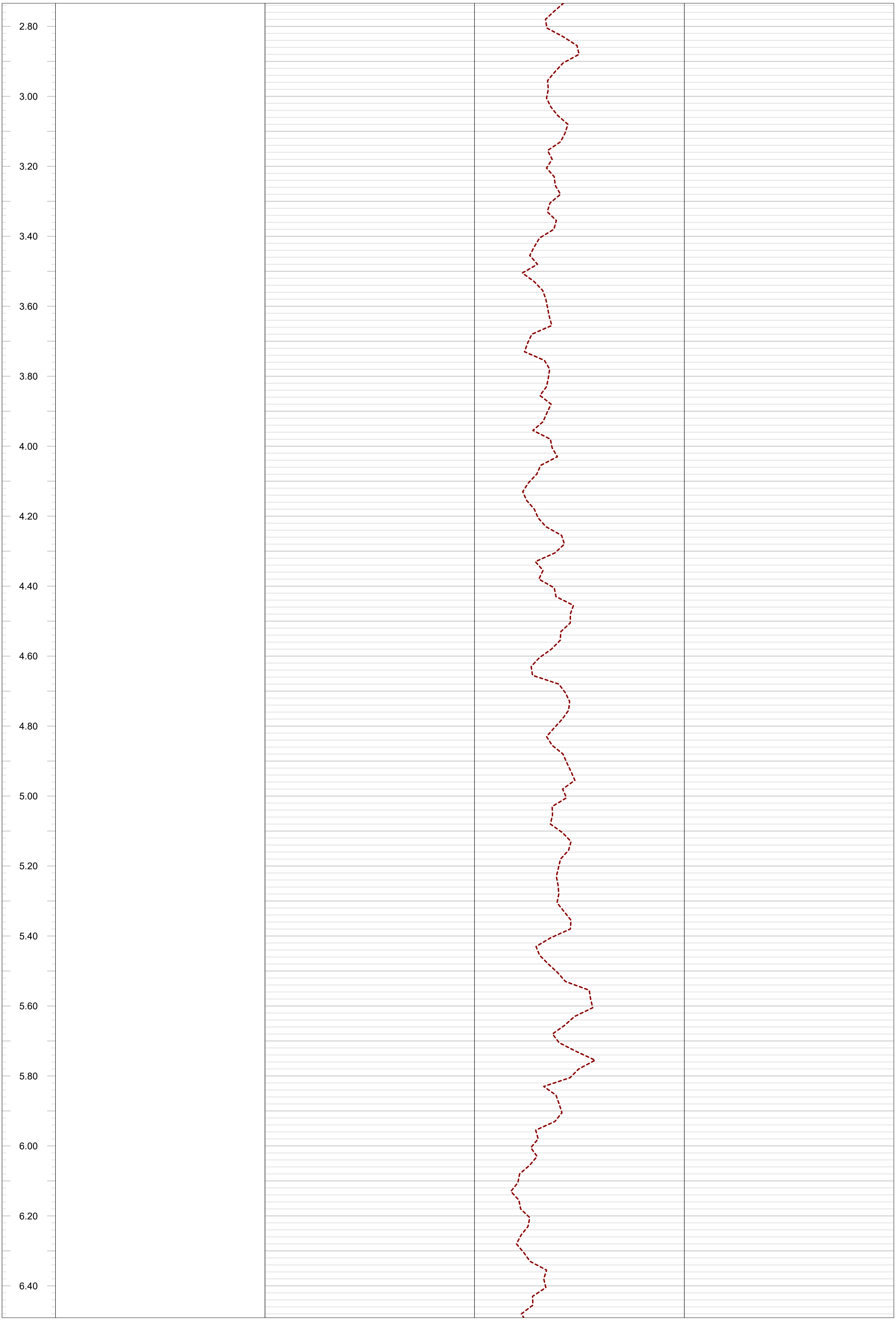

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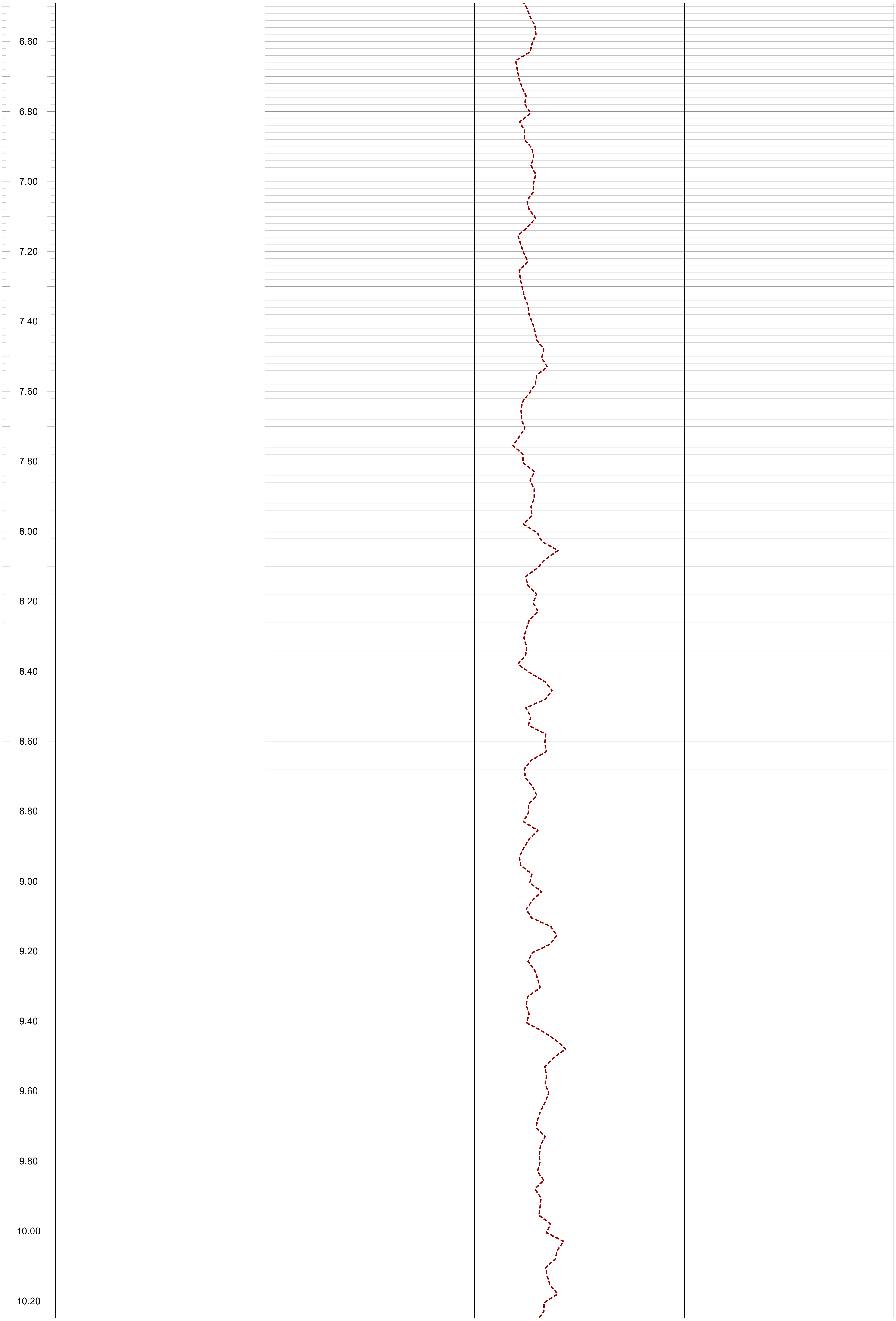
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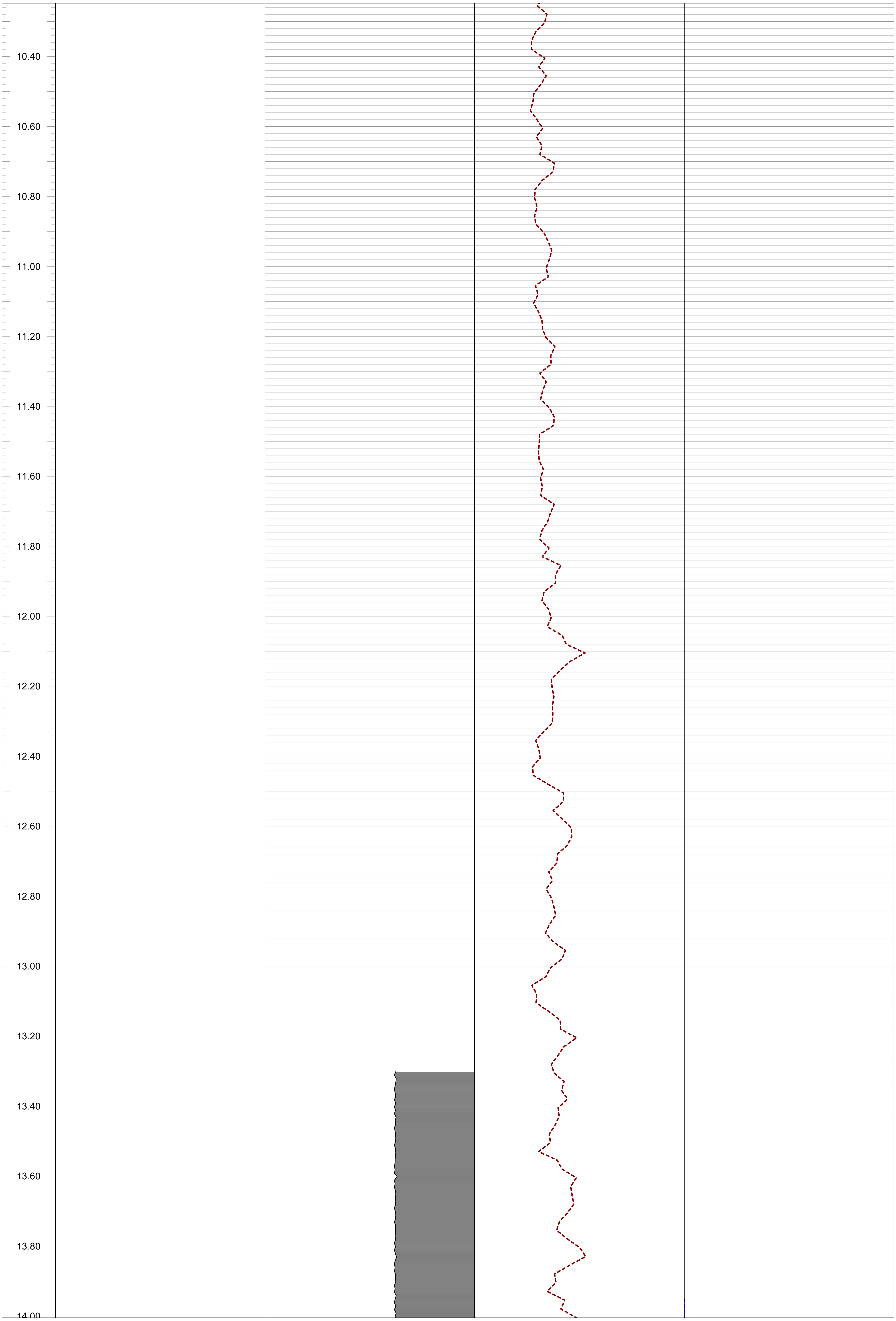
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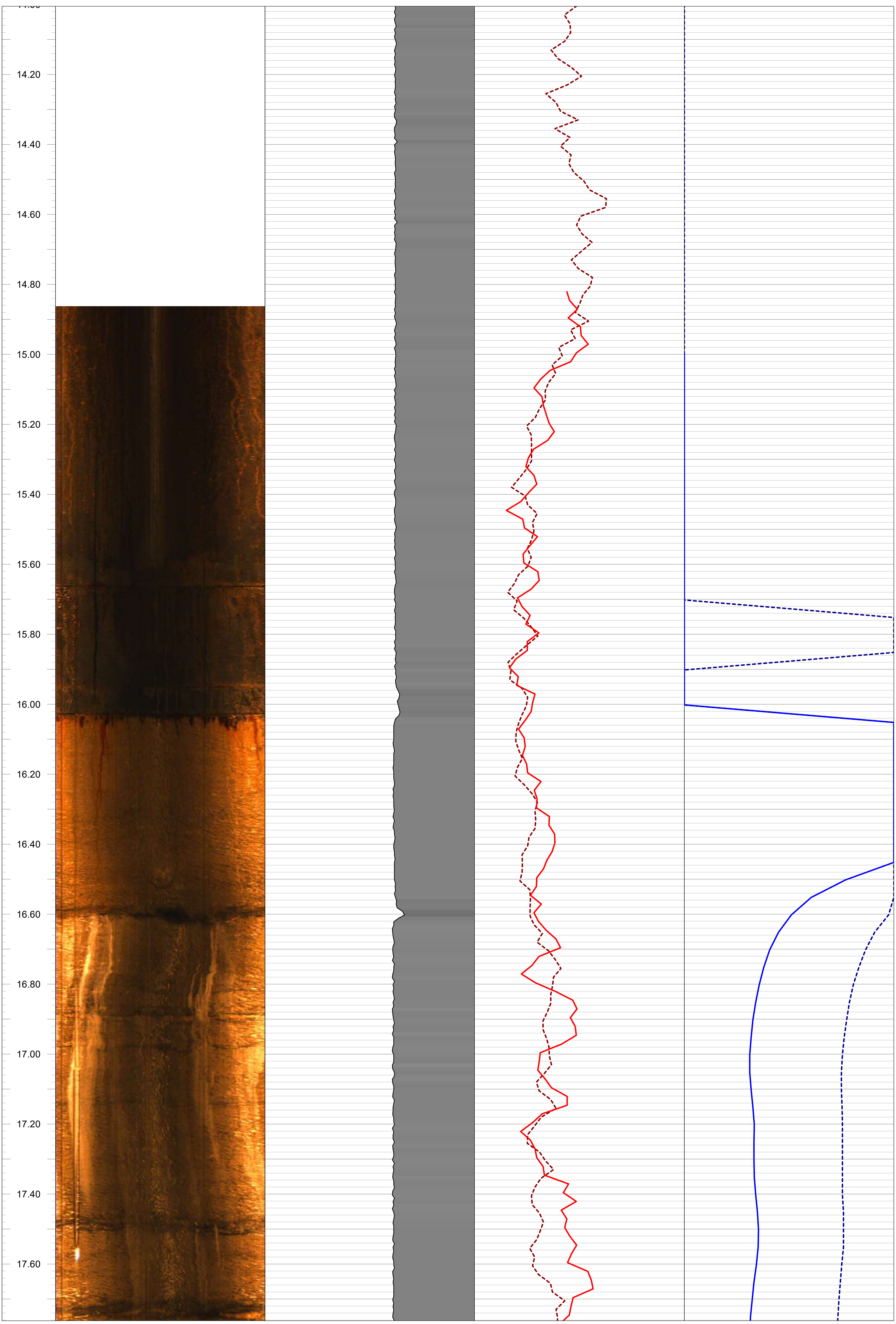
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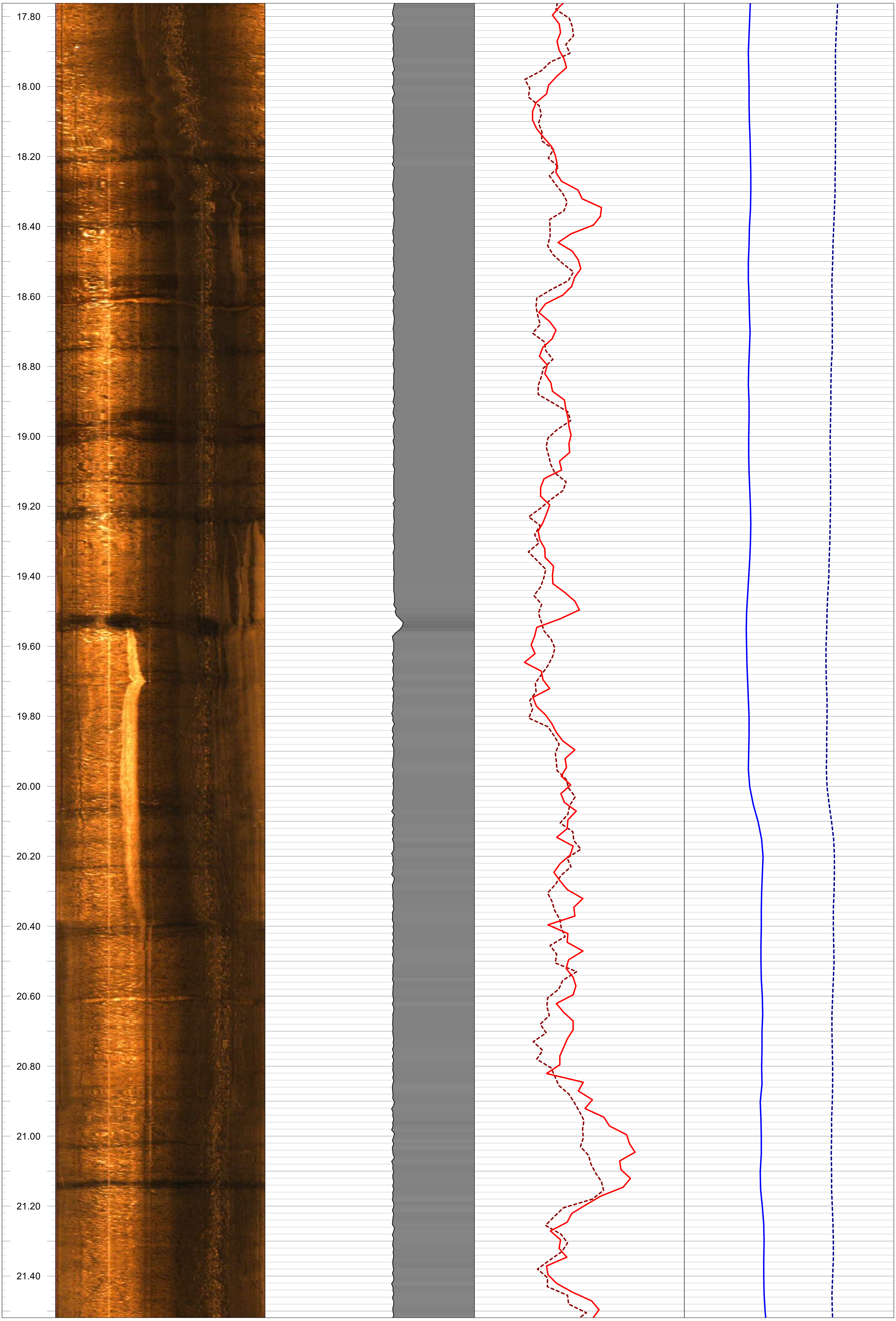
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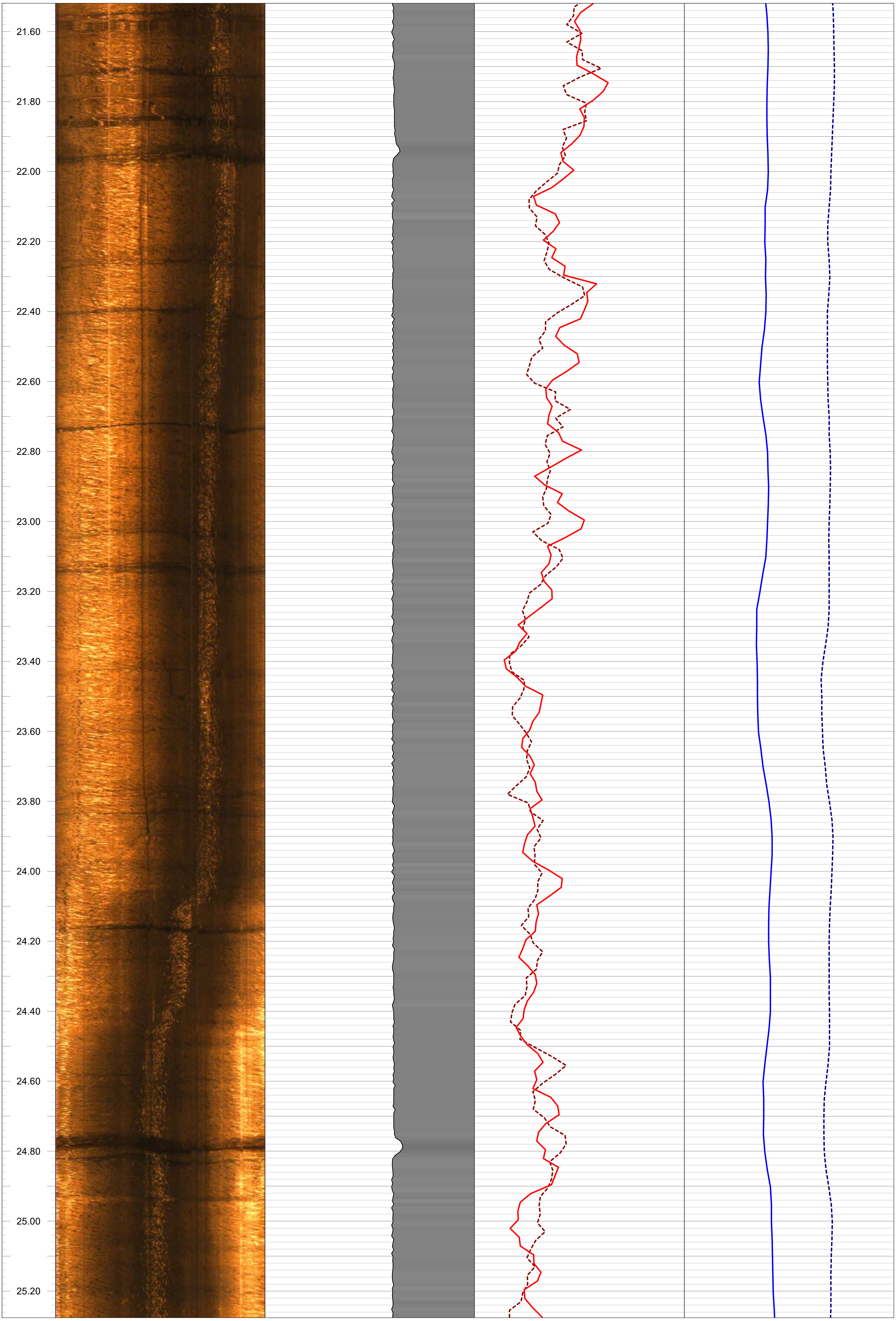
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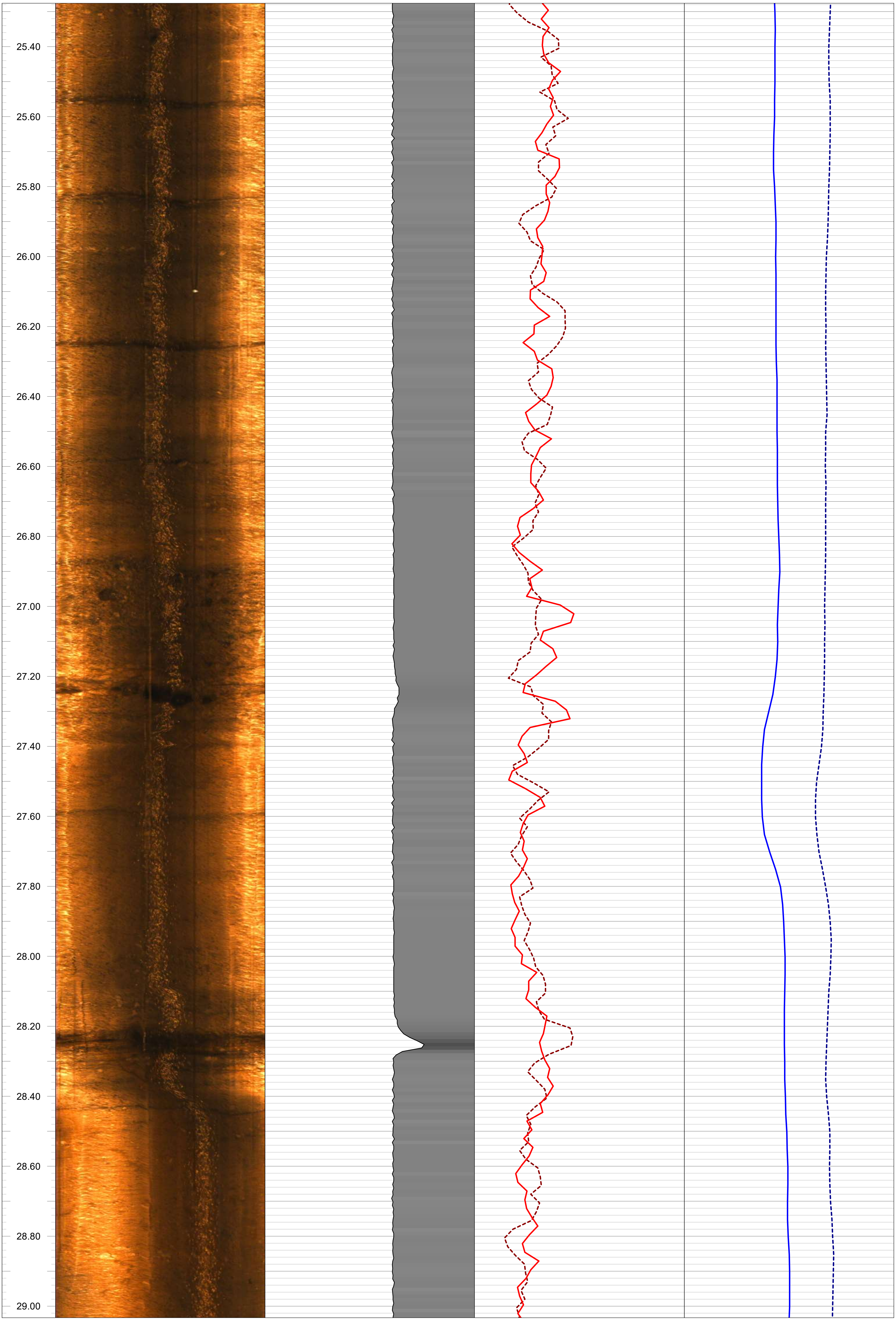
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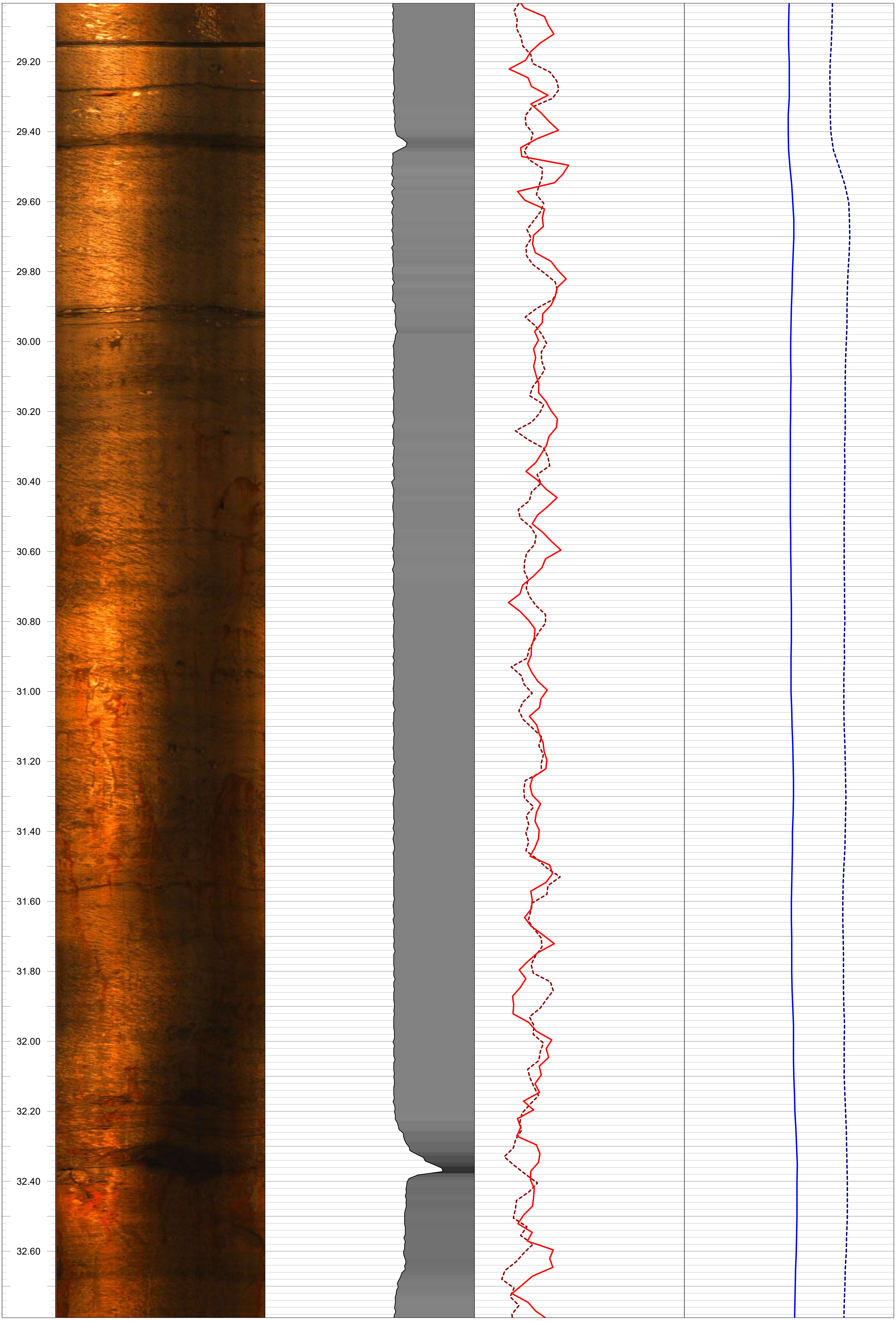

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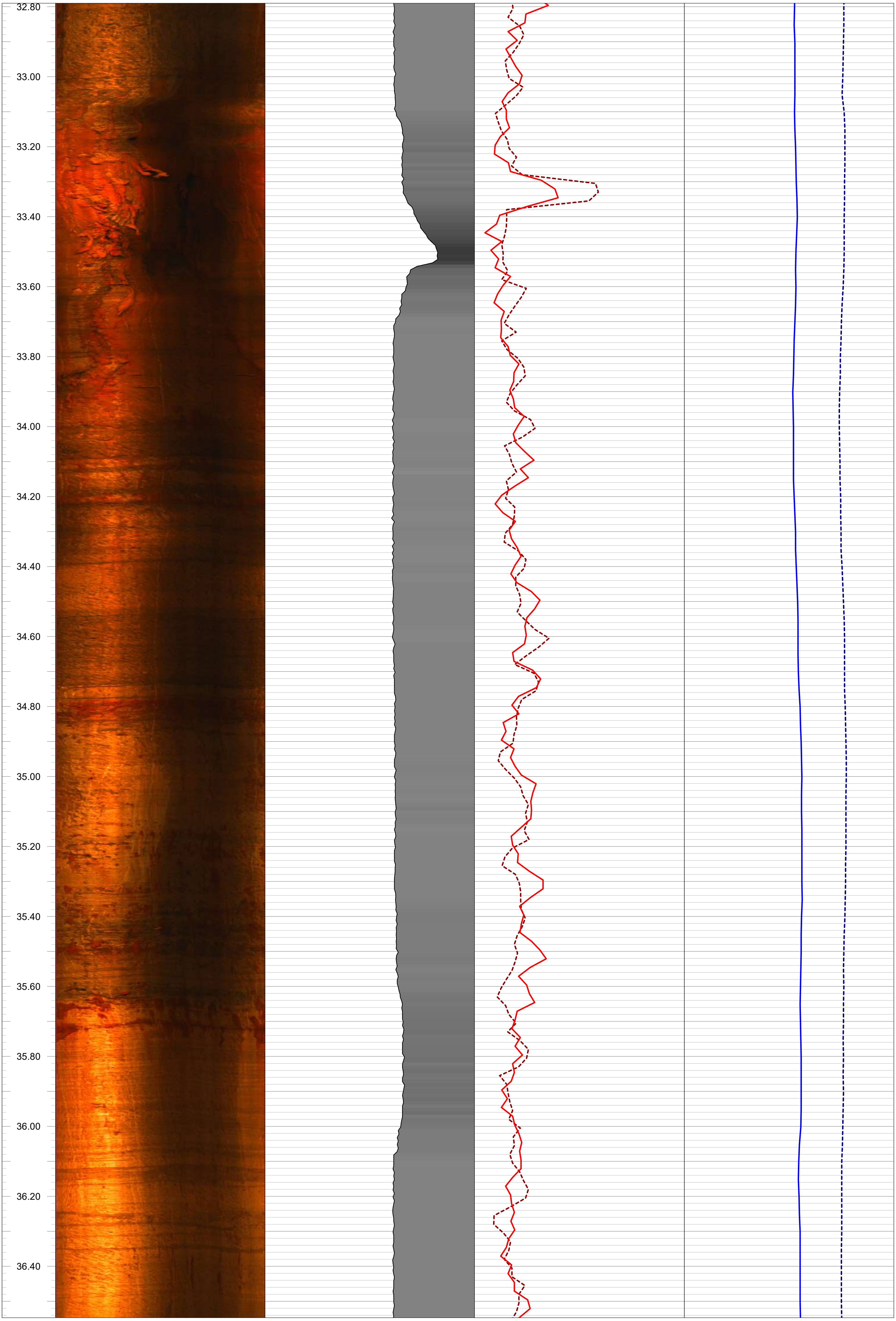
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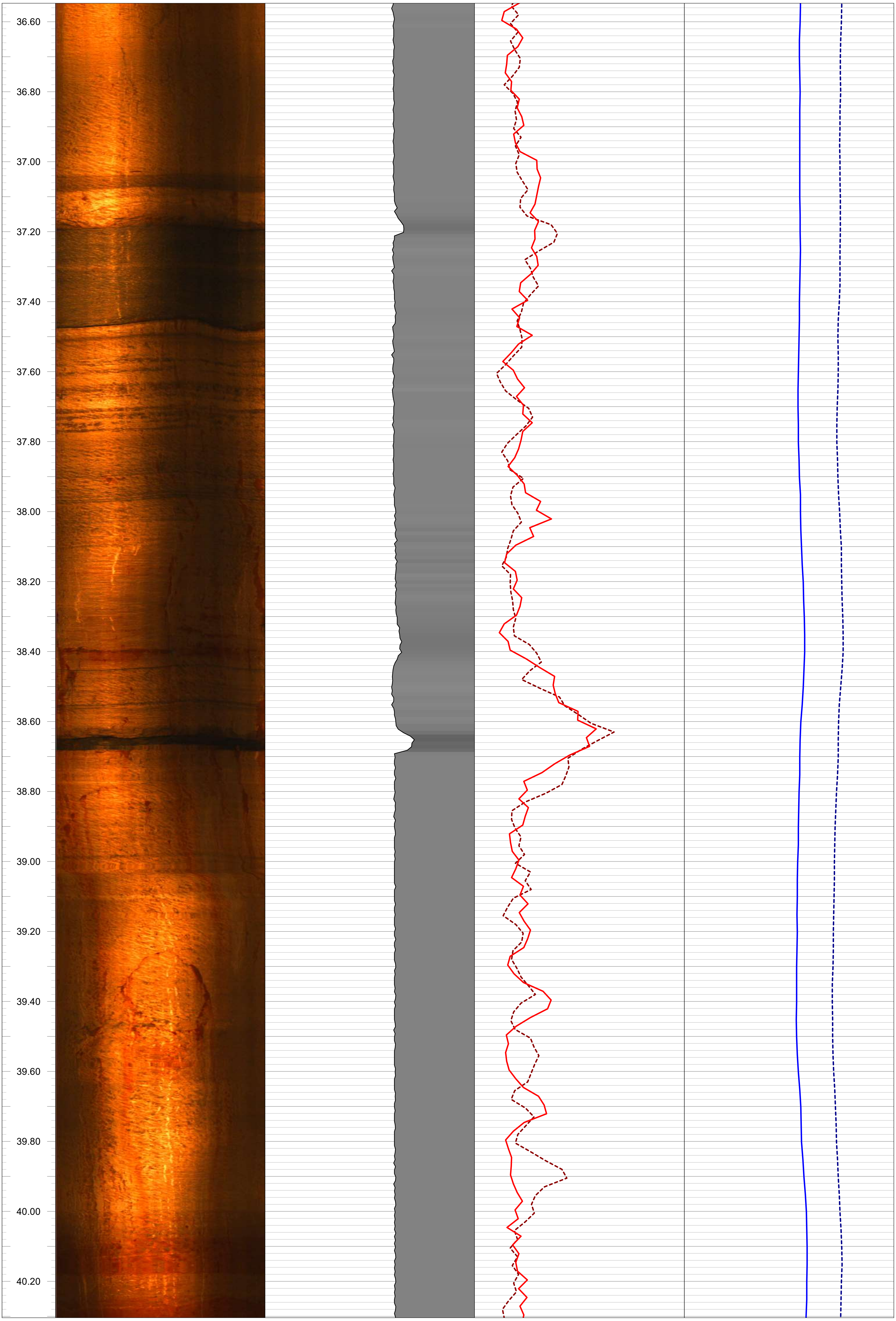
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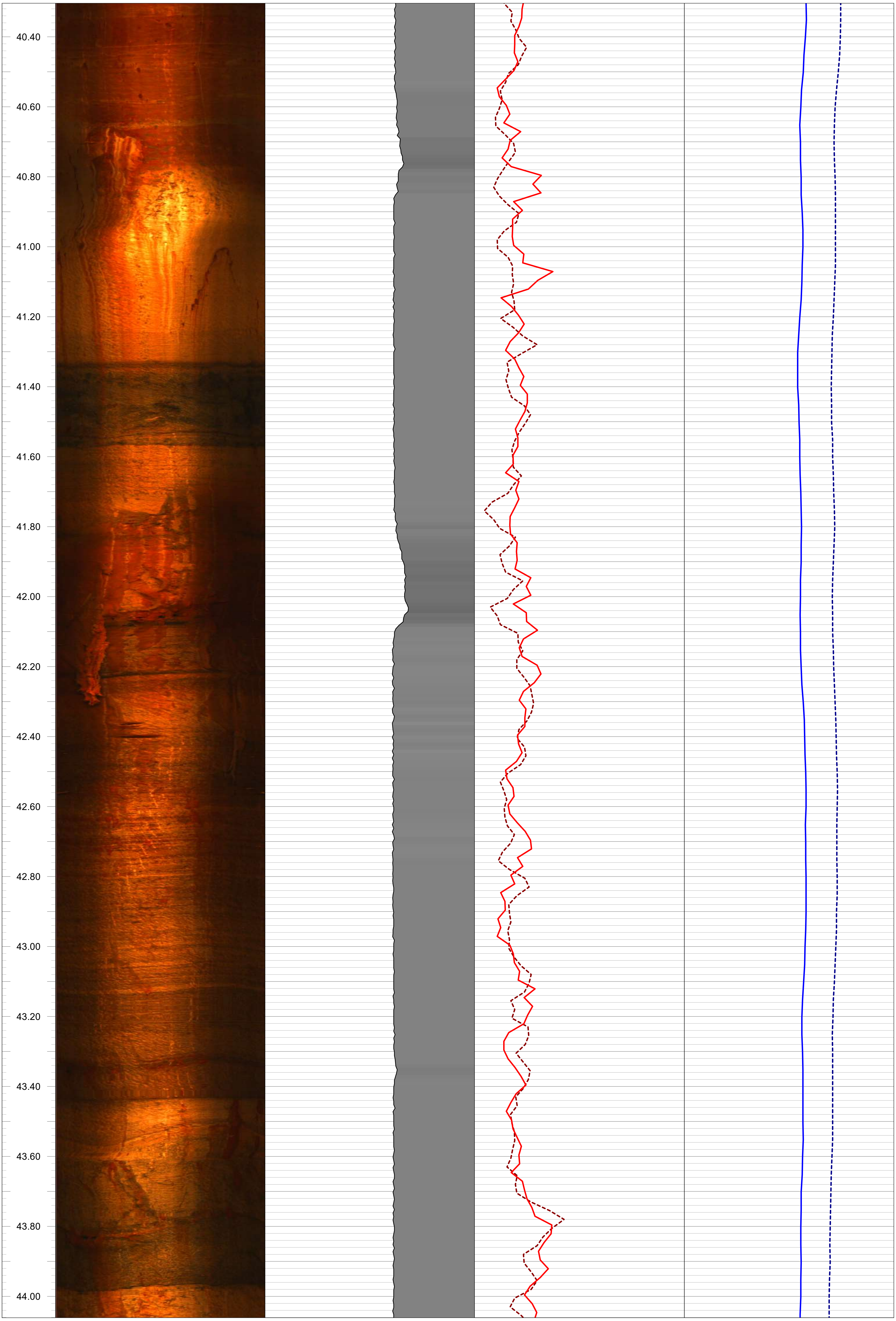
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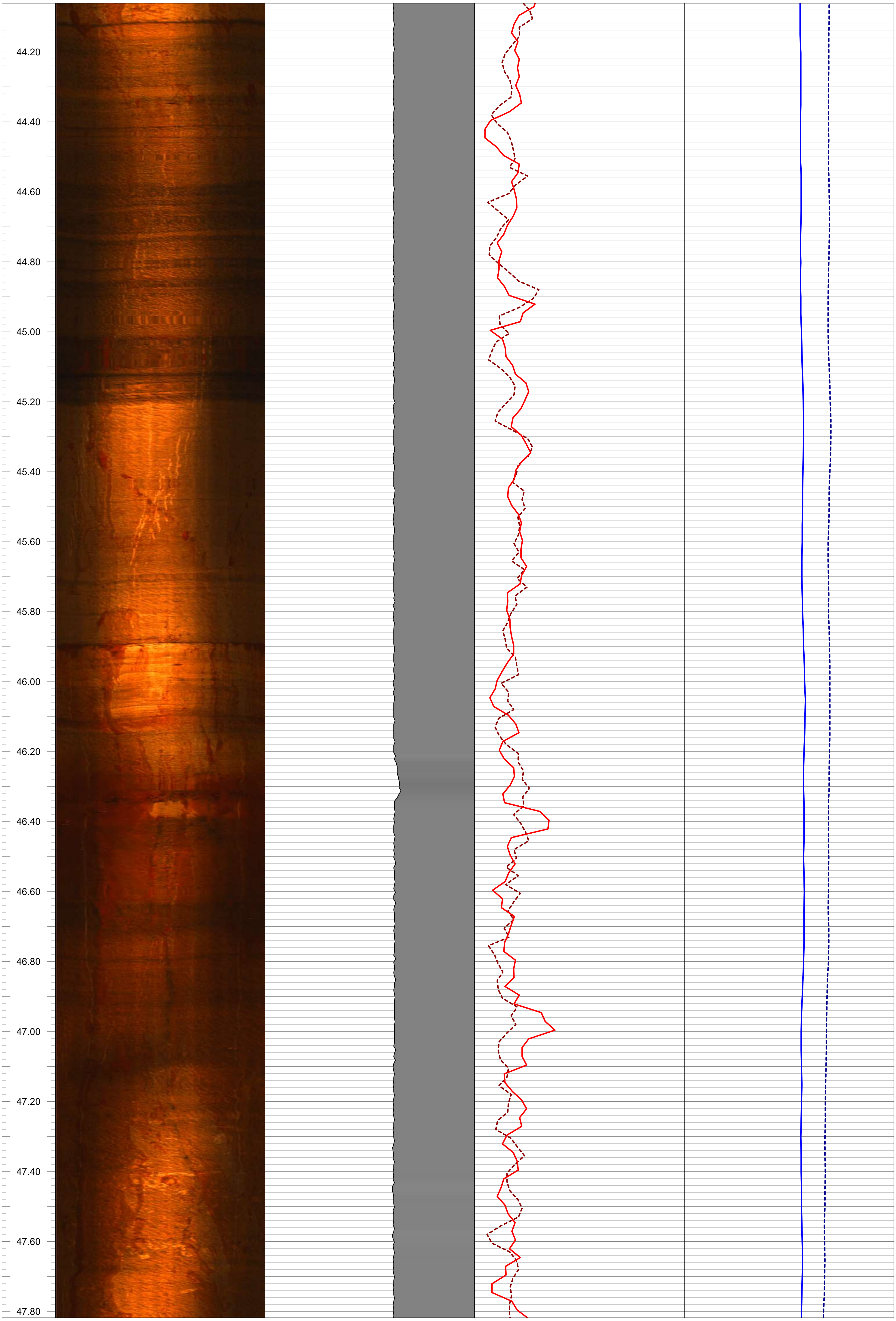
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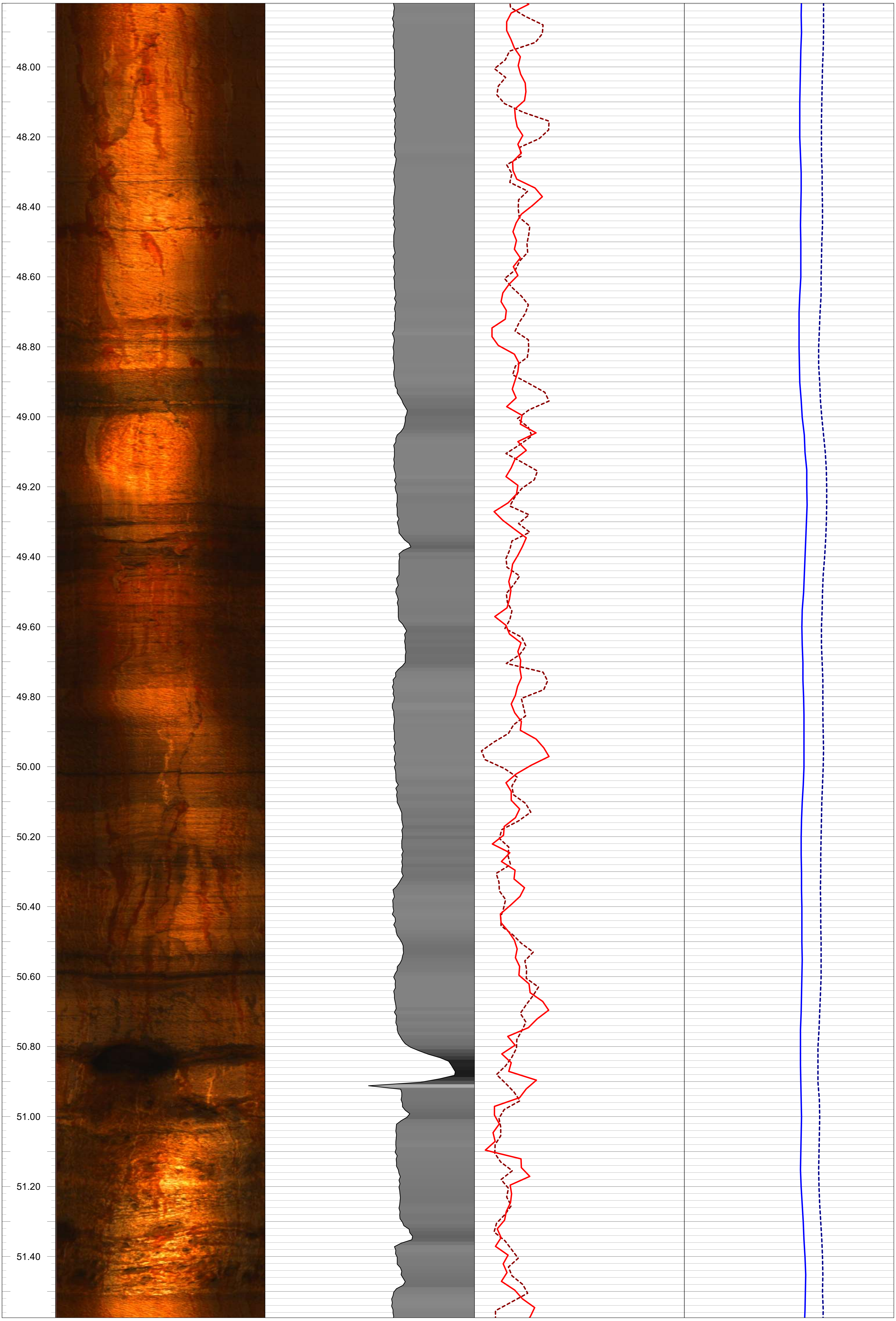
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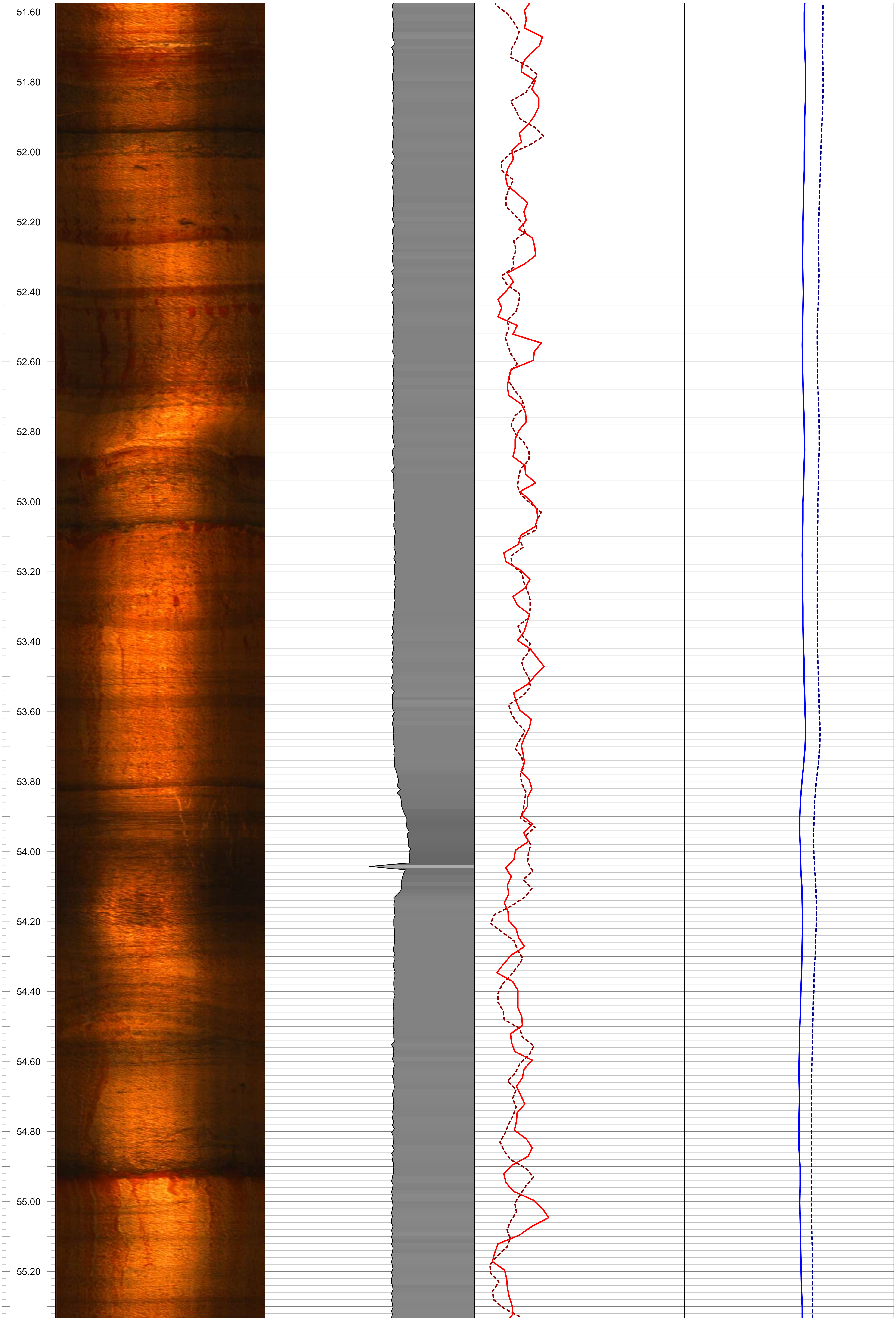
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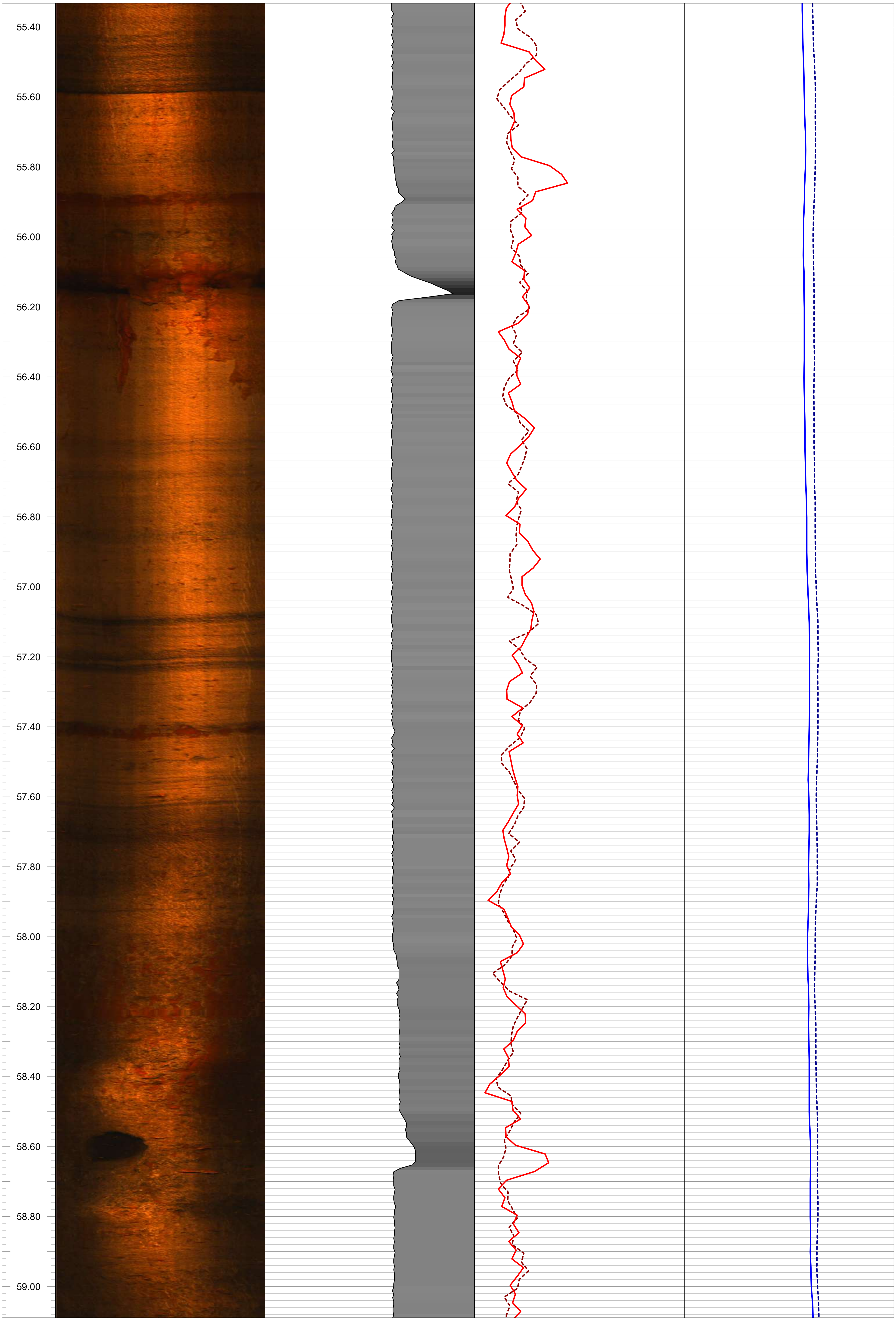
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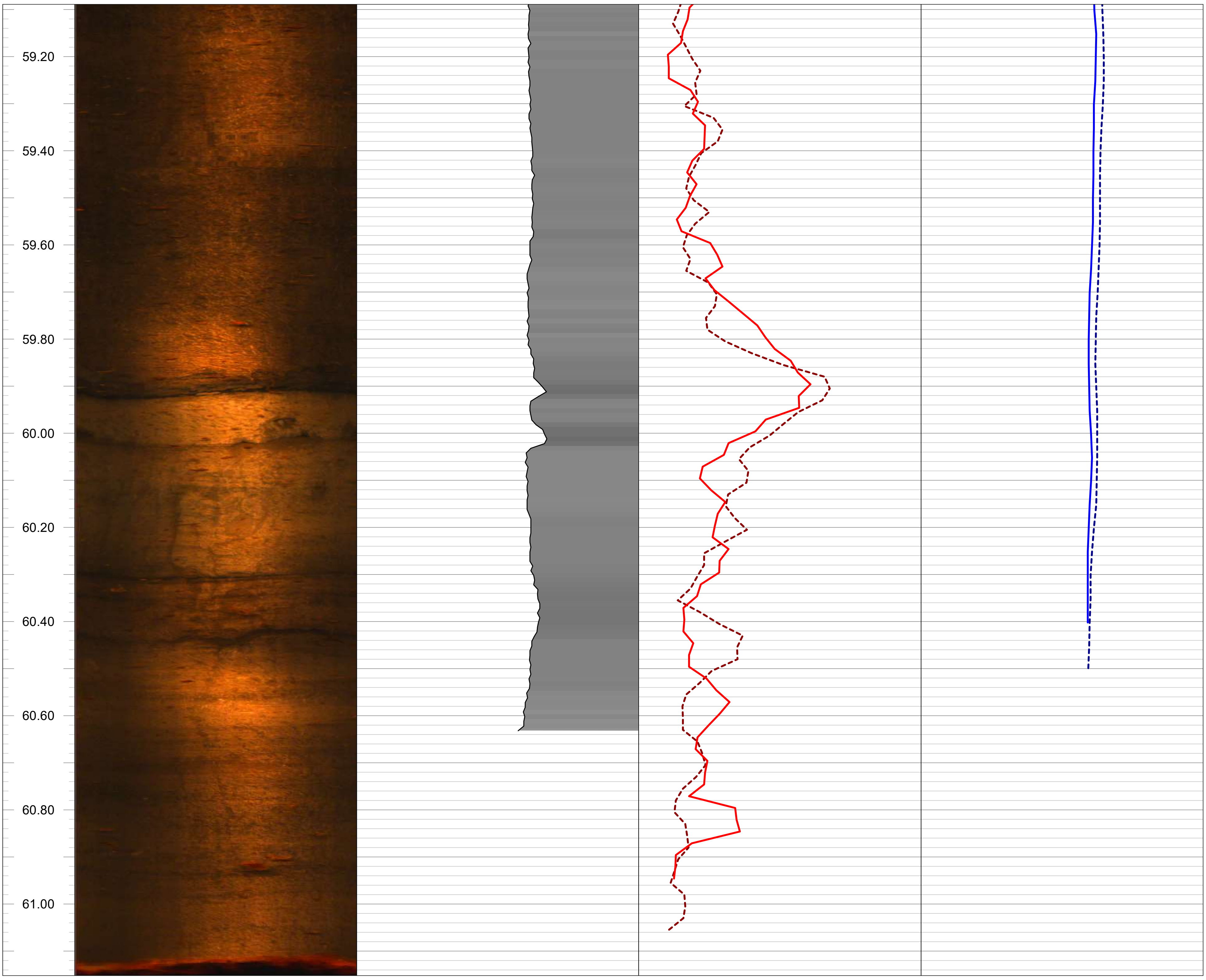
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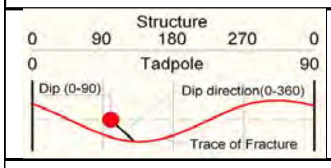
GEOPHYSICAL RECORD OF BOREHOLE: MW17-03
Project Number: 1781508
Client:
Date: January 2018

Datum:
Easting:
Northing:
Elevation:
Depth Reference:
Drilled Depth:
Borehole Diameter:
Casing Diameter:
Casing Depth:
Water Level:
Borehole Inclination:
Borehole Azimuth:
Location: St. Mary's
Log Date: 15-Jan-2018
Logged By: PG



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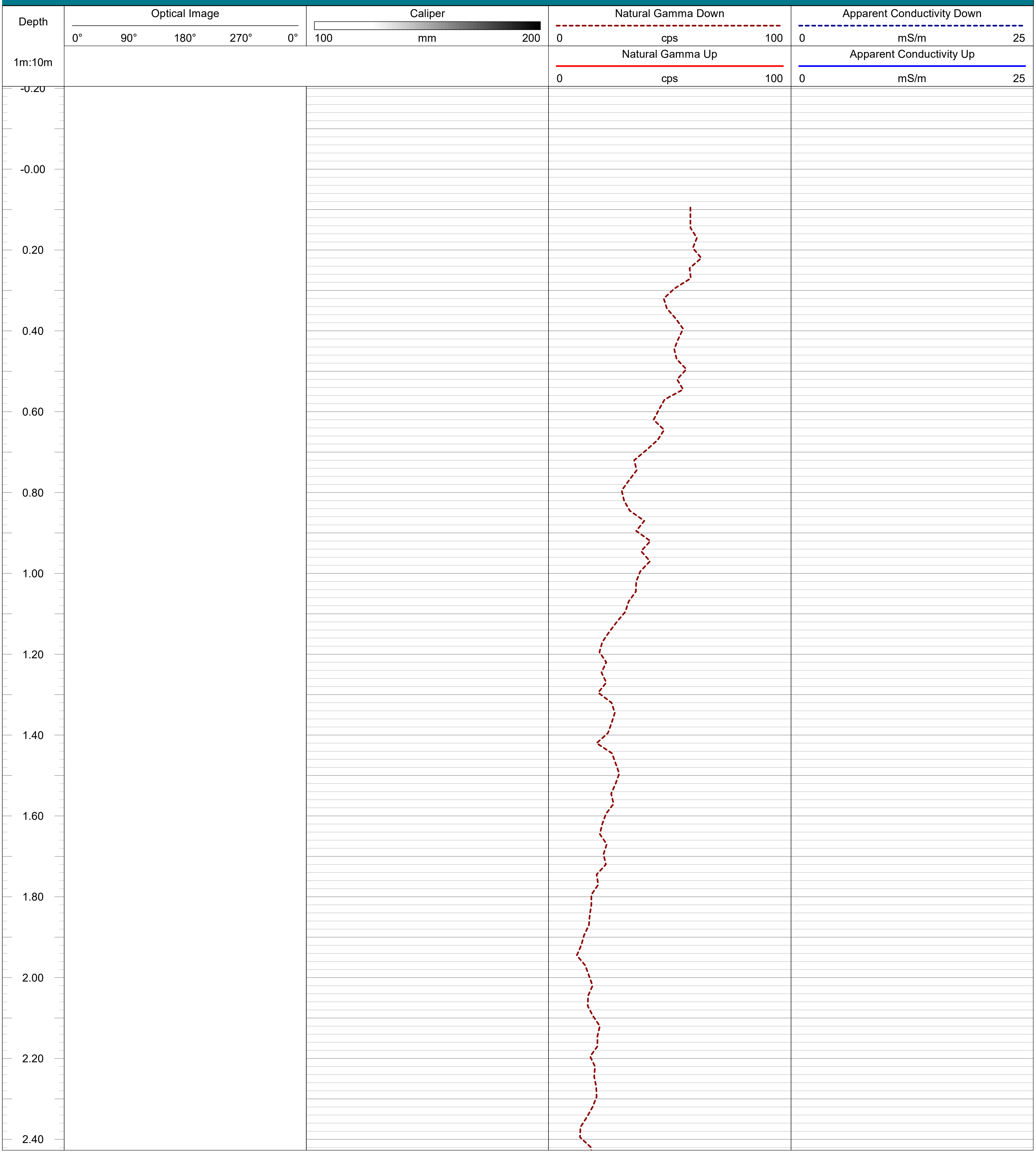

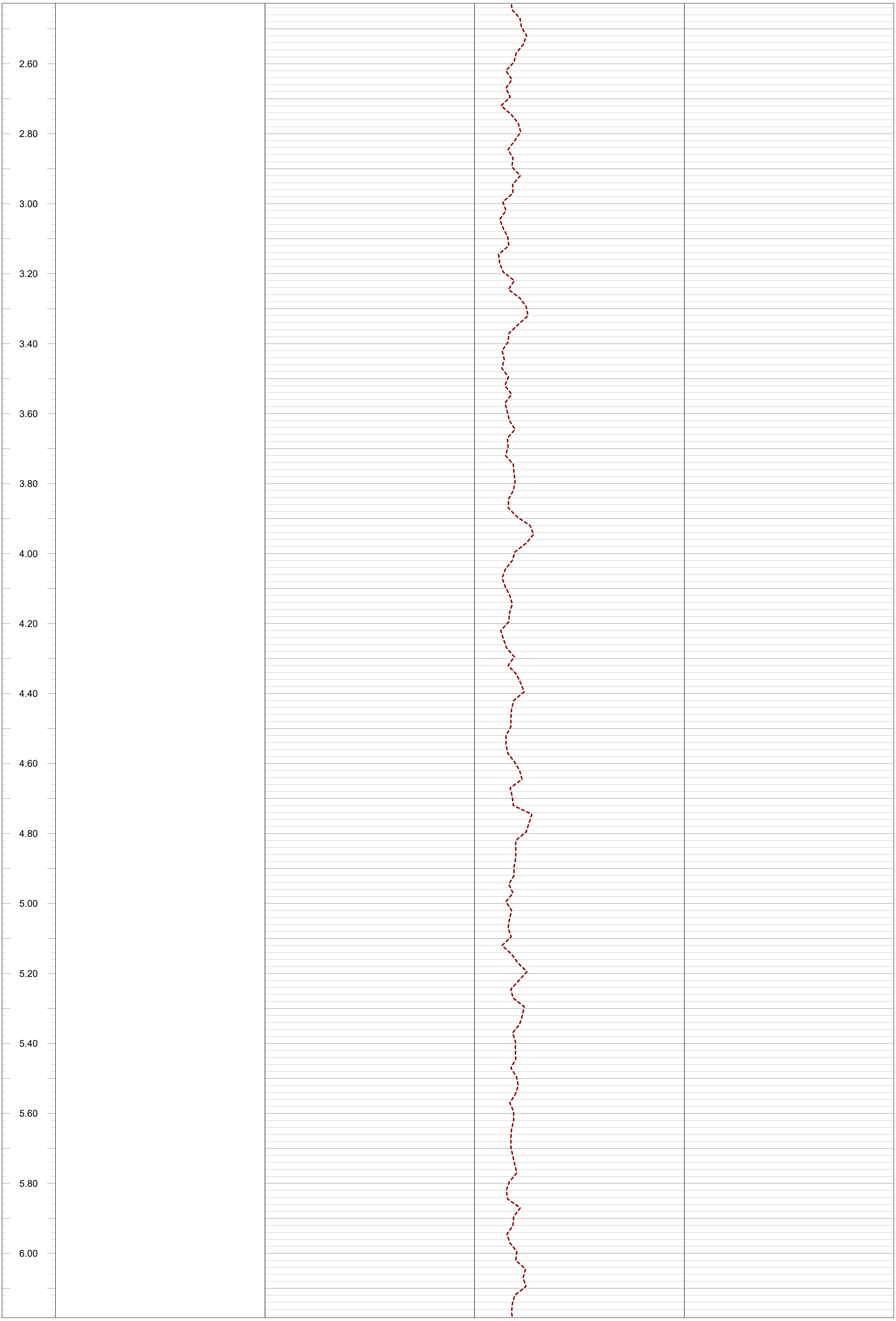
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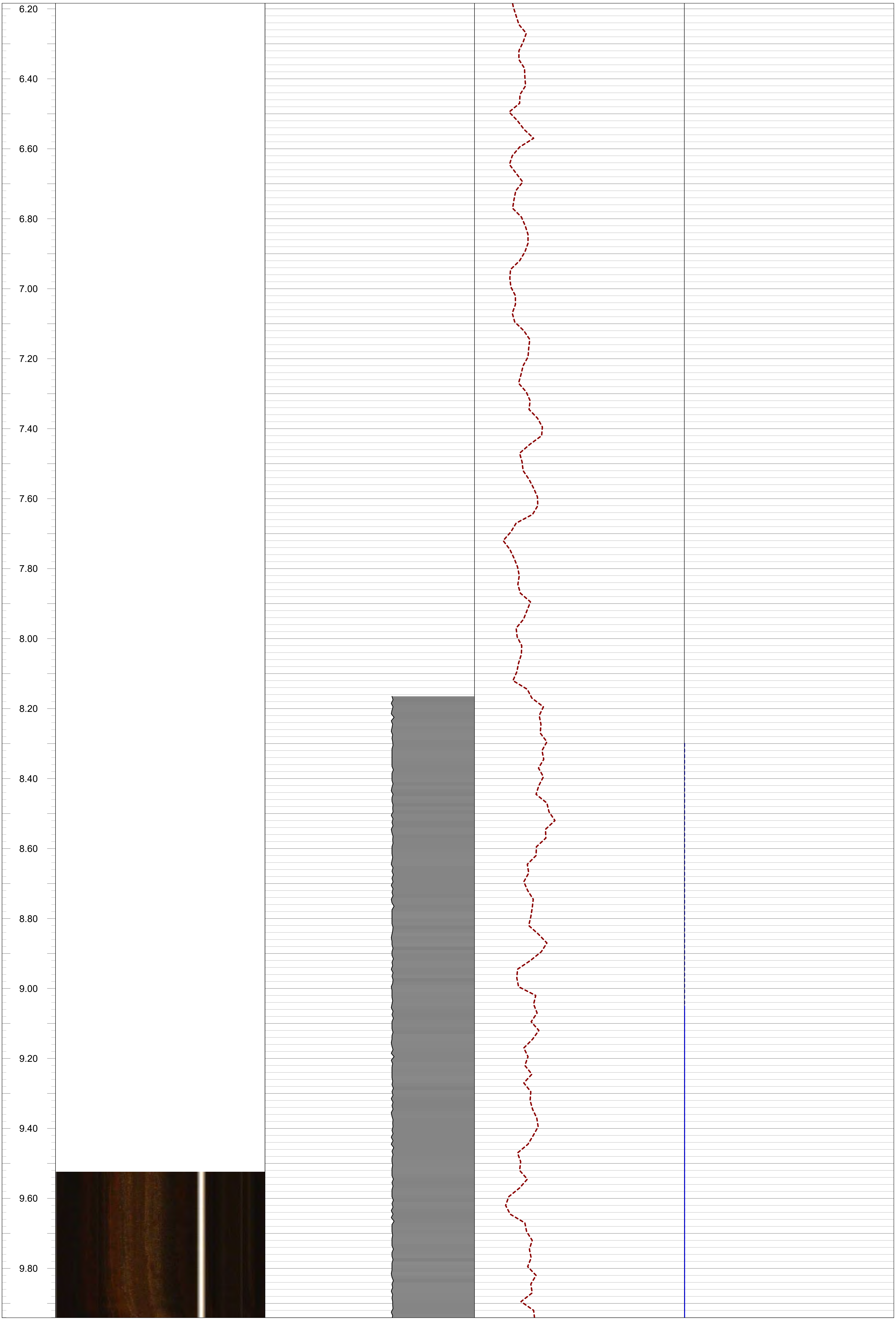
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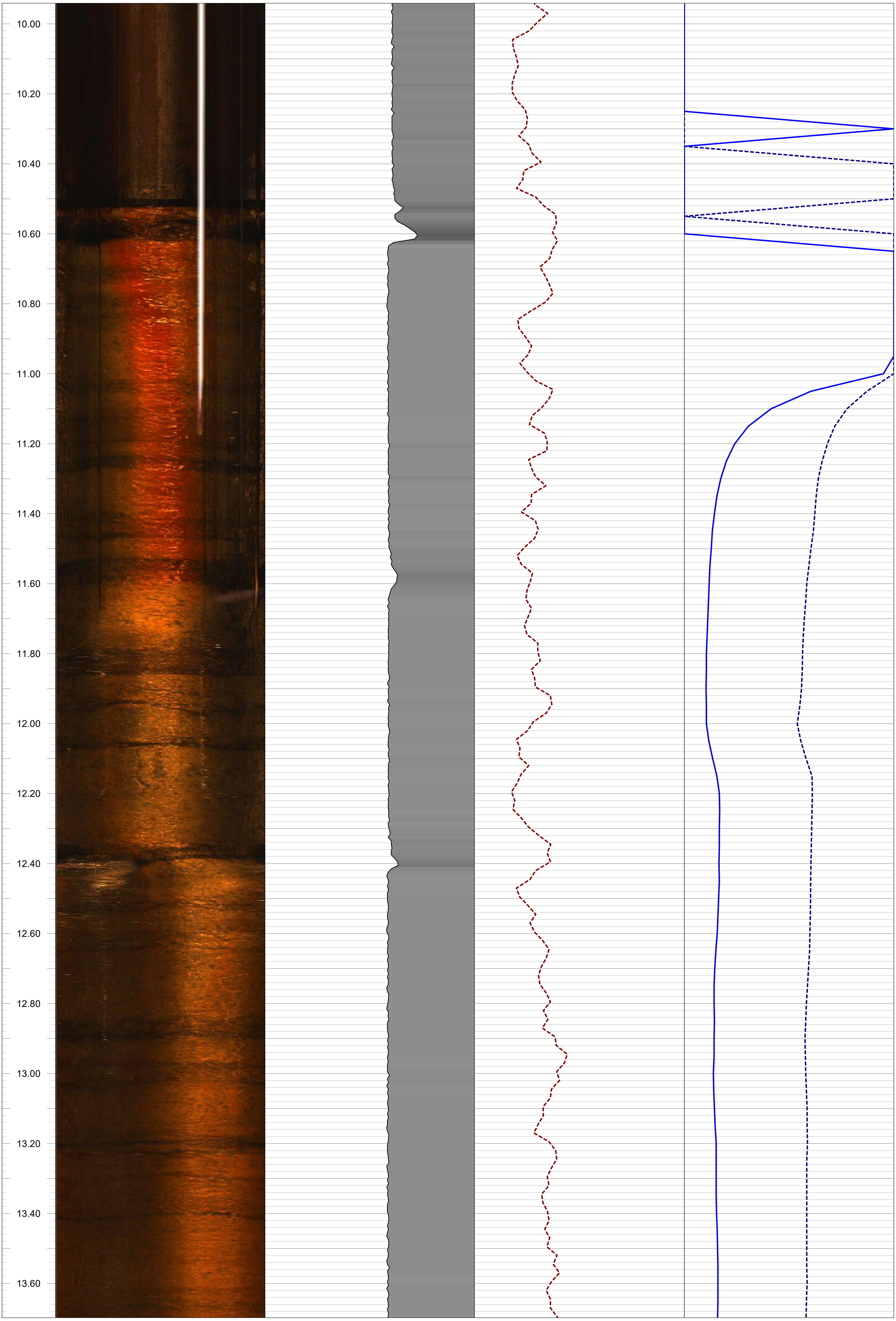
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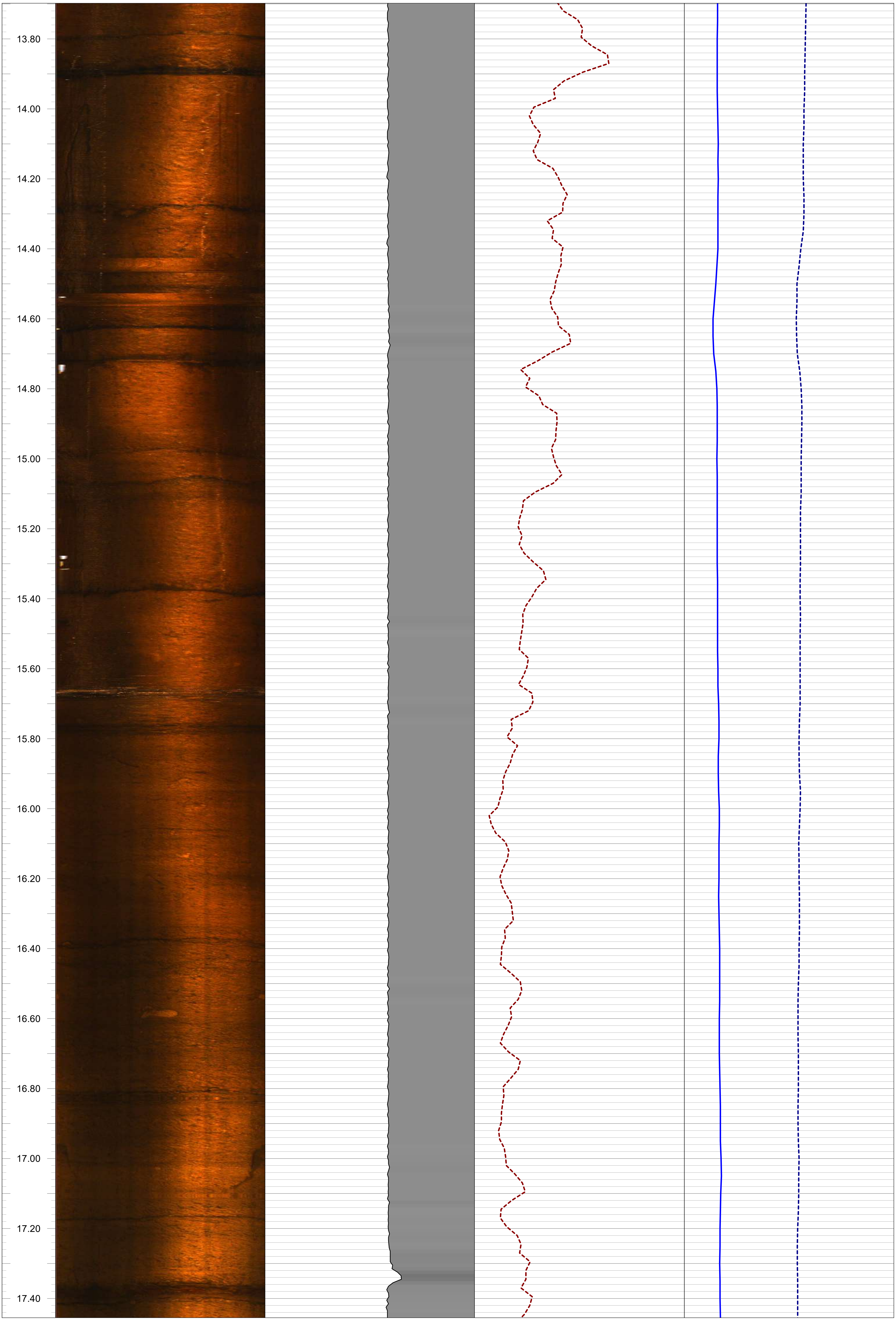
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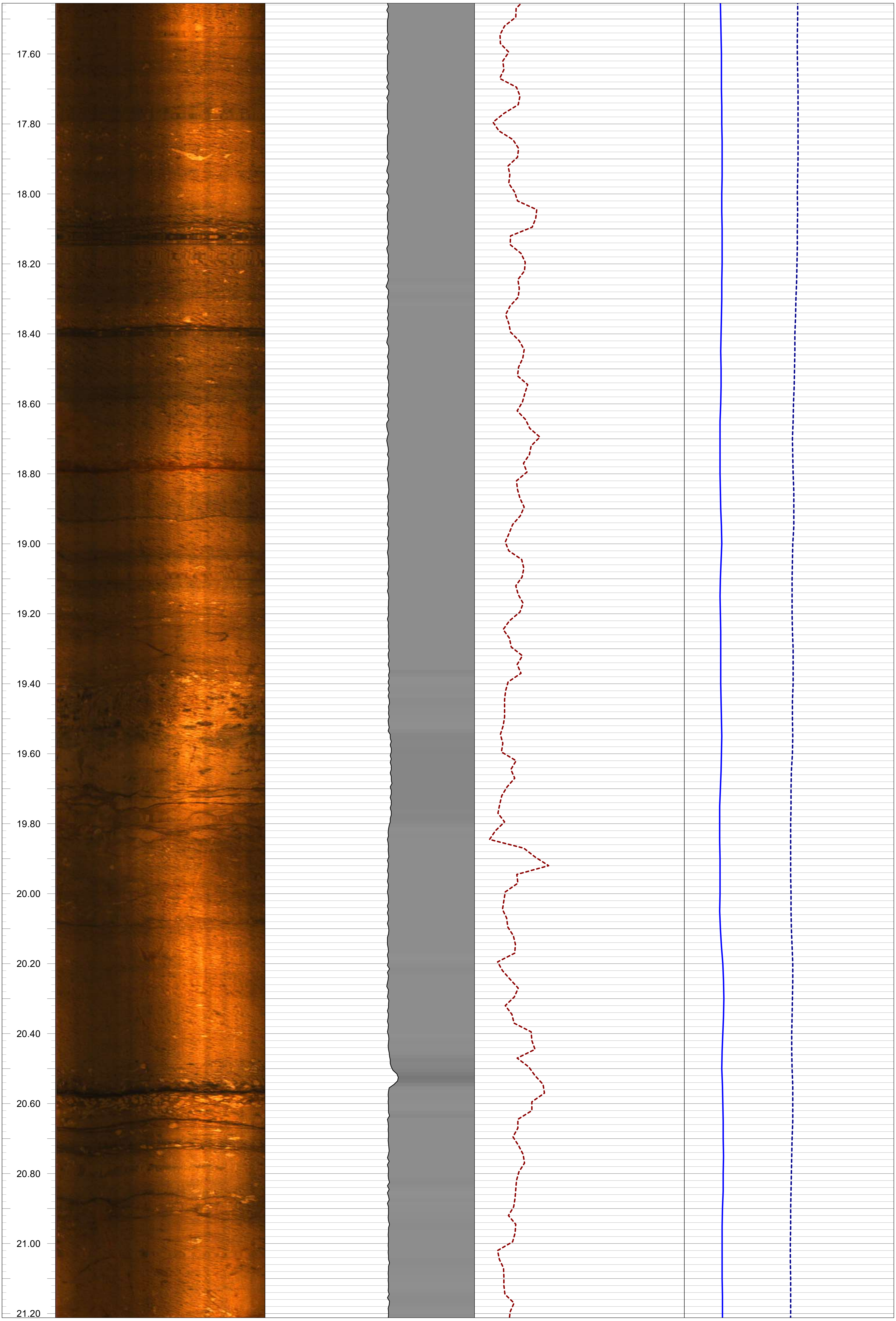
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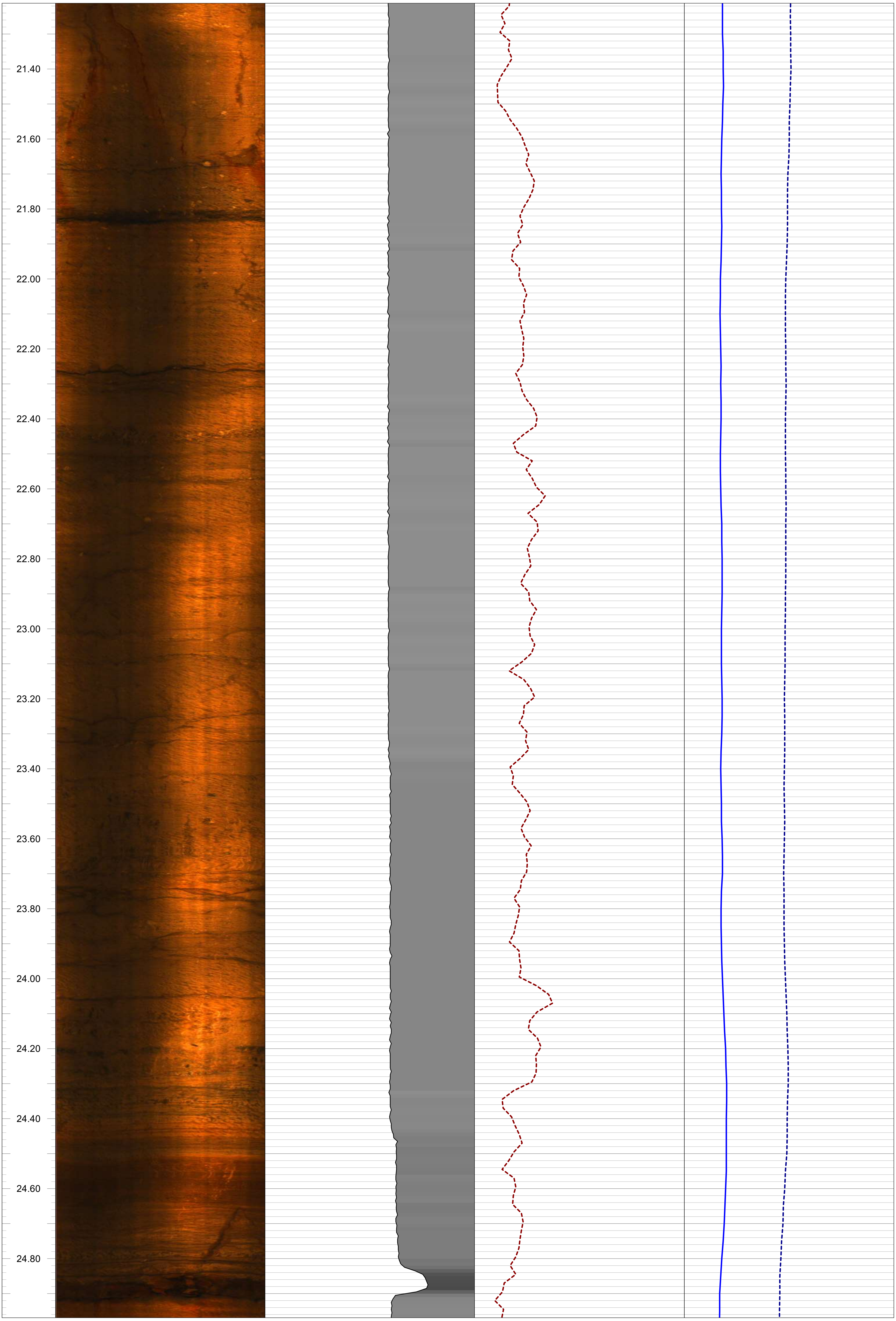
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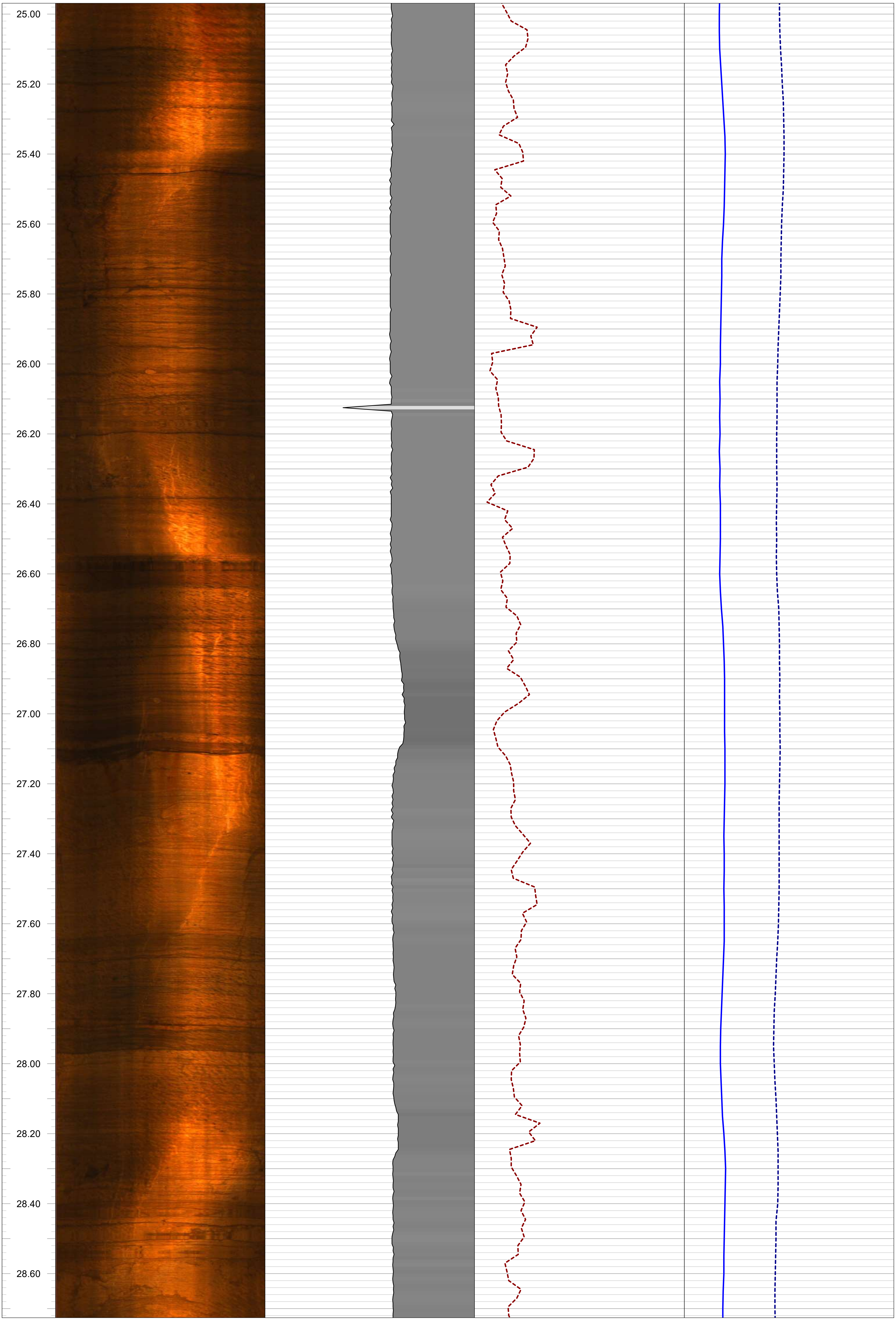
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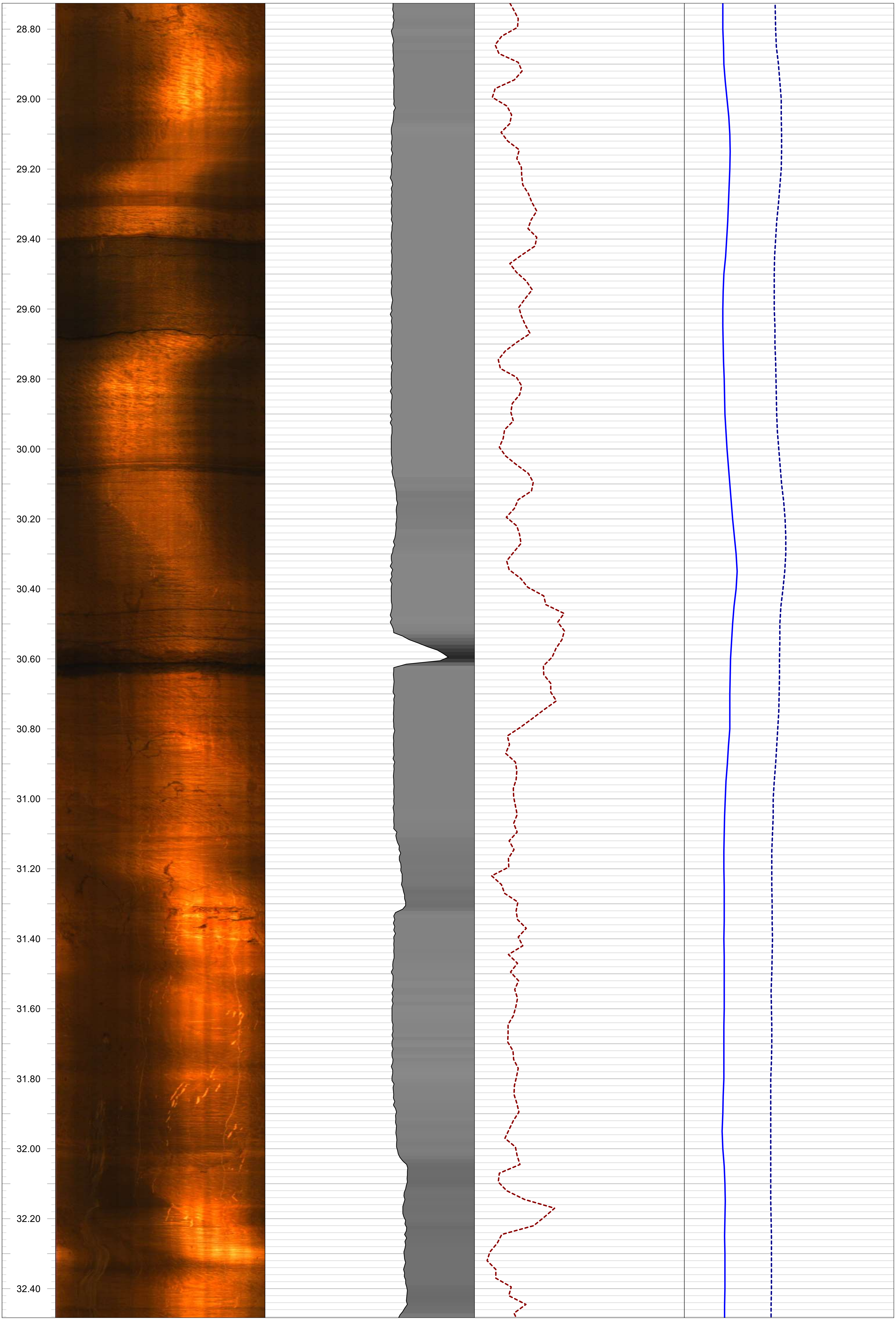
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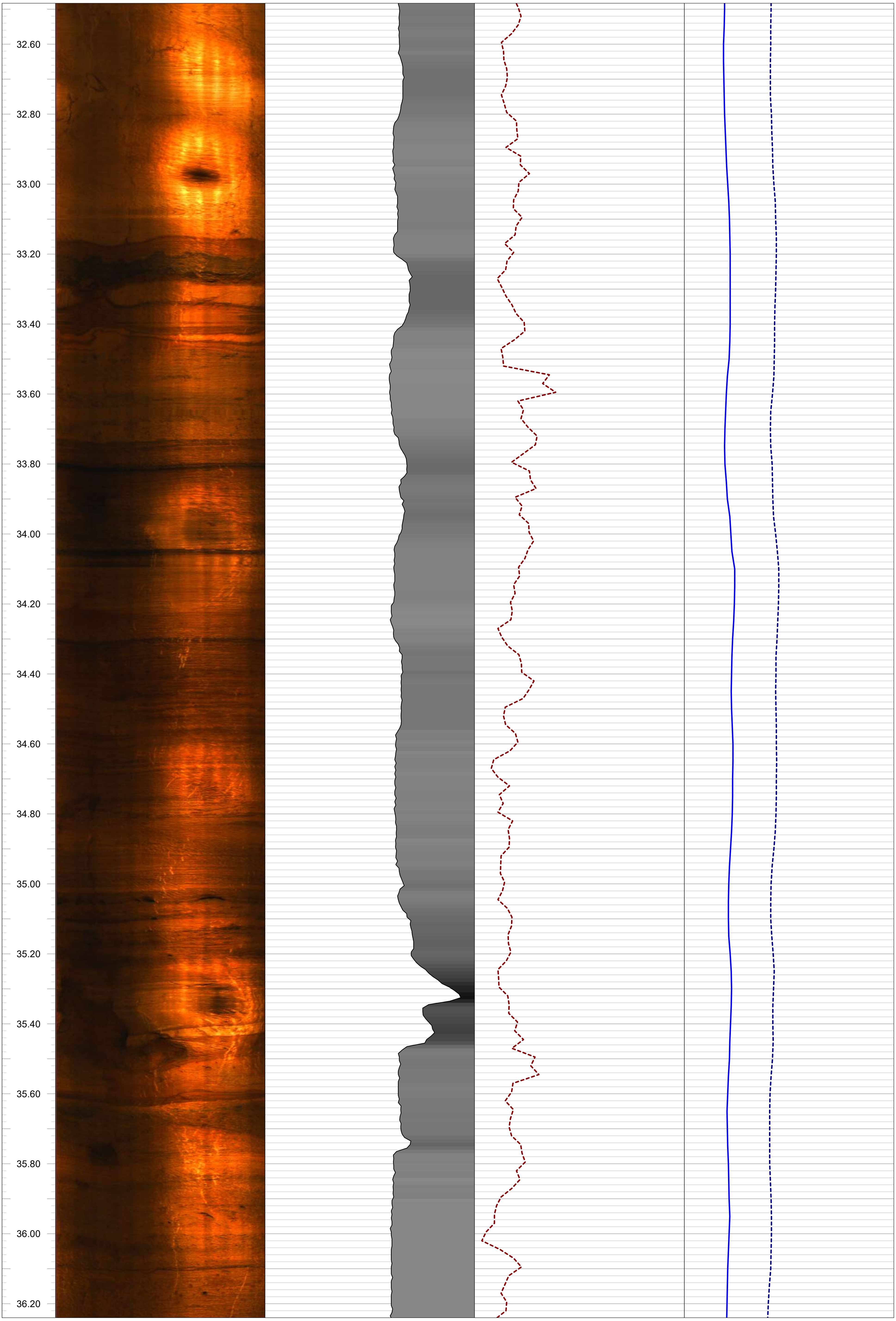
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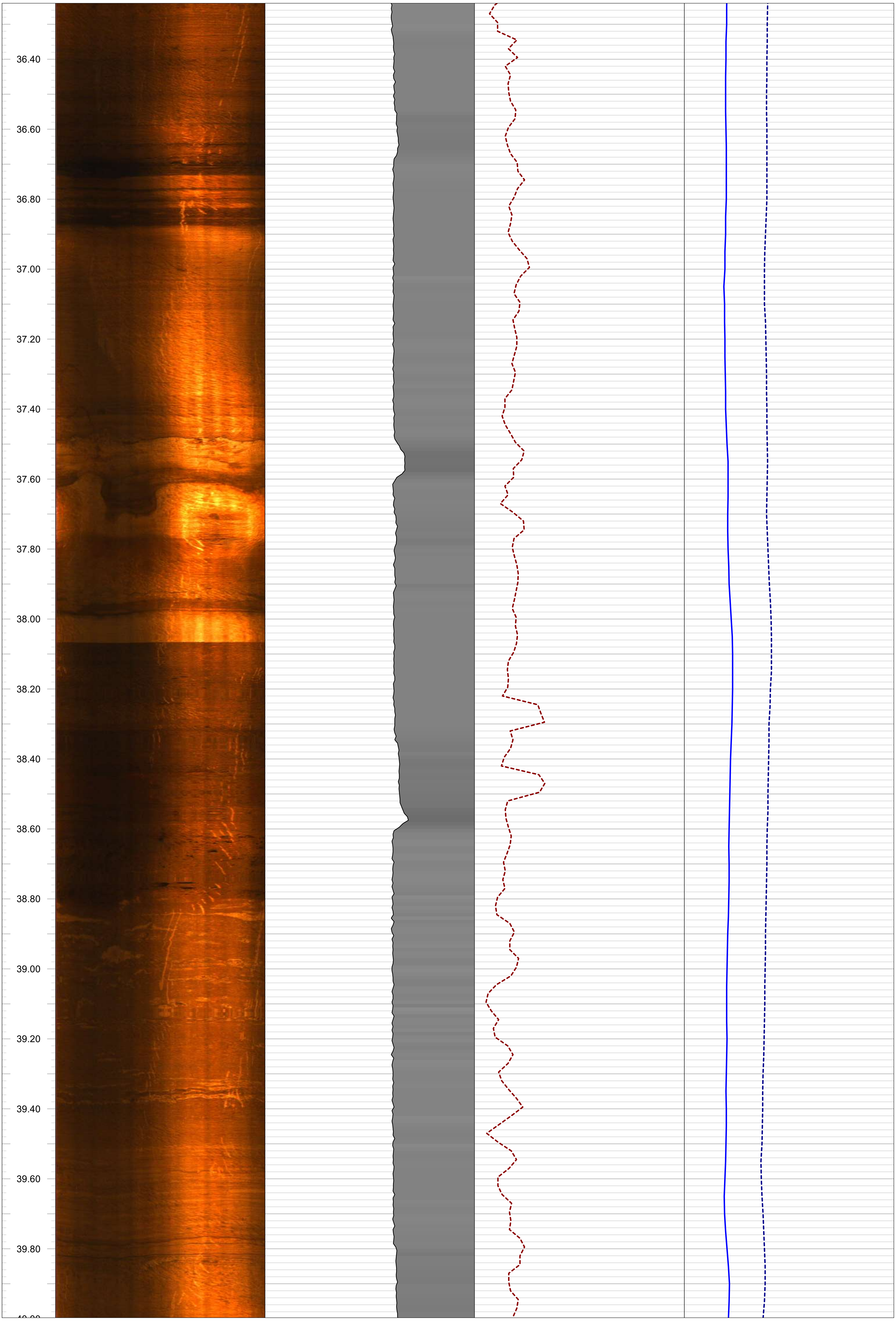
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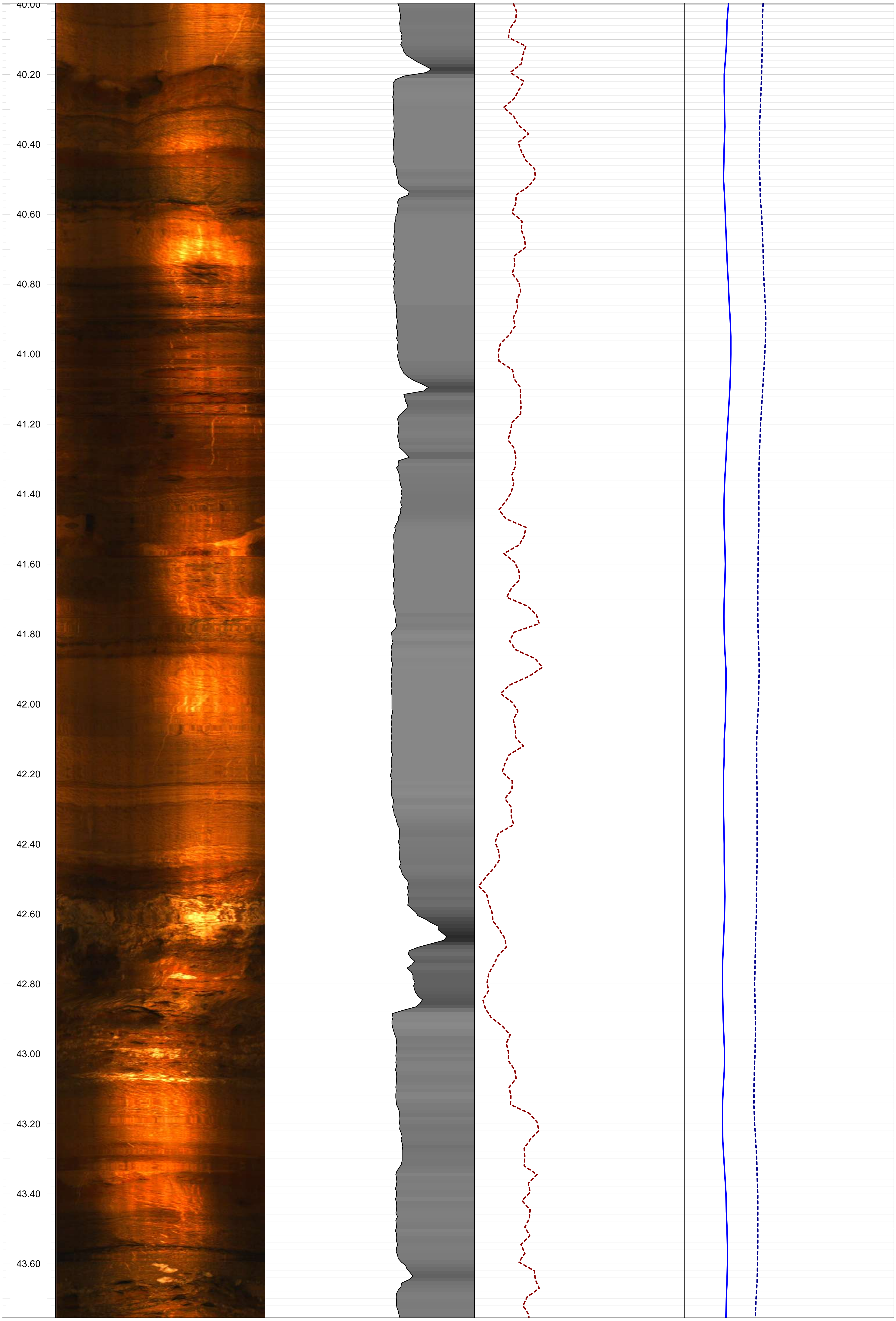
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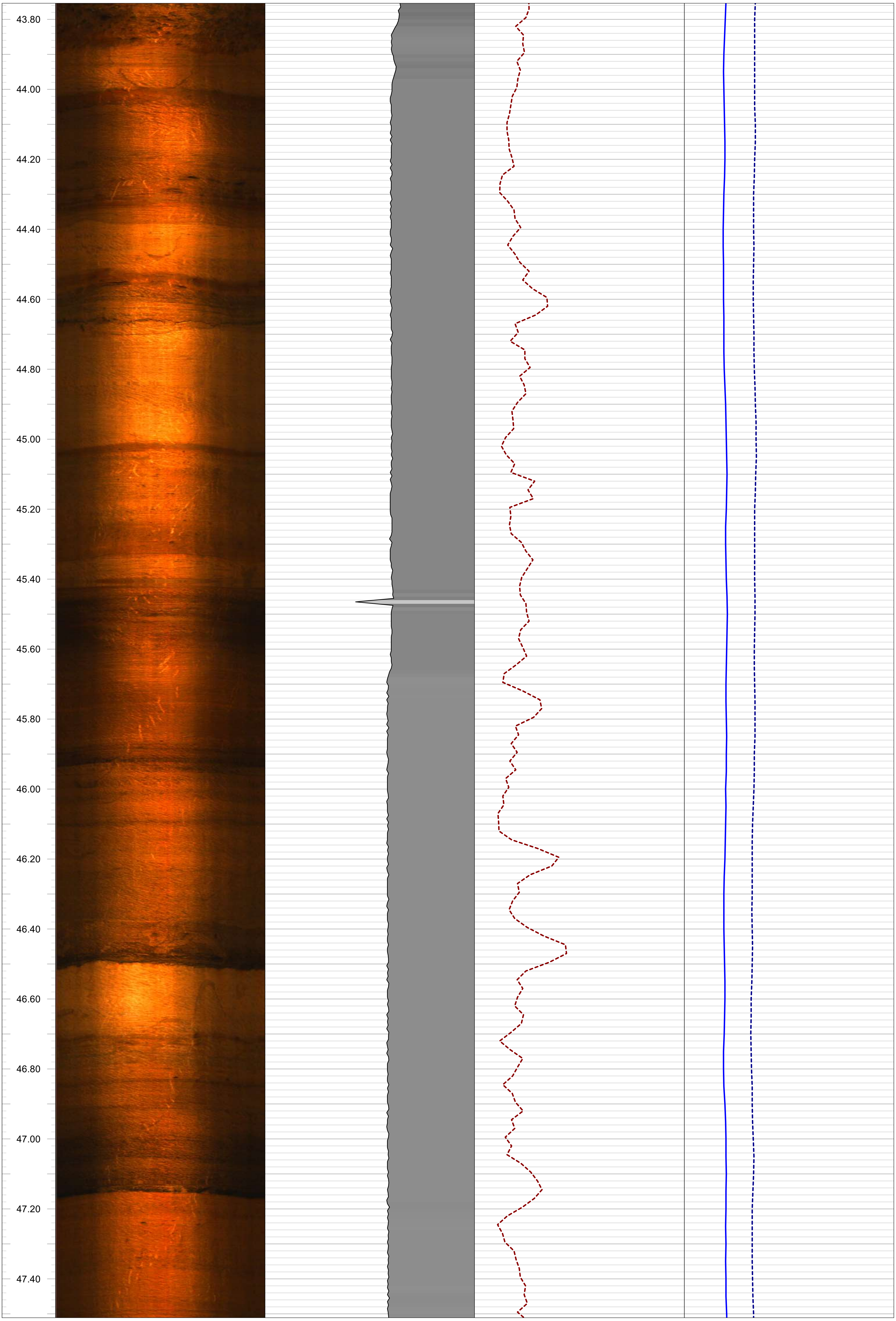
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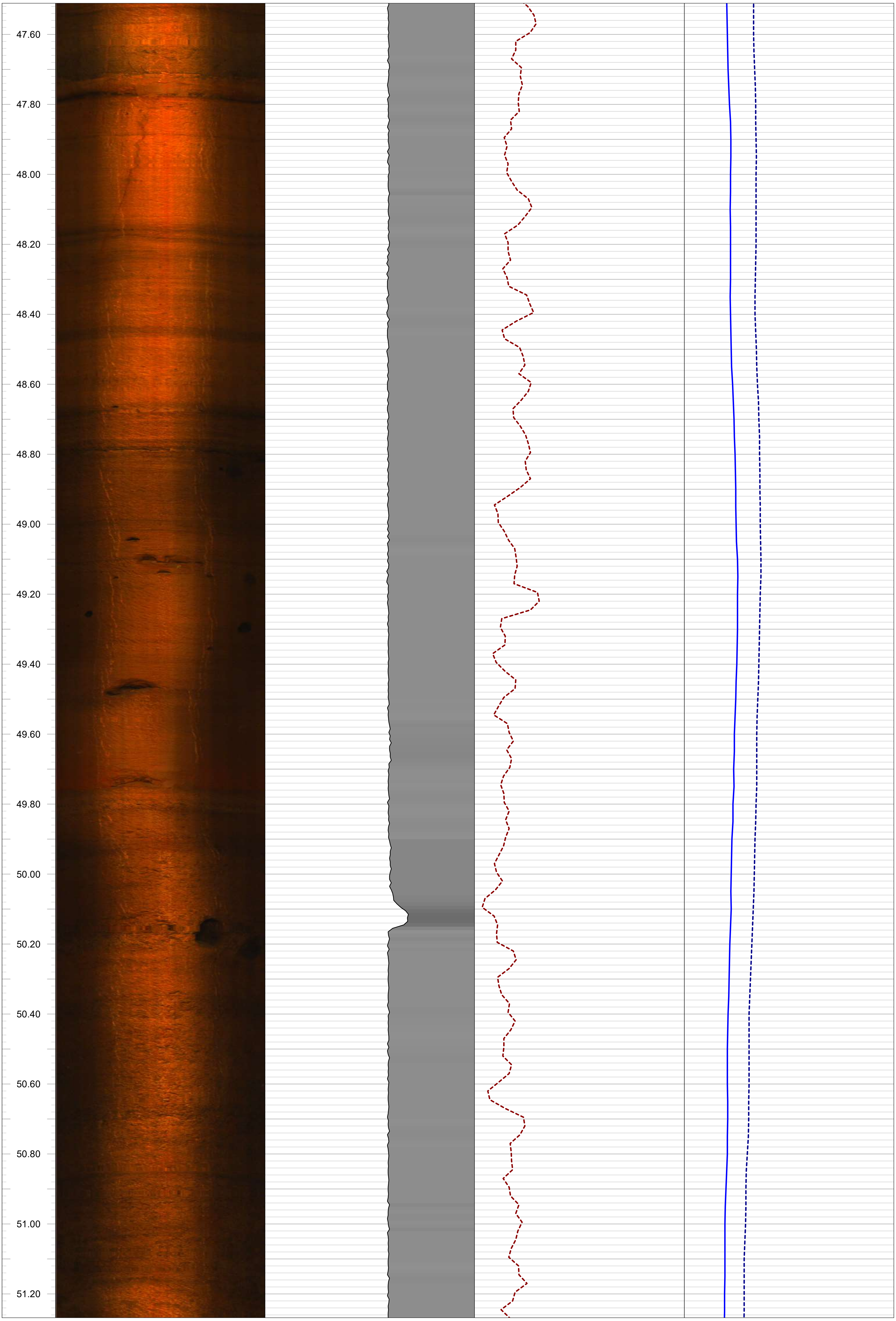
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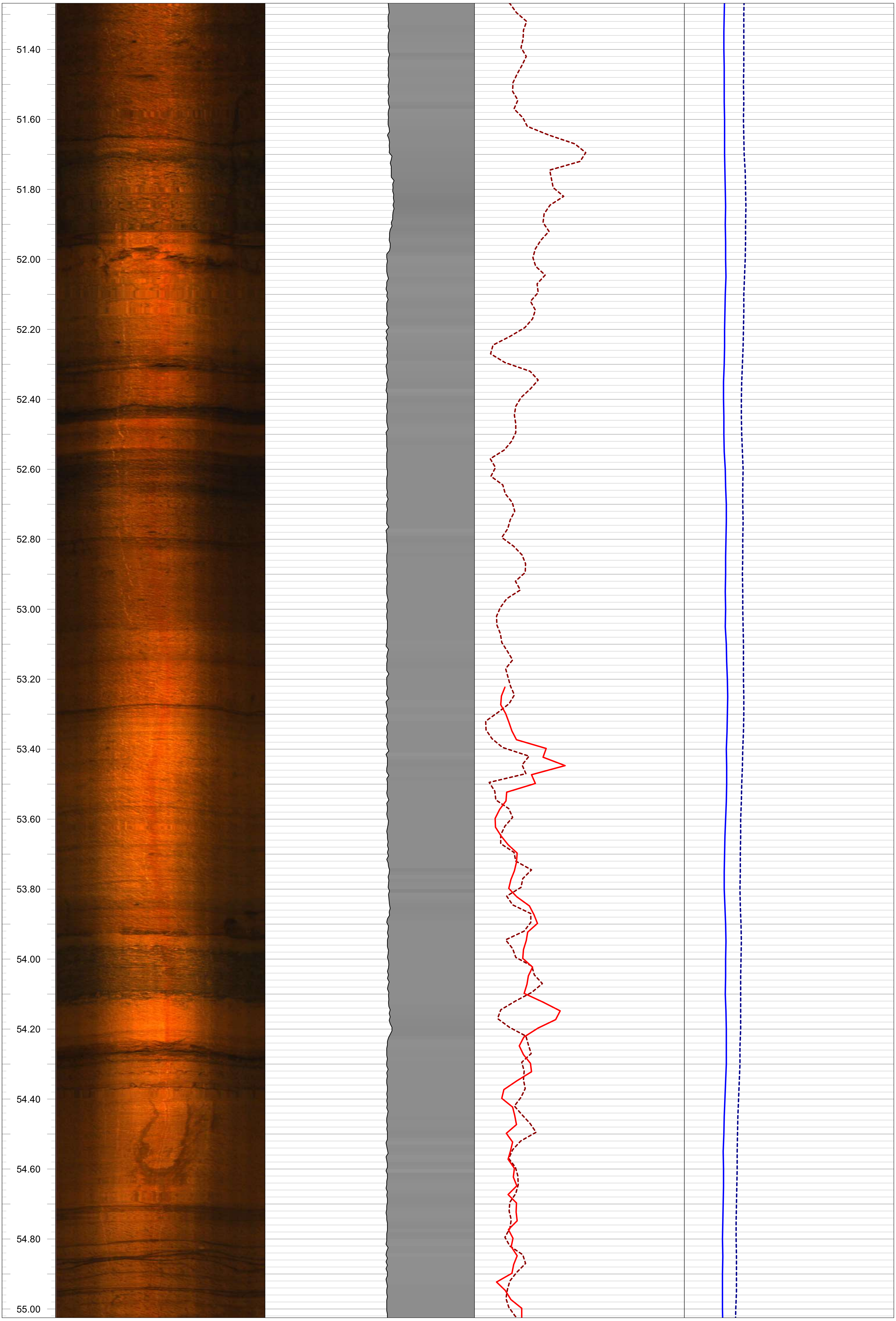
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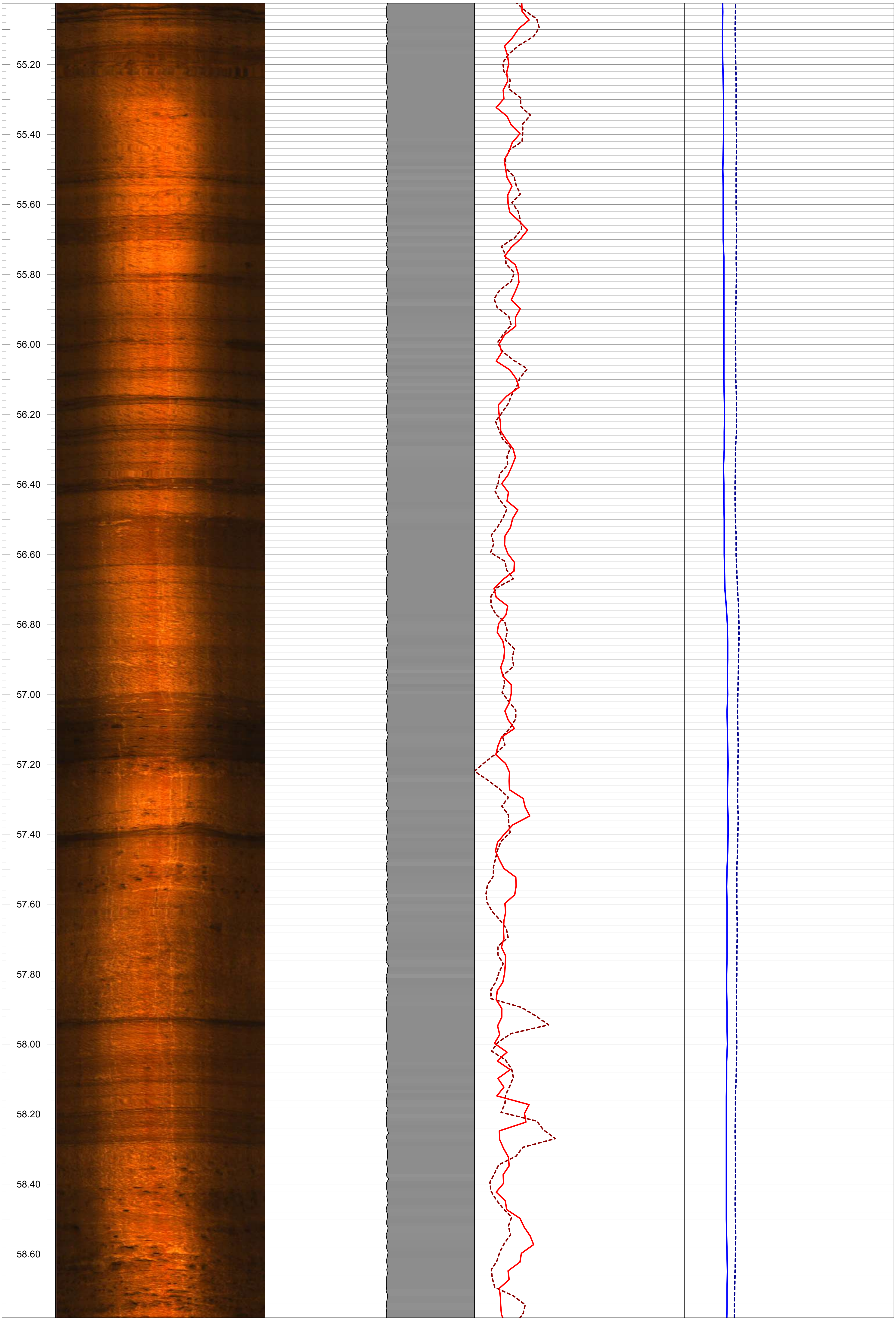
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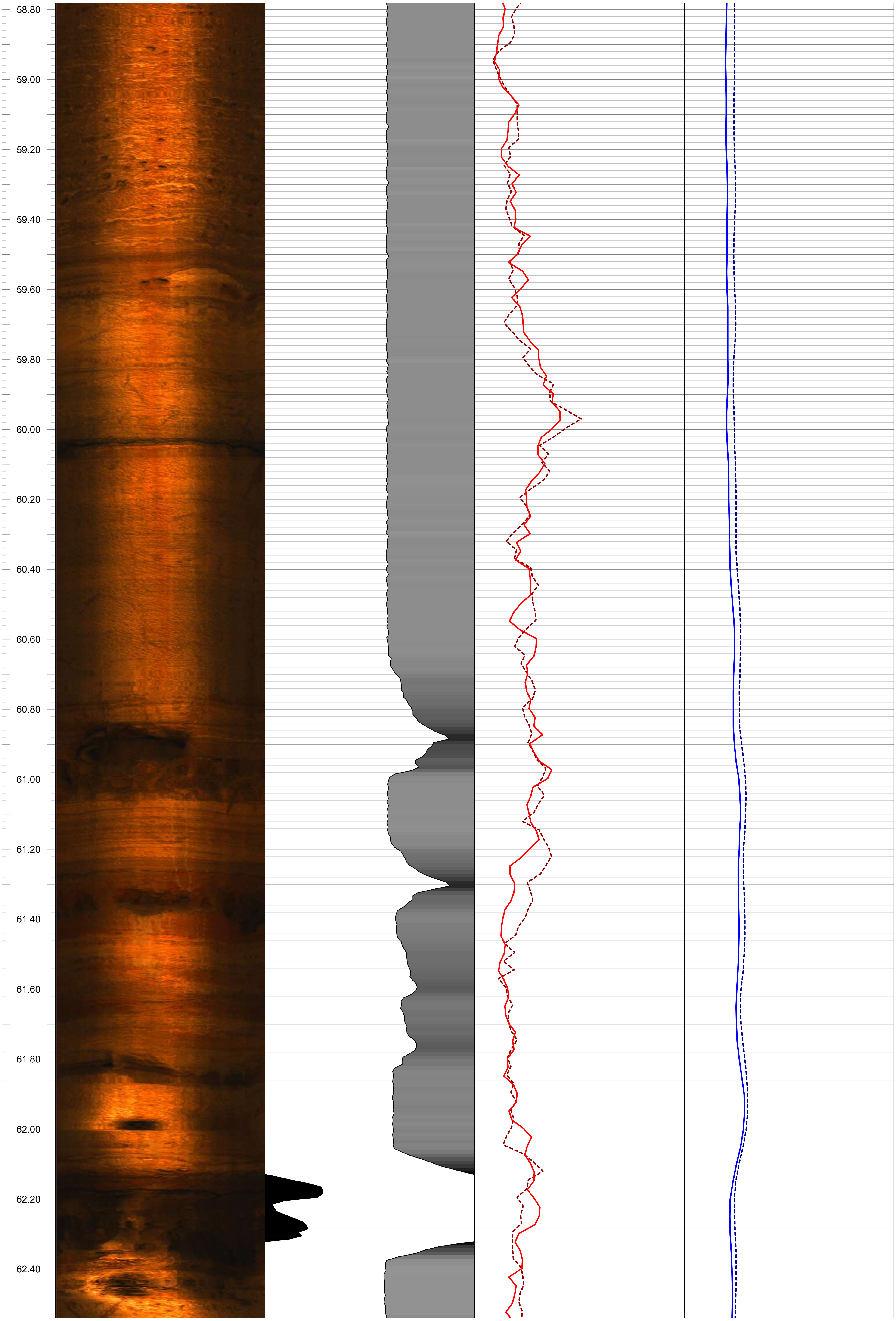
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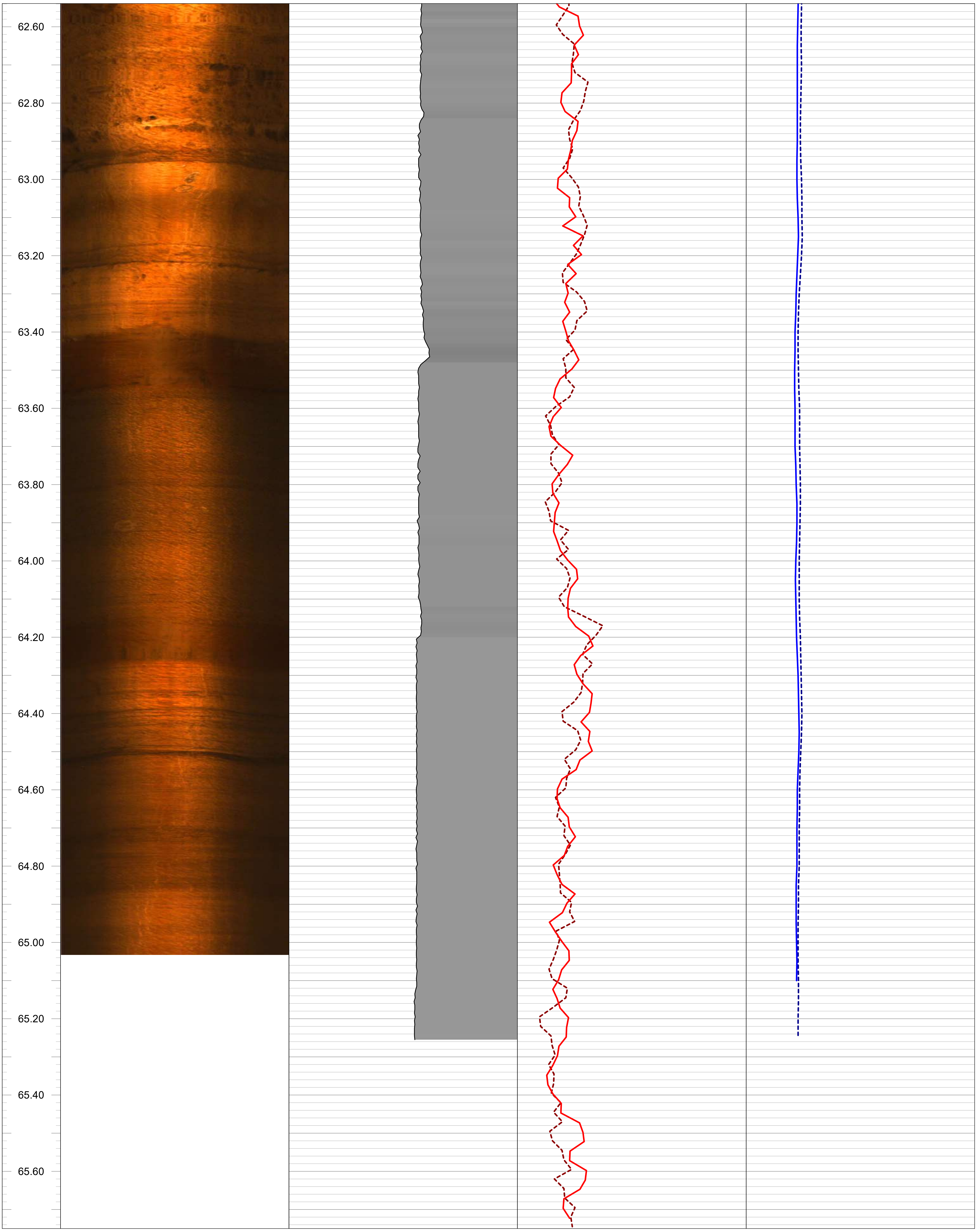
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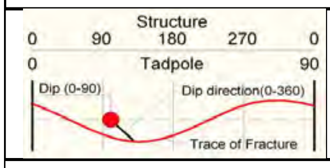
GEOPHYSICAL RECORD OF BOREHOLE: MW17-04

Project Number: 1781508
Client:
Date: January 2018

Datum:	**Elevation:**	**Borehole Diameter:**	**Water Level:**	**Location:**	St. Mary's
Easting:	**Depth Reference:**	**Casing Diameter:**	**Borehole Inclination:**	**Log Date:**	19-Jan-2018
Northing:	**Drilled Depth:**	**Casing Depth:**	**Borehole Azimuth:**	**Logged By:**	PG



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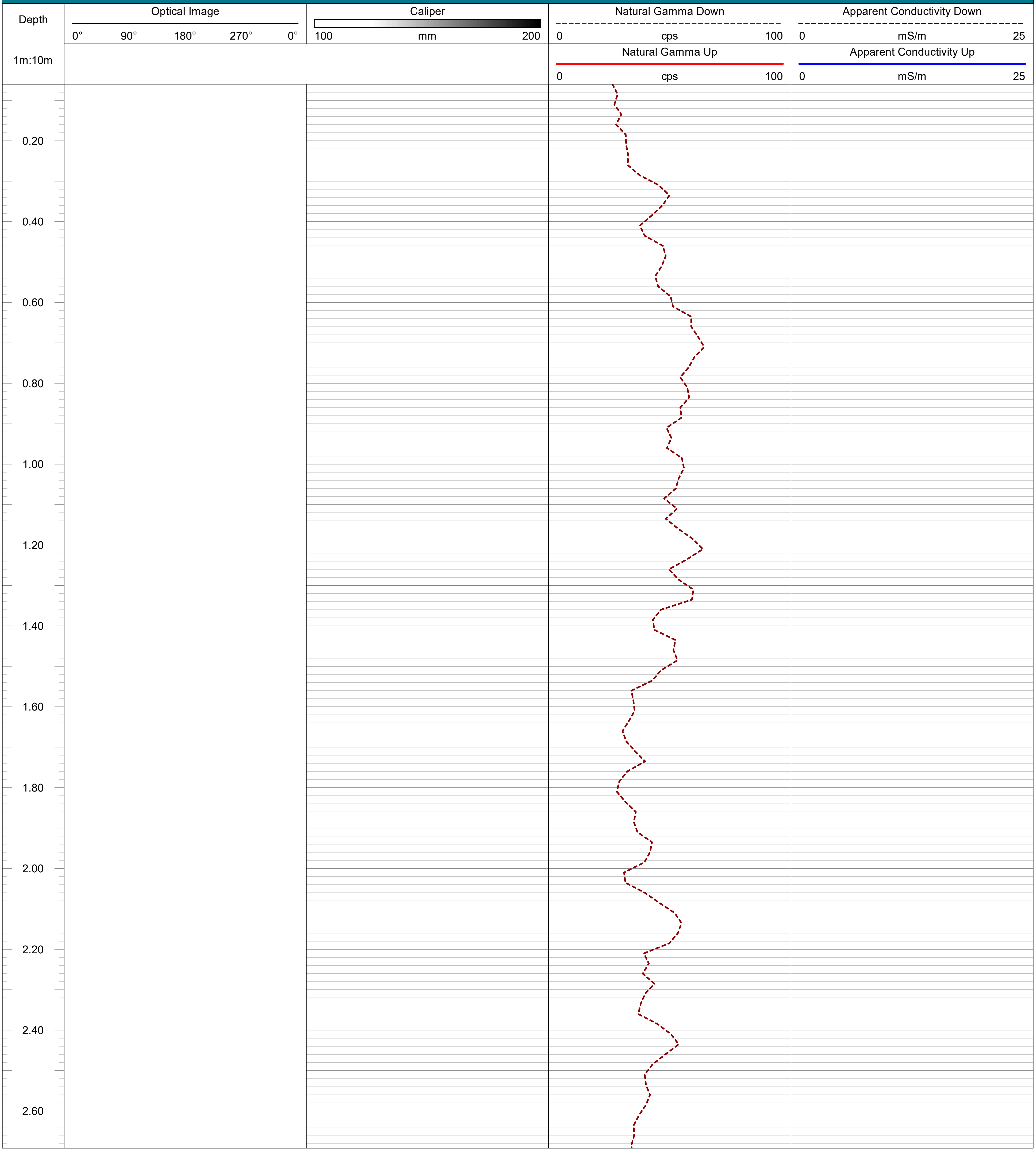

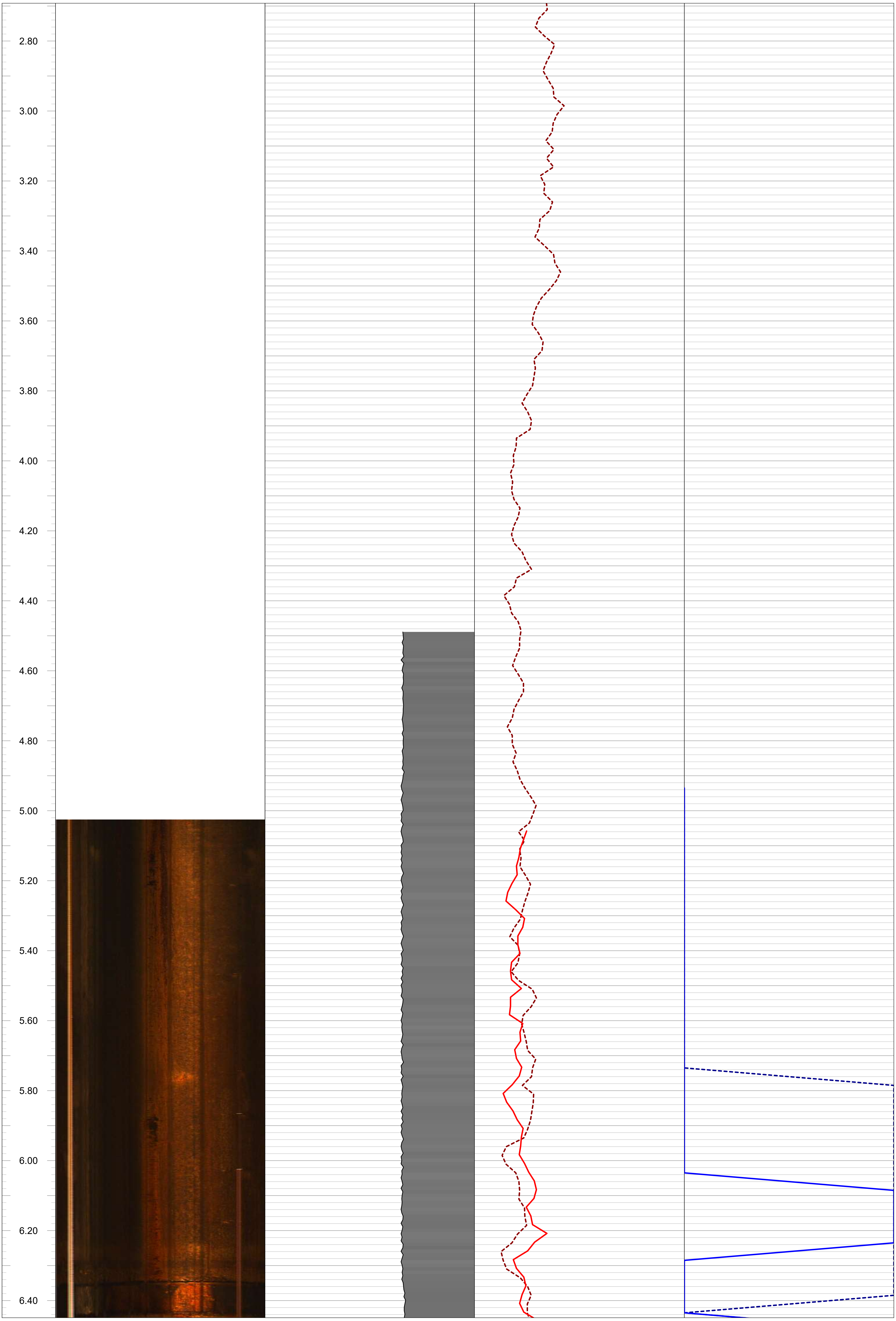
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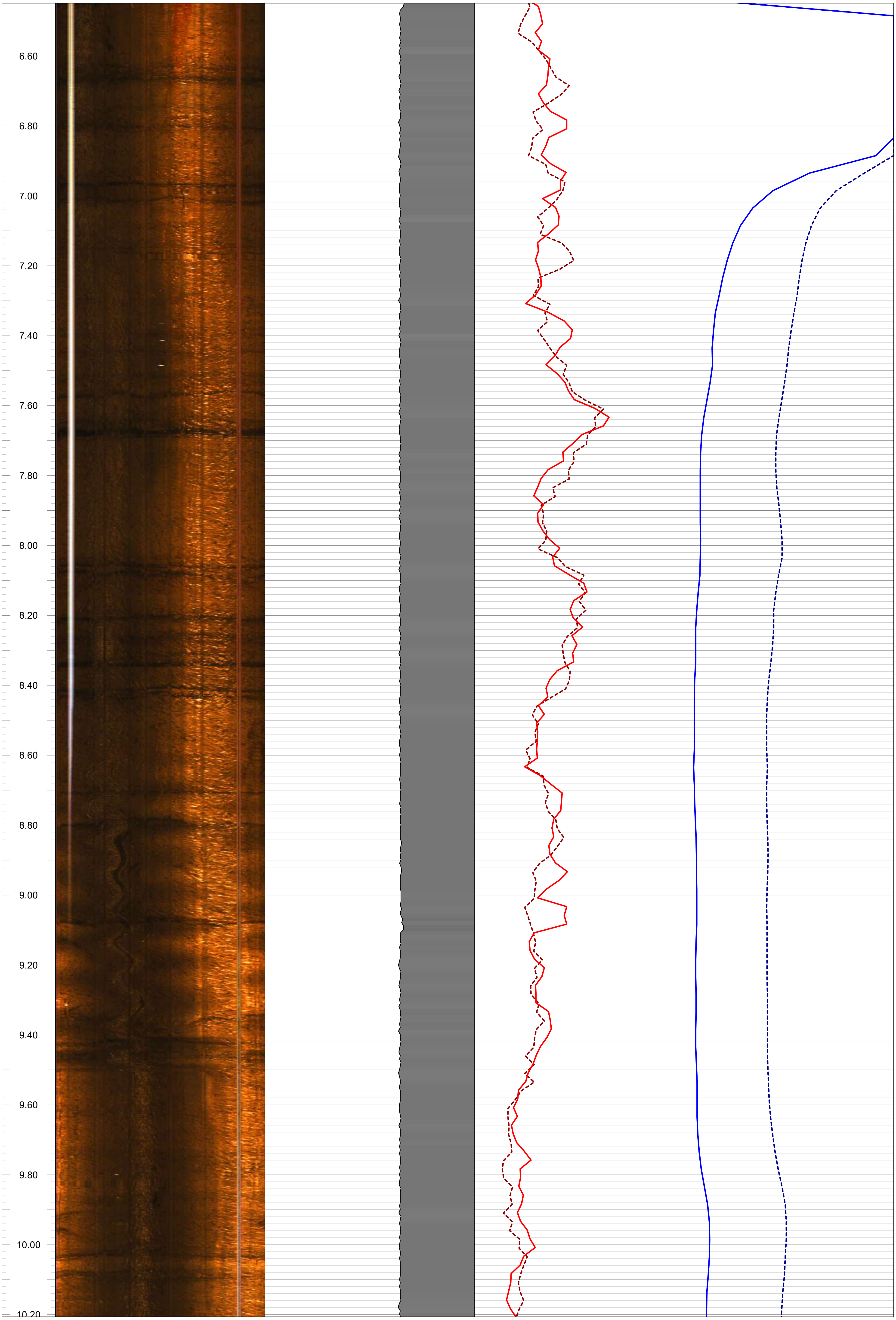
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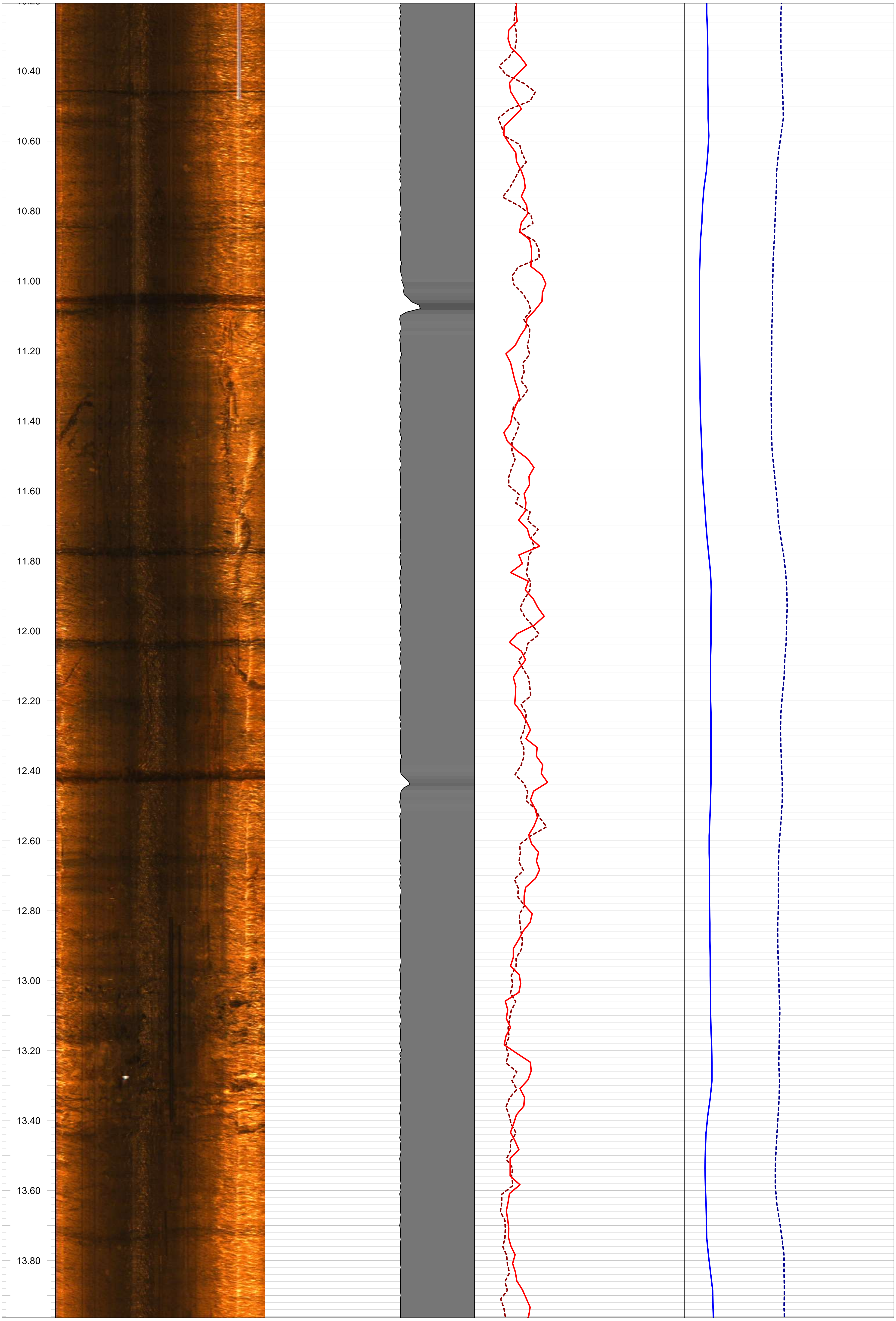
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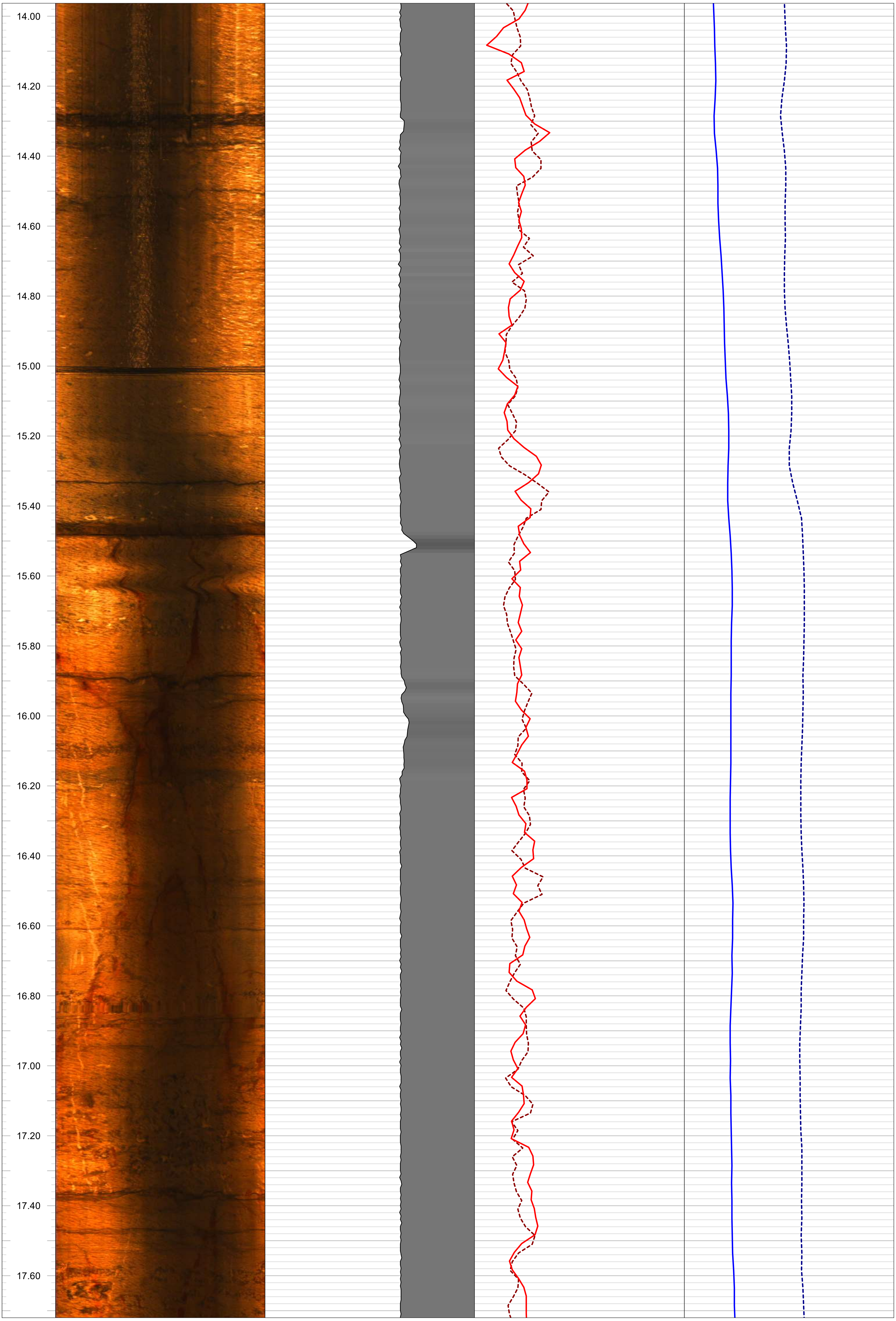
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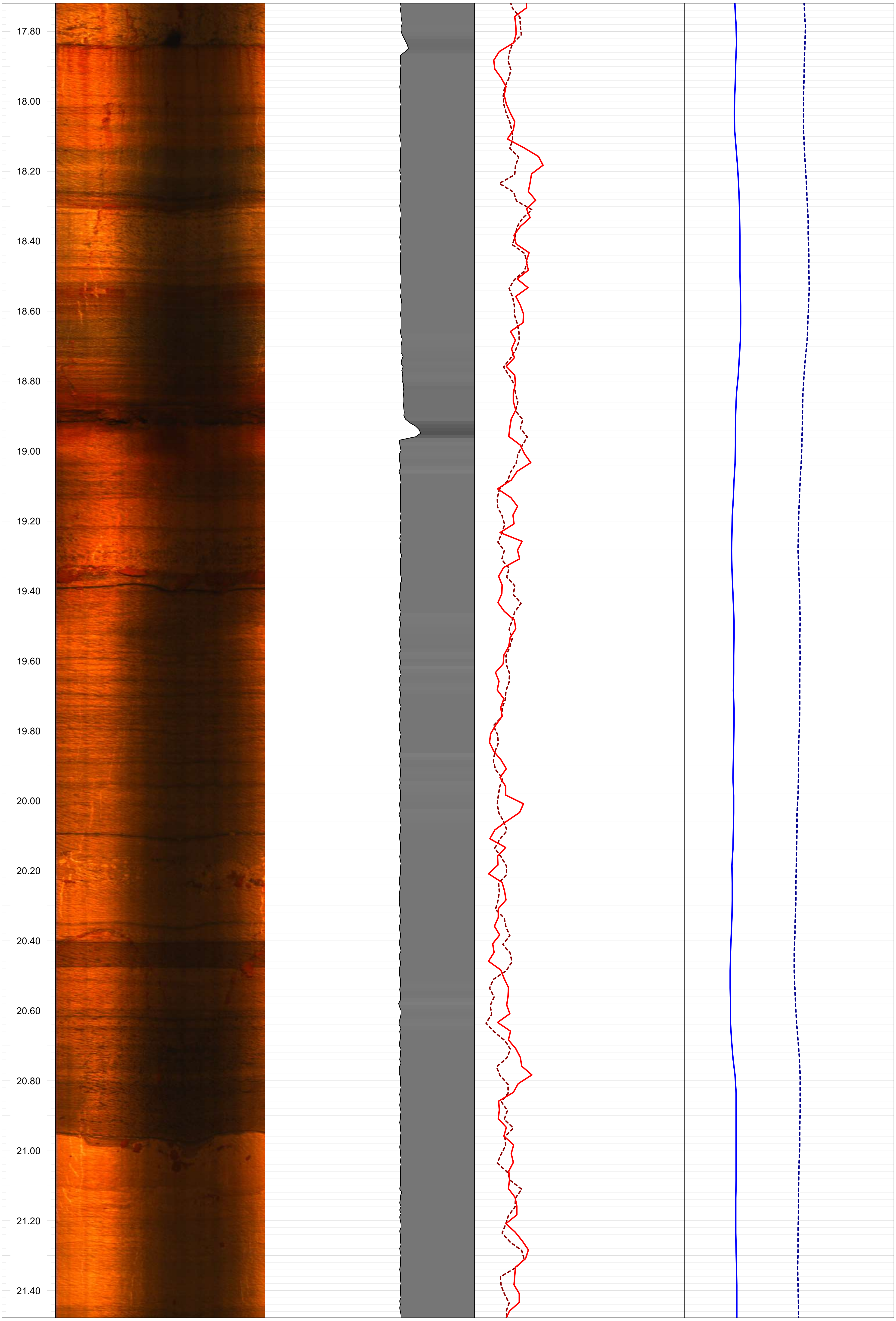
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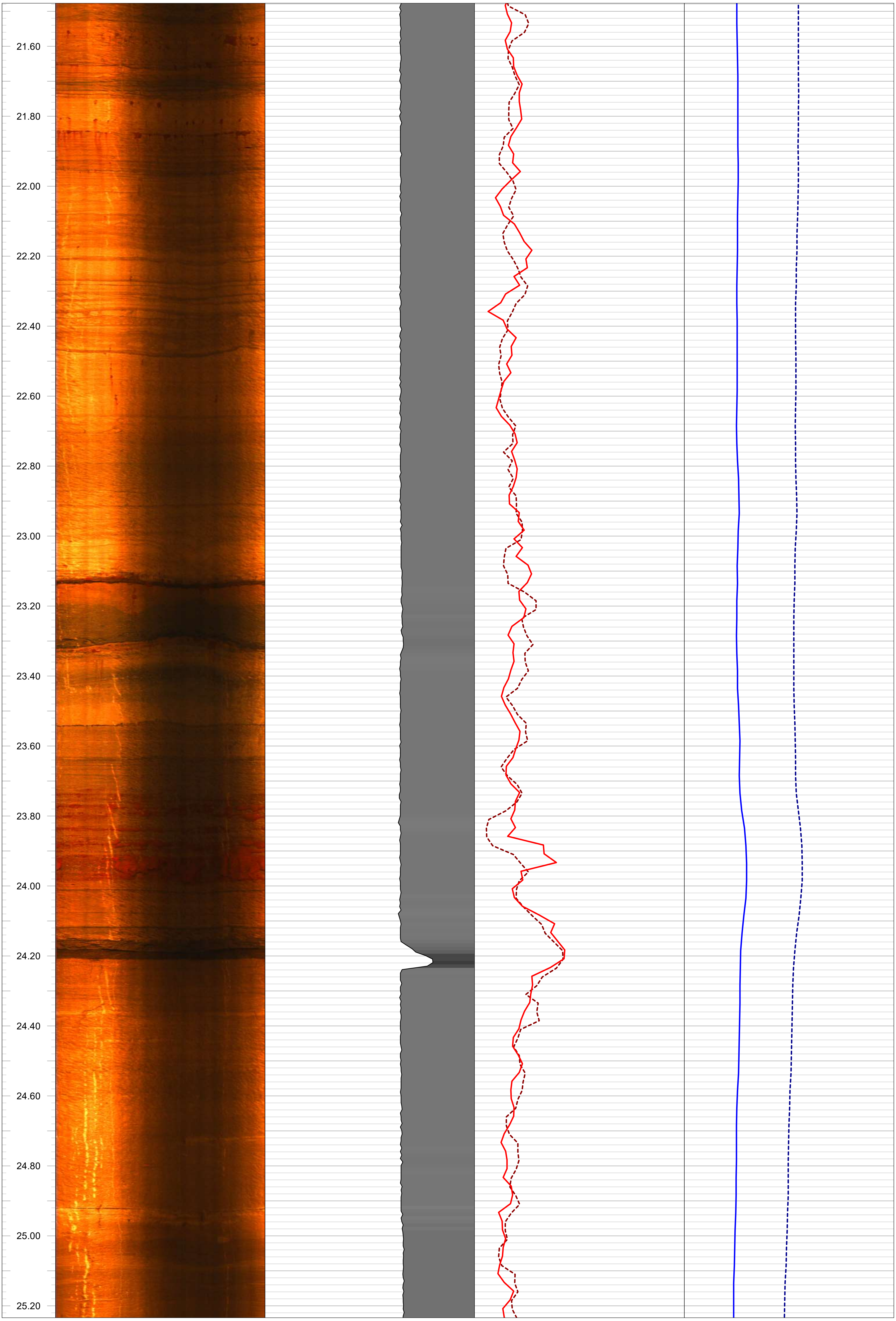
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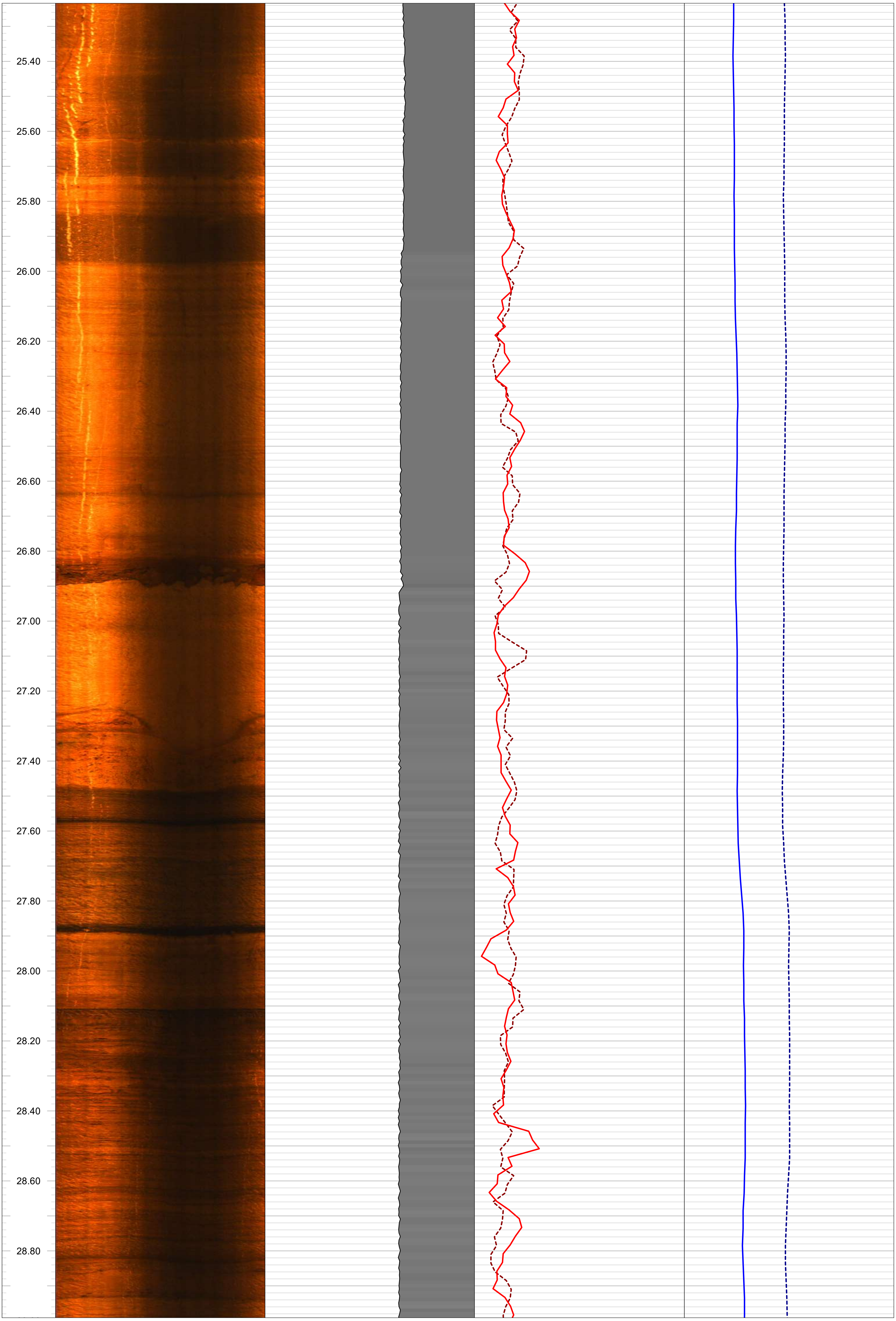
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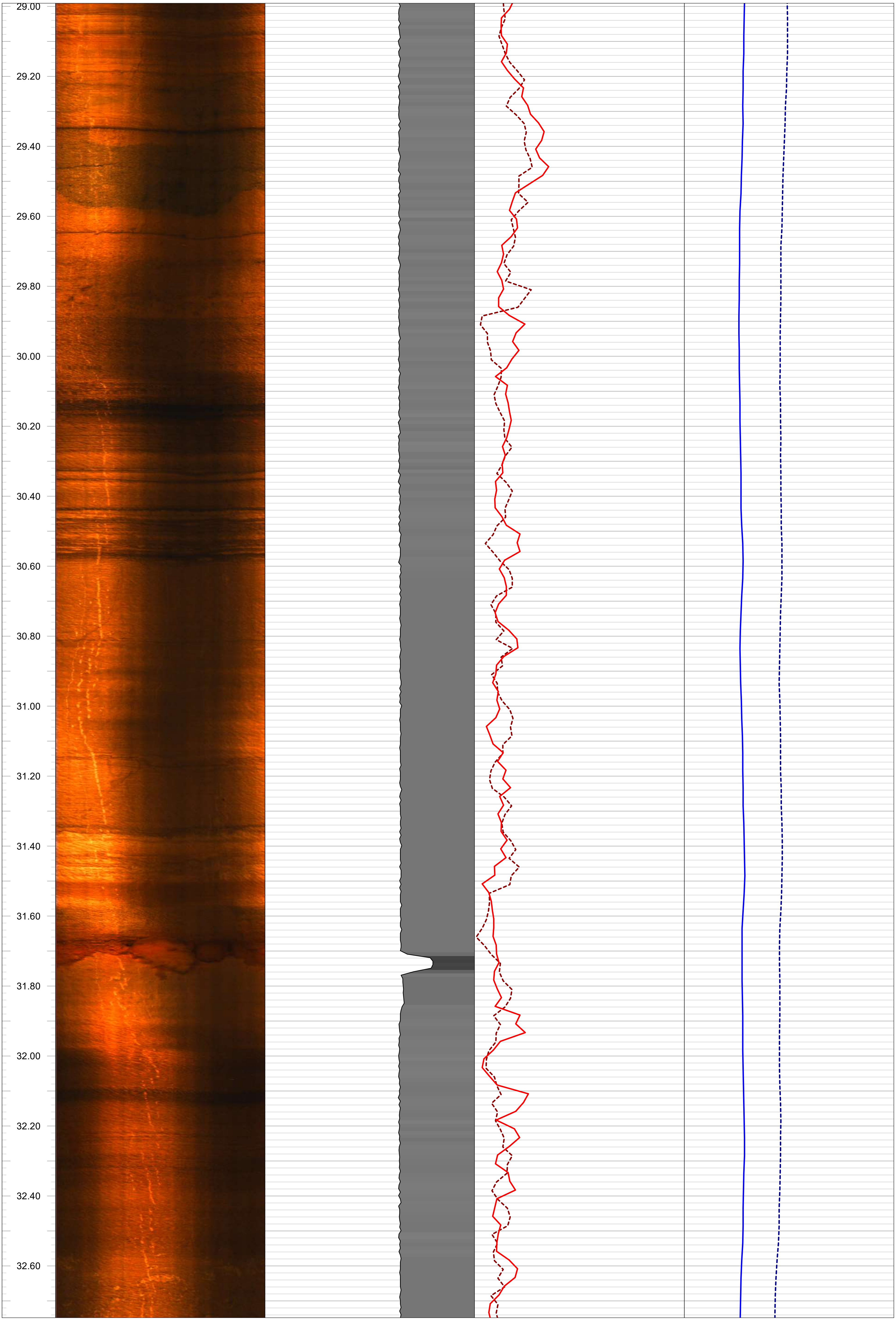
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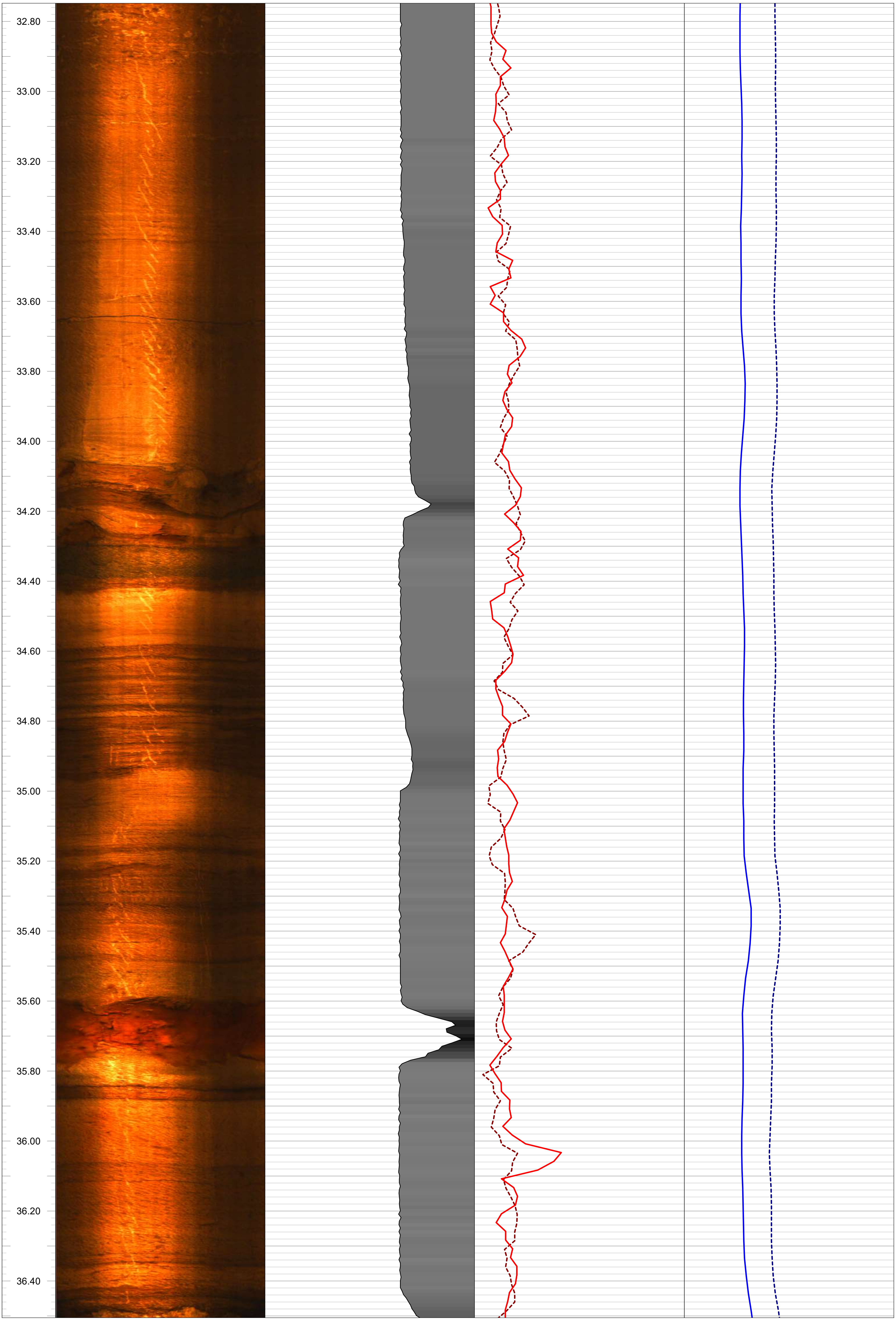
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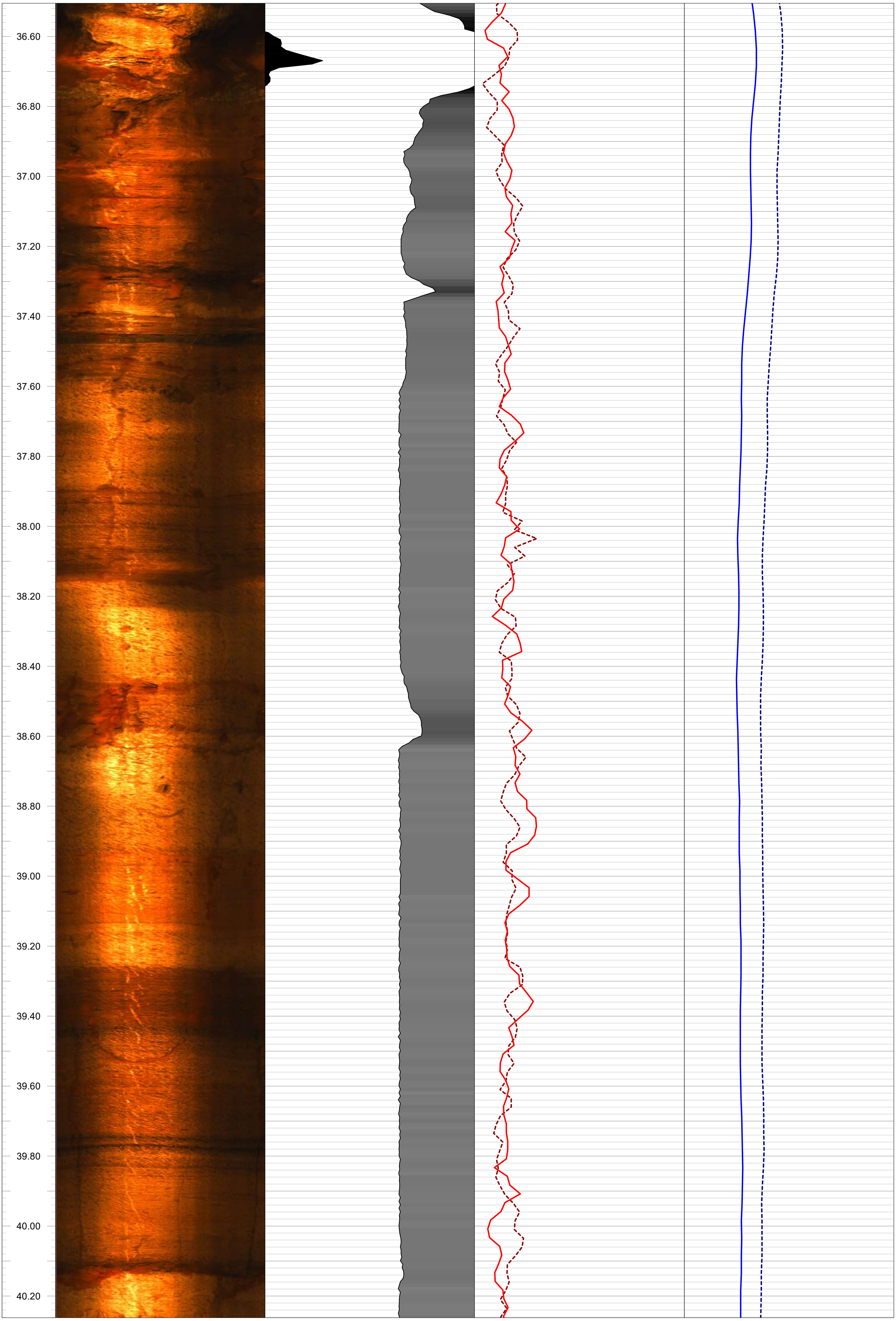
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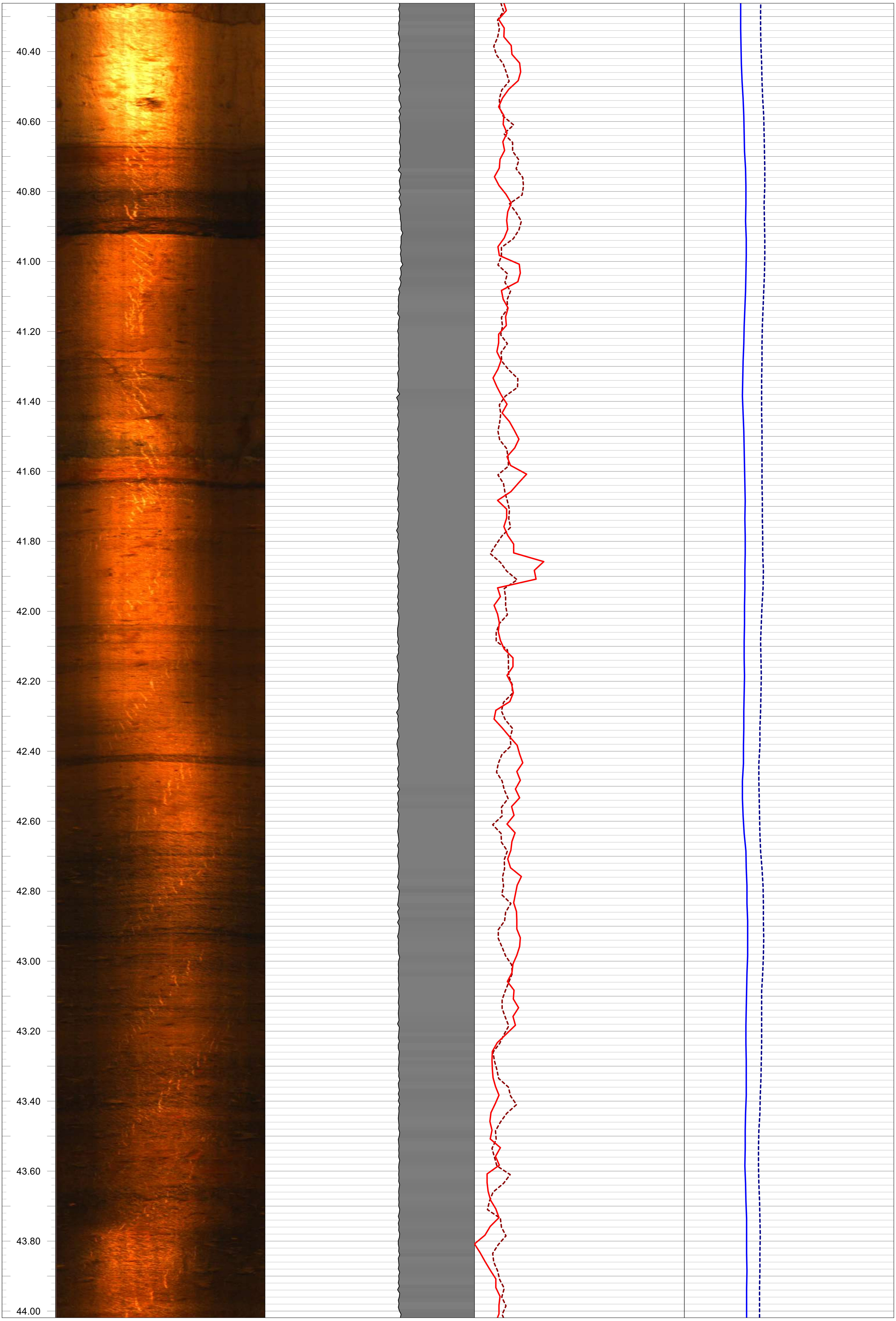
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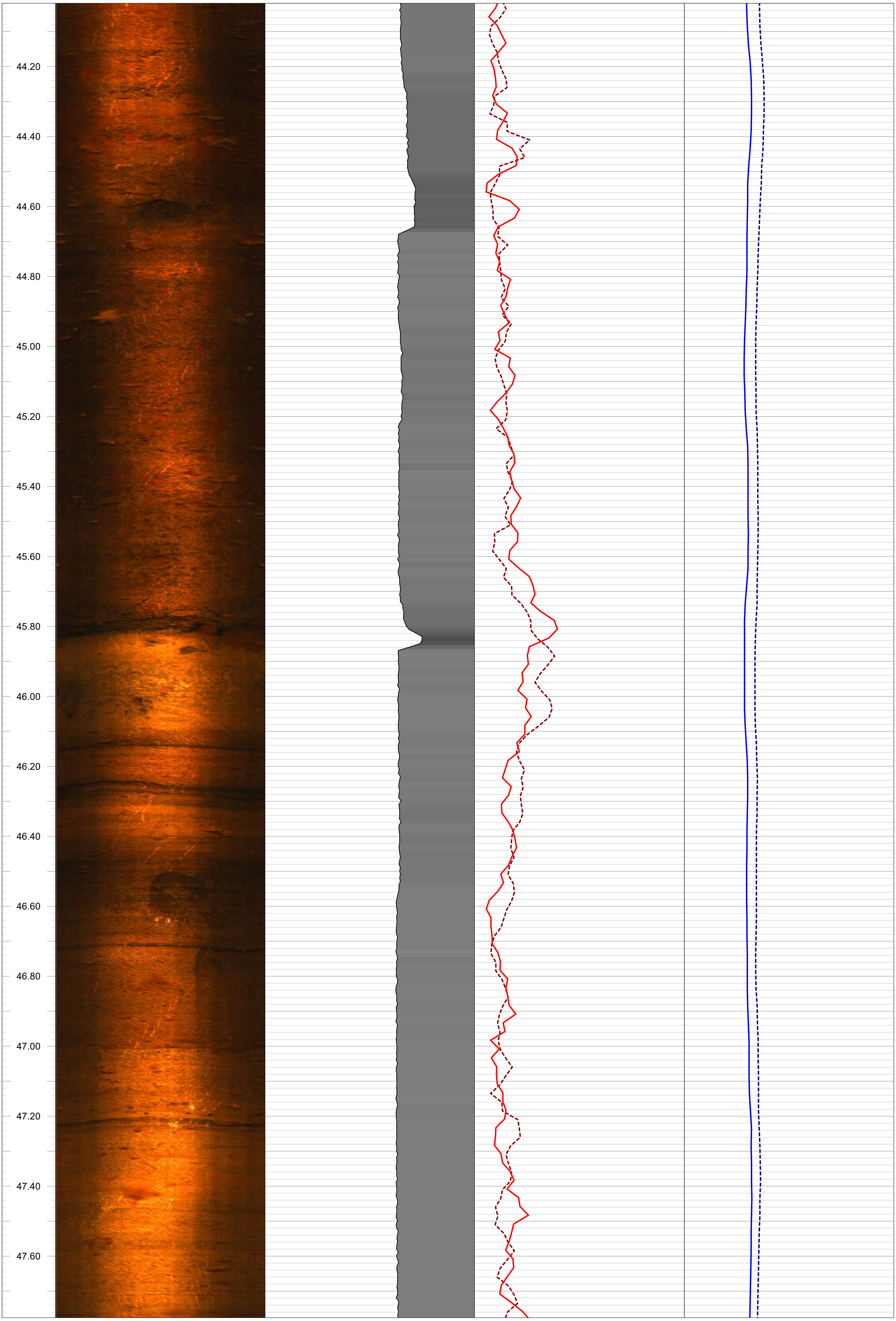
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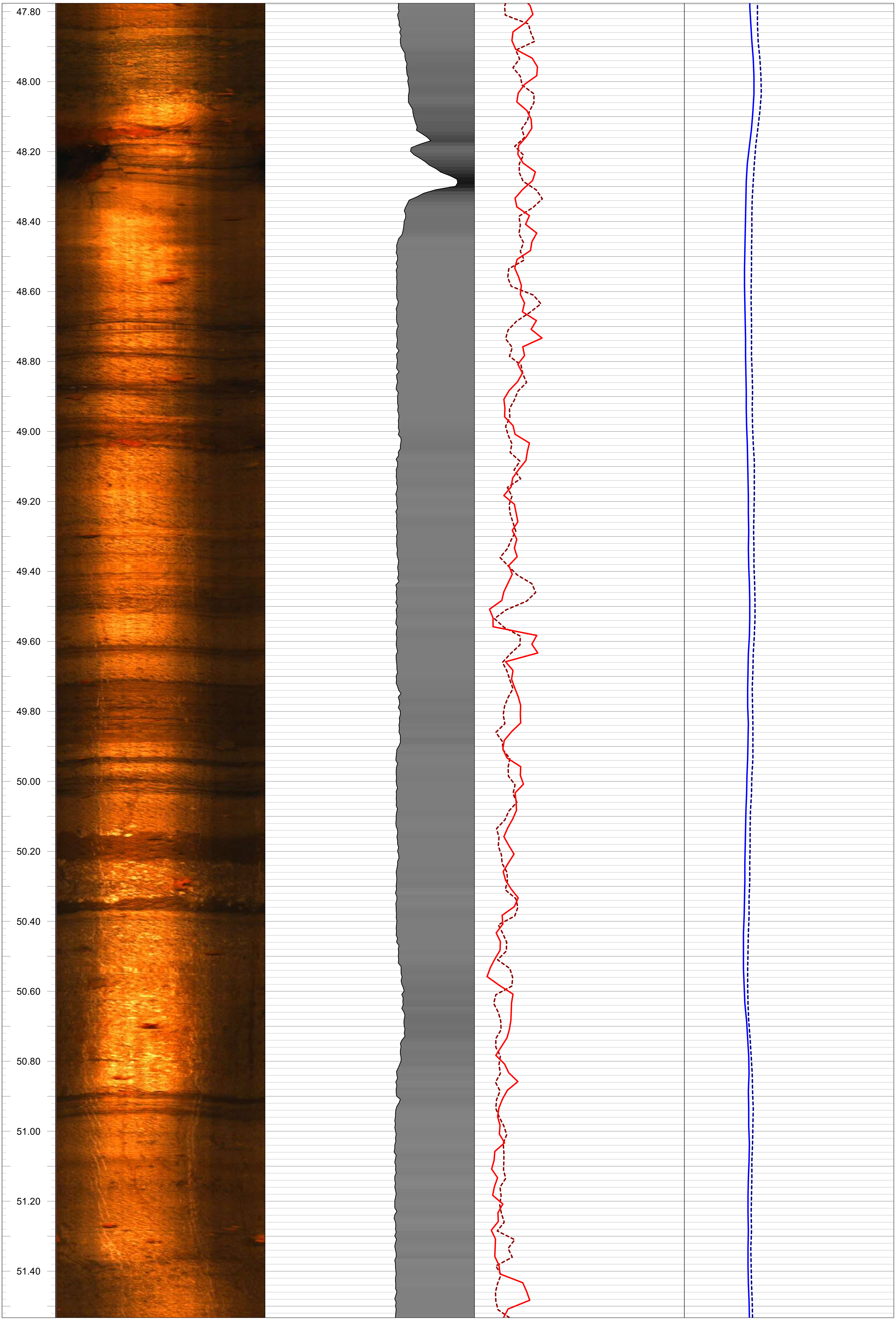
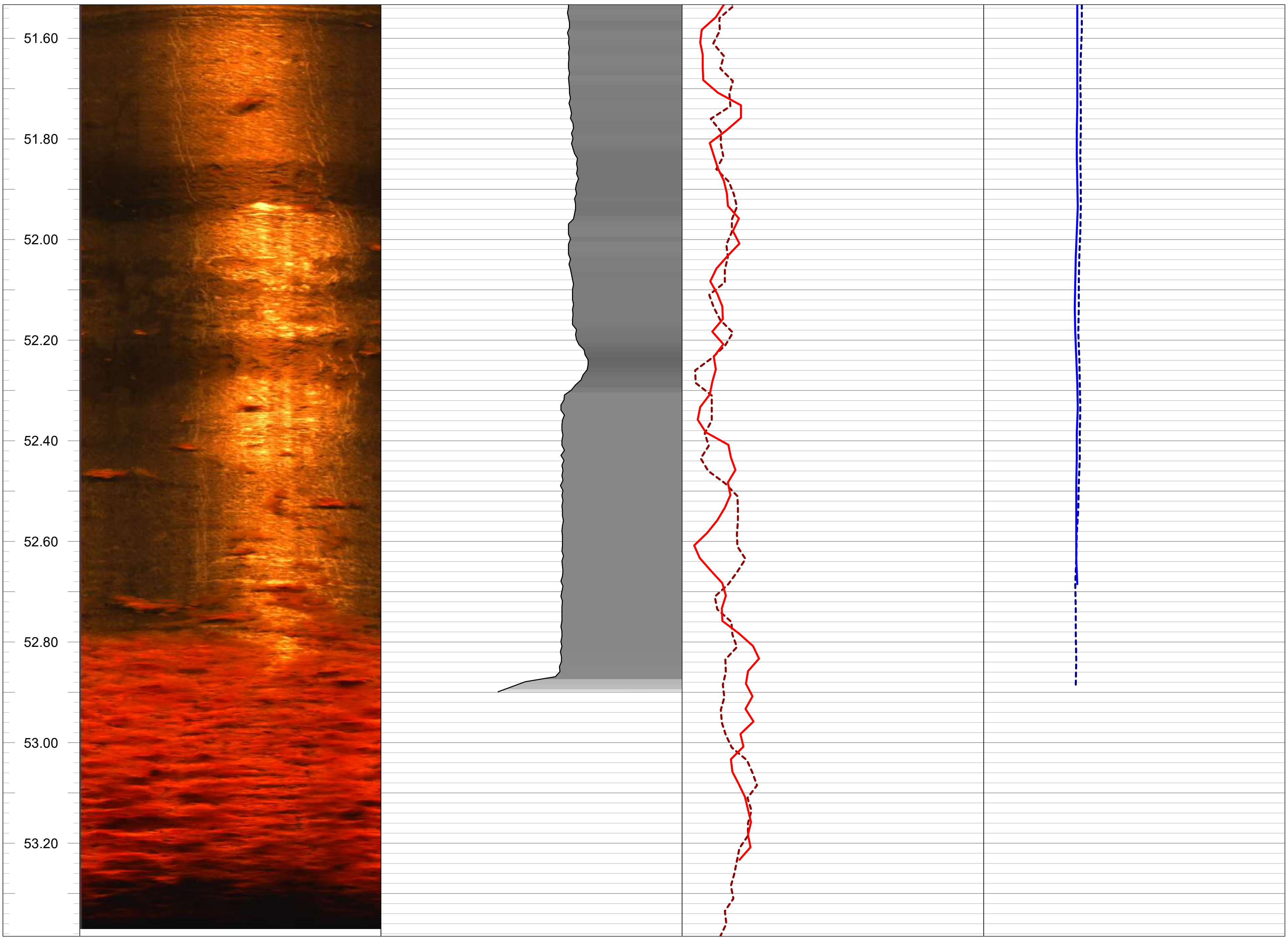
44.60
44.80
45.00
45.20
45.40
45.60
45.80
46.00
46.20
46.40
46.60
46.80
47.00
47.20
47.40
47.60


47.80
48.00
48.20
48.40
48.60
48.80
49.00
49.20
49.40
49.60
49.80
50.00
50.20
50.40
50.60
50.80
51.00
51.20
51.40


51.60
51.80
52.00
52.20
52.40
52.60
52.80
53.00
53.20

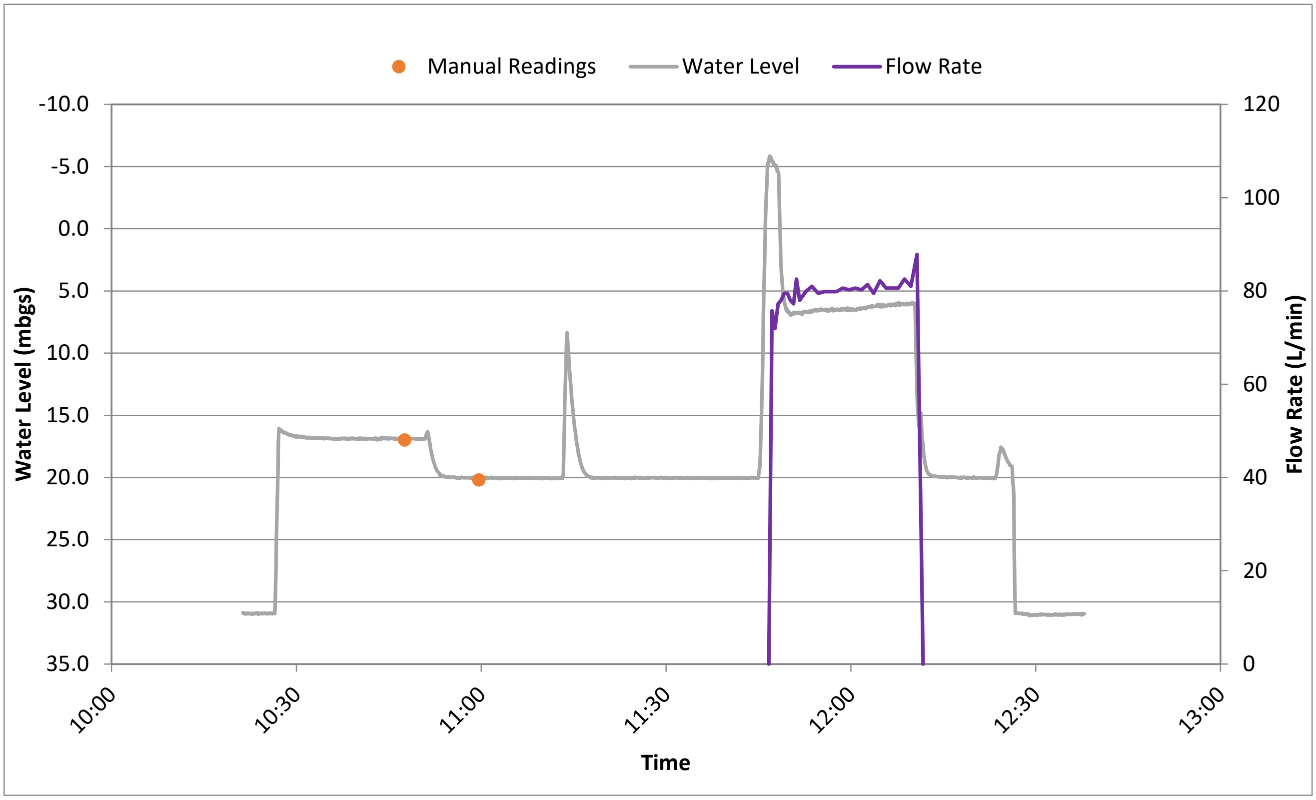
APPENDIX D

Hydraulic (Packer) Testing Results

Packer Test Result (CRI)

BH17-01 Test #1

FIGURE D.1



Test Interval (below ground surface)

30.2 m to 35.2 m

Test Interval (L) = 5.04 m

Borehole Radius (R) = 0.048 m

Flow Rate (Q) = 82.5 L/min

Head (H) 13.9 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **1E-5** **m/s**

TEST DATE: 01-June-2018

PROJECT: 1781508

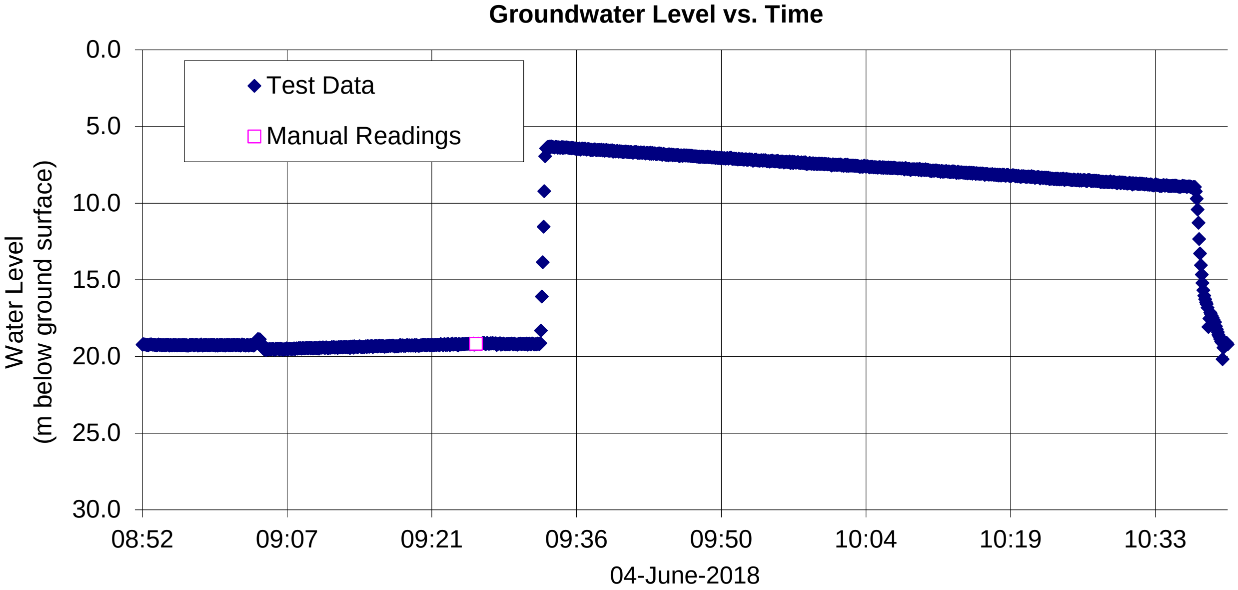
Prepared by: AS

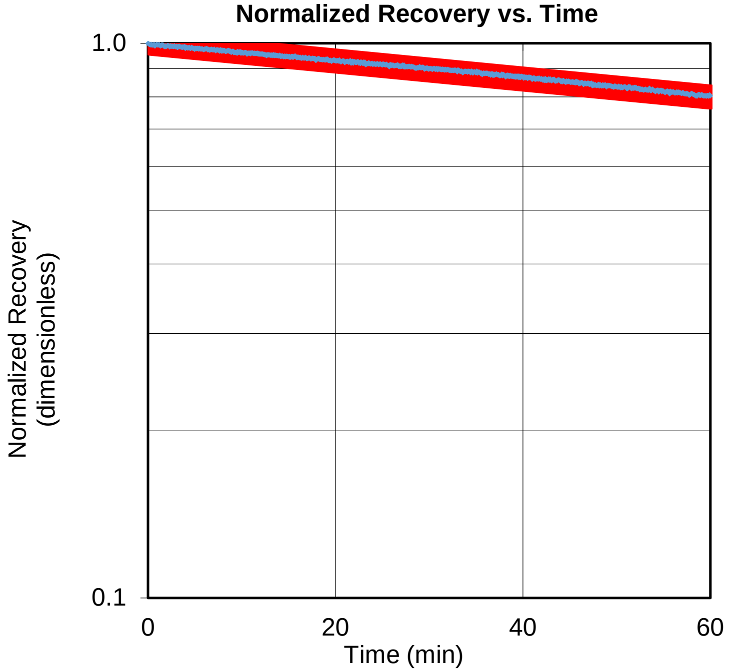
Checked by: ML

Packer Test Result (FHT)

BH17-01 Test #2

FIGURE D.2





Test Interval (below ground surface)

25.3 m to 30.4 m

Static Water Level (below ground surface)

19.17 m

Test Interval (L) = 5.11 m

Casing Radius (r) = 0.039 m

Borehole Radius (R) = 0.048 m

Points Used for Match Line

h_1/H_0 =	1.00	t_1 = 0.35 min
h_2/H_0 =	0.80	t_2 = 60 min

Hvorslev Analysis

Hydraulic Conductivity (K) = $\frac{(r^2) \bullet \ln(^L/_R)}{2 \bullet L} \bullet \frac{\ln(h1/H_0) - \ln(h2/H_0)}{t_2 - t_1}$ = **4E-8 m/s**

TEST DATE: 04-June-2018

PROJECT: 1781508

GOLDER

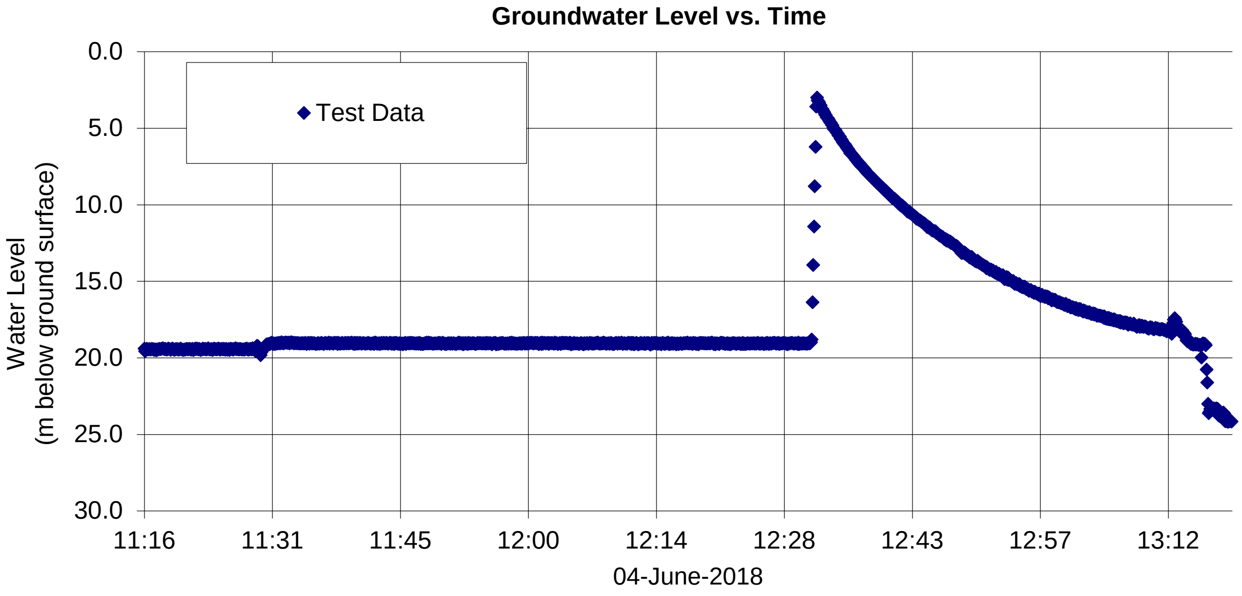
Prepared by: AS

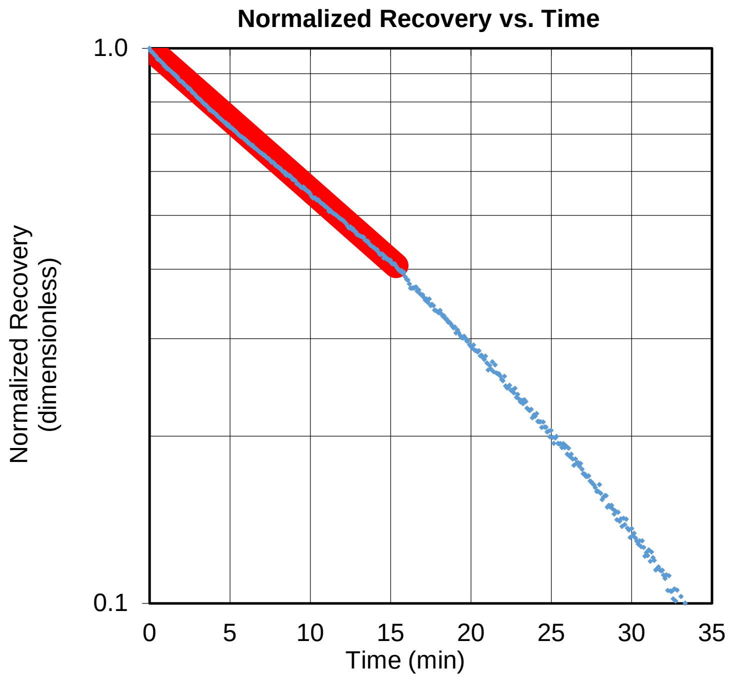
Checked by: ML

Packer Test Result (FHT)

BH17-01 Test #3

FIGURE D.3





Test Interval (below ground surface)

20.3 m to 25.4 m

Static Water Level (below ground surface)

19.1 m

Test Interval (L) = 5.1 m

Casing Radius (r) = 0.039 m

Borehole Radius (R) = 0.048 m

Points Used for Match Line

$h_1/H_0 =$ 1.00 $t_1 =$ 0 min

$h_2/H_0 =$ 0.41 $t_2 =$ 15.333 min

Hvorslev Analysis

$$\text{Hydraulic Conductivity (K)} = \frac{(r^2) \bullet \ln(^L/_R)}{2 \bullet L} \bullet \frac{\ln(h1/H_0) - \ln(h2/H_0)}{t_2 - t_1} =$$ **7E-7 m/s**

TEST DATE: 04-June-2018

PROJECT: 1781508

GOLDER

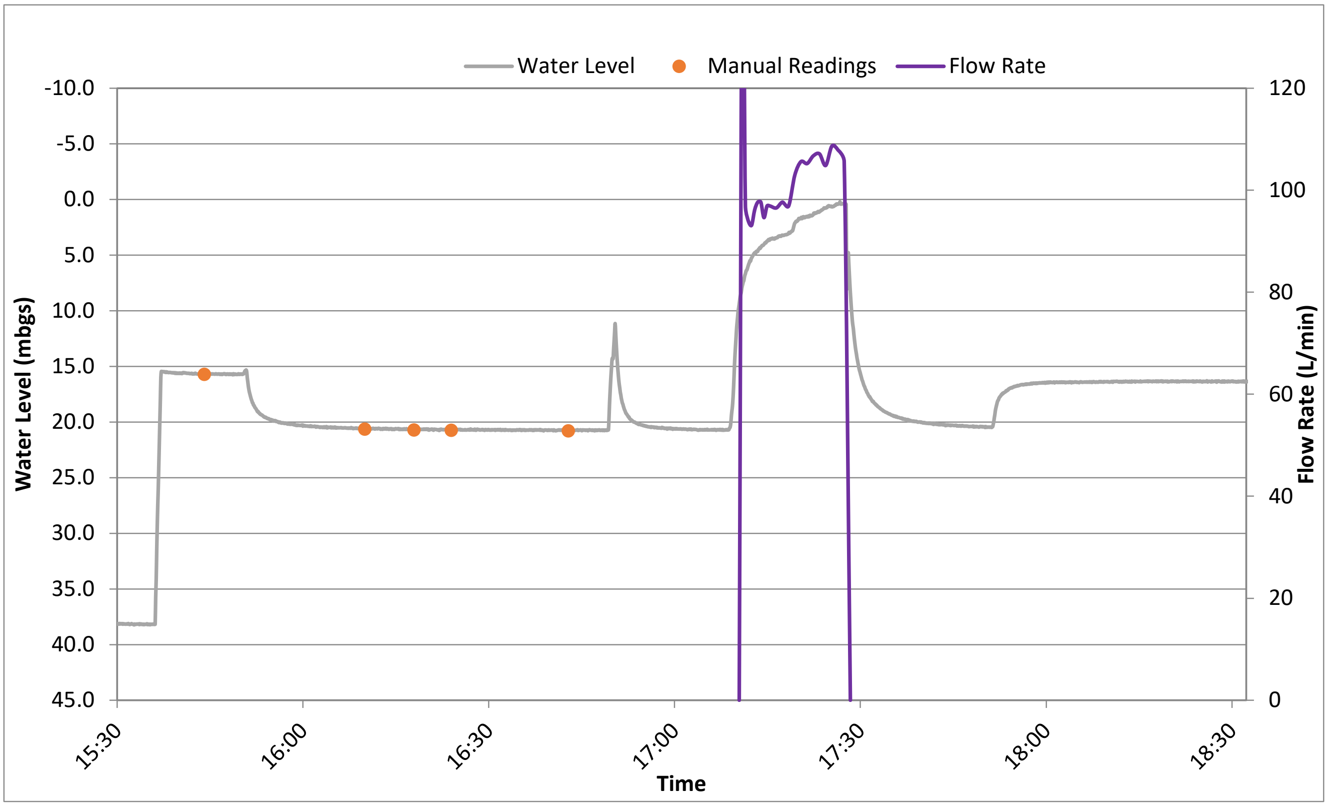
Prepared by: AS

Checked by: ML

Packer Test Result (CRI)

BH17-02 Test #1

FIGURE D.4



Test Interval (below ground surface)

37.3 m to 42.4 m

Test Interval (L) = 5.16 m

Flow Rate (Q) = 106.8 L/min

Borehole Radius (R) = 0.048 m

Head (H) 20.1 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **1E-5** **m/s**

TEST DATE: 04-June-2018

PROJECT: 1781508

GOLDER

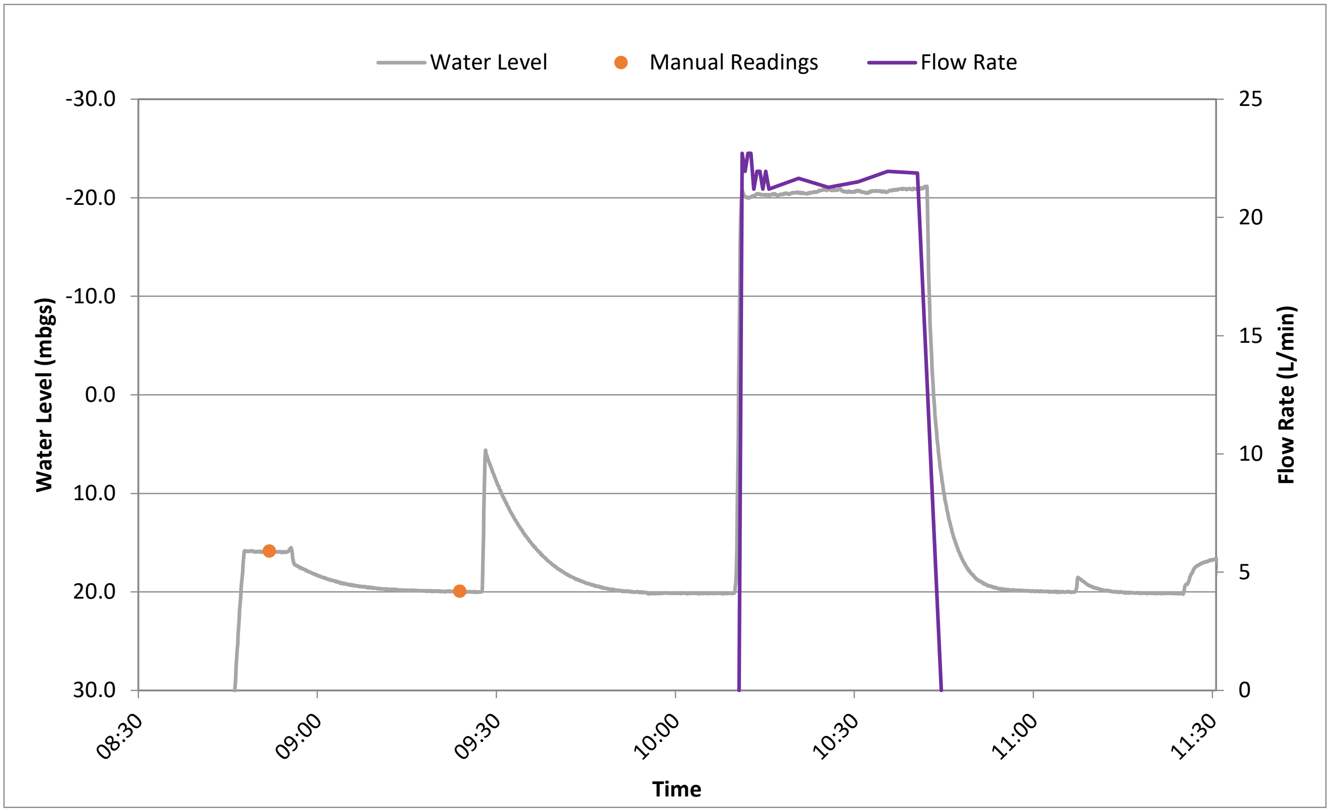
Prepared by: AS

Checked by: ML

Packer Test Result (CRI)

BH17-02 Test #2

FIGURE D.5



Test Interval (below ground surface)

32.8 m to 37.9 m

Test Interval (L) = 5.1 m

Borehole Radius (R) = 0.048 m

Flow Rate (Q) = 21.8 L/min

Head (H) 40.7 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **1E-6** **m/s**

TEST DATE: 05-June-2018

PROJECT: 1781508

GOLDER

Prepared by: AS

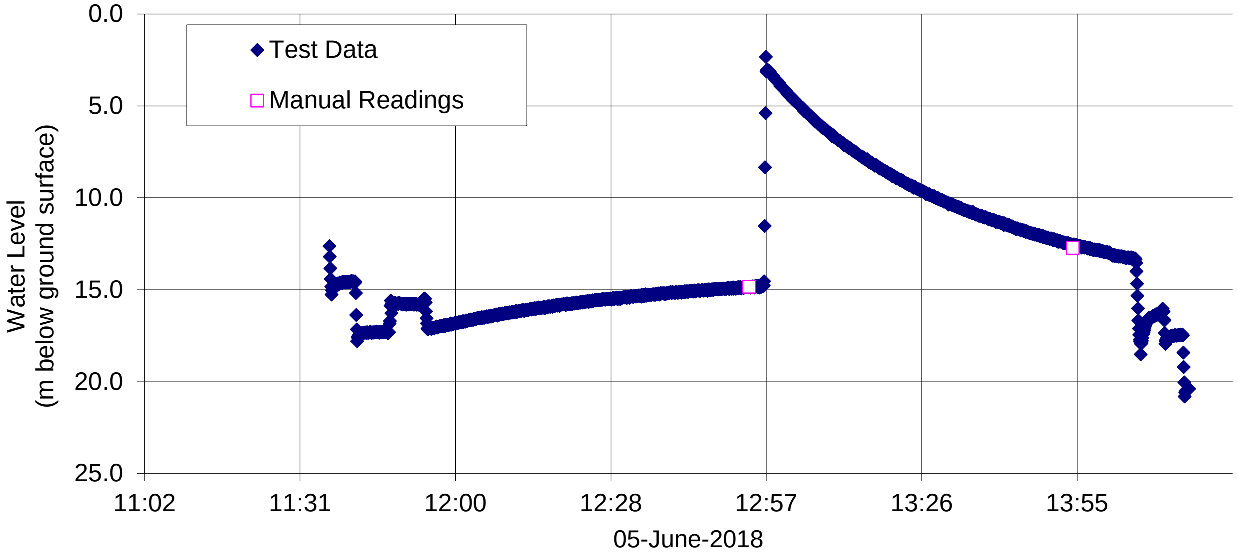
Checked by: ML

Packer Test Result (FHT)

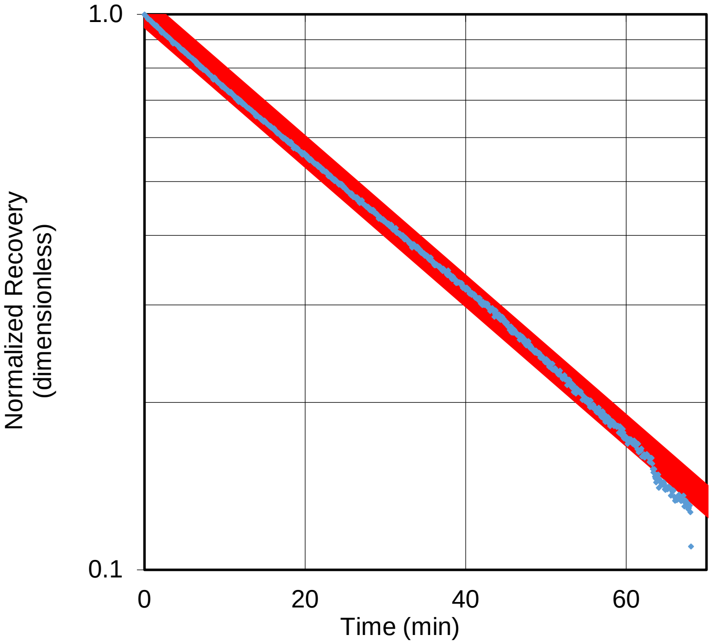
BH17-02 Test #3

FIGURE D.6

Groundwater Level vs. Time



Normalized Recovery vs. Time



Test Interval (below ground surface)

27.8 m to 32.9 m

Static Water Level (below ground surface)

14.84 m

Test Interval (L) = 5.1 m

Casing Radius (r) = 0.039 m

Borehole Radius (R) = 0.048 m

Points Used for Match Line

$h_1/H_0 =$	1.00	$t_1 =$ 0.35 min
$h_2/H_0 =$	0.10	$t_2 =$ 80 min

Hvorslev Analysis

$$\text{Hydraulic Conductivity (K)} = \frac{(r^2) \bullet \ln({}^{L}/_{R})}{2 \bullet L} \bullet \frac{\ln(h1/H_0) - \ln(h2/H_0)}{t_2 - t_1} = \mathbf{3E\text{-}7 \quad m/s}$$

TEST DATE: 05-June-2018

PROJECT: 1781508

GOLDER

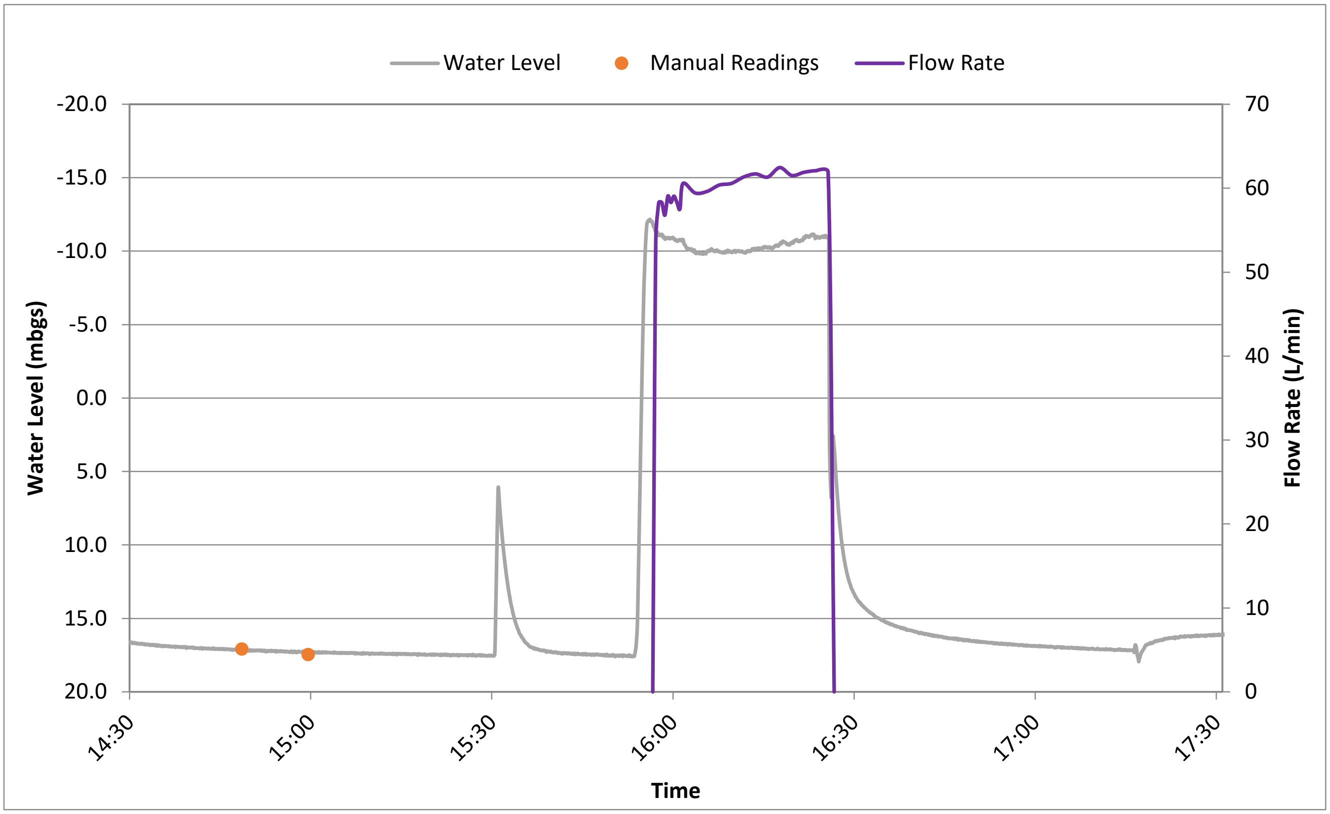
Prepared by: AS

Checked by: ML

Packer Test Result (CRI)

BH17-02 Test #4

FIGURE D.7



Test Interval (below ground surface)

22.7 m to 27.8 m

Test Interval (L) =	5.1 m	Flow Rate (Q) =	61.8 L/min
Borehole Radius (R) =	0.048 m	Head (H)	28.4 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **5E-6** **m/s**

TEST DATE: 05-June-2018

PROJECT: 1781508

GOLDER

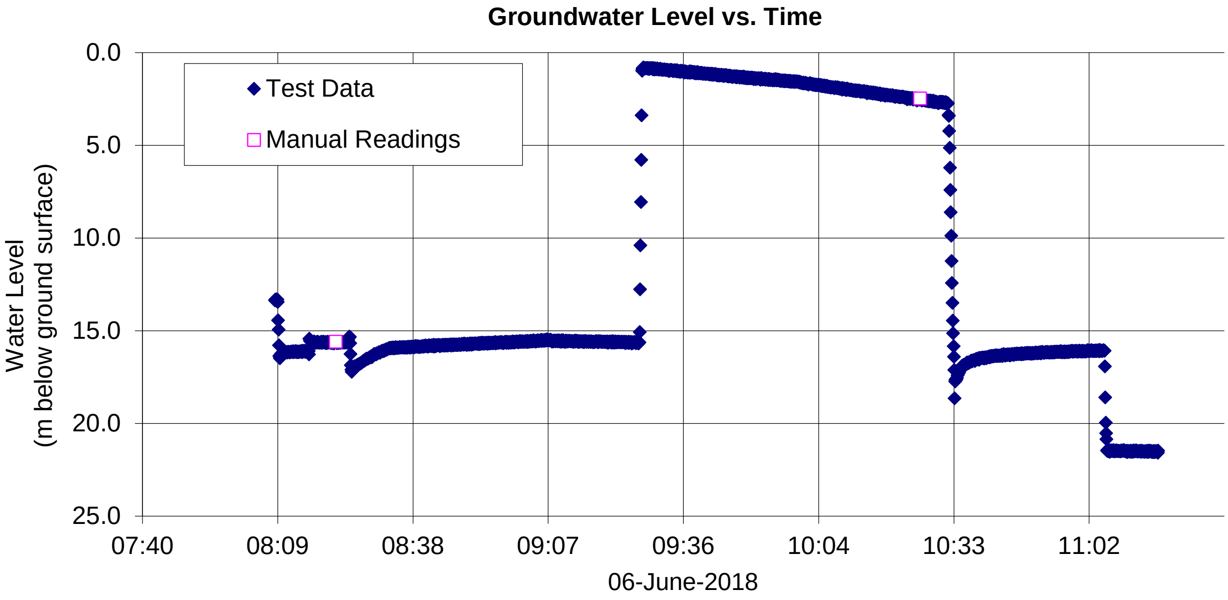
Prepared by: AS

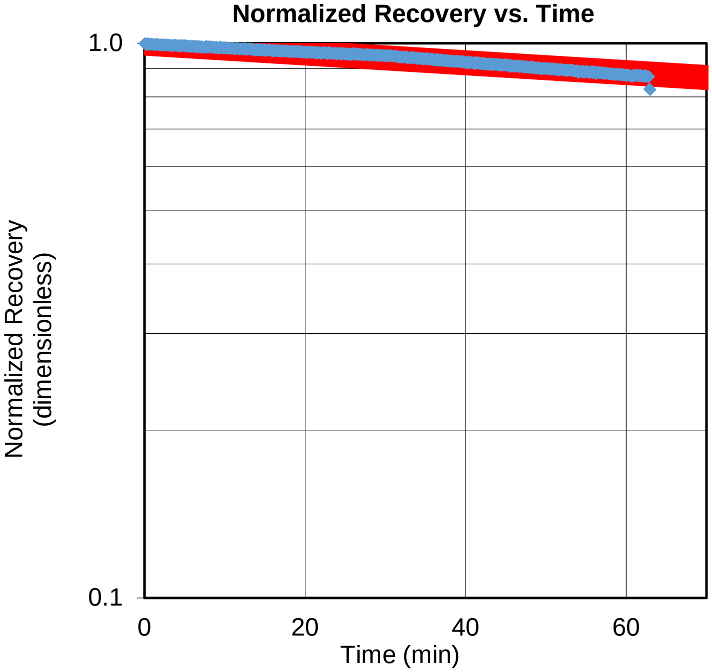
Checked by: ML

Packer Test Result (FHT)

BH17-02 Test #5

FIGURE D.8





Test Interval (below ground surface)

17.7 m to 22.8 m

Static Water Level (below ground surface)

15.64 m

Test Interval (L) = 5.1 m

Casing Radius (r) = 0.039 m

Borehole Radius (R) = 0.048 m

Points Used for Match Line

h_1/H_0 =	1.00	t_1 =	0.35 min
h_2/H_0 =	0.85	t_2 =	80 min

Hvorslev Analysis

$$\text{Hydraulic Conductivity (K)} = \frac{(r^2) \bullet \ln(^L/_R)}{2 \bullet L} \bullet \frac{\ln(h1/H_0) - \ln(h2/H_0)}{t_2 - t_1} = \textbf{2E-8} \quad \textbf{m/s}$$

TEST DATE: 06-June-2018

PROJECT: 1781508

GOLDER

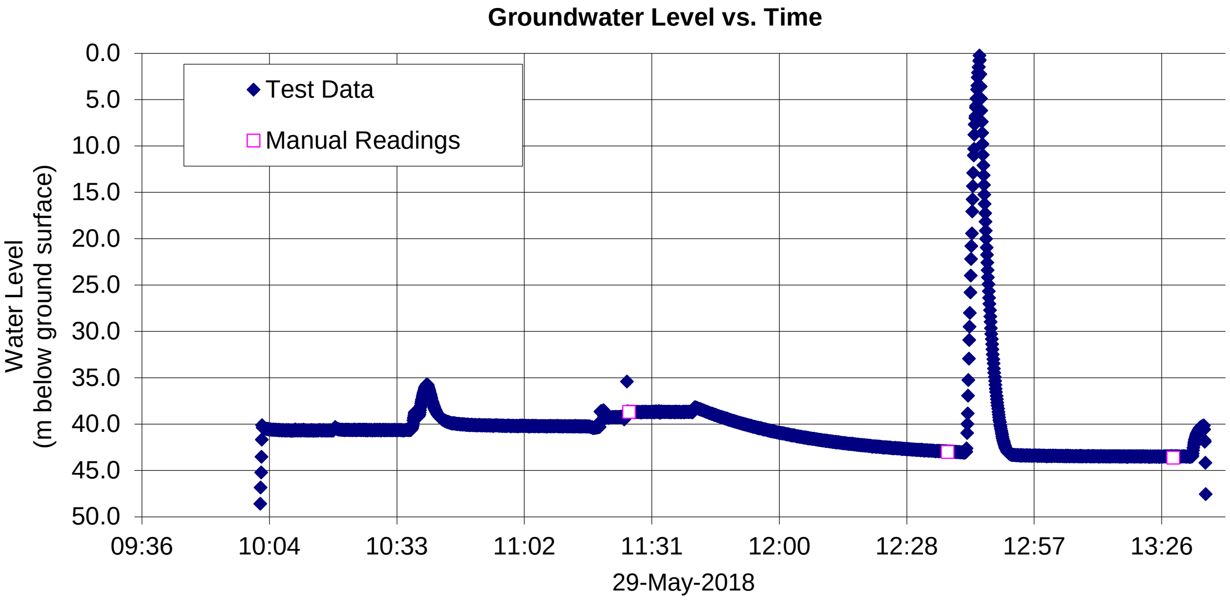
Prepared by: AS

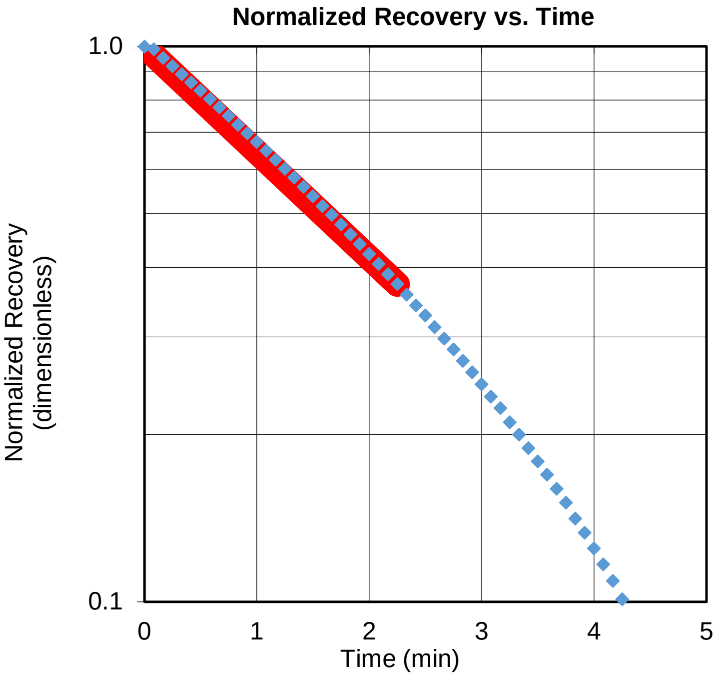
Checked by: ML

Packer Test Result (FHT)

BH17-03 Test #1

FIGURE D.9





Test Interval (below ground surface)

54.3 m to 57.6 m

Static Water Level (below ground surface)

43.5 m

Test Interval (L) = 3.31 m

Casing Radius (r) = 0.039 m

Borehole Radius (R) = 0.048 m

Points Used for Match Line

$h_1/H_0 =$	1.00	$t_1 =$ 0 min
$h_2/H_0 =$	0.37	$t_2 =$ 2.25 min

Hvorslev Analysis

$$\text{Hydraulic Conductivity (K)} = \frac{(r^2) \bullet \ln(^L/_R)}{2 \bullet L} \bullet \frac{\ln(h1/H_0) - \ln(h2/H_0)}{t_2 - t_1} = \mathbf{7E\text{-}6 \quad m/s}$$

TEST DATE: 29-May-2018

PROJECT: 1781508

GOLDER

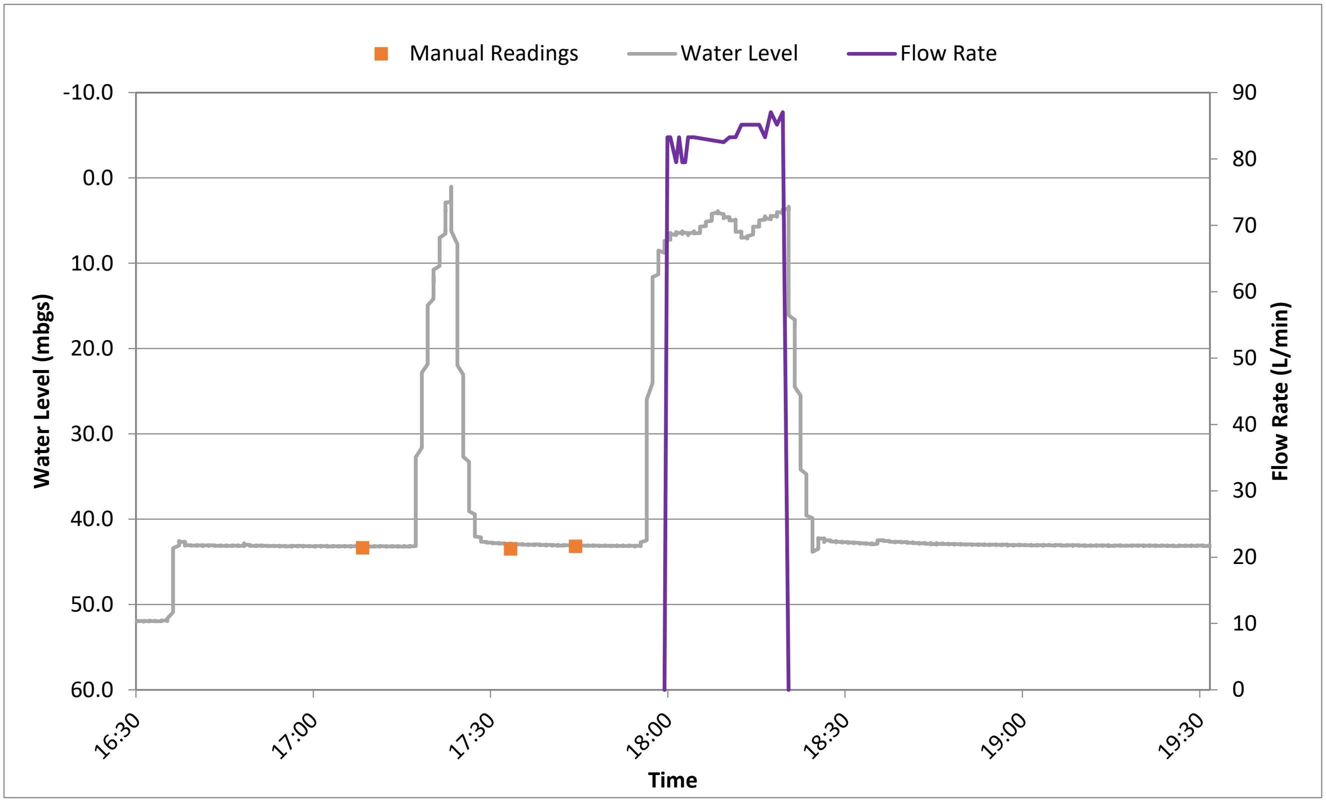
Prepared by: AS

Checked by: ML

Packer Test Result (CRI)

BH17-03 Test #2

FIGURE D.10



Test Interval (below ground surface)

48.3 m to 53.4 m

Test Interval (L) =	5.1 m	Flow Rate (Q) =	85.6 L/min
Borehole Radius (R) =	0.048 m	Head (H)	38.7 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **5E-6** **m/s**

TEST DATE: 29-May-2018

PROJECT: 1781508

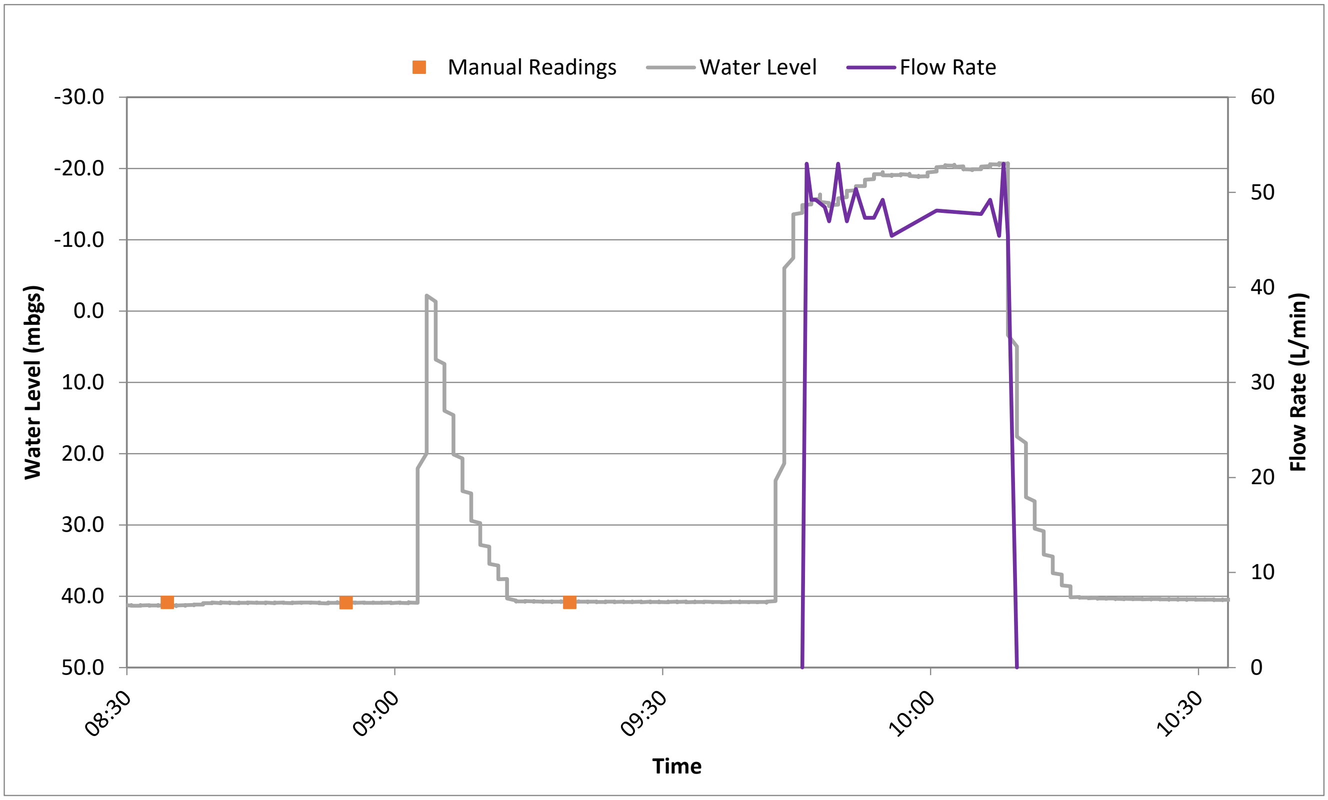
Prepared by: AS

Checked by: ML

Packer Test Result (CRI)

BH17-03 Test #3

FIGURE D.11



Test Interval (below ground surface)

42.6 m to 47.7 m

Test Interval (L) = 5.1 m

Borehole Radius (R) = 0.048 m

Flow Rate (Q) = 47.6 L/min

Head (H) 61.1 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **2E-6** **m/s**

TEST DATE: 30-May-2018

PROJECT: 1781508

GOLDER

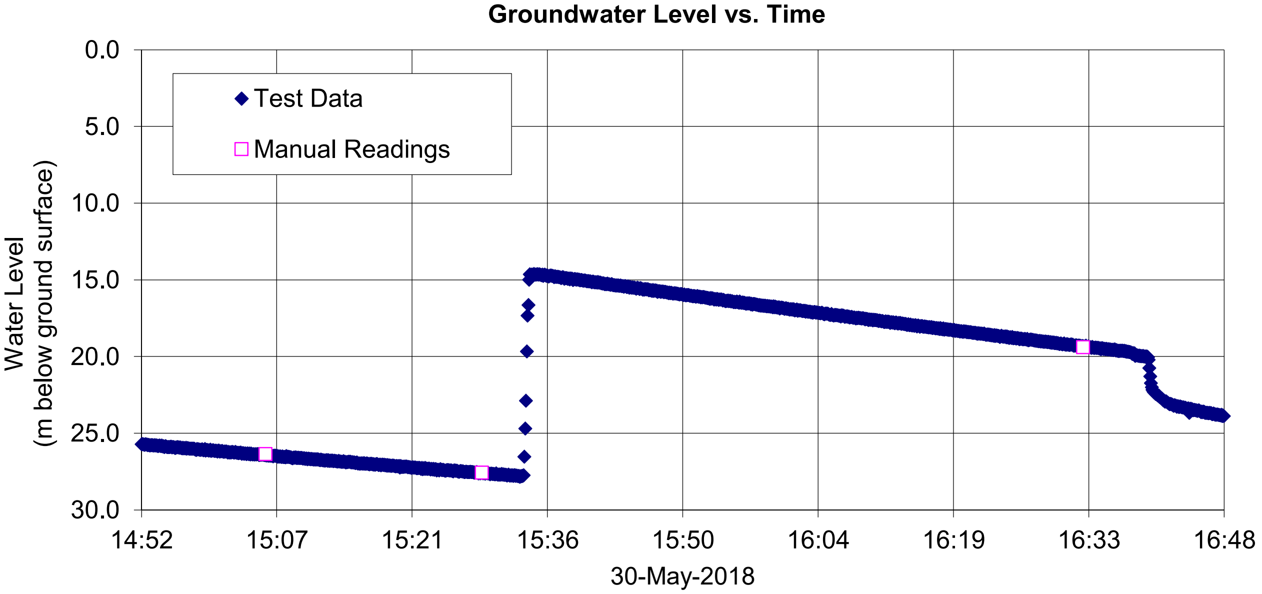
Prepared by: AS

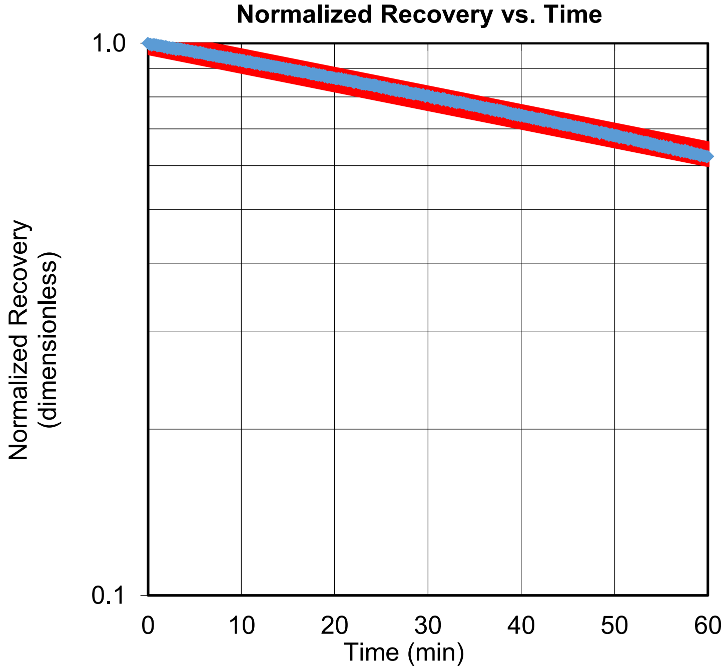
Checked by: ML

Packer Test Result (FHT)

BH17-04 Test #1

FIGURE D.12





Test Interval (below ground surface)

43.9 m to 47.6 m

Static Water Level (below ground surface)

27.57 m

Test Interval (L) = 3.74 m

Casing Radius (r) = 0.039 m

Borehole Radius (R) = 0.048 m

Points Used for Match Line

h_1/H_0 =	1.00	t_1 = 0.5 min
h_2/H_0 =	0.63	t_2 = 60 min

Hvorslev Analysis

$$\text{Hydraulic Conductivity (K)} = \frac{(r^2) \cdot \ln(^L/_R)}{2 \cdot L} \cdot \frac{\ln(h1/H_0) - \ln(h2/H_0)}{t_2 - t_1} = \mathbf{1E\text{-}7} \quad \mathbf{m/s}$$

DATE: 30-May-2018

PROJECT: 1781508

GOLDER

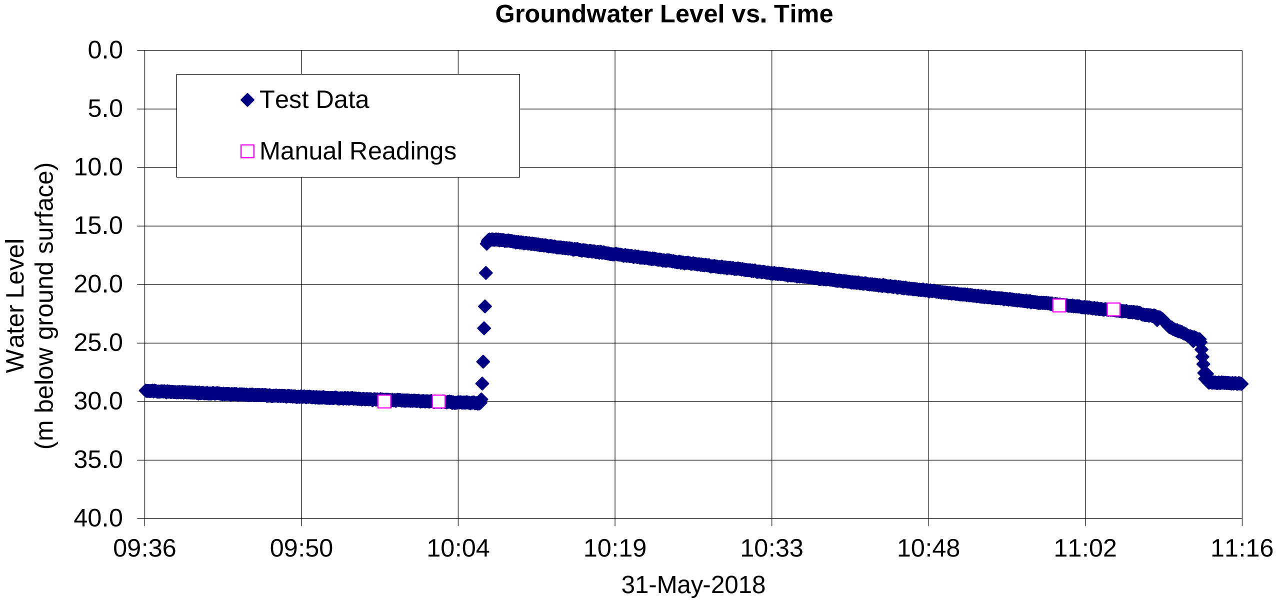
Prepared by: AS

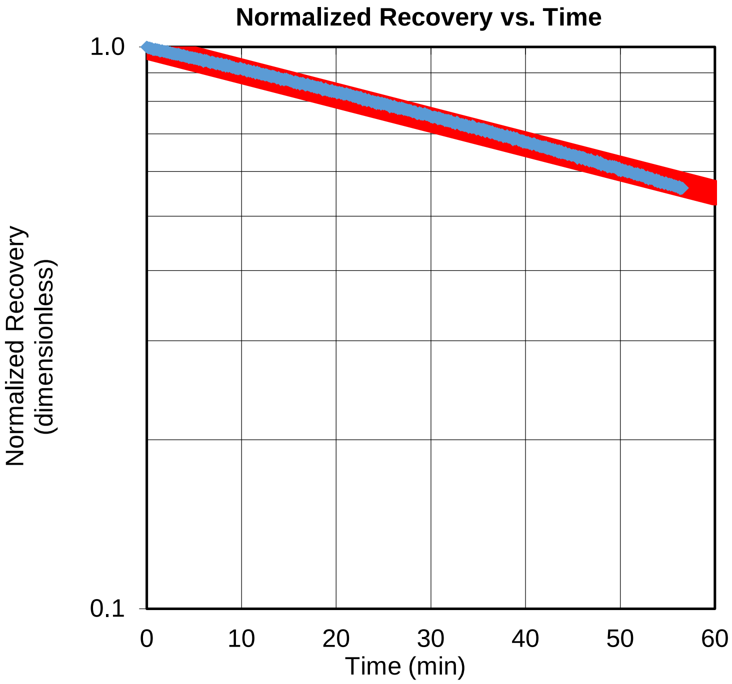
Checked by: ML

Packer Test Result (FHT)

BH17-04 Test #2

FIGURE D.13





Test Interval (below ground surface)

38.1 m to 43.2 m

Static Water Level (below ground surface)

29.99 m

Test Interval (L) = 5.1 m

Casing Radius (r) = 0.039 m

Borehole Radius (R) = 0.048 m

Points Used for Match Line

$h_1/H_0 =$	1.00	$t_1 =$ 0 min
$h_2/H_0 =$	0.55	$t_2 =$ 60 min

Hvorslev Analysis

$$\text{Hydraulic Conductivity (K)} = \frac{(r^2) \bullet \ln(^L/_R)}{2 \bullet L} \bullet \frac{\ln(h1/H_0) - \ln(h2/H_0)}{t_2 - t_1} = \mathbf{1E\text{-}7 \quad m/s}$$

DATE: 31-May-2018

PROJECT: 1781508

GOLDER

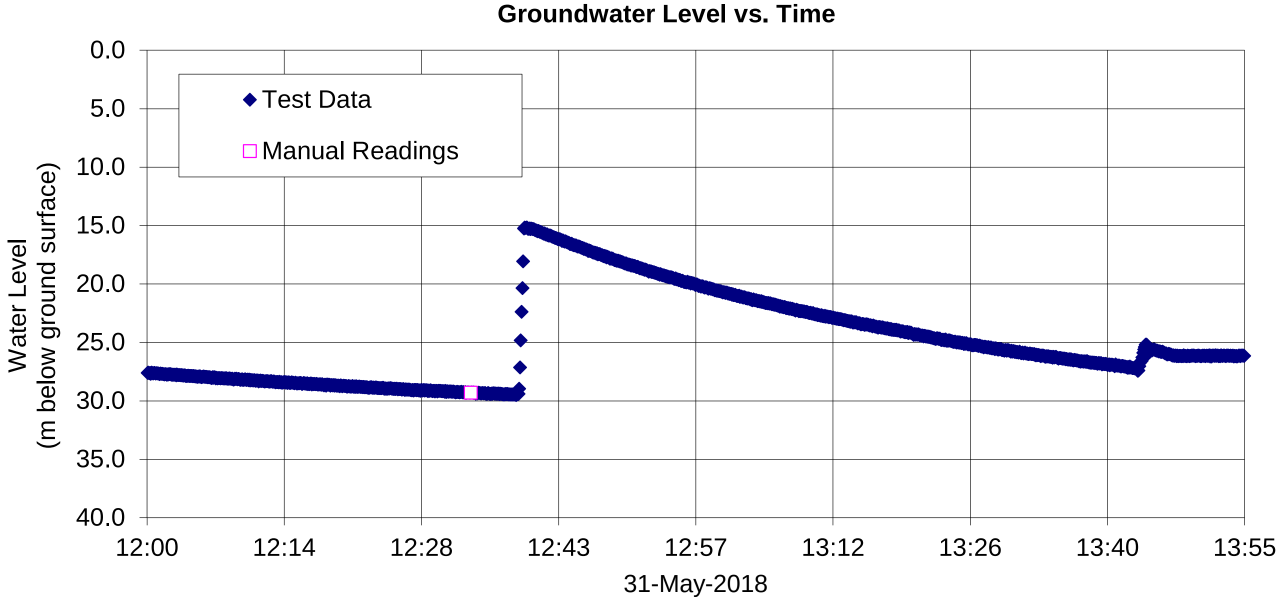
Prepared by: AS

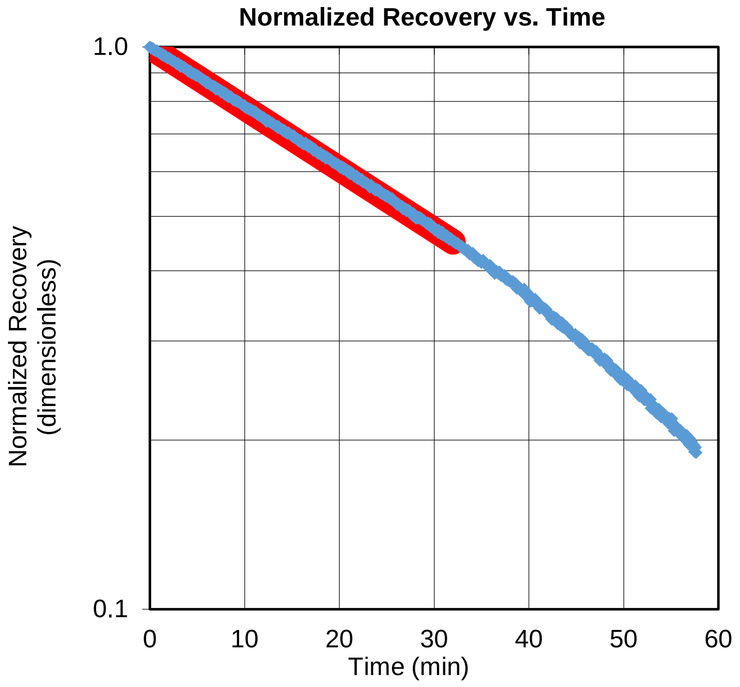
Checked by: ML

Packer Test Result (FHT)

BH17-04 Test #3

FIGURE D.14





Test Interval (below ground surface)

33.1 m to 38.2 m

Static Water Level (below ground surface)

29.4 m

Test Interval (L) = 5.1 m

Casing Radius (r) = 0.039 m

Borehole Radius (R) = 0.048 m

Points Used for Match Line

h_1/H_0 =	1.00	t_1 = 0 min
h_2/H_0 =	0.45	t_2 = 32 min

Hvorslev Analysis

$$\text{Hydraulic Conductivity (K)} = \frac{(r^2) \bullet \ln(^L/_R)}{2 \bullet L} \bullet \frac{\ln(h1/H_0) - \ln(h2/H_0)}{t_2 - t_1} = \mathbf{3E\text{-}7 \quad m/s}$$

DATE: 31-May-2018

PROJECT: 1781508

GOLDER

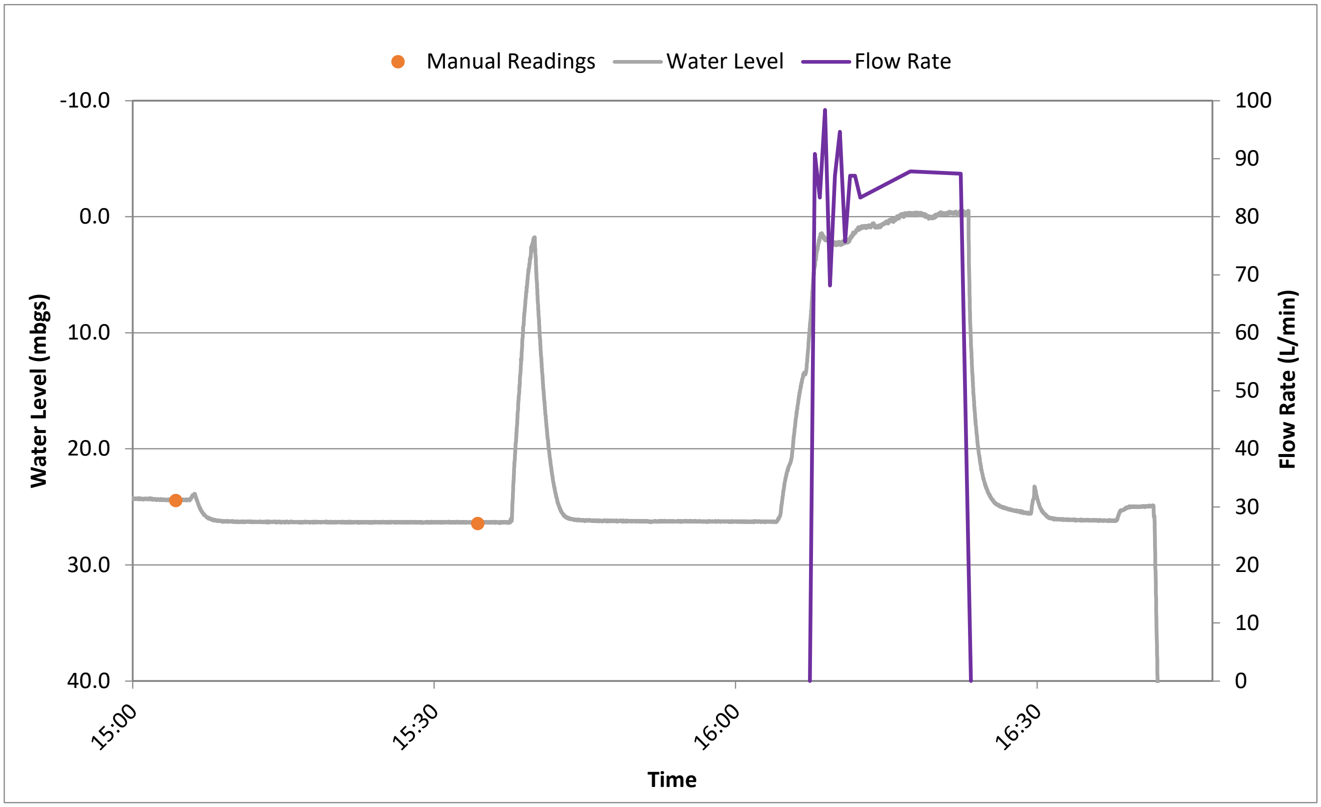
Prepared by: AS

Checked by: ML

Packer Test Result (CRI)

BH17-05 Test #1

FIGURE D.15



Test Interval (below ground surface)

43.8 m to 48.9 m

Test Interval (L) = 5.08 m

Borehole Radius (R) = 0.048 m

Flow Rate (Q) = 86.3 L/min

Head (H) = 25.9 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **8E-6** **m/s**

TEST DATE: 24-May-2018

PROJECT: 1781508

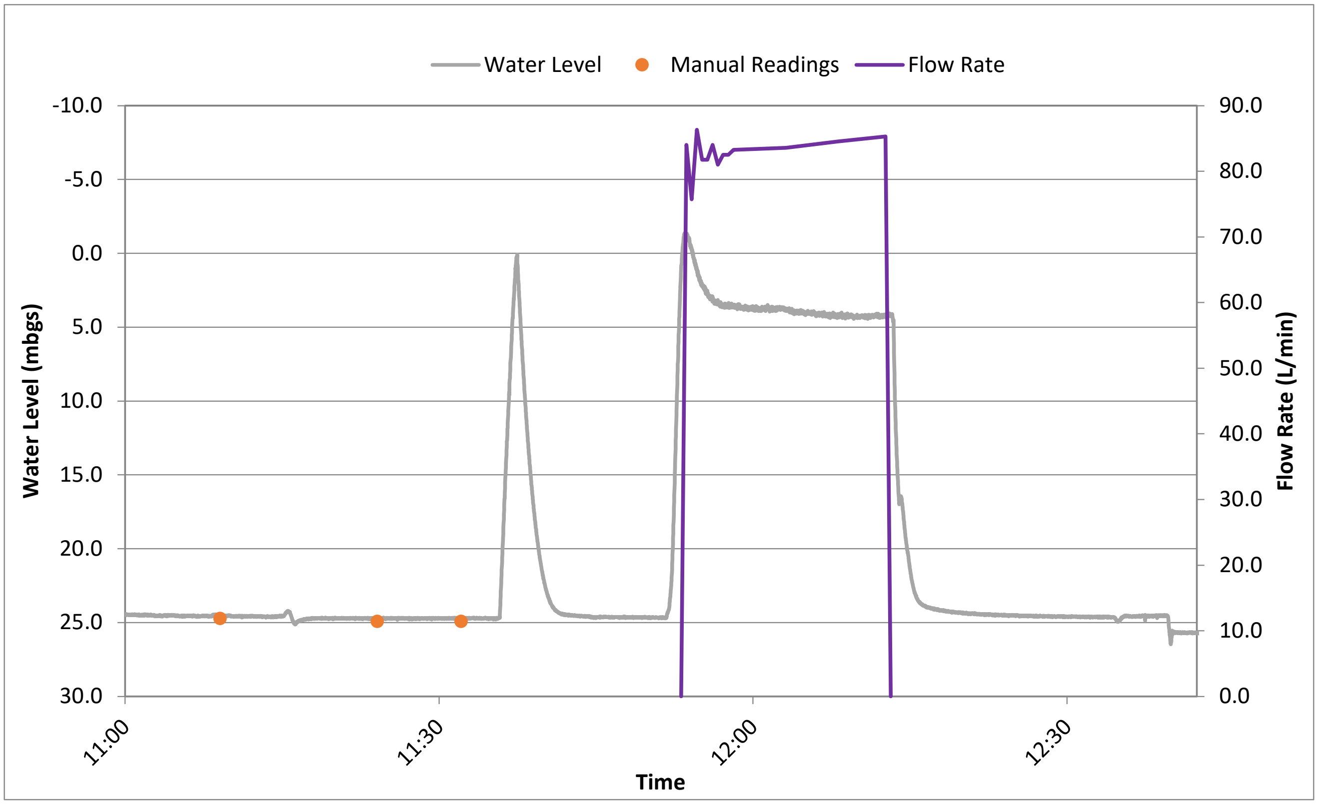
Prepared by: AS

Checked by: ML

Packer Test Result (CRI)

BH17-05 Test #2

FIGURE D.16



Test Interval (below ground surface)

39.4 m to 44.5 m

Test Interval (L) =	5.1 m	Flow Rate (Q) =	82.3 L/min
Borehole Radius (R) =	0.048 m	Head (H) =	21.2 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **9E-6** **m/s**

TEST DATE: 25-May-2018

PROJECT: 1781508

GOLDER

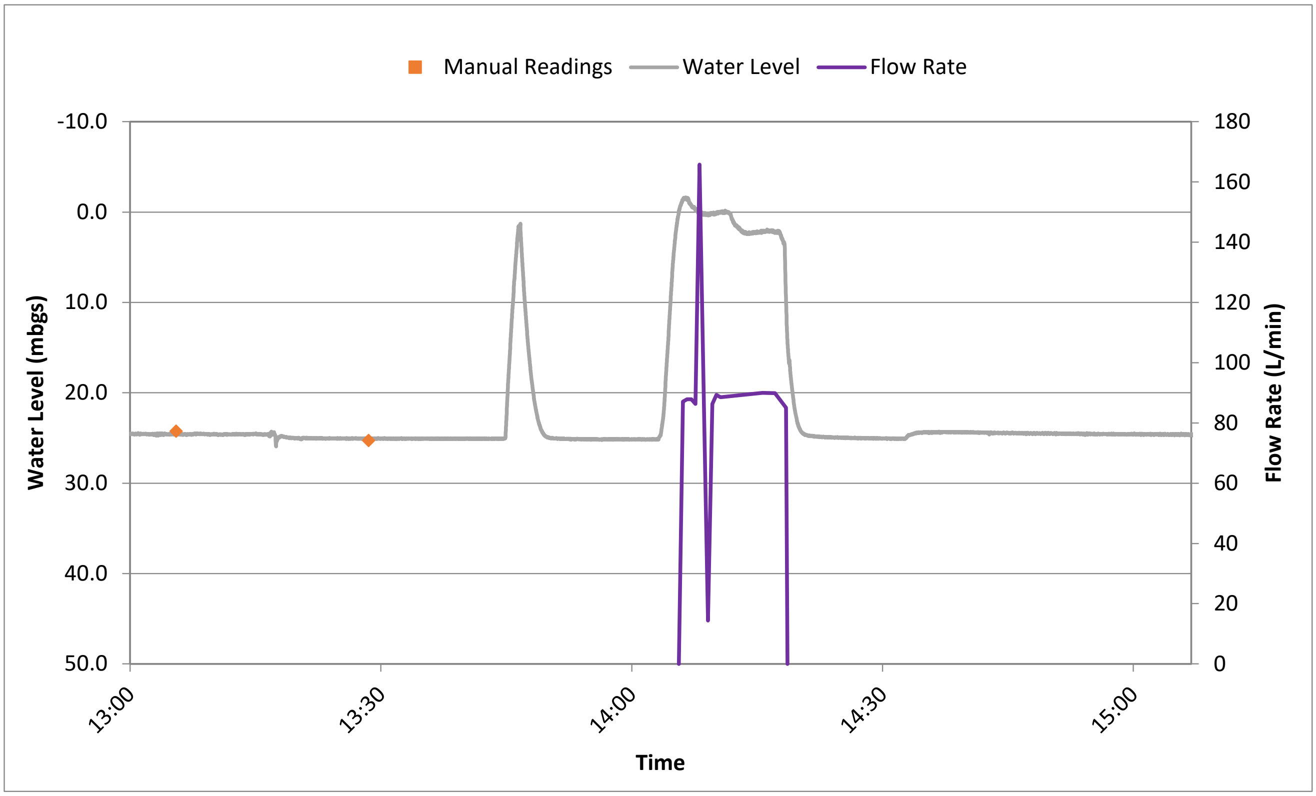
Prepared by: AS

Checked by: ML

Packer Test Result (CRI)

BH17-05 Test #3

FIGURE D.17



Test Interval (below ground surface)

34.3 m to 39.4 m

Test Interval (L) = 5.1 m

Flow Rate (Q) = 88.1 L/min

Borehole Radius (R) = 0.048 m

Head (H) = 22.9 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **9E-6** **m/s**

TEST DATE: 25-May-2018

PROJECT: 1781508

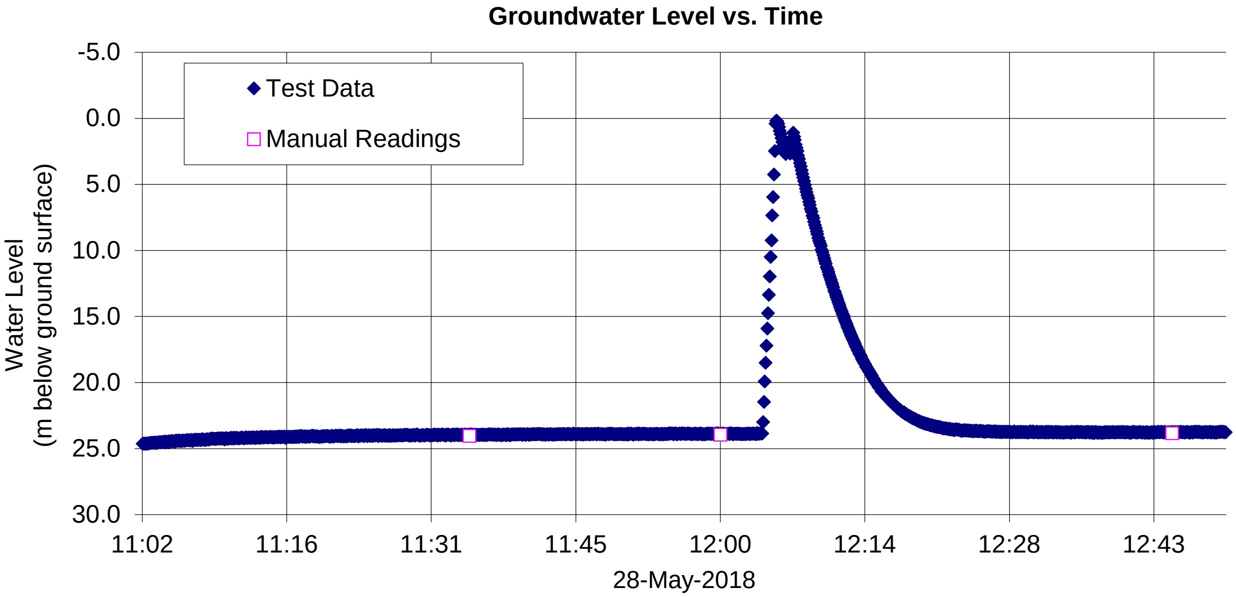
Prepared by: AS

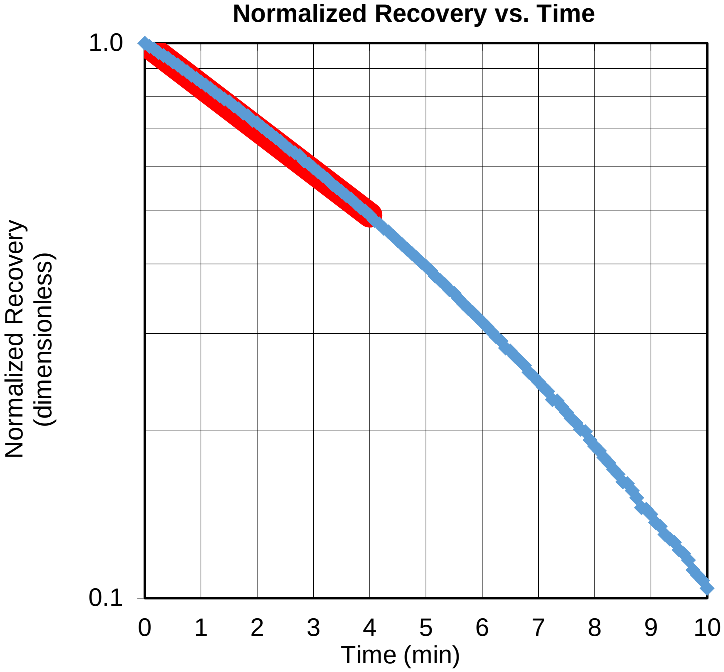
Checked by: ML

Packer Test Result (FHT)

BH17-05 Test #4

FIGURE D.18





Test Interval (below ground surface)

29.2 m to 34.3 m

Static Water Level (below ground surface)

23.82 m

Test Interval (L) = 5.1 m

Casing Radius (r) = 0.048 m

Borehole Radius (R) = 0 m

Points Used for Match Line

$h_1/H_0 =$	1.00	$t_1 =$ 0 min
$h_2/H_0 =$	0.49	$t_2 =$ 4 min

Hvorslev Analysis

$$\text{Hydraulic Conductivity (K)} = \frac{(r^2) \bullet \ln(^L/_R)}{2 \bullet L} \bullet \frac{\ln(h1/H_0) - \ln(h2/H_0)}{t_2 - t_1} = \mathbf{2E\text{-}6 \quad m/s}$$

TEST DATE: 28-May-2018

PROJECT: 1781508

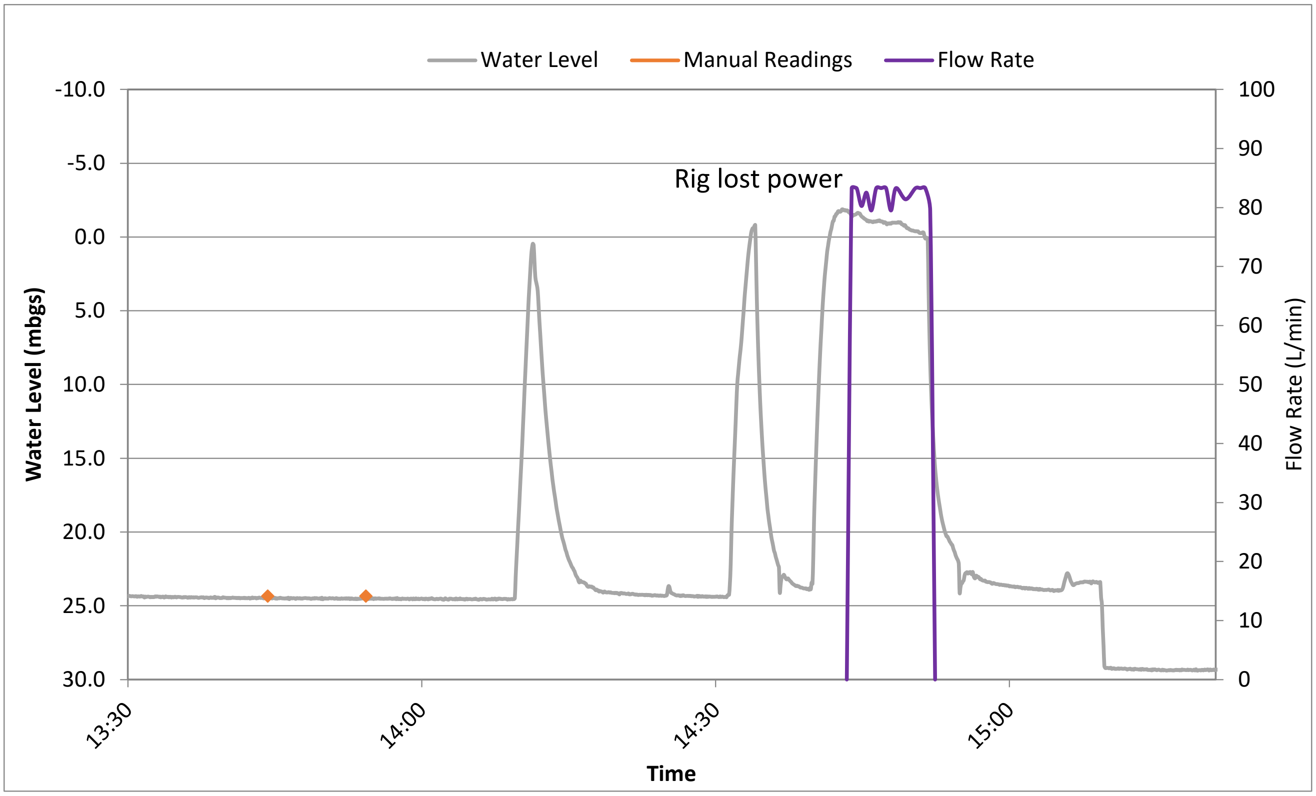
Prepared by: AS

Checked by: ML

Packer Test Result (CRI)

BH17-05 Test #5

FIGURE D.19



Test Interval (below ground surface)

26.1 m to 31.2 m

Test Interval (L) = 5.1 m

Borehole Radius (R) = 0.048 m

Flow Rate (Q) = 82.8 L/min

Head (H) = 25 m

Steady State Equation (Theim, 1906)

Hydraulic Conductivity (K) = [Q*ln(L/R)] / [2(PI)LH] = **8E-6** **m/s**

TEST DATE: 28-May-2018

PROJECT: 1781508

GOLDER

Prepared by: AS

Checked by: ML

APPENDIX E

Groundwater Quality Results

Table E.1

ANALYTICAL RESULTS FOR GENERAL CHEMISTRY, NUTRIENTS, MICROBIOLOGY IN GROUNDWATER

Hydrogeology and Hydrology Level 1 and 2 Study
Proposed Thomas Street Quarry Expansion

Sample Location:		BH17-01	BH17-02	BH17-04	BH17-05	MW17-01	MW17-02	DUP	MW17-03	MW17-04	2011 MECP TABLE 2	
Sample Date:		16-Jan-19	24-Jan-19	24-Jan-19	24-Jan-19	17-Jan-19	24-Jan-19	24-Jan-19	16-Jan-19	16-Jan-19	STANDARDS[1]	ODWS[2]
Calculated Parameters	Units											
Anion Sum	me/L	6.13	5.67	3.73	5.80	5.23	5.88	5.97	5.87	6.50	--	--
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	230	210	140	220	200	230	230	220	230	--	--
Calculated TDS	mg/L	340	320	220	310	270	310	320	320	360	--	500[5]
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.6	1.5	2.2	1.5	1.5	1.3	1.5	1.5	1.4	--	--
Cation Sum	me/L	6.11	5.74	3.99	5.87	4.54	5.99	6.00	5.95	6.42	--	--
Hardness (CaCO3)	mg/L	**300**	**280**	**73**	**270**	**210**	**280**	**280**	**290**	**290**	--	80 - 100[3]
Ion Balance (% Difference)	%	0.190	0.560	3.36	0.560	7.10	0.960	0.260	0.740	0.670	--	--
Langelier Index (@ 20C)	N/A	0.765	0.719	0.138	0.621	0.510	0.580	0.635	0.728	0.658	--	--
Langelier Index (@ 4C)	N/A	0.515	0.470	-0.112	0.372	0.260	0.331	0.386	0.479	0.409	--	--
Saturation pH (@ 20C)	N/A	7.10	7.16	8.07	7.23	7.38	7.20	7.20	7.15	7.15	--	--
Saturation pH (@ 4C)	N/A	7.34	7.41	8.32	7.47	7.63	7.45	7.45	7.40	7.40	--	--
Measured Parameters												--
Total Ammonia-N	mg/L	<0.050	<0.050	0.14	0.078	<0.050	<0.050	<0.050	<0.050	0.055	--	--
Conductivity	umho/cm	580	550	370	550	510	560	560	560	640	--	--
Dissolved Organic Carbon	mg/L	0.69	0.94	1.2	0.96	0.92	0.74	0.74	1.3	1.3	--	5.0[5]
Orthophosphate (P)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	--	--
pH	pH	7.86	7.88	8.20	7.85	7.89	7.78	7.83	7.87	7.81	--	6.5-8.5[3]
Dissolved Sulphate (SO4)	mg/L	16	18	36	38	54	50	50	36	41	--	500[5]
Alkalinity (Total as CaCO3)	mg/L	240	210	150	220	200	230	230	220	230	--	30 - 500[3]
Dissolved Chloride (Cl)	mg/L	8.0	12	1.8	14	1.2	6.9	6.8	8.9	20	790	250[5]
Nitrite (N)	mg/L	<0.010	<0.010	<0.010	0.015	<0.010	<0.010	<0.010	<0.010	<0.010	--	1.0[4]
Nitrate (N)	mg/L	**11.7**	**10.7**	<0.10	2.08	<0.10	0.92	1.05	6.46	6.01	--	10.0[4]
Nitrate + Nitrite (N)	mg/L	11.7	10.7	<0.10	2.10	<0.10	0.92	1.05	6.46	6.01	--	--
Microbiology												
Background	CFU/100mL	--	--	--	--	2	36	29	0	NDOGT	--	--
Total Coliforms	CFU/100mL	--	--	--	--	0	**5**	**1**	**27**	NDOGT	--	Not detectable
Escherichia coli	CFU/100mL	--	--	--	--	0	0	0	0	NDOGT	--	Not detectable

NOTES:
1. O. Reg. 153/04 - Ministry of the Environment, Conservation and Parks (MECP). Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (April 2011), Table 2 Standard is for a potable groundwater situation for all types of property uses.
2. O. Reg. 169/03 - Ontario Drinking Water Quality Standards (amended December 2016), Under Safe Drinking Water Act.
3. Reflects an Operational Guideline established for parameters that need to be controlled to ensure efficient and effective treatment and distribution of the water.
4. Maximum acceptable concentration or interim maximum acceptable concentration (health related criteria).
5. Reflects an Aesthetic Objective established for parameters that may impair taste, odour or colour of water, or which may interfere with good water quality practices.
6. "NDGOT" = no data due to overgrowth, total coliforms and/or E. Coli detected.
7. "<" Below reportable detection limit.
8. Bolded indicate exceedance of applicable ODWS Standards, and highlighted value indicate exceedance of the MECP Table 2 Standard.
9. " **--** " No applicable criterion, or not analysed.

Table E.2

ANALYTICAL RESULTS FOR METALS AND INORGANICS IN GROUNDWATER

Hydrogeology and Hydrology Level 1 and 2 Study
Proposed Thomas Street Quarry Expansion

Sample Location:		BH17-01	BH17-02	BH17-04	BH17-05	MW17-01	MW17-02	DUP	MW17-03	MW17-04	2011 MECP TABLE 2 STANDARDS[1]	ODWS[2]
Sample Date:		16-Jan-19	24-Jan-19	24-Jan-19	24-Jan-19	17-Jan-19	24-Jan-19	24-Jan-19	16-Jan-19	16-Jan-19		
Dissolved Metals	Units											
Aluminum (Al)	µg/L	<5.0	<5.0	10	<5.0	<5.0	<5.0	<5.0	6.3	5.9	--	100[3]
Antimony (Sb)	µg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.59	<0.50	6	6[4]
Arsenic (As)	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.9	<1.0	25	10[4]
Barium (Ba)	µg/L	71	35	49	200	80	210	210	150	80	1000	1000[4]
Beryllium (Be)	µg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	4	--
Boron (B)	µg/L	16	12	200	60	36	55	53	21	54	5000	5000[4]
Cadmium (Cd)	µg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	2.7	5[4]
Calcium (Ca)	µg/L	91000	88000	15000	71000	53000	73000	72000	86000	82000	--	--
Chromium (Cr)	µg/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	50	50[4]
Cobalt (Co)	µg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	3.8	--
Copper (Cu)	µg/L	<1.0	<1.0	1.5	<1.0	<1.0	5.2	<1.0	<1.0	1.1	87	1000[5]
Iron (Fe)	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	--	300[5]
Lead (Pb)	µg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	10	10[4]
Magnesium (Mg)	µg/L	17000	15000	8900	22000	19000	23000	23000	18000	21000	--	--
Manganese (Mn)	µg/L	2.2	<2.0	5.3	12	5.2	13	13	<2.0	6.4	--	50[5]
Molybdenum (Mo)	µg/L	1.2	1.1	15	3.4	9.5	5.5	5.7	5.8	3.5	70	--
Mercury (Hg)	µg/L	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.1	--	--	0.29	1[4]
Nickel (Ni)	µg/L	<1.0	<1.0	1.1	<1.0	1.5	4.5	4.4	1.9	1.9	100	--
Phosphorus (P)	µg/L	<100	<100	100	<100	<100	<100	<100	110	<100	--	--
Potassium (K)	µg/L	1200	1400	1000	1400	770	1200	1200	1300	4000	--	--
Selenium (Se)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	10	50[4]
Silicon (Si)	µg/L	3400	3000	5100	4000	3900	4000	4000	3200	4200	--	--
Silver (Ag)	µg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	1.5	--
Sodium (Na)	µg/L	2200	1800	57000	11000	7600	9900	9700	2200	12000	490000	200000[5]
Strontium (Sr)	µg/L	450	160	660	970	38000	7400	7400	910	7300	--	--
Thallium (Tl)	µg/L	<0.050	<0.050	<0.050	<0.050	0.10	0.069	0.067	<0.050	<0.050	2	--
Titanium (Ti)	µg/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	--	--
Uranium (U)	µg/L	0.97	0.70	<0.10	1.1	0.26	1.7	1.6	5.6	0.54	20	20[4]
Vanadium (V)	µg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	6.2	--
Zinc (Zn)	µg/L	16	<5.0	<5.0	<5.0	<5.0	11	5.2	<5.0	<5.0	1100	5000[5]

NOTES:
1. O. Reg. 153/04 - Ministry of the Environment, Conservation and Parks (MECP). Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (April 2011), Table 2 Standard is for a potable groundwater situation for all types of property uses.
2. O. Reg. 169/03 - Ontario Drinking Water Quality Standards (amended December 2016), Under Safe Drinking Water Act.
3. Reflects an Operational Guideline established for parameters that need to be controlled to ensure efficient and effective treatment and distribution of the water.
4. Maximum acceptable concentration or interim maximum acceptable concentration (health related criteria).
5. Reflects an Aesthetic Objective established for parameters that may impair taste, odour or colour of water, or which may interfere with good water quality practices.
6. "<" Below reportable detection limit.
7. Bolded indicate exceedance of applicable ODWS Standards, and highlighted value indicate exceedance of the MECP Table 2 Standard.
8. " **--** " No applicable criterion, or not analysed.

Table E.3

ANALYTICAL RESULTS FOR PETROLEUM HYDROCARBONS IN GROUNDWATER

Hydrogeology and Hydrology Level 1 and 2 Study
Proposed Thomas Street Quarry Expansion

Sample Location:		BH17-01	BH17-02	BH17-04	BH17-05	MW17-01	MW17-02	DUP	MW17-03	MW17-04	2011 MECP TABLE 2 STANDARDS[1]	ODWS[2]
Sample Date:		16-Jan-19	24-Jan-19	24-Jan-19	24-Jan-19	17-Jan-19	24-Jan-19	24-Jan-19	16-Jan-19	16-Jan-19		
BTEX	Units											
Benzene	µg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	5	1[3]
Toluene	µg/L	<0.20	<0.20	<0.20	<0.20	0.44	<0.20	<0.20	<0.20	<0.20	24	60[3]
Ethylbenzene	µg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	2.4	140[3] , 1.6[4]
o-Xylene	µg/L	<0.20	<0.20	<0.20	<0.20	0.25	<0.20	<0.20	<0.20	<0.20	--	--
p+m-Xylene	µg/L	<0.40	<0.40	<0.40	<0.40	0.43	<0.40	<0.40	<0.40	<0.40	--	--
Total Xylenes	µg/L	<0.40	<0.40	<0.40	<0.40	0.67	<0.40	<0.40	<0.40	<0.40	300	90[3] , 20[4]
Petroleum Hydrocarbons												
PHC F1 (C6-C10)	µg/L	<25	<25	<25	<25	<25	<25	<25	<25	<25	750	--
PHC F2 (C10-C16)	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	150	--
PHC F3 (C16-C34)	µg/L	<200	<200	<200	<200	<200	<200	<200	<200	<200	500	--
PHC F4 (C34-C50)	µg/L	<200	<200	<200	<200	<200	<200	<200	<200	<200	500	--

NOTES:

1. O. Reg. 153/04 - Ministry of the Environment, Conservation and Parks (MECP). Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (April 2011), Table 2 Standard is for a potable groundwater situation for all types of property uses.
2. O. Reg. 169/03 - Ontario Drinking Water Quality Standards (amended December 2016), Under Safe Drinking Water Act.
3. Maximum acceptable concentration or interim maximum acceptable concentration (health related criteria).
4. Reflects an Aesthetic Objective established for parameters that may impair taste, odour or colour of water, or which may interfere with good water quality practices.
5. "<" Below reportable detection limit.
6. Bolded indicate exceedance of applicable ODWS Standards, and highlighted value indicate exceedance of the MECP Table 2 Standard.
7. " **--** " No applicable criterion, or not analysed.

Your Project #: 1781508-8000
Your C.O.C. #: 699630-01-01

Attention: Alexandra Smofsky

Golder Associates Ltd
309 Exeter Rd
Unit 1
London, ON
CANADA N6L 1C1

Report Date: 2019/01/24
Report #: R5569605
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B916378
Received: 2019/01/18, 08:35

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Alkalinity	1	N/A	2019/01/22	CAM SOP-00448	SM 23 2320 B m
Carbonate, Bicarbonate and Hydroxide	1	N/A	2019/01/22	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	1	N/A	2019/01/22	CAM SOP-00463	EPA 325.2 m
Conductivity	1	N/A	2019/01/22	CAM SOP-00414	SM 23 2510 m
Dissolved Organic Carbon (DOC) (1)	1	N/A	2019/01/22	CAM SOP-00446	SM 23 5310 B m
Petroleum Hydro. CCME F1 & BTEX in Water	1	N/A	2019/01/21	CAM SOP-00315	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (2)	1	2019/01/22	2019/01/23	CAM SOP-00316	CCME PHC-CWS m
Hardness (calculated as CaCO3)	1	N/A	2019/01/23	CAM SOP 00102/00408/00447	SM 2340 B
Lab Filtered Metals by ICPMS	1	2019/01/22	2019/01/23	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	1	N/A	2019/01/23		
Anion and Cation Sum	1	N/A	2019/01/23		
Total Coliforms/ E. coli, CFU/100mL	1	N/A	2019/01/18	CAM SOP-00551	MOE E3407
Total Ammonia-N	1	N/A	2019/01/22	CAM SOP-00441	EPA GS I-2522-90 m
Nitrate (NO3) and Nitrite (NO2) in Water (3)	1	N/A	2019/01/22	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	1	N/A	2019/01/22	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	1	N/A	2019/01/22	CAM SOP-00461	EPA 365.1 m
Sat. pH and Langelier Index (@ 20C)	1	N/A	2019/01/23		
Sat. pH and Langelier Index (@ 4C)	1	N/A	2019/01/23		
Sulphate by Automated Colourimetry	1	N/A	2019/01/22	CAM SOP-00464	EPA 375.4 m
Total Dissolved Solids (TDS calc)	1	N/A	2019/01/23		

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Your Project #: 1781508-8000
Your C.O.C. #: 699630-01-01

Attention: Alexandra Smofsky
Golder Associates Ltd
309 Exeter Rd
Unit 1
London, ON
CANADA N6L 1C1

Report Date: 2019/01/24
Report #: R5569605
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B916378
Received: 2019/01/18, 08:35

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) All CCME PHC results met required criteria unless otherwise stated in the report. The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following “Alberta Environment’s Interpretation of the Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil Validation of Performance-Based Alternative Methods September 2003”. Documentation is available upon request. Modifications from Reference Method for the Canada-wide Standard for Petroleum Hydrocarbons in Soil-Tier 1 Method: F2/F3/F4 data reported using validated cold solvent extraction instead of Soxhlet extraction.
(3) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Christine Gripton
Senior Project Manager
24 Jan 2019 15:55:41

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Christine Gripton, Senior Project Manager
Email: CGripton@maxxam.ca
Phone# (800)268-7396 Ext:250

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B916378
Report Date: 2019/01/24

Golder Associates Ltd
Client Project #: 1781508-8000
Sampler Initials: VT

RCAP - COMPREHENSIVE (LAB FILTERED)

Maxxam ID		IUG826		
Sampling Date		2019/01/17 11:55		
COC Number		699630-01-01		
	UNITS	**MW17-01**	**RDL**	**QC Batch**
Calculated Parameters				
Anion Sum	me/L	5.23	N/A	5934961
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	200	1.0	5934959
Calculated TDS	mg/L	270	1.0	5934957
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.5	1.0	5934959
Cation Sum	me/L	4.54	N/A	5934961
Hardness (CaCO3)	mg/L	210	1.0	5934826
Ion Balance (% Difference)	%	7.10	N/A	5934960
Langelier Index (@ 20C)	N/A	0.510		5934955
Langelier Index (@ 4C)	N/A	0.260		5934956
Saturation pH (@ 20C)	N/A	7.38		5934955
Saturation pH (@ 4C)	N/A	7.63		5934956
Inorganics				
Total Ammonia-N	mg/L	<0.050	0.050	5939543
Conductivity	umho/cm	510	1.0	5939416
Dissolved Organic Carbon	mg/L	0.92	0.50	5940140
Orthophosphate (P)	mg/L	<0.010	0.010	5938656
pH	pH	7.89		5939415
Dissolved Sulphate (SO4)	mg/L	54	1.0	5938655
Alkalinity (Total as CaCO3)	mg/L	200	1.0	5939410
Dissolved Chloride (Cl-)	mg/L	1.2	1.0	5938647
Nitrite (N)	mg/L	<0.010	0.010	5937820
Nitrate (N)	mg/L	<0.10	0.10	5937820
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	5937820
Metals				
Dissolved Aluminum (Al)	ug/L	<5.0	5.0	5940526
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	5940526
Dissolved Arsenic (As)	ug/L	<1.0	1.0	5940526
Dissolved Barium (Ba)	ug/L	80	2.0	5940526
Dissolved Beryllium (Be)	ug/L	<0.50	0.50	5940526
Dissolved Boron (B)	ug/L	36	10	5940526
Dissolved Cadmium (Cd)	ug/L	<0.10	0.10	5940526
Dissolved Calcium (Ca)	ug/L	53000	1000	5940526
Dissolved Chromium (Cr)	ug/L	<5.0	5.0	5940526
Dissolved Cobalt (Co)	ug/L	<0.50	0.50	5940526

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

RCAP - COMPREHENSIVE (LAB FILTERED)

Maxxam ID		IUG826		
Sampling Date		2019/01/17 11:55		
COC Number		699630-01-01		
	UNITS	**MW17-01**	**RDL**	**QC Batch**
Dissolved Copper (Cu)	ug/L	<1.0	1.0	5940526
Dissolved Iron (Fe)	ug/L	<100	100	5940526
Dissolved Lead (Pb)	ug/L	<0.50	0.50	5940526
Dissolved Magnesium (Mg)	ug/L	19000	50	5940526
Dissolved Manganese (Mn)	ug/L	5.2	2.0	5940526
Dissolved Molybdenum (Mo)	ug/L	9.5	0.50	5940526
Dissolved Nickel (Ni)	ug/L	1.5	1.0	5940526
Dissolved Phosphorus (P)	ug/L	<100	100	5940526
Dissolved Potassium (K)	ug/L	770	200	5940526
Dissolved Selenium (Se)	ug/L	<2.0	2.0	5940526
Dissolved Silicon (Si)	ug/L	3900	50	5940526
Dissolved Silver (Ag)	ug/L	<0.10	0.10	5940526
Dissolved Sodium (Na)	ug/L	7600	100	5940526
Dissolved Strontium (Sr)	ug/L	38000	1.0	5940526
Dissolved Thallium (Tl)	ug/L	0.10	0.050	5940526
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	5940526
Dissolved Uranium (U)	ug/L	0.26	0.10	5940526
Dissolved Vanadium (V)	ug/L	<0.50	0.50	5940526
Dissolved Zinc (Zn)	ug/L	<5.0	5.0	5940526

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

MICROBIOLOGY (WATER)

Maxxam ID		IUG826	
Sampling Date		2019/01/17 11:55	
COC Number		699630-01-01	
	UNITS	**MW17-01**	**QC Batch**
Microbiological			
Background	CFU/100mL	2	5936300
Total Coliforms	CFU/100mL	0	5936300
Escherichia coli	CFU/100mL	0	5936300
QC Batch = Quality Control Batch			

O.REG 153 PHCS, BTEX/F1-F4 (WATER)

Maxxam ID		IUG826		
Sampling Date		2019/01/17 11:55		
COC Number		699630-01-01		
	UNITS	**MW17-01**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons				
Benzene	ug/L	<0.20	0.20	5936926
Toluene	ug/L	0.44	0.20	5936926
Ethylbenzene	ug/L	<0.20	0.20	5936926
o-Xylene	ug/L	0.25	0.20	5936926
p+m-Xylene	ug/L	0.43	0.40	5936926
Total Xylenes	ug/L	0.67	0.40	5936926
F1 (C6-C10)	ug/L	<25	25	5936926
F1 (C6-C10) - BTEX	ug/L	<25	25	5936926
F2-F4 Hydrocarbons				
F2 (C10-C16 Hydrocarbons)	ug/L	<100	100	5939546
F3 (C16-C34 Hydrocarbons)	ug/L	<200	200	5939546
F4 (C34-C50 Hydrocarbons)	ug/L	<200	200	5939546
Reached Baseline at C50	ug/L	Yes		5939546
Surrogate Recovery (%)				
1,4-Difluorobenzene	%	105		5936926
4-Bromofluorobenzene	%	95		5936926
D10-Ethylbenzene	%	109		5936926
D4-1,2-Dichloroethane	%	95		5936926
o-Terphenyl	%	95		5939546

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

TEST SUMMARY

Maxxam ID: IUG826
Sample ID: MW17-01
Matrix: Water

Collected: 2019/01/17
Shipped:
Received: 2019/01/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5939410	N/A	2019/01/22	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	5934959	N/A	2019/01/22	Automated Statchk
Chloride by Automated Colourimetry	KONE	5938647	N/A	2019/01/22	Deonarine Ramnarine
Conductivity	AT	5939416	N/A	2019/01/22	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5940140	N/A	2019/01/22	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5936926	N/A	2019/01/21	Domnica Andronescu
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5939546	2019/01/22	2019/01/23	(Kent) Maolin Li
Hardness (calculated as CaCO3)		5934826	N/A	2019/01/23	Automated Statchk
Lab Filtered Metals by ICPMS	ICP/MS	5940526	2019/01/22	2019/01/23	Thao Nguyen
Ion Balance (% Difference)	CALC	5934960	N/A	2019/01/23	Automated Statchk
Anion and Cation Sum	CALC	5934961	N/A	2019/01/23	Automated Statchk
Total Coliforms/ E. coli, CFU/100mL	PL	5936300	N/A	2019/01/18	Ranju Chaudhari
Total Ammonia-N	LACH/NH4	5939543	N/A	2019/01/22	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5937820	N/A	2019/01/22	Chandra Nandlal
pH	AT	5939415	N/A	2019/01/22	Surinder Rai
Orthophosphate	KONE	5938656	N/A	2019/01/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5934955	N/A	2019/01/23	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5934956	N/A	2019/01/23	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5938655	N/A	2019/01/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5934957	N/A	2019/01/23	Automated Statchk

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	6.7°C

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5936926	1,4-Difluorobenzene	2019/01/21	103	70 - 130	102	70 - 130	102	%		
5936926	4-Bromofluorobenzene	2019/01/21	100	70 - 130	101	70 - 130	99	%		
5936926	D10-Ethylbenzene	2019/01/21	103	70 - 130	103	70 - 130	105	%		
5936926	D4-1,2-Dichloroethane	2019/01/21	100	70 - 130	107	70 - 130	106	%		
5939546	o-Terphenyl	2019/01/23	102	60 - 130	99	60 - 130	96	%		
5936926	Benzene	2019/01/21	93	70 - 130	90	70 - 130	<0.20	ug/L	NC	30
5936926	Ethylbenzene	2019/01/21	99	70 - 130	95	70 - 130	<0.20	ug/L	4.0	30
5936926	F1 (C6-C10) - BTEX	2019/01/21					<25	ug/L	NC	30
5936926	F1 (C6-C10)	2019/01/21	90	70 - 130	96	70 - 130	<25	ug/L	NC	30
5936926	o-Xylene	2019/01/21	102	70 - 130	101	70 - 130	<0.20	ug/L	NC	30
5936926	p+m-Xylene	2019/01/21	102	70 - 130	99	70 - 130	<0.40	ug/L	NC	30
5936926	Toluene	2019/01/21	102	70 - 130	100	70 - 130	<0.20	ug/L	NC	30
5936926	Total Xylenes	2019/01/21					<0.40	ug/L	NC	30
5937820	Nitrate (N)	2019/01/22	99	80 - 120	101	80 - 120	<0.10	mg/L	NC	20
5937820	Nitrite (N)	2019/01/22	104	80 - 120	102	80 - 120	<0.010	mg/L	NC	20
5938647	Dissolved Chloride (Cl-)	2019/01/22	NC	80 - 120	103	80 - 120	<1.0	mg/L	3.5	20
5938655	Dissolved Sulphate (SO4)	2019/01/22	NC	75 - 125	102	80 - 120	<1.0	mg/L	0.58	20
5938656	Orthophosphate (P)	2019/01/22	103	75 - 125	99	80 - 120	<0.010	mg/L	NC	25
5939410	Alkalinity (Total as CaCO3)	2019/01/22			93	85 - 115	<1.0	mg/L	0.36	20
5939415	pH	2019/01/22			102	98 - 103			0.63	N/A
5939416	Conductivity	2019/01/22			100	85 - 115	<1.0	umho/cm	0.17	25
5939543	Total Ammonia-N	2019/01/22	104	75 - 125	103	80 - 120	<0.050	mg/L	NC	20
5939546	F2 (C10-C16 Hydrocarbons)	2019/01/23	97	50 - 130	92	60 - 130	<100	ug/L	NC	30
5939546	F3 (C16-C34 Hydrocarbons)	2019/01/23	98	50 - 130	94	60 - 130	<200	ug/L	NC	30
5939546	F4 (C34-C50 Hydrocarbons)	2019/01/23	98	50 - 130	93	60 - 130	<200	ug/L	NC	30
5940140	Dissolved Organic Carbon	2019/01/22	94	80 - 120	97	80 - 120	<0.50	mg/L	1.8	20
5940526	Dissolved Aluminum (Al)	2019/01/23	107	80 - 120	101	80 - 120	<5.0	ug/L		
5940526	Dissolved Antimony (Sb)	2019/01/23	108	80 - 120	103	80 - 120	<0.50	ug/L	NC	20
5940526	Dissolved Arsenic (As)	2019/01/23	106	80 - 120	104	80 - 120	<1.0	ug/L	NC	20
5940526	Dissolved Barium (Ba)	2019/01/23	104	80 - 120	100	80 - 120	<2.0	ug/L	0.15	20
5940526	Dissolved Beryllium (Be)	2019/01/23	105	80 - 120	101	80 - 120	<0.50	ug/L	NC	20
5940526	Dissolved Boron (B)	2019/01/23	103	80 - 120	99	80 - 120	<10	ug/L	4.3	20

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**
5940526	Dissolved Cadmium (Cd)	2019/01/23	104	80 - 120	100	80 - 120	<0.10	ug/L	NC	20
5940526	Dissolved Calcium (Ca)	2019/01/23	NC	80 - 120	100	80 - 120	<200	ug/L		
5940526	Dissolved Chromium (Cr)	2019/01/23	102	80 - 120	99	80 - 120	<5.0	ug/L	NC	20
5940526	Dissolved Cobalt (Co)	2019/01/23	102	80 - 120	101	80 - 120	<0.50	ug/L	2.5	20
5940526	Dissolved Copper (Cu)	2019/01/23	103	80 - 120	101	80 - 120	<1.0	ug/L	NC	20
5940526	Dissolved Iron (Fe)	2019/01/23	103	80 - 120	100	80 - 120	<100	ug/L		
5940526	Dissolved Lead (Pb)	2019/01/23	99	80 - 120	97	80 - 120	<0.50	ug/L	NC	20
5940526	Dissolved Magnesium (Mg)	2019/01/23	NC	80 - 120	100	80 - 120	<50	ug/L		
5940526	Dissolved Manganese (Mn)	2019/01/23	NC	80 - 120	99	80 - 120	<2.0	ug/L		
5940526	Dissolved Molybdenum (Mo)	2019/01/23	110	80 - 120	103	80 - 120	<0.50	ug/L	0.41	20
5940526	Dissolved Nickel (Ni)	2019/01/23	99	80 - 120	99	80 - 120	<1.0	ug/L	0.13	20
5940526	Dissolved Phosphorus (P)	2019/01/23	112	80 - 120	111	80 - 120	<100	ug/L		
5940526	Dissolved Potassium (K)	2019/01/23	105	80 - 120	101	80 - 120	<200	ug/L		
5940526	Dissolved Selenium (Se)	2019/01/23	109	80 - 120	102	80 - 120	<2.0	ug/L	NC	20
5940526	Dissolved Silicon (Si)	2019/01/23	107	80 - 120	100	80 - 120	<50	ug/L		
5940526	Dissolved Silver (Ag)	2019/01/23	103	80 - 120	100	80 - 120	<0.10	ug/L	NC	20
5940526	Dissolved Sodium (Na)	2019/01/23	NC	80 - 120	99	80 - 120	<100	ug/L	2.2	20
5940526	Dissolved Strontium (Sr)	2019/01/23	100	80 - 120	98	80 - 120	<1.0	ug/L		
5940526	Dissolved Thallium (Tl)	2019/01/23	97	80 - 120	95	80 - 120	<0.050	ug/L	NC	20
5940526	Dissolved Titanium (Ti)	2019/01/23	110	80 - 120	98	80 - 120	<5.0	ug/L		
5940526	Dissolved Uranium (U)	2019/01/23	102	80 - 120	99	80 - 120	<0.10	ug/L	0.53	20
5940526	Dissolved Vanadium (V)	2019/01/23	106	80 - 120	100	80 - 120	<0.50	ug/L	NC	20

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5940526	Dissolved Zinc (Zn)	2019/01/23	100	80 - 120	100	80 - 120	<5.0	ug/L	NC	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Eva R

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
Eva Pranjic
CHEMIST

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

Ranju.

Ranju Chaudhari

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam
A Bureau Veritas Group Company

Your Project #: 1781508-8000
Your C.O.C. #: 699630-02-01

Attention: Alexandra Smofsky

Golder Associates Ltd
309 Exeter Rd
Unit 1
London, ON
CANADA N6L 1C1

Report Date: 2019/01/28
Report #: R5573804
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B915044
Received: 2019/01/17, 08:45

Sample Matrix: Water
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Alkalinity	3	N/A	2019/01/21	CAM SOP-00448	SM 23 2320 B m
Carbonate, Bicarbonate and Hydroxide	3	N/A	2019/01/22	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	3	N/A	2019/01/21	CAM SOP-00463	EPA 325.2 m
Conductivity	3	N/A	2019/01/21	CAM SOP-00414	SM 23 2510 m
Dissolved Organic Carbon (DOC) (1)	3	N/A	2019/01/22	CAM SOP-00446	SM 23 5310 B m
Petroleum Hydro. CCME F1 & BTEX in Water	3	N/A	2019/01/21	CAM SOP-00315	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (2)	3	2019/01/21	2019/01/22	CAM SOP-00316	CCME PHC-CWS m
Hardness (calculated as CaCO3)	3	N/A	2019/01/23	CAM SOP 00102/00408/00447	SM 2340 B
Dissolved Mercury in Water by CVAA	1	2019/01/22	2019/01/22	CAM SOP-00453	EPA 7470A m
Lab Filtered Metals by ICPMS	2	2019/01/22	2019/01/22	CAM SOP-00447	EPA 6020B m
Dissolved Metals by ICPMS	1	N/A	2019/01/22	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	3	N/A	2019/01/23		
Anion and Cation Sum	3	N/A	2019/01/23		
Total Coliforms/ E. coli, CFU/100mL	2	N/A	2019/01/18	CAM SOP-00551	MOE E3407
Total Ammonia-N	3	N/A	2019/01/22	CAM SOP-00441	EPA GS I-2522-90 m
Nitrate (NO3) and Nitrite (NO2) in Water (3)	3	N/A	2019/01/22	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	3	N/A	2019/01/21	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	3	N/A	2019/01/21	CAM SOP-00461	EPA 365.1 m
Sat. pH and Langelier Index (@ 20C)	3	N/A	2019/01/23		
Sat. pH and Langelier Index (@ 4C)	3	N/A	2019/01/23		
Sulphate by Automated Colourimetry	3	N/A	2019/01/21	CAM SOP-00464	EPA 375.4 m
Total Dissolved Solids (TDS calc)	3	N/A	2019/01/23		

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been

Your Project #: 1781508-8000
Your C.O.C. #: 699630-02-01

Attention: Alexandra Smofsky

Golder Associates Ltd
309 Exeter Rd
Unit 1
London, ON
CANADA N6L 1C1

Report Date: 2019/01/28
Report #: R5573804
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B915044
Received: 2019/01/17, 08:45

accounted for when stating conformity to the referenced standard.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) All CCME PHC results met required criteria unless otherwise stated in the report. The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following “Alberta Environment’s Interpretation of the Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil Validation of Performance-Based Alternative Methods September 2003”. Documentation is available upon request. Modifications from Reference Method for the Canada-wide Standard for Petroleum Hydrocarbons in Soil-Tier 1 Method: F2/F3/F4 data reported using validated cold solvent extraction instead of Soxhlet extraction.
(3) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

```
Christine Gripton
Senior Project Manager
28 Jan 2019 12:57:58
```

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Christine Gripton, Senior Project Manager
Email: CGripton@maxxam.ca
Phone# (800)268-7396 Ext:250
==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		IUA198		
Sampling Date		2019/01/16 12:05		
COC Number		699630-02-01		
	UNITS	**BH17-01**	**RDL**	**QC Batch**
Calculated Parameters				
Anion Sum	me/L	6.13	N/A	5934961
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	230	1.0	5934959
Calculated TDS	mg/L	340	1.0	5934957
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.6	1.0	5934959
Cation Sum	me/L	6.11	N/A	5934961
Hardness (CaCO3)	mg/L	300	1.0	5934826
Ion Balance (% Difference)	%	0.190	N/A	5934960
Langelier Index (@ 20C)	N/A	0.765		5934955
Langelier Index (@ 4C)	N/A	0.515		5934956
Saturation pH (@ 20C)	N/A	7.10		5934955
Saturation pH (@ 4C)	N/A	7.34		5934956
Inorganics				
Total Ammonia-N	mg/L	<0.050	0.050	5937627
Conductivity	umho/cm	580	1.0	5936818
Dissolved Organic Carbon	mg/L	0.69	0.50	5939591
Orthophosphate (P)	mg/L	<0.010	0.010	5936800
pH	pH	7.86		5936819
Dissolved Sulphate (SO4)	mg/L	16	1.0	5936798
Alkalinity (Total as CaCO3)	mg/L	240	1.0	5936781
Dissolved Chloride (Cl-)	mg/L	8.0	1.0	5936797
Nitrite (N)	mg/L	<0.010	0.010	5936805
Nitrate (N)	mg/L	11.7	0.10	5936805
Nitrate + Nitrite (N)	mg/L	11.7	0.10	5936805
Metals				
Dissolved Aluminum (Al)	ug/L	<5.0	5.0	5933882
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	5933882
Dissolved Arsenic (As)	ug/L	<1.0	1.0	5933882
Dissolved Barium (Ba)	ug/L	71	2.0	5933882
Dissolved Beryllium (Be)	ug/L	<0.50	0.50	5933882
Dissolved Boron (B)	ug/L	16	10	5933882
Dissolved Cadmium (Cd)	ug/L	<0.10	0.10	5933882
Dissolved Calcium (Ca)	ug/L	91000	200	5933882
Dissolved Chromium (Cr)	ug/L	<5.0	5.0	5933882
Dissolved Cobalt (Co)	ug/L	<0.50	0.50	5933882

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		IUA198		
Sampling Date		2019/01/16 12:05		
COC Number		699630-02-01		
	UNITS	**BH17-01**	**RDL**	**QC Batch**
Dissolved Copper (Cu)	ug/L	<1.0	1.0	5933882
Dissolved Iron (Fe)	ug/L	<100	100	5933882
Dissolved Lead (Pb)	ug/L	<0.50	0.50	5933882
Dissolved Magnesium (Mg)	ug/L	17000	50	5933882
Dissolved Manganese (Mn)	ug/L	2.2	2.0	5933882
Dissolved Molybdenum (Mo)	ug/L	1.2	0.50	5933882
Dissolved Nickel (Ni)	ug/L	<1.0	1.0	5933882
Dissolved Phosphorus (P)	ug/L	<100	100	5933882
Dissolved Potassium (K)	ug/L	1200	200	5933882
Dissolved Selenium (Se)	ug/L	<2.0	2.0	5933882
Dissolved Silicon (Si)	ug/L	3400	50	5933882
Dissolved Silver (Ag)	ug/L	<0.10	0.10	5933882
Dissolved Sodium (Na)	ug/L	2200	100	5933882
Dissolved Strontium (Sr)	ug/L	450	1.0	5933882
Dissolved Thallium (Tl)	ug/L	<0.050	0.050	5933882
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	5933882
Dissolved Uranium (U)	ug/L	0.97	0.10	5933882
Dissolved Vanadium (V)	ug/L	<0.50	0.50	5933882
Dissolved Zinc (Zn)	ug/L	16	5.0	5933882

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

RCAP - COMPREHENSIVE (LAB FILTERED)

Maxxam ID		IUA197		IUA199			IUA199		
Sampling Date		2019/01/16 12:40		2019/01/16 14:50			2019/01/16 14:50		
COC Number		699630-02-01		699630-02-01			699630-02-01		
	UNITS	**MW17-04**	**RDL**	**MW17-03**	**RDL**	**QC Batch**	**MW17-03 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters									
Anion Sum	me/L	6.50	N/A	5.87	N/A	5934961			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	230	1.0	220	1.0	5934959			
Calculated TDS	mg/L	360	1.0	320	1.0	5934957			
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.4	1.0	1.5	1.0	5934959			
Cation Sum	me/L	6.42	N/A	5.95	N/A	5934961			
Hardness (CaCO3)	mg/L	290	1.0	290	1.0	5934826			
Ion Balance (% Difference)	%	0.670	N/A	0.740	N/A	5934960			
Langelier Index (@ 20C)	N/A	0.658		0.728		5934955			
Langelier Index (@ 4C)	N/A	0.409		0.479		5934956			
Saturation pH (@ 20C)	N/A	7.15		7.15		5934955			
Saturation pH (@ 4C)	N/A	7.40		7.40		5934956			
Inorganics									
Total Ammonia-N	mg/L	0.055	0.050	<0.050	0.050	5937627			
Conductivity	umho/cm	640	1.0	560	1.0	5936818			
Dissolved Organic Carbon	mg/L	1.3	0.50	1.3	0.50	5939591			
Orthophosphate (P)	mg/L	<0.010	0.010	<0.010	0.010	5936800			
pH	pH	7.81		7.87		5936819			
Dissolved Sulphate (SO4)	mg/L	41	1.0	36	1.0	5936798			
Alkalinity (Total as CaCO3)	mg/L	230	1.0	220	1.0	5936817			
Dissolved Chloride (Cl-)	mg/L	20	1.0	8.9	1.0	5936797			
Nitrite (N)	mg/L	<0.010	0.010	<0.010	0.010	5936805			
Nitrate (N)	mg/L	6.01	0.10	6.46	0.10	5936805			
Nitrate + Nitrite (N)	mg/L	6.01	0.10	6.46	0.10	5936805			
Metals									
Dissolved Aluminum (Al)	ug/L	5.9	5.0	6.3	5.0	5938142	<5.0	5.0	5938142
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	0.59	0.50	5938142	0.52	0.50	5938142
Dissolved Arsenic (As)	ug/L	<1.0	1.0	1.9	1.0	5938142	1.5	1.0	5938142
Dissolved Barium (Ba)	ug/L	80	2.0	150	2.0	5938142	150	2.0	5938142
Dissolved Beryllium (Be)	ug/L	<0.50	0.50	<0.50	0.50	5938142	<0.50	0.50	5938142
Dissolved Boron (B)	ug/L	54	10	21	10	5938142	20	10	5938142
Dissolved Cadmium (Cd)	ug/L	<0.10	0.10	<0.10	0.10	5938142	<0.10	0.10	5938142
Dissolved Calcium (Ca)	ug/L	82000	400	86000	200	5938142	85000	200	5938142
Dissolved Chromium (Cr)	ug/L	<5.0	5.0	<5.0	5.0	5938142	<5.0	5.0	5938142

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

RCAP - COMPREHENSIVE (LAB FILTERED)

Maxxam ID		IUA197		IUA199			IUA199		
Sampling Date		2019/01/16 12:40		2019/01/16 14:50			2019/01/16 14:50		
COC Number		699630-02-01		699630-02-01			699630-02-01		
	UNITS	**MW17-04**	**RDL**	**MW17-03**	**RDL**	**QC Batch**	**MW17-03 Lab-Dup**	**RDL**	**QC Batch**
Dissolved Cobalt (Co)	ug/L	<0.50	0.50	<0.50	0.50	5938142	<0.50	0.50	5938142
Dissolved Copper (Cu)	ug/L	1.1	1.0	<1.0	1.0	5938142	<1.0	1.0	5938142
Dissolved Iron (Fe)	ug/L	<100	100	<100	100	5938142	<100	100	5938142
Dissolved Lead (Pb)	ug/L	<0.50	0.50	<0.50	0.50	5938142	<0.50	0.50	5938142
Dissolved Magnesium (Mg)	ug/L	21000	50	18000	50	5938142	18000	50	5938142
Dissolved Manganese (Mn)	ug/L	6.4	2.0	<2.0	2.0	5938142	<2.0	2.0	5938142
Dissolved Molybdenum (Mo)	ug/L	3.5	0.50	5.8	0.50	5938142	6.0	0.50	5938142
Dissolved Nickel (Ni)	ug/L	1.9	1.0	1.9	1.0	5938142	1.6	1.0	5938142
Dissolved Phosphorus (P)	ug/L	<100	100	110	100	5938142	<100	100	5938142
Dissolved Potassium (K)	ug/L	4000	200	1300	200	5938142	1300	200	5938142
Dissolved Selenium (Se)	ug/L	<2.0	2.0	<2.0	2.0	5938142	<2.0	2.0	5938142
Dissolved Silicon (Si)	ug/L	4200	50	3200	50	5938142	3200	50	5938142
Dissolved Silver (Ag)	ug/L	<0.10	0.10	<0.10	0.10	5938142	<0.10	0.10	5938142
Dissolved Sodium (Na)	ug/L	12000	100	2200	100	5938142	2200	100	5938142
Dissolved Strontium (Sr)	ug/L	7300	1.0	910	1.0	5938142	900	1.0	5938142
Dissolved Thallium (Tl)	ug/L	<0.050	0.050	<0.050	0.050	5938142	<0.050	0.050	5938142
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	<5.0	5.0	5938142	<5.0	5.0	5938142
Dissolved Uranium (U)	ug/L	0.54	0.10	5.6	0.10	5938142	5.5	0.10	5938142
Dissolved Vanadium (V)	ug/L	<0.50	0.50	<0.50	0.50	5938142	<0.50	0.50	5938142
Dissolved Zinc (Zn)	ug/L	<5.0	5.0	<5.0	5.0	5938142	<5.0	5.0	5938142

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		IUA198		
Sampling Date		2019/01/16 12:05		
COC Number		699630-02-01		
	UNITS	**BH17-01**	**RDL**	**QC Batch**
Metals				
Dissolved Mercury (Hg)	ug/L	<0.1	0.1	5939599

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

PETROLEUM HYDROCARBONS (CCME)

Maxxam ID		IUA197		
Sampling Date		2019/01/16 12:40		
COC Number		699630-02-01		
	UNITS	**MW17-04**	**RDL**	**QC Batch**
F2-F4 Hydrocarbons				
F2 (C10-C16 Hydrocarbons)	ug/L	<100	100	5938162
F3 (C16-C34 Hydrocarbons)	ug/L	<200	200	5938162
F4 (C34-C50 Hydrocarbons)	ug/L	<200	200	5938162
Reached Baseline at C50	ug/L	Yes		5938162
Surrogate Recovery (%)				
o-Terphenyl	%	104		5938162

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

MICROBIOLOGY (WATER)

Maxxam ID		IUA197	IUA199	
Sampling Date		2019/01/16 12:40	2019/01/16 14:50	
COC Number		699630-02-01	699630-02-01	
	UNITS	**MW17-04**	**MW17-03**	**QC Batch**
Microbiological				
Background	CFU/100mL	NDOGT (1)	0	5935629
Total Coliforms	CFU/100mL	NDOGT (1)	27	5935629
Escherichia coli	CFU/100mL	NDOGT (1)	0	5935629

QC Batch = Quality Control Batch

(1) NDOGT: No data due to overgrowth. Total coliforms and / or E.coli detected

O.REG 153 PHCS, BTEX/F1-F4 (WATER)

Maxxam ID		IUA197			IUA198	IUA199		
Sampling Date		2019/01/16 12:40			2019/01/16 12:05	2019/01/16 14:50		
COC Number		699630-02-01			699630-02-01	699630-02-01		
	UNITS	**MW17-04**	**RDL**	**QC Batch**	**BH17-01**	**MW17-03**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons								
Benzene	ug/L	<0.20	0.20	5936926	<0.20	<0.20	0.20	5936926
Toluene	ug/L	<0.20	0.20	5936926	<0.20	<0.20	0.20	5936926
Ethylbenzene	ug/L	<0.20	0.20	5936926	<0.20	<0.20	0.20	5936926
o-Xylene	ug/L	<0.20	0.20	5936926	<0.20	<0.20	0.20	5936926
p+m-Xylene	ug/L	<0.40	0.40	5936926	<0.40	<0.40	0.40	5936926
Total Xylenes	ug/L	<0.40	0.40	5936926	<0.40	<0.40	0.40	5936926
F1 (C6-C10)	ug/L	<25	25	5936926	<25	<25	25	5936926
F1 (C6-C10) - BTEX	ug/L	<25	25	5936926	<25	<25	25	5936926
F2-F4 Hydrocarbons								
F2 (C10-C16 Hydrocarbons)	ug/L				<100	<100	100	5938162
F3 (C16-C34 Hydrocarbons)	ug/L				<200	<200	200	5938162
F4 (C34-C50 Hydrocarbons)	ug/L				<200	<200	200	5938162
Reached Baseline at C50	ug/L				Yes	Yes		5938162
Surrogate Recovery (%)								
1,4-Difluorobenzene	%	106		5936926	104	110		5936926
4-Bromofluorobenzene	%	98		5936926	96	100		5936926
D10-Ethylbenzene	%	109		5936926	108	111		5936926
D4-1,2-Dichloroethane	%	103		5936926	102	104		5936926
o-Terphenyl	%				107	108		5938162

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

TEST SUMMARY

Maxxam ID: IUA197
Sample ID: MW17-04
Matrix: Water

Collected: 2019/01/16
Shipped:
Received: 2019/01/17

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5936817	N/A	2019/01/21	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	5934959	N/A	2019/01/22	Automated Statchk
Chloride by Automated Colourimetry	KONE	5936797	N/A	2019/01/21	Deonarine Ramnarine
Conductivity	AT	5936818	N/A	2019/01/21	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5939591	N/A	2019/01/22	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5936926	N/A	2019/01/21	Domnica Andronescu
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5938162	2019/01/21	2019/01/22	Zhiyue (Frank) Zhu
Hardness (calculated as CaCO3)		5934826	N/A	2019/01/23	Automated Statchk
Lab Filtered Metals by ICPMS	ICP/MS	5938142	2019/01/22	2019/01/22	Thao Nguyen
Ion Balance (% Difference)	CALC	5934960	N/A	2019/01/23	Automated Statchk
Anion and Cation Sum	CALC	5934961	N/A	2019/01/23	Automated Statchk
Total Coliforms/ E. coli, CFU/100mL	PL	5935629	N/A	2019/01/18	Farhana Rahman
Total Ammonia-N	LACH/NH4	5937627	N/A	2019/01/22	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5936805	N/A	2019/01/22	Chandra Nandlal
pH	AT	5936819	N/A	2019/01/21	Surinder Rai
Orthophosphate	KONE	5936800	N/A	2019/01/21	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5934955	N/A	2019/01/23	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5934956	N/A	2019/01/23	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5936798	N/A	2019/01/21	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5934957	N/A	2019/01/23	Automated Statchk

Maxxam ID: IUA198
Sample ID: BH17-01
Matrix: Water

Collected: 2019/01/16
Shipped:
Received: 2019/01/17

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5936781	N/A	2019/01/21	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	5934959	N/A	2019/01/22	Automated Statchk
Chloride by Automated Colourimetry	KONE	5936797	N/A	2019/01/21	Deonarine Ramnarine
Conductivity	AT	5936818	N/A	2019/01/21	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5939591	N/A	2019/01/22	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5936926	N/A	2019/01/21	Domnica Andronescu
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5938162	2019/01/21	2019/01/22	Zhiyue (Frank) Zhu
Hardness (calculated as CaCO3)		5934826	N/A	2019/01/23	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5939599	2019/01/22	2019/01/22	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5933882	N/A	2019/01/22	Thao Nguyen
Ion Balance (% Difference)	CALC	5934960	N/A	2019/01/23	Automated Statchk
Anion and Cation Sum	CALC	5934961	N/A	2019/01/23	Automated Statchk
Total Ammonia-N	LACH/NH4	5937627	N/A	2019/01/22	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5936805	N/A	2019/01/22	Chandra Nandlal
pH	AT	5936819	N/A	2019/01/21	Surinder Rai
Orthophosphate	KONE	5936800	N/A	2019/01/21	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5934955	N/A	2019/01/23	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5934956	N/A	2019/01/23	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5936798	N/A	2019/01/21	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5934957	N/A	2019/01/23	Automated Statchk

TEST SUMMARY

Maxxam ID: IUA199
Sample ID: MW17-03
Matrix: Water

Collected: 2019/01/16
Shipped:
Received: 2019/01/17

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5936817	N/A	2019/01/21	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	5934959	N/A	2019/01/22	Automated Statchk
Chloride by Automated Colourimetry	KONE	5936797	N/A	2019/01/21	Deonarine Ramnarine
Conductivity	AT	5936818	N/A	2019/01/21	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5939591	N/A	2019/01/22	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5936926	N/A	2019/01/21	Domnica Andronescu
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5938162	2019/01/21	2019/01/22	Zhiyue (Frank) Zhu
Hardness (calculated as CaCO3)		5934826	N/A	2019/01/23	Automated Statchk
Lab Filtered Metals by ICPMS	ICP/MS	5938142	2019/01/22	2019/01/22	Thao Nguyen
Ion Balance (% Difference)	CALC	5934960	N/A	2019/01/23	Automated Statchk
Anion and Cation Sum	CALC	5934961	N/A	2019/01/23	Automated Statchk
Total Coliforms/ E. coli, CFU/100mL	PL	5935629	N/A	2019/01/18	Farhana Rahman
Total Ammonia-N	LACH/NH4	5937627	N/A	2019/01/22	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5936805	N/A	2019/01/22	Chandra Nandlal
pH	AT	5936819	N/A	2019/01/21	Surinder Rai
Orthophosphate	KONE	5936800	N/A	2019/01/21	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5934955	N/A	2019/01/23	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5934956	N/A	2019/01/23	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5936798	N/A	2019/01/21	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5934957	N/A	2019/01/23	Automated Statchk

Maxxam ID: IUA199 Dup
Sample ID: MW17-03
Matrix: Water

Collected: 2019/01/16
Shipped:
Received: 2019/01/17

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Lab Filtered Metals by ICPMS	ICP/MS	5938142	2019/01/22	2019/01/22	Thao Nguyen

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	0.0°C

Revised report (2019/01/28): Includes F2-4 results for sample MW17-04.

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5936926	1,4-Difluorobenzene	2019/01/21	103	70 - 130	102	70 - 130	102	%		
5936926	4-Bromofluorobenzene	2019/01/21	100	70 - 130	101	70 - 130	99	%		
5936926	D10-Ethylbenzene	2019/01/21	103	70 - 130	103	70 - 130	105	%		
5936926	D4-1,2-Dichloroethane	2019/01/21	100	70 - 130	107	70 - 130	106	%		
5938162	o-Terphenyl	2019/01/22	121	60 - 130	114	60 - 130	110	%		
5933882	Dissolved Aluminum (Al)	2019/01/22	102	80 - 120	103	80 - 120	<5.0	ug/L		
5933882	Dissolved Antimony (Sb)	2019/01/22	110	80 - 120	104	80 - 120	<0.50	ug/L		
5933882	Dissolved Arsenic (As)	2019/01/22	99	80 - 120	99	80 - 120	<1.0	ug/L		
5933882	Dissolved Barium (Ba)	2019/01/22	74 (1)	80 - 120	102	80 - 120	<2.0	ug/L		
5933882	Dissolved Beryllium (Be)	2019/01/22	101	80 - 120	101	80 - 120	<0.50	ug/L		
5933882	Dissolved Boron (B)	2019/01/22	80	80 - 120	103	80 - 120	<10	ug/L		
5933882	Dissolved Cadmium (Cd)	2019/01/22	104	80 - 120	101	80 - 120	<0.10	ug/L		
5933882	Dissolved Calcium (Ca)	2019/01/22	NC	80 - 120	101	80 - 120	<200	ug/L		
5933882	Dissolved Chromium (Cr)	2019/01/22	95	80 - 120	97	80 - 120	<5.0	ug/L		
5933882	Dissolved Cobalt (Co)	2019/01/22	94	80 - 120	97	80 - 120	<0.50	ug/L		
5933882	Dissolved Copper (Cu)	2019/01/22	96	80 - 120	99	80 - 120	<1.0	ug/L		
5933882	Dissolved Iron (Fe)	2019/01/22	102	80 - 120	98	80 - 120	<100	ug/L	0.034	20
5933882	Dissolved Lead (Pb)	2019/01/22	94	80 - 120	96	80 - 120	<0.50	ug/L		
5933882	Dissolved Magnesium (Mg)	2019/01/22	78 (1)	80 - 120	99	80 - 120	<50	ug/L		
5933882	Dissolved Manganese (Mn)	2019/01/22	77 (1)	80 - 120	99	80 - 120	<2.0	ug/L	0.43	20
5933882	Dissolved Molybdenum (Mo)	2019/01/22	104	80 - 120	103	80 - 120	<0.50	ug/L		
5933882	Dissolved Nickel (Ni)	2019/01/22	91	80 - 120	97	80 - 120	<1.0	ug/L		
5933882	Dissolved Phosphorus (P)	2019/01/22	107	80 - 120	122 (1)	80 - 120	<100	ug/L		
5933882	Dissolved Potassium (K)	2019/01/22	74 (1)	80 - 120	100	80 - 120	<200	ug/L		
5933882	Dissolved Selenium (Se)	2019/01/22	96	80 - 120	105	80 - 120	<2.0	ug/L		
5933882	Dissolved Silicon (Si)	2019/01/22	80	80 - 120	102	80 - 120	<50	ug/L		
5933882	Dissolved Silver (Ag)	2019/01/22	60 (1)	80 - 120	98	80 - 120	<0.10	ug/L		
5933882	Dissolved Sodium (Na)	2019/01/22	NC	80 - 120	96	80 - 120	<100	ug/L		
5933882	Dissolved Strontium (Sr)	2019/01/22	70 (1)	80 - 120	99	80 - 120	<1.0	ug/L		
5933882	Dissolved Thallium (Tl)	2019/01/22	95	80 - 120	96	80 - 120	<0.050	ug/L		
5933882	Dissolved Titanium (Ti)	2019/01/22	98	80 - 120	101	80 - 120	<5.0	ug/L		
5933882	Dissolved Uranium (U)	2019/01/22	96	80 - 120	97	80 - 120	<0.10	ug/L		

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5933882	Dissolved Vanadium (V)	2019/01/22	99	80 - 120	99	80 - 120	<0.50	ug/L		
5933882	Dissolved Zinc (Zn)	2019/01/22	95	80 - 120	98	80 - 120	<5.0	ug/L		
5936781	Alkalinity (Total as CaCO3)	2019/01/21			94	85 - 115	<1.0	mg/L	1.5	20
5936797	Dissolved Chloride (Cl-)	2019/01/21	NC	80 - 120	103	80 - 120	<1.0	mg/L	0.38	20
5936798	Dissolved Sulphate (SO4)	2019/01/21	NC	75 - 125	98	80 - 120	<1.0	mg/L	1.0	20
5936800	Orthophosphate (P)	2019/01/21	103	75 - 125	99	80 - 120	<0.010	mg/L	NC	25
5936805	Nitrate (N)	2019/01/22	100	80 - 120	102	80 - 120	<0.10	mg/L	NC	20
5936805	Nitrite (N)	2019/01/22	104	80 - 120	102	80 - 120	<0.010	mg/L	NC	20
5936817	Alkalinity (Total as CaCO3)	2019/01/21			95	85 - 115	<1.0	mg/L	0.74	20
5936818	Conductivity	2019/01/21			101	85 - 115	<1.0	umho/cm	0.23	25
5936819	pH	2019/01/21			102	98 - 103			0.081	N/A
5936926	Benzene	2019/01/21	93	70 - 130	90	70 - 130	<0.20	ug/L	NC	30
5936926	Ethylbenzene	2019/01/21	99	70 - 130	95	70 - 130	<0.20	ug/L	4.0	30
5936926	F1 (C6-C10) - BTEX	2019/01/21					<25	ug/L	NC	30
5936926	F1 (C6-C10)	2019/01/21	90	70 - 130	96	70 - 130	<25	ug/L	NC	30
5936926	o-Xylene	2019/01/21	102	70 - 130	101	70 - 130	<0.20	ug/L	NC	30
5936926	p+m-Xylene	2019/01/21	102	70 - 130	99	70 - 130	<0.40	ug/L	NC	30
5936926	Toluene	2019/01/21	102	70 - 130	100	70 - 130	<0.20	ug/L	NC	30
5936926	Total Xylenes	2019/01/21					<0.40	ug/L	NC	30
5937627	Total Ammonia-N	2019/01/22	102	75 - 125	103	80 - 120	<0.050	mg/L	14	20
5938142	Dissolved Aluminum (Al)	2019/01/22	100	80 - 120	105	80 - 120	<5.0	ug/L	NC	20
5938142	Dissolved Antimony (Sb)	2019/01/22	103	80 - 120	105	80 - 120	<0.50	ug/L	14	20
5938142	Dissolved Arsenic (As)	2019/01/22	99	80 - 120	99	80 - 120	<1.0	ug/L	NC	20
5938142	Dissolved Barium (Ba)	2019/01/22	99	80 - 120	104	80 - 120	<2.0	ug/L	0.68	20
5938142	Dissolved Beryllium (Be)	2019/01/22	99	80 - 120	101	80 - 120	<0.50	ug/L	NC	20
5938142	Dissolved Boron (B)	2019/01/22	98	80 - 120	104	80 - 120	<10	ug/L	3.3	20
5938142	Dissolved Cadmium (Cd)	2019/01/22	100	80 - 120	101	80 - 120	<0.10	ug/L	NC	20
5938142	Dissolved Calcium (Ca)	2019/01/22	NC	80 - 120	102	80 - 120	<200	ug/L	1.4	20
5938142	Dissolved Chromium (Cr)	2019/01/22	97	80 - 120	97	80 - 120	<5.0	ug/L	NC	20
5938142	Dissolved Cobalt (Co)	2019/01/22	95	80 - 120	97	80 - 120	<0.50	ug/L	NC	20
5938142	Dissolved Copper (Cu)	2019/01/22	97	80 - 120	100	80 - 120	<1.0	ug/L	NC	20
5938142	Dissolved Iron (Fe)	2019/01/22	97	80 - 120	99	80 - 120	<100	ug/L	NC	20

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**
5938142	Dissolved Lead (Pb)	2019/01/22	92	80 - 120	96	80 - 120	<0.50	ug/L	NC	20
5938142	Dissolved Magnesium (Mg)	2019/01/22	97	80 - 120	99	80 - 120	<50	ug/L	0.011	20
5938142	Dissolved Manganese (Mn)	2019/01/22	96	80 - 120	99	80 - 120	<2.0	ug/L	NC	20
5938142	Dissolved Molybdenum (Mo)	2019/01/22	102	80 - 120	103	80 - 120	<0.50	ug/L	3.2	20
5938142	Dissolved Nickel (Ni)	2019/01/22	94	80 - 120	97	80 - 120	<1.0	ug/L	18	20
5938142	Dissolved Phosphorus (P)	2019/01/22	101	80 - 120	124 (1)	80 - 120	<100	ug/L	6.8	20
5938142	Dissolved Potassium (K)	2019/01/22	99	80 - 120	100	80 - 120	<200	ug/L	1.1	20
5938142	Dissolved Selenium (Se)	2019/01/22	102	80 - 120	105	80 - 120	<2.0	ug/L	NC	20
5938142	Dissolved Silicon (Si)	2019/01/22	99	80 - 120	101	80 - 120	<50	ug/L	0.36	20
5938142	Dissolved Silver (Ag)	2019/01/22	98	80 - 120	98	80 - 120	<0.10	ug/L	NC	20
5938142	Dissolved Sodium (Na)	2019/01/22	95	80 - 120	96	80 - 120	<100	ug/L	0.77	20
5938142	Dissolved Strontium (Sr)	2019/01/22	NC	80 - 120	98	80 - 120	<1.0	ug/L	0.098	20
5938142	Dissolved Thallium (Tl)	2019/01/22	93	80 - 120	96	80 - 120	<0.050	ug/L	NC	20
5938142	Dissolved Titanium (Ti)	2019/01/22	97	80 - 120	100	80 - 120	<5.0	ug/L	NC	20
5938142	Dissolved Uranium (U)	2019/01/22	94	80 - 120	97	80 - 120	<0.10	ug/L	2.6	20
5938142	Dissolved Vanadium (V)	2019/01/22	98	80 - 120	99	80 - 120	<0.50	ug/L	NC	20
5938142	Dissolved Zinc (Zn)	2019/01/22	96	80 - 120	99	80 - 120	<5.0	ug/L	NC	20
5938162	F2 (C10-C16 Hydrocarbons)	2019/01/22	114	50 - 130	111	60 - 130	<100	ug/L	NC	30
5938162	F3 (C16-C34 Hydrocarbons)	2019/01/22	110	50 - 130	107	60 - 130	<200	ug/L	NC	30
5938162	F4 (C34-C50 Hydrocarbons)	2019/01/22	107	50 - 130	104	60 - 130	<200	ug/L	NC	30
5939591	Dissolved Organic Carbon	2019/01/22	95	80 - 120	99	80 - 120	<0.50	mg/L	0.76	20

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5939599	Dissolved Mercury (Hg)	2019/01/22	94	75 - 125	96	80 - 120	<0.1	ug/L	NC	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Anastassia Hamanov, Scientific Specialist

Eva P

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
Eva Pranjic
CHEMIST

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

Farhana Rahman

Farhana Rahman

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Your Project #: 1781508-8000
Site#: 508
Your C.O.C. #: n/a

Attention: Alexandra Smofsky

Golder Associates Ltd
309 Exeter Rd
Unit 1
London, ON
CANADA N6L 1C1

Report Date: 2019/01/31
Report #: R5577847
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B923310
Received: 2019/01/25, 08:45

Sample Matrix: Water
Samples Received: 5

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Alkalinity	5	N/A	2019/01/29	CAM SOP-00448	SM 23 2320 B m
Carbonate, Bicarbonate and Hydroxide	5	N/A	2019/01/29	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	5	N/A	2019/01/29	CAM SOP-00463	EPA 325.2 m
Conductivity	5	N/A	2019/01/29	CAM SOP-00414	SM 23 2510 m
Dissolved Organic Carbon (DOC) (1)	5	N/A	2019/01/29	CAM SOP-00446	SM 23 5310 B m
Petroleum Hydro. CCME F1 & BTEX in Water	5	N/A	2019/01/28	CAM SOP-00315	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (2)	5	2019/01/29	2019/01/30	CAM SOP-00316	CCME PHC-CWS m
Hardness (calculated as CaCO3)	5	N/A	2019/01/30	CAM SOP 00102/00408/00447	SM 2340 B
Dissolved Mercury in Water by CVAA	5	2019/01/28	2019/01/29	CAM SOP-00453	EPA 7470A m
Dissolved Metals by ICPMS	5	N/A	2019/01/30	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	5	N/A	2019/01/30		
Anion and Cation Sum	5	N/A	2019/01/30		
Total Coliforms/ E. coli, CFU/100mL	2	N/A	2019/01/26	CAM SOP-00551	MOE E3407
Total Ammonia-N	5	N/A	2019/01/30	CAM SOP-00441	EPA GS I-2522-90 m
Nitrate (NO3) and Nitrite (NO2) in Water (3)	5	N/A	2019/01/29	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	5	N/A	2019/01/29	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	5	N/A	2019/01/30	CAM SOP-00461	EPA 365.1 m
Sat. pH and Langelier Index (@ 20C)	5	N/A	2019/01/30		
Sat. pH and Langelier Index (@ 4C)	5	N/A	2019/01/30		
Sulphate by Automated Colourimetry	5	N/A	2019/01/29	CAM SOP-00464	EPA 375.4 m
Total Dissolved Solids (TDS calc)	5	N/A	2019/01/30		

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Your Project #: 1781508-8000
Site#: 508
Your C.O.C. #: n/a

Attention: Alexandra Smofsky

Golder Associates Ltd
309 Exeter Rd
Unit 1
London, ON
CANADA N6L 1C1

Report Date: 2019/01/31
Report #: R5577847
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B923310
Received: 2019/01/25, 08:45

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) All CCME PHC results met required criteria unless otherwise stated in the report. The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following “Alberta Environment’s Interpretation of the Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil Validation of Performance-Based Alternative Methods September 2003”. Documentation is available upon request. Modifications from Reference Method for the Canada-wide Standard for Petroleum Hydrocarbons in Soil-Tier 1 Method: F2/F3/F4 data reported using validated cold solvent extraction instead of Soxhlet extraction.
(3) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

```
Christine Gripton
Senior Project Manager
31 Jan 2019 14:22:02
```

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Christine Gripton, Senior Project Manager
Email: CGripton@maxxam.ca
Phone# (800)268-7396 Ext:250
==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		IVT879			IVT879			IVT880		
Sampling Date		2019/01/24 11:45			2019/01/24 11:45			2019/01/24 12:15		
COC Number		n/a			n/a			n/a		
	UNITS	**MW17-02**	**RDL**	**QC Batch**	**MW17-02 Lab-Dup**	**RDL**	**QC Batch**	**DUP**	**RDL**	**QC Batch**
Calculated Parameters										
Anion Sum	me/L	5.88	N/A	5947537				5.97	N/A	5947537
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	230	1.0	5947542				230	1.0	5947542
Calculated TDS	mg/L	310	1.0	5947540				320	1.0	5947540
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.3	1.0	5947542				1.5	1.0	5947542
Cation Sum	me/L	5.99	N/A	5947537				6.00	N/A	5947537
Hardness (CaCO3)	mg/L	280	1.0	5947544				280	1.0	5947544
Ion Balance (% Difference)	%	0.960	N/A	5947536				0.260	N/A	5947536
Langelier Index (@ 20C)	N/A	0.580		5947538				0.635		5947538
Langelier Index (@ 4C)	N/A	0.331		5947539				0.386		5947539
Saturation pH (@ 20C)	N/A	7.20		5947538				7.20		5947538
Saturation pH (@ 4C)	N/A	7.45		5947539				7.45		5947539
Inorganics										
Total Ammonia-N	mg/L	<0.050	0.050	5950220				<0.050	0.050	5950220
Conductivity	umho/cm	560	1.0	5948976				560	1.0	5948976
Dissolved Organic Carbon	mg/L	0.74	0.50	5948877				0.74	0.50	5948877
Orthophosphate (P)	mg/L	<0.010	0.010	5948955				<0.010	0.010	5948955
pH	pH	7.78		5948975				7.83		5948975
Dissolved Sulphate (SO4)	mg/L	50	1.0	5948954				50	1.0	5948954
Alkalinity (Total as CaCO3)	mg/L	230	1.0	5948973				230	1.0	5948973
Dissolved Chloride (Cl-)	mg/L	6.9	1.0	5948950				6.8	1.0	5948950
Nitrite (N)	mg/L	<0.010	0.010	5948965	<0.010	0.010	5948965	<0.010	0.010	5948965
Nitrate (N)	mg/L	0.92	0.10	5948965	0.91	0.10	5948965	1.05	0.10	5948965
Nitrate + Nitrite (N)	mg/L	0.92	0.10	5948965	0.91	0.10	5948965	1.05	0.10	5948965
Metals										
Dissolved Aluminum (Al)	ug/L	<5.0	5.0	5951826	<5.0	5.0	5951826	<5.0	5.0	5951826
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	5951826	<0.50	0.50	5951826	<0.50	0.50	5951826
Dissolved Arsenic (As)	ug/L	<1.0	1.0	5951826	<1.0	1.0	5951826	<1.0	1.0	5951826
Dissolved Barium (Ba)	ug/L	210	2.0	5951826	210	2.0	5951826	210	2.0	5951826
Dissolved Beryllium (Be)	ug/L	<0.50	0.50	5951826	<0.50	0.50	5951826	<0.50	0.50	5951826
Dissolved Boron (B)	ug/L	55	10	5951826	54	10	5951826	53	10	5951826
Dissolved Cadmium (Cd)	ug/L	<0.10	0.10	5951826	<0.10	0.10	5951826	<0.10	0.10	5951826
Dissolved Calcium (Ca)	ug/L	73000	400	5951826	72000	400	5951826	72000	400	5951826
Dissolved Chromium (Cr)	ug/L	<5.0	5.0	5951826	<5.0	5.0	5951826	<5.0	5.0	5951826

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		IVT879			IVT879			IVT880		
Sampling Date		2019/01/24 11:45			2019/01/24 11:45			2019/01/24 12:15		
COC Number		n/a			n/a			n/a		
	UNITS	**MW17-02**	**RDL**	**QC Batch**	**MW17-02 Lab-Dup**	**RDL**	**QC Batch**	**DUP**	**RDL**	**QC Batch**
Dissolved Cobalt (Co)	ug/L	<0.50	0.50	5951826	<0.50	0.50	5951826	<0.50	0.50	5951826
Dissolved Copper (Cu)	ug/L	5.2	1.0	5951826	5.3	1.0	5951826	<1.0	1.0	5951826
Dissolved Iron (Fe)	ug/L	<100	100	5951826	<100	100	5951826	<100	100	5951826
Dissolved Lead (Pb)	ug/L	<0.50	0.50	5951826	<0.50	0.50	5951826	<0.50	0.50	5951826
Dissolved Magnesium (Mg)	ug/L	23000	50	5951826	23000	50	5951826	23000	50	5951826
Dissolved Manganese (Mn)	ug/L	13	2.0	5951826	13	2.0	5951826	13	2.0	5951826
Dissolved Molybdenum (Mo)	ug/L	5.5	0.50	5951826	5.9	0.50	5951826	5.7	0.50	5951826
Dissolved Nickel (Ni)	ug/L	4.5	1.0	5951826	4.7	1.0	5951826	4.4	1.0	5951826
Dissolved Phosphorus (P)	ug/L	<100	100	5951826	110	100	5951826	<100	100	5951826
Dissolved Potassium (K)	ug/L	1200	200	5951826	1200	200	5951826	1200	200	5951826
Dissolved Selenium (Se)	ug/L	<2.0	2.0	5951826	<2.0	2.0	5951826	<2.0	2.0	5951826
Dissolved Silicon (Si)	ug/L	4000	50	5951826	4000	50	5951826	4000	50	5951826
Dissolved Silver (Ag)	ug/L	<0.10	0.10	5951826	<0.10	0.10	5951826	<0.10	0.10	5951826
Dissolved Sodium (Na)	ug/L	9900	100	5951826	9600	100	5951826	9700	100	5951826
Dissolved Strontium (Sr)	ug/L	7400	1.0	5951826	7600	1.0	5951826	7400	1.0	5951826
Dissolved Thallium (Tl)	ug/L	0.069	0.050	5951826	0.072	0.050	5951826	0.067	0.050	5951826
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	5951826	<5.0	5.0	5951826	<5.0	5.0	5951826
Dissolved Uranium (U)	ug/L	1.7	0.10	5951826	1.6	0.10	5951826	1.6	0.10	5951826
Dissolved Vanadium (V)	ug/L	<0.50	0.50	5951826	<0.50	0.50	5951826	<0.50	0.50	5951826
Dissolved Zinc (Zn)	ug/L	11	5.0	5951826	11	5.0	5951826	5.2	5.0	5951826

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		IVT881			IVT881			IVT882	IVT883		
Sampling Date		2019/01/24 15:25			2019/01/24 15:25			2019/01/24 12:36	2019/01/24 16:00		
COC Number		n/a			n/a			n/a	n/a		
	UNITS	**BH17-05**	**RDL**	**QC Batch**	**BH17-05 Lab-Dup**	**RDL**	**QC Batch**	**BH17-02**	**BH17-04**	**RDL**	**QC Batch**
Calculated Parameters											
Anion Sum	me/L	5.80	N/A	5947537				5.67	3.73	N/A	5947537
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	220	1.0	5947542				210	140	1.0	5947542
Calculated TDS	mg/L	310	1.0	5947540				320	220	1.0	5947540
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.5	1.0	5947542				1.5	2.2	1.0	5947542
Cation Sum	me/L	5.87	N/A	5947537				5.74	3.99	N/A	5947537
Hardness (CaCO3)	mg/L	270	1.0	5947544				280	73	1.0	5947544
Ion Balance (% Difference)	%	0.560	N/A	5947536				0.560	3.36	N/A	5947536
Langelier Index (@ 20C)	N/A	0.621		5947538				0.719	0.138		5947538
Langelier Index (@ 4C)	N/A	0.372		5947539				0.470	-0.112		5947539
Saturation pH (@ 20C)	N/A	7.23		5947538				7.16	8.07		5947538
Saturation pH (@ 4C)	N/A	7.47		5947539				7.41	8.32		5947539
Inorganics											
Total Ammonia-N	mg/L	0.078	0.050	5950220				<0.050	0.14	0.050	5950220
Conductivity	umho/cm	550	1.0	5948976				550	370	1.0	5948976
Dissolved Organic Carbon	mg/L	0.96	0.50	5948877	0.97	0.50	5948877	0.94	1.2	0.50	5948877
Orthophosphate (P)	mg/L	<0.010	0.010	5948955				<0.010	<0.010	0.010	5948955
pH	pH	7.85		5948975				7.88	8.20		5948975
Dissolved Sulphate (SO4)	mg/L	38	1.0	5948954				18	36	1.0	5948954
Alkalinity (Total as CaCO3)	mg/L	220	1.0	5948973				210	150	1.0	5948973
Dissolved Chloride (Cl-)	mg/L	14	1.0	5948950				12	1.8	1.0	5948950
Nitrite (N)	mg/L	0.015	0.010	5948965				<0.010	<0.010	0.010	5948965
Nitrate (N)	mg/L	2.08	0.10	5948965				10.7	<0.10	0.10	5948965
Nitrate + Nitrite (N)	mg/L	2.10	0.10	5948965				10.7	<0.10	0.10	5948965
Metals											
Dissolved Aluminum (Al)	ug/L	<5.0	5.0	5951826				<5.0	10	5.0	5951826
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	5951826				<0.50	<0.50	0.50	5951826
Dissolved Arsenic (As)	ug/L	<1.0	1.0	5951826				<1.0	<1.0	1.0	5951826
Dissolved Barium (Ba)	ug/L	200	2.0	5951826				35	49	2.0	5951826
Dissolved Beryllium (Be)	ug/L	<0.50	0.50	5951826				<0.50	<0.50	0.50	5951826
Dissolved Boron (B)	ug/L	60	10	5951826				12	200	10	5951826
Dissolved Cadmium (Cd)	ug/L	<0.10	0.10	5951826				<0.10	<0.10	0.10	5951826
Dissolved Calcium (Ca)	ug/L	71000	200	5951826				88000	15000	200	5951826
Dissolved Chromium (Cr)	ug/L	<5.0	5.0	5951826				<5.0	<5.0	5.0	5951826

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		IVT881			IVT881			IVT882	IVT883		
Sampling Date		2019/01/24 15:25			2019/01/24 15:25			2019/01/24 12:36	2019/01/24 16:00		
COC Number		n/a			n/a			n/a	n/a		
	UNITS	**BH17-05**	**RDL**	**QC Batch**	**BH17-05 Lab-Dup**	**RDL**	**QC Batch**	**BH17-02**	**BH17-04**	**RDL**	**QC Batch**
Dissolved Cobalt (Co)	ug/L	<0.50	0.50	5951826				<0.50	<0.50	0.50	5951826
Dissolved Copper (Cu)	ug/L	<1.0	1.0	5951826				<1.0	1.5	1.0	5951826
Dissolved Iron (Fe)	ug/L	<100	100	5951826				<100	<100	100	5951826
Dissolved Lead (Pb)	ug/L	<0.50	0.50	5951826				<0.50	<0.50	0.50	5951826
Dissolved Magnesium (Mg)	ug/L	22000	50	5951826				15000	8900	50	5951826
Dissolved Manganese (Mn)	ug/L	12	2.0	5951826				<2.0	5.3	2.0	5951826
Dissolved Molybdenum (Mo)	ug/L	3.4	0.50	5951826				1.1	15	0.50	5951826
Dissolved Nickel (Ni)	ug/L	<1.0	1.0	5951826				<1.0	1.1	1.0	5951826
Dissolved Phosphorus (P)	ug/L	<100	100	5951826				<100	100	100	5951826
Dissolved Potassium (K)	ug/L	1400	200	5951826				1400	1000	200	5951826
Dissolved Selenium (Se)	ug/L	<2.0	2.0	5951826				<2.0	<2.0	2.0	5951826
Dissolved Silicon (Si)	ug/L	4000	50	5951826				3000	5100	50	5951826
Dissolved Silver (Ag)	ug/L	<0.10	0.10	5951826				<0.10	<0.10	0.10	5951826
Dissolved Sodium (Na)	ug/L	11000	100	5951826				1800	57000	100	5951826
Dissolved Strontium (Sr)	ug/L	970	1.0	5951826				160	660	1.0	5951826
Dissolved Thallium (Tl)	ug/L	<0.050	0.050	5951826				<0.050	<0.050	0.050	5951826
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	5951826				<5.0	<5.0	5.0	5951826
Dissolved Uranium (U)	ug/L	1.1	0.10	5951826				0.70	<0.10	0.10	5951826
Dissolved Vanadium (V)	ug/L	<0.50	0.50	5951826				<0.50	<0.50	0.50	5951826
Dissolved Zinc (Zn)	ug/L	<5.0	5.0	5951826				<5.0	<5.0	5.0	5951826

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		IVT879	IVT880	IVT881	IVT882	IVT882	IVT883		
Sampling Date		2019/01/24 11:45	2019/01/24 12:15	2019/01/24 15:25	2019/01/24 12:36	2019/01/24 12:36	2019/01/24 16:00		
COC Number		n/a	n/a	n/a	n/a	n/a	n/a		
	UNITS	**MW17-02**	**DUP**	**BH17-05**	**BH17-02**	**BH17-02 Lab-Dup**	**BH17-04**	**RDL**	**QC Batch**
Metals									
Dissolved Mercury (Hg)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	5948687

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

Lab-Dup = Laboratory Initiated Duplicate

MICROBIOLOGY (WATER)

Maxxam ID		IVT879	IVT880	
Sampling Date		2019/01/24 11:45	2019/01/24 12:15	
COC Number		n/a	n/a	
	UNITS	**MW17-02**	**DUP**	**QC Batch**
Microbiological				
Background	CFU/100mL	36	29	5947707
Total Coliforms	CFU/100mL	5	1	5947707
Escherichia coli	CFU/100mL	0	0	5947707

QC Batch = Quality Control Batch

O.REG 153 PHCS, BTEX/F1-F4 (WATER)

Maxxam ID		IVT879			IVT879			IVT880		
Sampling Date		2019/01/24 11:45			2019/01/24 11:45			2019/01/24 12:15		
COC Number		n/a			n/a			n/a		
	UNITS	**MW17-02**	**RDL**	**QC Batch**	**MW17-02 Lab-Dup**	**RDL**	**QC Batch**	**DUP**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons										
Benzene	ug/L	<0.20	0.20	5949146	<0.20	0.20	5949146	<0.20	0.20	5949146
Toluene	ug/L	<0.20	0.20	5949146	<0.20	0.20	5949146	<0.20	0.20	5949146
Ethylbenzene	ug/L	<0.20	0.20	5949146	<0.20	0.20	5949146	<0.20	0.20	5949146
o-Xylene	ug/L	<0.20	0.20	5949146	<0.20	0.20	5949146	<0.20	0.20	5949146
p+m-Xylene	ug/L	<0.40	0.40	5949146	<0.40	0.40	5949146	<0.40	0.40	5949146
Total Xylenes	ug/L	<0.40	0.40	5949146	<0.40	0.40	5949146	<0.40	0.40	5949146
F1 (C6-C10)	ug/L	<25	25	5949146	<25	25	5949146	<25	25	5949146
F1 (C6-C10) - BTEX	ug/L	<25	25	5949146	<25	25	5949146	<25	25	5949146
F2-F4 Hydrocarbons										
F2 (C10-C16 Hydrocarbons)	ug/L	<100	100	5951447				<100	100	5951447
F3 (C16-C34 Hydrocarbons)	ug/L	<200	200	5951447				<200	200	5951447
F4 (C34-C50 Hydrocarbons)	ug/L	<200	200	5951447				<200	200	5951447
Reached Baseline at C50	ug/L	Yes		5951447				Yes		5951447
Surrogate Recovery (%)										
1,4-Difluorobenzene	%	102		5949146	103		5949146	103		5949146
4-Bromofluorobenzene	%	99		5949146	96		5949146	98		5949146
D10-Ethylbenzene	%	105		5949146	105		5949146	104		5949146
D4-1,2-Dichloroethane	%	97		5949146	96		5949146	96		5949146
o-Terphenyl	%	116		5951447				116		5951447

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

O.REG 153 PHCS, BTEX/F1-F4 (WATER)

Maxxam ID		IVT880			IVT881	IVT882	IVT883		
Sampling Date		2019/01/24 12:15			2019/01/24 15:25	2019/01/24 12:36	2019/01/24 16:00		
COC Number		n/a			n/a	n/a	n/a		
	UNITS	**DUP Lab-Dup**	**RDL**	**QC Batch**	**BH17-05**	**BH17-02**	**BH17-04**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons									
Benzene	ug/L				<0.20	<0.20	<0.20	0.20	5949146
Toluene	ug/L				<0.20	<0.20	<0.20	0.20	5949146
Ethylbenzene	ug/L				<0.20	<0.20	<0.20	0.20	5949146
o-Xylene	ug/L				<0.20	<0.20	<0.20	0.20	5949146
p+m-Xylene	ug/L				<0.40	<0.40	<0.40	0.40	5949146
Total Xylenes	ug/L				<0.40	<0.40	<0.40	0.40	5949146
F1 (C6-C10)	ug/L				<25	<25	<25	25	5949146
F1 (C6-C10) - BTEX	ug/L				<25	<25	<25	25	5949146
F2-F4 Hydrocarbons									
F2 (C10-C16 Hydrocarbons)	ug/L	<100	100	5951447	<100	<100	<100	100	5951447
F3 (C16-C34 Hydrocarbons)	ug/L	<200	200	5951447	<200	<200	<200	200	5951447
F4 (C34-C50 Hydrocarbons)	ug/L	<200	200	5951447	<200	<200	<200	200	5951447
Reached Baseline at C50	ug/L	Yes		5951447	Yes	Yes	Yes		5951447
Surrogate Recovery (%)									
1,4-Difluorobenzene	%				103	103	103		5949146
4-Bromofluorobenzene	%				96	98	97		5949146
D10-Ethylbenzene	%				103	104	101		5949146
D4-1,2-Dichloroethane	%				96	96	98		5949146
o-Terphenyl	%	112		5951447	115	109	116		5951447

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

TEST SUMMARY

Maxxam ID: IVT879
Sample ID: MW17-02
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5948973	N/A	2019/01/29	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	5947542	N/A	2019/01/29	Automated Statchk
Chloride by Automated Colourimetry	KONE	5948950	N/A	2019/01/29	Alina Dobreanu
Conductivity	AT	5948976	N/A	2019/01/29	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5948877	N/A	2019/01/29	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5949146	N/A	2019/01/28	Georgeta Rusu
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5951447	2019/01/29	2019/01/30	Prabhjot Gulati
Hardness (calculated as CaCO3)		5947544	N/A	2019/01/30	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5948687	2019/01/28	2019/01/29	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5951826	N/A	2019/01/30	Prempal Bhatti
Ion Balance (% Difference)	CALC	5947536	N/A	2019/01/30	Automated Statchk
Anion and Cation Sum	CALC	5947537	N/A	2019/01/30	Automated Statchk
Total Coliforms/ E. coli, CFU/100mL	PL	5947707	N/A	2019/01/26	Ranju Chaudhari
Total Ammonia-N	LACH/NH4	5950220	N/A	2019/01/30	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5948965	N/A	2019/01/29	Chandra Nandlal
pH	AT	5948975	N/A	2019/01/29	Surinder Rai
Orthophosphate	KONE	5948955	N/A	2019/01/30	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5947538	N/A	2019/01/30	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5947539	N/A	2019/01/30	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5948954	N/A	2019/01/29	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5947540	N/A	2019/01/30	Automated Statchk

Maxxam ID: IVT879 Dup
Sample ID: MW17-02
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5949146	N/A	2019/01/28	Georgeta Rusu
Dissolved Metals by ICPMS	ICP/MS	5951826	N/A	2019/01/30	Prempal Bhatti
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5948965	N/A	2019/01/29	Chandra Nandlal

Maxxam ID: IVT880
Sample ID: DUP
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5948973	N/A	2019/01/29	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	5947542	N/A	2019/01/29	Automated Statchk
Chloride by Automated Colourimetry	KONE	5948950	N/A	2019/01/29	Alina Dobreanu
Conductivity	AT	5948976	N/A	2019/01/29	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5948877	N/A	2019/01/29	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5949146	N/A	2019/01/28	Georgeta Rusu
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5951447	2019/01/29	2019/01/30	Prabhjot Gulati
Hardness (calculated as CaCO3)		5947544	N/A	2019/01/30	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5948687	2019/01/28	2019/01/29	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5951826	N/A	2019/01/30	Prempal Bhatti

TEST SUMMARY

Maxxam ID: IVT880
Sample ID: DUP
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Ion Balance (% Difference)	CALC	5947536	N/A	2019/01/30	Automated Statchk
Anion and Cation Sum	CALC	5947537	N/A	2019/01/30	Automated Statchk
Total Coliforms/ E. coli, CFU/100mL	PL	5947707	N/A	2019/01/26	Ranju Chaudhari
Total Ammonia-N	LACH/NH4	5950220	N/A	2019/01/30	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5948965	N/A	2019/01/29	Chandra Nandlal
pH	AT	5948975	N/A	2019/01/29	Surinder Rai
Orthophosphate	KONE	5948955	N/A	2019/01/30	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5947538	N/A	2019/01/30	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5947539	N/A	2019/01/30	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5948954	N/A	2019/01/29	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5947540	N/A	2019/01/30	Automated Statchk

Maxxam ID: IVT880 Dup
Sample ID: DUP
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5951447	2019/01/29	2019/01/30	Prabhjot Gulati

Maxxam ID: IVT881
Sample ID: BH17-05
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5948973	N/A	2019/01/29	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	5947542	N/A	2019/01/29	Automated Statchk
Chloride by Automated Colourimetry	KONE	5948950	N/A	2019/01/29	Alina Dobreanu
Conductivity	AT	5948976	N/A	2019/01/29	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5948877	N/A	2019/01/29	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5949146	N/A	2019/01/28	Georgeta Rusu
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5951447	2019/01/29	2019/01/30	Prabhjot Gulati
Hardness (calculated as CaCO3)		5947544	N/A	2019/01/30	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5948687	2019/01/28	2019/01/29	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5951826	N/A	2019/01/30	Prempal Bhatti
Ion Balance (% Difference)	CALC	5947536	N/A	2019/01/30	Automated Statchk
Anion and Cation Sum	CALC	5947537	N/A	2019/01/30	Automated Statchk
Total Ammonia-N	LACH/NH4	5950220	N/A	2019/01/30	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5948965	N/A	2019/01/29	Chandra Nandlal
pH	AT	5948975	N/A	2019/01/29	Surinder Rai
Orthophosphate	KONE	5948955	N/A	2019/01/30	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5947538	N/A	2019/01/30	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5947539	N/A	2019/01/30	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5948954	N/A	2019/01/29	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5947540	N/A	2019/01/30	Automated Statchk

TEST SUMMARY

Maxxam ID: IVT881 Dup
Sample ID: BH17-05
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5948877	N/A	2019/01/29	Mandeep Kaur

Maxxam ID: IVT882
Sample ID: BH17-02
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5948973	N/A	2019/01/29	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	5947542	N/A	2019/01/29	Automated Statchk
Chloride by Automated Colourimetry	KONE	5948950	N/A	2019/01/29	Alina Dobreanu
Conductivity	AT	5948976	N/A	2019/01/29	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5948877	N/A	2019/01/29	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5949146	N/A	2019/01/28	Georgeta Rusu
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5951447	2019/01/29	2019/01/30	Prabhjot Gulati
Hardness (calculated as CaCO3)		5947544	N/A	2019/01/30	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5948687	2019/01/28	2019/01/29	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5951826	N/A	2019/01/30	Prempal Bhatti
Ion Balance (% Difference)	CALC	5947536	N/A	2019/01/30	Automated Statchk
Anion and Cation Sum	CALC	5947537	N/A	2019/01/30	Automated Statchk
Total Ammonia-N	LACH/NH4	5950220	N/A	2019/01/30	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5948965	N/A	2019/01/29	Chandra Nandlal
pH	AT	5948975	N/A	2019/01/29	Surinder Rai
Orthophosphate	KONE	5948955	N/A	2019/01/30	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5947538	N/A	2019/01/30	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5947539	N/A	2019/01/30	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5948954	N/A	2019/01/29	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5947540	N/A	2019/01/30	Automated Statchk

Maxxam ID: IVT882 Dup
Sample ID: BH17-02
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Dissolved Mercury in Water by CVAA	CV/AA	5948687	2019/01/28	2019/01/29	Ron Morrison

Maxxam ID: IVT883
Sample ID: BH17-04
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5948973	N/A	2019/01/29	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	5947542	N/A	2019/01/29	Automated Statchk
Chloride by Automated Colourimetry	KONE	5948950	N/A	2019/01/29	Alina Dobreanu
Conductivity	AT	5948976	N/A	2019/01/29	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5948877	N/A	2019/01/29	Mandeep Kaur
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5949146	N/A	2019/01/28	Georgeta Rusu

TEST SUMMARY

Maxxam ID: IVT883
Sample ID: BH17-04
Matrix: Water

Collected: 2019/01/24
Shipped:
Received: 2019/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5951447	2019/01/29	2019/01/30	Prabhjot Gulati
Hardness (calculated as CaCO3)		5947544	N/A	2019/01/30	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5948687	2019/01/28	2019/01/29	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5951826	N/A	2019/01/30	Prempal Bhatti
Ion Balance (% Difference)	CALC	5947536	N/A	2019/01/30	Automated Statchk
Anion and Cation Sum	CALC	5947537	N/A	2019/01/30	Automated Statchk
Total Ammonia-N	LACH/NH4	5950220	N/A	2019/01/30	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5948965	N/A	2019/01/29	Chandra Nandlal
pH	AT	5948975	N/A	2019/01/29	Surinder Rai
Orthophosphate	KONE	5948955	N/A	2019/01/30	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5947538	N/A	2019/01/30	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5947539	N/A	2019/01/30	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5948954	N/A	2019/01/29	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5947540	N/A	2019/01/30	Automated Statchk

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	-0.7°C

E.Coli/Total Coliform Analysis: The sample MW17-02 was analyzed past the recommended hold time, as it was incubated on January 26th, 2019 at 11:46am.

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5949146	1,4-Difluorobenzene	2019/01/29	104	70 - 130	100	70 - 130	100	%		
5949146	4-Bromofluorobenzene	2019/01/29	99	70 - 130	99	70 - 130	100	%		
5949146	D10-Ethylbenzene	2019/01/29	103	70 - 130	97	70 - 130	97	%		
5949146	D4-1,2-Dichloroethane	2019/01/29	98	70 - 130	105	70 - 130	98	%		
5951447	o-Terphenyl	2019/01/29	113	60 - 130	119	60 - 130	112	%		
5948687	Dissolved Mercury (Hg)	2019/01/29	99	75 - 125	98	80 - 120	<0.1	ug/L	NC	20
5948877	Dissolved Organic Carbon	2019/01/29	93	80 - 120	97	80 - 120	<0.50	mg/L	1.5	20
5948950	Dissolved Chloride (Cl-)	2019/01/29	106	80 - 120	102	80 - 120	<1.0	mg/L	0.43	20
5948954	Dissolved Sulphate (SO4)	2019/01/29	106	75 - 125	106	80 - 120	<1.0	mg/L	8.1	20
5948955	Orthophosphate (P)	2019/01/30	101	75 - 125	100	80 - 120	<0.010	mg/L	NC	25
5948965	Nitrate (N)	2019/01/29	101	80 - 120	103	80 - 120	<0.10	mg/L	0.89	20
5948965	Nitrite (N)	2019/01/29	100	80 - 120	102	80 - 120	<0.010	mg/L	NC	20
5948973	Alkalinity (Total as CaCO3)	2019/01/29			93	85 - 115	<1.0	mg/L	0.30	20
5948975	pH	2019/01/29			101	98 - 103			0.79	N/A
5948976	Conductivity	2019/01/29			100	85 - 115	<1.0	umho/cm	0.50	25
5949146	Benzene	2019/01/28	101	70 - 130	95	70 - 130	<0.20	ug/L	NC	30
5949146	Ethylbenzene	2019/01/28	101	70 - 130	91	70 - 130	<0.20	ug/L	NC	30
5949146	F1 (C6-C10) - BTEX	2019/01/28					<25	ug/L	NC	30
5949146	F1 (C6-C10)	2019/01/28	94	70 - 130	92	70 - 130	<25	ug/L	NC	30
5949146	o-Xylene	2019/01/28	99	70 - 130	91	70 - 130	<0.20	ug/L	NC	30
5949146	p+m-Xylene	2019/01/28	101	70 - 130	89	70 - 130	<0.40	ug/L	NC	30
5949146	Toluene	2019/01/28	104	70 - 130	95	70 - 130	<0.20	ug/L	NC	30
5949146	Total Xylenes	2019/01/28					<0.40	ug/L	NC	30
5950220	Total Ammonia-N	2019/01/30	96	75 - 125	100	80 - 120	<0.050	mg/L	0.0089	20
5951447	F2 (C10-C16 Hydrocarbons)	2019/01/30	114	50 - 130	116	60 - 130	<100	ug/L	NC	30
5951447	F3 (C16-C34 Hydrocarbons)	2019/01/30	99	50 - 130	105	60 - 130	<200	ug/L	NC	30
5951447	F4 (C34-C50 Hydrocarbons)	2019/01/30	105	50 - 130	107	60 - 130	<200	ug/L	NC	30
5951826	Dissolved Aluminum (Al)	2019/01/30	100	80 - 120	100	80 - 120	<5.0	ug/L	NC	20
5951826	Dissolved Antimony (Sb)	2019/01/30	105	80 - 120	102	80 - 120	<0.50	ug/L	NC	20
5951826	Dissolved Arsenic (As)	2019/01/30	100	80 - 120	102	80 - 120	<1.0	ug/L	NC	20
5951826	Dissolved Barium (Ba)	2019/01/30	102	80 - 120	98	80 - 120	<2.0	ug/L	1.3	20
5951826	Dissolved Beryllium (Be)	2019/01/30	101	80 - 120	101	80 - 120	<0.50	ug/L	NC	20

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5951826	Dissolved Boron (B)	2019/01/30	97	80 - 120	92	80 - 120	<10	ug/L	1.0	20
5951826	Dissolved Cadmium (Cd)	2019/01/30	102	80 - 120	99	80 - 120	<0.10	ug/L	NC	20
5951826	Dissolved Calcium (Ca)	2019/01/30	NC	80 - 120	102	80 - 120	<200	ug/L	0.92	20
5951826	Dissolved Chromium (Cr)	2019/01/30	97	80 - 120	97	80 - 120	<5.0	ug/L	NC	20
5951826	Dissolved Cobalt (Co)	2019/01/30	100	80 - 120	103	80 - 120	<0.50	ug/L	NC	20
5951826	Dissolved Copper (Cu)	2019/01/30	104	80 - 120	100	80 - 120	<1.0	ug/L	2.5	20
5951826	Dissolved Iron (Fe)	2019/01/30	99	80 - 120	102	80 - 120	<100	ug/L	NC	20
5951826	Dissolved Lead (Pb)	2019/01/30	98	80 - 120	97	80 - 120	<0.50	ug/L	NC	20
5951826	Dissolved Magnesium (Mg)	2019/01/30	99	80 - 120	104	80 - 120	<50	ug/L	0.64	20
5951826	Dissolved Manganese (Mn)	2019/01/30	96	80 - 120	98	80 - 120	<2.0	ug/L	1.6	20
5951826	Dissolved Molybdenum (Mo)	2019/01/30	106	80 - 120	102	80 - 120	<0.50	ug/L	6.1	20
5951826	Dissolved Nickel (Ni)	2019/01/30	97	80 - 120	100	80 - 120	<1.0	ug/L	4.5	20
5951826	Dissolved Phosphorus (P)	2019/01/30	106	80 - 120	117	80 - 120	<100	ug/L	9.1	20
5951826	Dissolved Potassium (K)	2019/01/30	103	80 - 120	102	80 - 120	<200	ug/L	0.021	20
5951826	Dissolved Selenium (Se)	2019/01/30	101	80 - 120	101	80 - 120	<2.0	ug/L	NC	20
5951826	Dissolved Silicon (Si)	2019/01/30	103	80 - 120	103	80 - 120	<50	ug/L	0.31	20
5951826	Dissolved Silver (Ag)	2019/01/30	103	80 - 120	101	80 - 120	<0.10	ug/L	NC	20
5951826	Dissolved Sodium (Na)	2019/01/30	101	80 - 120	102	80 - 120	<100	ug/L	2.1	20
5951826	Dissolved Strontium (Sr)	2019/01/30	NC	80 - 120	99	80 - 120	<1.0	ug/L	1.6	20
5951826	Dissolved Thallium (Tl)	2019/01/30	100	80 - 120	98	80 - 120	<0.050	ug/L	4.3	20
5951826	Dissolved Titanium (Ti)	2019/01/30	102	80 - 120	102	80 - 120	<5.0	ug/L	NC	20
5951826	Dissolved Uranium (U)	2019/01/30	102	80 - 120	99	80 - 120	<0.10	ug/L	3.0	20
5951826	Dissolved Vanadium (V)	2019/01/30	98	80 - 120	99	80 - 120	<0.50	ug/L	NC	20

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**
5951826	Dissolved Zinc (Zn)	2019/01/30	98	80 - 120	100	80 - 120	<5.0	ug/L	2.0	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Eva Pranjic

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

Ranju

Ranju Chaudhari

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

APPENDIX F

Private Well Survey Results

Table F.1

SUMMARY OF PRIVATE WELL SURVEY RESULTS

Hydrogeology and Hydrology Level 1 and 2 Study
Proposed Thomas Street Quarry Expansion

ID #	RESPONSE DATE[2]	EASTING[3]	NORTHING[3]	APPROXIMATE YEAR CONSTRUCTED	WELL TYPE	CASING TYPE	CASING DIAMETER (mm)	REPORTED WELL DEPTH (m)	REPORTED WATER LEVEL (mbgs)	REPORTED WATER QUALITY	WATER USE	COMMENTS
1	-	-	-	-	-	-	-	-	-	-	-	
2	02-Apr-19	486693	4786844	1985	Drilled	Steel	152.4	82.3	-	Good	Domestic/ Livestock	Replaced a shallower well that went dry.
3	-	-	-	-	-	-	-	-	-	-	-	Same property as 4546 Line 3.
4	-	-	-	-	-	-	-	-	-	-	-	
5	-	-	-	-	-	-	-	-	-	-	-	
6	-	-	-	-	-	-	-	-	-	-	-	Residence appeared vacant, left survey in mailbox, no response.
7	-	-	-	-	-	-	-	-	-	-	-	
8	-	-	-	-	-	-	-	-	-	-	-	
9	-	-	-	-	-	-	-	-	-	-	-	
10	03-Apr-19	484982	4786738	-	Drilled	Steel	-	-	-	Good	Domestic and Livestock	
11	03-Apr-19	*485406*	*4787487*	1953	Drilled	Steel	152.4	24.0	16.8	Good	Domestic / Barn	
12	05-Apr-19	484446	4788600	1970	Drilled	Concrete	127.0	115.8	64.0	Good	Domestic and Livestock	Replaced an older well that went dry.
13	03-Apr-19	484631	4788907	-	Drilled	Steel	-	-	-	Good	Domestic	Had well deepened because it previously went dry.
14	04-Apr-19	484598	4789056	1988	Drilled	Steel	127.0	83.8	76.2	Good	Domestic	
15	-	-	-	-	Drilled	-	-	-	-	-	-	Drilled well in front of house observed, no response received.
16	-	487085	4787112	-	-	-	-	-	-	-	-	Coordinates of well were recorded. Owner agreed to mail response, not received.
17	-	-	-	-	Drilled	-	-	-	-	-	-	Drilled well in front of house observed, no response received.
18	-	-	-	-	-	-	-	-	-	-	-	
19	02-May-19	487091	4787246	1995	Drilled	-	152.4	36.9 - 54.9	37 to 55	Good	Domestic	
20	-	-	-	-	Dug	-	-	-	-	-	-	Dug well observed, no response received.
21	29-Apr-19	*487085*	*4787278*	1996	Drilled	-	152.4	83.8 - 91.4	-	Good	Domestic and Shops	
22	09-Apr-19	487082	4787307	1995	Drilled	Steel	152.4	-	-	Good	Domestic	
23	-	487100	4787342	-	Dug	-	-	-	-	-	-	Coordinates of well were recorded. Owner agreed to mail response, not received.
24	-	-	-	-	-	-	-	-	-	-	-	Drilled well was observed on west side of house in gardens, no response received.
25	-	-	-	-	-	-	-	-	-	-	-	
26	02-Apr-19	-	-	-	-	-	-	-	-	-	-	No well on property, shared with MN 1800 and 1806.
27	02-Apr-19	-	-	-	-	-	-	-	-	-	-	No well on porperty, shared well with MN 1798, and 1806.
28	-	484654	4789057	-	Dug	-	-	-	-	-	-	Coordinates of well were recorded. Owner agreed to mail response, not received.

Prepared By: MC/VT
Checked By: AS

Table F.1

SUMMARY OF PRIVATE WELL SURVEY RESULTS

Hydrogeology and Hydrology Level 1 and 2 Study
Proposed Thomas Street Quarry Expansion

ID #	RESPONSE DATE^2	EASTING^3	NORTHING^3	APPROXIMATE YEAR CONSTRUCTED	WELL TYPE	CASING TYPE	CASING DIAMETER (mm)	REPORTED WELL DEPTH (m)	REPORTED WATER LEVEL (mbgs)	REPORTED WATER QUALITY	WATER USE	COMMENTS
29	-	-	-	-	-	-	-	-	-	-	-	No response received from well owner, shared with MN 1811.
30	-	-	-	-	-	-	-	-	-	-	-	Drilled well was observed south of house, no response received.
31	-	-	-	-	-	-	-	-	-	-	-	No response received from well owner. Shared well with MN 1798, and 1800.
32	02-Apr-19	-	-	-	-	-	-	-	-	-	-	No well on property, share with MN 1803.
33	02-Apr-19	484684	4789103	1986	Drilled	Steel	101.6	>91	-	Good	Domestic/ Irrigation	
34	09-Apr-19	-	-	-	-	-	-	-	-	-	-	Shared well with 1821 Perth Rd 139.
35	09-Apr-19	484822	4789060	1970s or earlier	Drilled	Steel	152.4	76.2	-	Hard water, Good	Domestic	Shared well with 1813 Perth Rd 139.
36	02-Apr-19	484906	4789067	2017	Drilled	Steel	152.4	83.8	-	Good	Domestic	Had a third well on property that was decommissioned.
37	02-Apr-19	484913	4789085	-	Dug	-	-	-	-	Not used	Not used	
38	02-Apr-19	*485881*	*4789460*	1970	Dug	-	1524 - 2438	6 - 11	-	Good	Domestic and Farming	Wells have run dry previously, have dug pond for increased aquifer capacity.
39	02-Apr-19	*485907*	*4789607*	1970	Dug	-	1524 - 2438	6 - 11	-	Good	Domestic and Farming	
40	02-Apr-19	*485907*	*4789607*	1970	Dug	-	1524 - 2438	6 - 11	-	Good	Domestic and Farming	
41	02-Apr-19	486163	4789335	1997	Drilled	Steel	-	55.0	-	Good	Domestic	Uses well to fill pool.
42	02-Apr-19	*486191*	*4789222*	1980	Drilled	-	1524 - 2438	61.0		Dry	-	Owned by resident at 1930 Perth Road 139.
43	-	-	-	-	-	-	-	-	-	-	-	Same property as 1957 Perth Road 139.
44	12-Apr-19	*486235*	*4789337*	1971	Drilled	-	127.0	44.5	24.4	Good	Domestic	Replaced steel pipe with plastic pipe approximately 25 to 30 years ago, due to leak.
45	-	-	-	-	-	-	-	-	-	-	-	
46	-	-	-	-	-	-	-	-	-	-	-	
47	-	-	-	-	-	-	-	-	-	-	-	
48	02-Apr-19	-	-	-	-	-	-	-	-	-	-	No well on property.
49	-	-	-	-	-	-	-	-	-	-	-	
50	02-Apr-19	-	-	-	-	-	-	-	-	-	-	No well on property.
51	02-Apr-19	-	-	-	-	-	-	-	-	-	-	No well on property.

1. MN is the Municipal Number.
2. Notification letter delivered during initial door to door survey on April 2, 2019; follow-up door to door survey completed on April 9, 2019.
   A response date after April 9, 2019 indicates the survey was subsequently received by mail.
3. Approximate UTM coordinates (NAD 83) from handheld GPS, as reported by owner, or *estimated based on mapping.*
4. "-" indicates information not available or not applicable.

March 18, 2019

St Marys Cement
Bonis Quarry Project Licence Application
Voluntary Water Well Survey

Dear Resident:

On behalf of St Marys Cement, environmental consultant Golder Associates Ltd. (Golder) is planning to conduct a voluntary survey of water wells located within one kilometre of the proposed Thomas St. Quarry Extension Project (see attached figure). The Thomas St. Quarry Extension Project is a westward expansion of the adjacent Thomas St. Quarry. The water well survey is being conducted in preparation for a future St Marys Cement application for a Category 2, Class A Quarry Below Water licence under the Aggregate Resources Act (ARA).

With this letter, St Marys Cement is requesting your agreement to participate in the water well survey, which would include asking you a number of short questions about your water well. As part of the survey, and subject to your consent, a technician from Golder would also like to briefly view the external condition of your well and GPS its location.

We anticipate conducting the water well survey on April 2, 2019, and April 9, 2019, between the hours of 9:00 am and 6:00 pm. If you have a preferred time for this visit on either of those days, or any questions or concerns regarding the well survey please contact Golder Geoscientist Alexandra Smofsky at 905-567-4444 ext. 1298.

This package also includes a consent form and a questionnaire that will comprise the survey Golder would be essentially going over with you face to face. Should you not be home during the survey times provided, we kindly request that you complete the questionnaire to the best of your knowledge and mail it back to us with the post-paid envelope enclosed.

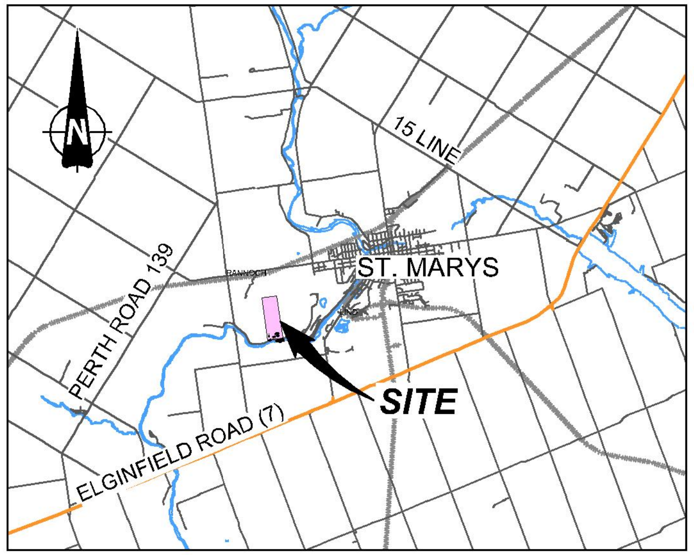
St Marys Cement would like to thank you for your time and your consideration of participation in this water well survey. If you have any questions related to St Marys Cement proposed future application, please do not hesitate to reach out to the undersigned.

Yours truly,

David Hanratty, P.Geo.
Director of Land & Resources
(705) 930-6180

St. Marys Cement
585 Water Street South
St Marys, Ontario N4X 1B6
Tel 519 284 1020
Fax 519 284 4104

votorantimcimentos.com
stmaryscement.com



KEY PLAN

LEGEND

- · - · APPROXIMATE SITE BOUNDARY
- – – 1km BUFFER FROM SITE BOUNDARY

REFERENCE

DRAWING BASED ON BING IMAGERY AS OF JULY 5, 2017 (IMAGE DATE UNKNOWN);

ARCH 2010 SURVEY OF THOMAS ST. QUARRY BY AGM, FILE NAME SM0906T1C3D.DWG, DATED MARCH 2010.

BASE MAP FROM ST. MARYS CEMENT INC.; AND

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

BING IMAGERY USED FOR ILLUSTRATION PURPOSES ONLY AND NOT TO BE USED FOR MEASUREMENTS.

ALL LOCATIONS ARE APPROXIMATE.

St Marys Cement

PROJECT

THOMAS STREET QUARRY EXTENSION

TITLE

SITE PLAN

GOLDER

PROJECT No.		1781508	FILE No. 1781508-8000-L01001	
			SCALE AS SHOWN	REV.
CADD	DCH/ZJB	Mar 19/19	FIGURE 1	
CHECK				

Client: Votorantim Cimentos

Original Format is Tabloid 279mm x 432mm

Drawing file: 1781508-8000-L01001.dwg Mar 19, 2019 - 3:31pm

St. Marys Cement
Bonis Quarry Project Licence Application
Voluntary Water Well Survey

CONSENT TO PARTICIPATE IN WATER WELL SURVEY

I, ______________________________, at
(Name of Resident – Please Print)

____
(Address)

____
(Contact Details)

Agree to:

1) Participate in the water well survey and answer a number of questions regarding my well   Yes   No (please circle one)

______________________________   ______________
(Signature of Resident)   (Date)

Water Well Reconnaissance Survey

Owner of Well:

Name: ______________________ Telephone (Bus.): __________

Address: ______________________ Telephone (Home): __________

Person Interviewed: ______________________ Date: __________

Interviewed By: ______________________ Time: __________

Occupant of House Served by Well: (if other than owner)

Name: ______________________ Telephone (Bus.): __________

Address: ______________________ Telephone (Home): __________

Well Construction Details:

Date Constructed: ______________________ Use: __________

Contractor: ______________________ Type (drilled or dug): __________

Diameter: ______________________ Well Depth: __________

Is well accessible for direct sampling? Or buried? ______________________

Screen: Yes / No If yes, length: __________m Depth of top of screen: __________m

Well Water Levels: (indicate whether measured from ground level or from top of casing)

Original water level depth: __________m

Subsequent water level measurements (give depths in metres and dates): ______________________

____

Pumping Equipment:

Pump type: suction lift / positive submergence / other Age: __________

Depth of intake setting: __________m Pumping rate: __________L/s

Storage tank type: ______________________ Capacity: __________

Do you have a: Chlorinator: Yes / No Water Softener: Yes / No Water Filter: Yes / No

Water Use: Domestic: Yes / No Number of people using water from well: __________

Pool: Yes / No Lawn watering: Yes / No

Other uses: ______________________

Private Waste and Water Disposal Type (septic, etc.): ____________________

Distance to well: ____________m Well is: uphill / downhill / same grade

Previous Problems:

How long have you owned, operated or lived on this property? ____________________

Have you ever experienced any <u>previous</u> problems with your well? ____________________

If so, when? ____________________

What was the cause of the previous problem? Drought: ____________ Pump Failure:

Increased Usage: ____________ Interference: ____________ Contamination:

If problem was contamination, what water quality changes were apparent? (note any differences in taste, odour, colour or clarity) ____________________

What action was taken to overcome the problem? ____________________

____

What were the effects of this problem? ____________________

Did you ever have your well:	deepened	yes / no
	or cleaned	yes / no
	or a new well constructed	yes / no

If so, why? ____________________

Outline briefly any previous repairs or changes in pumping equipment and dates:

____

____

____

Water Sample:

Sample taken: yes / no

Sample Number: ____________________ Number of bottles: ____________

Field Analysis: pH: ____________________ Temperature: ____________

Conductivity: ____________ Hardness: ____________

Iron: ____________________

Location Sketch:

Notes:

APPENDIX G

Water Balance Results

Table G1: Water Balance Existing Condition CBM Thomas St. Quarry Expansion

Wooded		Undifferentiated		Agricultural		Gravel		Buildings	
WHC	300 mm	WHC	300 mm	WHC	150 mm	WHC	100 mm	WHC	Precip - PE
Total Area (m^2)	10,431	Total Area (m^2)	24,189	Total Area (m^2)	428,427	Total Area (m^2)	442	Total Area (m^2)	1,140
Infiltration Factor	0.3	Infiltration Factor	0.3	Infiltration Factor	0.3	Infiltration Factor	0.3	Infiltration Factor	0.0

Month	Days	Temp	Precipitation	Potential Evapotranspiration	Actual Evapotranspiration Wooded Areas	Surplus		Actual Evapotranspiration Undifferentiated Areas	Surplus		Actual Evapotranspiration Agricultural Areas	Surplus		Actual Evapotranspiration Gravel Areas	Surplus		Actual Evapotranspiration Buildings Areas	Surplus		Total Surplus	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	31	-6.7	98.0	1	1	39	407	1	48	1,161	1	45	19,279	1	48	21	1	97	111	20,979	8	470	6,260	2	14,718	5
February	28	-6.2	72.0	1	1	50	522	1	54	1,306	1	53	22,707	1	54	24	1	71	81	24,639	10	611	7,367	3	17,272	7
March	31	-1.2	69.0	9	9	130	1,356	9	132	3,193	9	132	56,552	9	132	58	9	60	68	61,228	23	1,372	18,348	7	42,880	16
April	30	6.0	81.0	33	33	87	908	33	88	2,129	33	88	37,702	33	88	39	33	48	55	40,831	16	945	12,233	5	28,598	11
May	31	12.6	82.0	77	77	19	198	67	19	460	77	19	8,140	67	19	8	77	5	6	8,812	3	197	2,642	1	6,170	2
June	30	17.6	81.0	111	111	3	31	81	3	73	110	3	1,285	81	3	1	111	-30	-34	1,356	1	31	417	0	939	0
July	31	19.9	87.0	127	127	4	42	83	5	121	120	4	1,714	83	5	2	127	-40	-46	1,833	1	41	564	0	1,269	0
August	31	19.1	80.0	113	110	1	10	74	6	145	99	2	857	74	6	3	113	-33	-38	977	0	22	305	0	673	0
September	30	15.3	94.0	78	75	6	63	65	25	605	68	6	2,571	65	25	11	78	16	18	3,267	1	76	975	0	2,292	1
October	31	9.1	86.0	41	40	13	136	39	44	1,064	40	15	6,426	39	44	19	41	45	51	7,697	3	172	2,294	1	5,403	2
November	30	3.0	98.0	14	14	35	365	14	77	1,863	14	42	17,994	14	77	34	14	84	96	20,351	8	471	6,077	2	14,275	6
December	31	-3.3	107.0	3	3	47	490	3	62	1,500	3	51	21,850	3	62	27	3	104	119	23,986	9	537	7,160	3	16,826	6
Total			***1035.0***	***608.0***	***601***	***434***	***4,527***	***470***	***563***	***13,618***	***575***	***460***	***197,076***	***470***	***563***	***249***	***608***	***427***	***487***	***215,957***	***82***	***4,946***	***64,641***	***25***	***151,316***	***58***
Average		***7.1***																			***7***			***2.1***		***4.8***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

Table G2: Water Balance Operating Condition CBM Thomas St. Quarry Expansion

Open Pasture		Quarry	
WHC	100 mm	WHC	10 mm
Total Area (m^2)	61,085	Total Area (m^2)	403,544
Infiltration Factor	0.3	Infiltration Factor	0.0

Month	Days	Temp	Precipitation	Potential Evapo-transpiration	Actual Evapotranspiration Open Pasture Areas	Surplus		Actual Evapotranspiration Quarry Areas	Surplus		Total Surplus	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	31	-6.7	98.0	1	1	48	2,932	1	48	19,370	22,302	8	500	880	0	21,423	8
February	28	-6.2	72.0	1	1	54	3,299	1	54	21,791	25,090	10	622	990	0	24,100	10
March	31	-1.2	69.0	9	9	132	8,063	9	132	53,268	61,331	23	1,374	2,419	1	58,912	22
April	30	6.0	81.0	33	33	88	5,375	33	88	35,512	40,887	16	946	1,613	1	39,275	15
May	31	12.6	82.0	77	77	19	1,161	67	19	7,667	8,828	3	198	348	0	8,480	3
June	30	17.6	81.0	111	108	3	183	81	3	1,211	1,394	1	32	55	0	1,339	1
July	31	19.9	87.0	127	110	4	244	83	5	2,018	2,262	1	51	73	0	2,189	1
August	31	19.1	80.0	113	89	2	122	74	6	2,421	2,543	1	57	37	0	2,507	1
September	30	15.3	94.0	78	66	8	489	65	25	10,089	10,577	4	245	147	0	10,431	4
October	31	9.1	86.0	41	39	17	1,038	39	44	17,756	18,794	7	421	312	0	18,483	7
November	30	3.0	98.0	14	14	54	3,299	14	77	31,073	34,371	13	796	990	0	33,382	13
December	31	-3.3	107.0	3	3	56	3,421	3	62	25,020	28,440	11	637	1,026	0	27,414	10
Total			***1035.0***	***608.0***	***550***	***485***	***29,626***	***470***	***563***	***227,195***	***256,821***	***98***	***5,879***	***8,888***	***3***	***247,934***	***95***
Average		***7.1***										***8***			***0.3***		***7.9***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

Table G3: Water Balance Rehabilitated Condition CBM Thomas St. Quarry Expansion

Open Pasture		Pond	
WHC	100 mm	WHC	0 mm
Total Area (m^2)	78,949	Total Area (m^2)	385,679
Infiltration Factor	0.3	Infiltration Factor	0.0

Month	Days	Temp	Precipitation	Potential Evapo-transpiration	Actual Evapotranspiration Open Pasture Areas	Surplus		Actual Evapotranspiration Pond Areas	Surplus		Total Surplus	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	31	-6.7	98.0	1	1	48	3,790	1	97	37,411	41,200	15	923	1,137	0	40,064	15
February	28	-6.2	72.0	1	1	54	4,263	1	71	27,383	31,647	13	785	1,279	1	30,368	13
March	31	-1.2	69.0	9	9	132	10,421	9	60	23,141	33,562	13	752	3,126	1	30,436	11
April	30	6.0	81.0	33	33	88	6,948	33	48	18,513	25,460	10	589	2,084	1	23,376	9
May	31	12.6	82.0	77	77	19	1,500	77	5	1,928	3,428	1	77	450	0	2,978	1
June	30	17.6	81.0	111	108	3	237	111	-30	-11,570	-11,334	-4	-262	71	0	-11,405	-4
July	31	19.9	87.0	127	110	4	316	127	-40	-15,427	-15,111	-6	-339	95	0	-15,206	-6
August	31	19.1	80.0	113	89	2	158	113	-33	-12,727	-12,570	-5	-282	47	0	-12,617	-5
September	30	15.3	94.0	78	66	8	632	78	16	6,171	6,802	3	157	189	0	6,613	3
October	31	9.1	86.0	41	39	17	1,342	41	45	17,356	18,698	7	419	403	0	18,295	7
November	30	3.0	98.0	14	14	54	4,263	14	84	32,397	36,660	14	849	1,279	0	35,381	14
December	31	-3.3	107.0	3	3	56	4,421	3	104	40,111	44,532	17	998	1,326	0	43,205	16
Total			***1035.0***	***608.0***	***550***	***485***	***38,290***	***608***	***427***	***164,685***	***202,976***	***78***	***4,666***	***11,487***	***4***	***191,488***	***73***
Average		***7.1***										***6***			***0.4***		***6.1***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

Table G4: 2017 Water Balance Conditions for CBM Thomas St. Quarry

Wooded / Upland Thicket		Agricultural		Built Up Area (Impervious)		Open Water	
WHC	300 mm	WHC	150 mm	WHC	10 mm	WHC	0 mm
Total Area (m^2)	26,543	Total Area (m^2)	636,970	Total Area (m^2)	959,217	Total Area (m^2)	15,787
Infiltration Factor	0.3	Infiltration Factor	0.3	Infiltration Factor	0.0	Infiltration Factor	0.0

Month	Year	Days	Temp	Precipitation	Potential Evapotranspiration	Actual Evapotranspiration Wooded / Upland Thicket Areas	Surplus		Actual Evapotranspiration Agricultural Areas	Surplus		Actual Evapotranspiration Built Up Area (Impervious) Areas	Surplus		Actual Evapotranspiration Open Water Areas	Surplus		Total Surplus	Quarry Total Pumped Volume	Pumped minus Surplus	Pumped minus Runoff	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
			(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	2017	31	-2.0	79.8	4	4	83	2,214	4	83	53,140	3.7	83	80,024	4	76	1,201	136,580	333,467	196,887	213,494	51	3,060	16,606	6	119,973	45
February	2017	28	0.1	71.2	8	8	71	1,880	8	71	45,115	8.4	71	67,938	8	63	992	115,925	301,196	185,271	199,370	48	2,875	14,098	6	101,826	42
March	2017	31	0.2	85.7	11	11	74	1,977	11	74	47,454	11.2	74	71,461	11	74	1,176	122,068	333,467	211,399	226,229	46	2,734	14,829	6	107,238	40
April	2017	30	9.7	113.0	47	47	66	1,739	47	66	41,742	41.6	71	68,518	47	66	1,035	113,034	322,710	209,676	222,720	44	2,617	13,044	5	99,990	39
May	2017	31	12.1	133.4	67	67	71	1,895	67	71	45,467	54.0	83	79,755	67	66	1,045	128,161	333,467	205,306	219,514	48	2,871	14,208	5	113,953	43
June	2017	30	19.3	67.6	118	118	0	0	118	0	0	63.1	9	8,465	118	-50	-796	7,669	322,710	315,041	315,041	3	178	0	0	7,669	3
July	2017	31	21.0	49.6	132	125	0	0	88	0	0	42.3	9	8,864	132	-82	-1,295	7,569	333,467	325,898	325,898	3	170	0	0	7,569	3
August	2017	31	18.9	42.4	108	67	0	0	52	0	0	35.4	7	6,692	108	-66	-1,041	5,651	333,467	327,816	327,816	2	127	0	0	5,651	2
September	2017	30	17.3	32.0	79	46	0	0	37	0	0	29.3	1	1,196	79	-47	-739	457	322,710	322,253	322,253	0	11	0	0	457	0
October	2017	31	12.5	84.9	54	37	0	0	34	0	0	38.7	38	36,629	54	31	492	37,121	333,467	296,346	296,346	14	832	0	0	37,121	14
November	2017	30	2.8	90.8	10	10	0	0	10	23	14,557	10.4	80	76,671	10	80	1,269	92,496	322,710	230,214	234,581	36	2,141	4,367	2	88,129	34
December	2017	31	-5.2	63.5	2	2	0	0	2	26	16,494	2.2	26	24,839	2	61	968	42,302	333,467	291,165	296,114	16	948	4,948	2	37,353	14
Total				***913.9***	***641.1***	***544***	***366***	***9,706***	***479.3875396***	***414***	***263,968***	***340.1703744***	***554***	***531,051***	***641.0844988***	***273***	***4,307***	***809,032***	***3,926,305***	***3,117,273***	***3,199,375***	***309***	***18,561***	***82,102***	***31***	***726,930***	***278***
Average			***8.9***																			***26***			***2.6***		***23.2***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

APPENDIX H

Example Spill Prevention and Response Plan

SPILL PREVENTION AND CONTINGENCY PLAN

ST MARYS CEMENT INC. (CANADA), ST. MARYS PLANT
ST. MARYS, ONTARIO

DECEMBER 2019
(REVISION 7)
ORIGINAL DOCUMENT CREDIT TO CONESTOGA ROVERS & ASSOCIATES (2010)

LIST OF APPENDICES
(Attached Files)

APPENDIX A	Ontario Regulations
APPENDIX B	Material Safety Data Sheets (SDS)
APPENDIX C	PD00877 – Waste Handling, Diversion, and Disposal
APPENDIX D	PD00332- Spills Response Procedure
APPENDIX E	PD01337 – Aqueous Ammonia Procedure
APPENDIX F	Tank Inspection Routes
APPENDIX G	Spills History
APPENDIX H	Sample Incident Report
APPENDIX I	Site Location and Plant Areas
APPENDIX J	PD01446 - Responding to Dust Complaints

1 INTRODUCTION

1.1 Applicable Regulatory Information

St. Marys is a prescribed Municipal Industrial Strategy for Abatement (MISA) facility, as listed under the 'Regulated Persons' Section 3 (1), Table 1 of the O.Reg. 222/07 (Environmental Penalties Act). As such, the Facility has developed this Spill Prevention and Contingency Plan (SPCP) in compliance with the Regulation. The Regulation applies to those persons who own or operate an industrial plant that falls within one of the nine MISA industrial sectors, and that discharge to a surface water body or private sewage works. The Regulation ensures that appropriate prevention and contingency efforts are undertaken in the event of a spill, to reduce or eliminate the potential to cause adverse environmental effects.

This SPCP complies with both federal and provincial environmental regulations. These regulations contain specific clauses that stipulate the following:

1. Direct prohibitions against the discharge of contaminants
2. Mandatory reporting to Government Agencies or Police
3. Responsibility to minimize any potential environmental impacts

The legislative framework that regulates the prevention, preparedness, response, and reporting requirements of the SPCP include:

Federal
- a. Canadian Environmental Protection Act 1999 (CEPA)
- b. Fisheries Act (FA)

Provincial
- a. Environmental Protection Act (EPA)
- b. Ontario Water Resources Act (OWRA)
- c. Liquid Fuels Handling Code (LFHC)

The CEPA, 1999, Part 5-95. (1)(b) states that, in order to be in compliance, St. Marys shall

> "*…take all reasonable measures consistent with the protection of the environment and public safety to prevent the release of, if it cannot be prevented, to remedy any dangerous condition or reduce or mitigate any danger to the environment or to human life or health that results from the release or may reasonably be expected to result if the substance is released…*".

O. Reg 224/07 applies to facilities who were members of the class of persons prescribed under subsection 3(1) in O. Reg 222/07 (Environmental Penalties) for the purposes of 91.1 of the Act. O. Reg s. 3. (1) states that every person to whom this Regulation applies shall ensure that spill prevention and contingency plans are developed and implemented for each plant referred to in subsection 3(1) of Ontario Regulation 222/07 made under the Act, that the person owns or operates. As such, this Spill Prevention and Contingency Plan has been developed in accordance with O. Reg 224/07.

As per O. Reg 224-07 s. 3.(2) Spill Prevention and Contingency Plans must include,

a) the information listed in section 4;
    - As identified in Section 2 of St Marys Cement Spill Prevention and Contingency Plan
b) Plans required by clause of 91.1 (a) of the Act to prevent or reduced the risk of spills of pollutants; and
    - As identified in Section 3 of St Marys Cement Spill Prevention and Contingency Plan
c) Plans required by clause 91.1 (b) of the Act to prevent, eliminate or ameliorate any adverse effects that result or may result from spills of pollutants.
    - As identified in Section 4 of St Marys Cement Spill Prevention and Contingency Plan

1.2 Facility Information

St. Marys operates a manufacturing facility located 585 Water Street South in St. Marys, Ontario. A map of the Facility location is in Appendix I: Site Location and Plant Areas – Property Boundaries.

St. Marys manufactures fine cement powder that consists primarily of calcium silicates, aluminates, and alumino ferrites. Four main categories of raw materials include calcareous, siliceous, argillaceous, and ferriferous (calcium carbonate, silica, alumina, and iron) which are combined to produce the clinker for cement. The process steps include the following:

- Raw materials acquisition and handling
- Kiln feed preparation
- Chemical combination through pyroprocessing
- Grinding operations to achieve finished cement product

The limestone recovered from the Quarry is trucked to the primary crusher within the Quarry. An aboveground conveyor transports the limestone across the North Thames River to a stockpile, and a secondary crusher. From the secondary crusher, the limestone is transported to a limestone storage silo at the Cement Plant in the raw mill building via conveyor belt.

Raw materials such as shale, fly ash, alumina and iron oxide, are trucked in as necessary and stored in individual piles along the South side of the Water St. Location.

Kiln feed preparation includes a variety of blending and sizing operations that are designed to provide the cement kiln with raw feed mix having appropriate chemical and physical properties. The raw mix is mechanically and pneumatically blended and stored in specially constructed silos until it is fed to the pyroprocessing system.

A preheater tower containing two bucket elevators lifts the meal through a series of vertical cyclone chambers. Hot waste gases from the kiln heat the raw meal through the chambers as it passes through to the kiln.

The pyroprocessing system is fired using a blend of petroleum coke and natural gas. The coke is stored in silos or the yard at the Cement Plant until required as fuel. St. Marys Cement seeks to use alternative fuels such (such as polyethylene plastics or low carbon wood waste) in the future, to offset a portion of petcoke used.

The firing process transforms the raw meal into clinkers within the kiln. Clinkers are gray, glass-hard, spherically shaped nodules that range from approximately 0.3 to 5 cm in diameter. The steel kiln is approximately 75 metres (246 feet) long and rotates at approximately two revolutions per minute. The kiln is slightly inclined, cylindrical, and lined with refractory brick to protect the steel shell and retain heat within the kiln. The meal enters the kiln at the elevated end and the combustion fuels are introduced into the lower end of the kiln in a counter-current manner. The materials are continuously and slowly moved to the lower end by rotation of the kiln. As they move down the kiln, the raw materials are changed to clinkers as a result of the increasing temperature in the kiln.

The final step in the manufacture of cement involves a sequence of grinding and blending operations that transform clinker to finished cement product.

Baghouses are used to control particulate emissions at various points from start to finish within these operations. Other materials such as gypsum and grinding additives may be added to the clinker during grinding to control the cement setting time or to impart specific product properties.

1.3 Environmental Compliance Approvals

St. Marys has been issued environmental approvals for several on-Site Facility operations. The type of approval, approval number, and the location/sector to which the approval applies are summarized below:

Environmental Protection Act

Approval	*Approval Number or Regulation*	*Location*
Certificate of Approval (Air)	4546-AQ9GMB & 0710-6HSL9K	Cement Plant and Thomas Street Quarry, respectively
Permit to Take Water	5440-8YFHPP	Deep Wells 3, 4, 5, North Quarry Sump, South Quarry Pond, Garage Well, Crusher Well
MISA - Effluent Monitoring and Effluent Limits	O. Reg. 561/94	MISA Stations 0100 (Plant) and 0200 (Quarry)
Certificate of Approval – Industrial Sewage	4-0133-97-006	MISA 0100 Effluent

2 GENERAL INFORMATION

As per O. Reg 224-07 s. 4 General Information: Spill Prevention and Contingency Plans must include a written description of the plant that includes the following general information:

2.1 Identifying and Contact Information

2.1.1 Plant Information (s 4.1.i - v)

Legal Company Name:	St. Marys Cement Inc. (Canada)
Name of Facility:	St. Marys Cement – St. Marys Plant
Type of Facility:	Cement Manufacturing Plant and Quarry Operations
Mailing Address of Facility:	585 Water St. South, St. Marys, Ontario, N4X 1B6, P.O. Box 1000
Location of Facility:	Plant - 585 Water St. South, St. Marys, Ontario, N4X 1B6, P.O. Box 1000 Quarry - 524 Thomas St., St. Marys, Ontario
Facility Phone Number:	519-284-1020
Facility Fax Number:	519-284-4104

2.1.2 Contact Information (s 4.1.vi)

Title	*Name*	*E-mail Address*	*Phone Number*
Operations Manager	José Soraggi	jose.soraggi@vcimentos.com	519-284-1020 ext. 380
Production Manager	Robin Manzer	robin.manzer@vcimentos.com	519-284-1020 ext. 205
Mechanical Maintenance Manager	Bob Simon	bob.simon@vcimentos.com	519-284-1020 ext. 374
Electrical Maintenance Manager	Rodrigo Maia	rodrigo.maia@vcimentos.com	519-284-1020 ext. 216
Environmental Director	Ruben Plaza	ruben.plaza@vcimentos.com	905-623-3341 ext. 242
Security Personnel	Foreman on Duty		519-284-1020 ext. 234
Environmental Coordinator	Kara Terpstra	kara.terpstra@vcimentos.com	519-284-1020 ext. 235
Health & Safety Coordinator	Dee Muir	dee.muir@vcimentos.com	519-284-1020 ext. 316

Spill Response Personnel:	Foreman on Duty	& Environmental Coordinator if on site	
Emergency Response:	CANUTEC		613-996-6666

2.1.3 Contact Information (s 4.1.vii)

Personnel Responsible for Implementing Spill Prevention and Contingency Plan:	José Soraggi	519-284-1020 ext. 380 jose.soraggi@vcimentos.com
	Kara Terpstra	519-284-1020ext. 235 519-221-1849 (mobile) kara.terpstra@vcimentos.com
	Dee Muir	519-284-1020ext. 316 416-906-5535 (mobile) dee.muir@vcimentos.com

2.1.4 Contact Information (s 4.1.viii)

Senior Management Responsible for Ensuring Compliance with O. Reg 224/07:	José Soraggi	519-284-1020 ext. 380
	Kara Terpstra	519-284-1020 ext. 235

2.2 Entry to the plant

As per O. Reg 224-07 s. 4.2. the steps to gain entry to the plant are as follows:

1. If entering the Cement Plant, enter through the South Gate and proceed down the hill to the core building and visitor parking area. Sign in at the visitors' entrance and alert your site contact or the control room operator at ext. 233.
2. If entering the Quarry, Contact Tony Black at 519-284-1020 x 248.

All contractors performing work at the site need to complete the site orientation.

2.3 Plans and Drawings of the Plant

As per O. Reg 224-07 s. 4.3 the Spill Prevention and Contingency Plan must include Plans and drawings of the plant and each property on which the plant is located that are drawn to scale and that accurately show,

i. property boundaries
    - Refer to Figures in Appendix I: Site Location and Plant Areas – Property Boundaries

ii. the main storage, handling, processing, and disposal areas at the plant
    - Refer to Figures in Appendix I: Site Location and Plant Areas - Main Storage, Handling, and Processing Areas

iii. discharge points that are regulated under an Act of Ontario or Canada or by-law, including stacks and vents for discharges to the air
    - Refer to Figures in Appendix I: Site Location and Plant Areas - Discharge Points – Primary Air and Water

iv. the location of any work, container, or structure from which a spill identified in paragraph 1 of subsection 5 (1) may occur, including aboveground and underground storage tanks, and the volume that the work, container, or structure is capable of holding,
    - Refer to Figures in Appendix I: Site Location and Plant Areas - Tank Locations on Site. Also refer to Section 3.1: Potential Spill Sources.

v. any other works, containers, or structures at or from which a spill identified in paragraph 1 of subsection 5 (1) may occur,
    - Refer to Figures in Appendix I: Site Location and Plant Areas - Tank Locations on Site

vi. floor drains that have a potential to discharge pollutants into the natural environment and an indication of the destination to where the floor drains lead
    - Refer to Appendix I: Site Location and Plant Areas - Garage Floor Sumps
    - Also refer to Section 4.3.3.2: Sumps and Sump Pumps.

vii. loading and unloading areas including any docks or piers,
    - Refer to Figures in Appendix I: Site Location and Plant Areas - Loading and Unloading Areas

viii. sump pumps in areas where pollutants may be stored, handled, processed, transferred or disposed of an indication of the destination to where the pollutants are pumped
    - Refer to Appendix I: Site Location and Plant Areas - Garage Floor Sumps
    - Also refer to Section 4.3.3.2: Sumps and Sump Pumps.

ix. test holes as defined in Regulation 903 of the Revised Regulations of Ontario, 1990 (Wells) made under the Ontario Water Resources Act, or any other excavation that is made to monitor conditions of the natural environment
    - Refer to Appendix I: Site Location and Plant Areas - SMC Site Location and Water Features

x. ground water and surface water supplies used at the plant
    - Refer to Appendix I: Site Location and Plant Areas: SMC Site Location and Water Features

xi. structures that are designed to contain any spills that may occur

- Refer to Figures in Appendix I: Site Location and Plant Areas - Tank Locations on Site

xii. equipment for capturing and removing spilled pollutants,

- Refer to Figures in Appendix I: Site Location and Plant Areas - Spill Kit Locations

xiii. any works for collection, transmission, treatment, and disposal of storm water, including storm water ponds, storm water catch basins and, if a storm water catch basin discharges to surface water, an indication of whether there are valves or other mechanisms to control the discharge of the storm water from the catch basin, and

- Refer to Appendix I: Site Location and Plant Areas: SMC Site Location and Water Features

xiv. Any other structures or works at the plant that may be relevant to spill prevention and response, including pipes, gates, fences and barriers.

- n/a.

3 PLANS RE. PREVENTION OF SPILLS

As per O. Reg 224-07 s. 5 (1) and clause 91.1 (a) of the Environmental Protection Act, Plans required to prevent or reduce the risk of spills of pollutants must contain the following, in writing:

1. The identification of all spills that,
   i. May occur at the plant or relate to the operations of the plant,
   ii. Are reasonably foreseeable, and
   iii. Have the potential to cause adverse effects.

3.1 Potential Spill Sources

The following subsections outline the areas of concern (AOCs) at the Facility where, under certain conditions, a liquid spill could conceivably occur. The identification of these AOCs will help identify and control conditions to prevent or mitigate the potential impacts resulting from a spill. All areas described in the following subsections have been identified in Appendix I: Site Location and Plant Areas.

At the Facility, there are 22 above ground storage tanks (ASTs). The contents of the ASTs vary by container. In no particular order, the following table summarizes the AST contents, maximum volumes, location, and secondary tank spill prevention features (where present):

	Location	*Tank / Equipment ID*	*Contents*	*Maximum Volume (litres)*	*Secondary Containment*
1	Removed 2019				
2	Beside Butler Building	M-28-1	Diesel	25,000 L	Double-walled tank
3	Z1 Area – Outside North Wall of Z1 Building	12-0-248	Light Waste Oil	10,000 L	Double-walled tank
4	Garage	M-28-4	Diesel	1,000 L	Double-walled tank
5	Waste Oil Storage	M-28-5	Light Waste Oil	7,570 L	Double-walled tank
6	Beside Oil House	M-28-7	Gasoline, Diesel, Varsol	6,300 L	Double-walled tank
7	Thomas Street Quarry – between gate and garage	A-2	Diesel	45,400 L	Double-walled tank

8	Thomas Street Quarry – beside A-2 Diesel Tank	TSQ-Gasoline	Gasoline	2,200L	Double-walled tank
9	Thomas Street Quarry	N/A	Ice Axe – L - NB	11356L	Concrete Containment Pool
10	CBM Sanimax – Dryer Plant Fuel	CBM Diesel	Diesel	2,200L	Double-walled tank
11	Burner Floor	12-01	Ethylene Glycol	400 L	Inside Building
12	Between Glycol fans and backend firing building	W1K94	Ammonia (19% Solution)	38,000 L	Concrete Containment Pool
13	Finish Mill Building – Grind Additives	Z1K09	MTDA/CBA Grinding aid	30,000 L	Concrete Containment Pool
14		Z1K14	Hydrophobe 3.12 Air Entrainer	30,000 L	Concrete Containment Pool
15		Z1K22	RDA 330 Set Time Extender.	30,000 L	Concrete Containment Pool
16		Z1K25	Ethylene Glycol	151 L	Concrete Containment Pool
17	Main Plant – Standby Generator	10-0-120	Diesel	2,000 L[1]	Tank contained in generator
18	West of Kiln	N/A	Kiln Condensate	1000L	None
19	Impactor Building	Removed 2019			
20		Removed 2019			
21		N/A	WD-80 Deicer	5500L	None
22	Stores Area	n/a	Water Softener	1000L	None
23	Finish Mill	n/a	MTDA/CBA Grinding aid	1300L	None

Note 1: Volume is approximate.

The double wall tanks have a vacuum with gauges to monitor pressure. Tank inspection routes for tanks are distributed monthly. All ASTs are also inspected annually for tank integrity by a certified contractor. Examples can be found in Appendix F. There are no Underground Storage Tanks at the facility.

In addition to the above ASTs, there are other storage areas (as well as non-bulk chemical storage areas) including the following locations:

Location	*Tank ID/ Equipment*	*Storage Contents*	*Maximum Volume (litres)*	*Secondary Containment*
Main Transformer Substation T1	10-0-112	Transformer Oil	13,786	None
Main Transformer Substation T2	10-0-113	Transformer Oil	13,790	None
Impactor	K-11-2	Transformer Oil	2,555	None
Quarry	K-12-2	Transformer Oil	1,382	None
Step up	10-0-501	Transformer Oil	4,421	None
Substation #1	10-0-125	Transformer Oil	1,022	None
Main Transformer Substation	OCB	Transformer Oil	10,410	None
Oil Storage	N/A	Drums of Oils, Greases, Lubricants	205L per drum	None
Stockroom Area; Maintenance Shops	-	MS, VV, MC	< 10 L	Concrete floor with no drains
Stockpiles	-	MS, VV	Various	Yard

Notes: MS – multiple sources; VV – variable volumes; MC – multiple chemical types

3.2 Analysis of Likelihood of Spills

As per O. Reg 224-07 s. 5 (1) and clause 91.1 (a) of the Environmental Protection Act, Plans required to prevent or reduce the risk of spills of pollutants must contain the following, in writing,

2. An analysis of the likelihood of the each spill identified to occur, based on,

i. The properties and characteristics of all substances used at the plant and, for each substance, the maximum expected quantity that may be at the plant per area of concern (AOC);
   - Refer to Section 3.2.1 for properties and characteristics, and refer to Section 3.1 for volumes of each tank located at the facility.

ii. The manner in which each material is stored, handled, processed, and disposed of at the plant (or externally);
   - Refer to Section 3.2.2 for Handling, Processing, Storage, and Disposal

iii. The physical and geographical characteristics of the location at which each material is stored, handled, processed, and disposed of at the plant;
   - Refer to Appendix I: Site Location and Plant Areas - Tank Locations on Site
   - Refer to Section 3.2.3 for Physical and Geographical Characteristics

iv. Whether there have been previous spills of the pollutant at the plant or relating to its operations;
   - Refer to Section 3.2.4 Spill History

v. Any other relevant factors.

3.2.1 Properties and Characteristics of Substances Used at the Plant

A copy of the MSDS for each potential pollutant stored at the Facility is located in Appendix B. There is also a hard copy in the plant control room.

Safety Data Sheets can also be found online via the MSDS database
https://msdsmanagement.msdsonline.com/ebinder/

The following pages summarize the pertinent chemical properties of the chemicals listed above. Pertinent properties include tank contents, release type, DNALP/Air Toxic/ Toxic Substance denotation, WHMIS Classification, Composition Information, Physical Properties, Reactivity Information, First Aid Procedures, and Spill Procedures.

<table>
<tr><td>Tank Contents</td><td colspan="12">Ammonia – 19% Solution
Refer also to Ammonia Handling Procedure (Appendix E)</td></tr>
<tr><td colspan="13">** Refer to Safety Data Sheet for Further Information **</td></tr>
<tr><td>Release Type :</td><td colspan="12">Liquid, Air</td></tr>
<tr><td>DNALP/Air Toxic/Toxic Substance:</td><td colspan="12">Air Toxics</td></tr>
<tr><td>WHMIS Classification :</td><td colspan="12"> </td></tr>
<tr><td rowspan="3">Composition Information :</td><td colspan="4">Ingredient</td><td colspan="4">CAS#</td><td colspan="4">Percent</td></tr>
<tr><td colspan="4">Ammonia (in solution)</td><td colspan="4">1336-21-6</td><td colspan="4">19 (<1% in ammonium hydroxide form)</td></tr>
<tr><td colspan="4">Deionized Water</td><td colspan="4">-</td><td colspan="4">80-90%</td></tr>
<tr><td rowspan="2">Physical Properties:</td><td colspan="3">Appearance & Odour</td><td colspan="3">Boiling Point</td><td colspan="3">Melting/Freezing Point</td><td colspan="3">Vapour Pressure</td></tr>
<tr><td colspan="3">Colourless liquid with a pungent irritating odour.</td><td colspan="3">70C</td><td colspan="3">-15C</td><td colspan="3">1.5psi @ 15C</td></tr>
<tr><td>Reactivity Information:</td><td colspan="12">Will liberate ammonia vapours. Avoid excessive heat. Contact with strong iodine, bromine, calcium, hypo-chlorite mixtures, halogens may cause violent spattering.</td></tr>
<tr><td>First Aid Procedure:</td><td colspan="12">Inhaled: Move to Fresh air. If not breathing give artificial respiration. Keep the patient warm and at rest. Obtain medical attention.
Skin: Flush skin with running water for at least 15 minutes. Remove contaminated clothing.
Eyes: Flush with running water for at least 15 minutes. Seek medical attention.
Ingested: Give ½ to 1 glass of water. Do not induce vomiting. If vomiting occurs, have victim lean forward to avoid breathing vomits, rinse mouth and administer more water. Immediately transfer victim to an emergency facility.</td></tr>
<tr><td></td><td colspan="12"></td></tr>
<tr><td>Spill Procedure:</td><td colspan="12">Stop the discharge if possible. Use SCBA equipment with an ammonia cartridge. Construct barriers to contain run off. Downwind evacuation may be necessary.
Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

<table>
<tr><td><u>Tank Contents</u></td><td colspan="4"><u>Diesel Fuel</u></td></tr>
<tr><td colspan="5">** Refer to Safety Data Sheet for Further Information **</td></tr>
<tr><td>Release Type :</td><td colspan="4">Liquid, Air</td></tr>
<tr><td>DNALP/Air Toxic/Toxic Substance:</td><td colspan="4">Toxic Substance</td></tr>
<tr><td>WHMIS Classification :</td><td colspan="4"></td></tr>
<tr><td rowspan="8">Composition Information :</td><td colspan="2"><u>Ingredient</u></td><td><u>CAS#</u></td><td><u>Percent</u></td></tr>
<tr><td colspan="2">Fuels, diesel</td><td>68334-30-5</td><td>70-100%</td></tr>
<tr><td colspan="2">Kerosene (petroleum)</td><td>8008-20-6</td><td></td></tr>
<tr><td colspan="2">Kerosene (petroleum), hydrodesulfurized</td><td>64742-81-0</td><td></td></tr>
<tr><td colspan="2">Alkanes, C10-20 branched and linear</td><td>928771-01-1</td><td>0-25%</td></tr>
<tr><td colspan="2">Soybean oil, Methyl Ester</td><td>67784-80-9</td><td>0-5%</td></tr>
<tr><td colspan="2">Rape Oil, Methyl Ester</td><td>73891-99-3</td><td></td></tr>
<tr><td colspan="2">Fatty acids, tallow, Methyl Esters</td><td>61788-61-2</td><td></td></tr>
<tr><td rowspan="2">Physical Properties:</td><td>Appearance & Odour</td><td>Boiling Point</td><td>Melting/Freezing Point</td><td>Vapour Pressure</td></tr>
<tr><td>Bright oily liquid. Mild petroleum oil like odour.</td><td>150-371C</td><td>n/a</td><td>7.5mm Hg</td></tr>
<tr><td>Reactivity Information:</td><td colspan="4">Flammable in presence of open flames, sparks, and heat. Vapours are heavier than air and may travel considerable distance to sources of ignition. Stable under normal conditions. Avoid extremes of temperature and direct sunlight. Reactive with oxidising agents and direct sunlight.</td></tr>
<tr><td>First Aid Procedure:</td><td colspan="4">Inhaled: Move to Fresh air. Artificial respiration may be necessary.
Skin: Flush skin with running water for 15 minutes. Remove contaminated clothing.
Eyes: Flush with running water for at least 15 minutes. Seek medical attention.
Ingested: Rinse mouth with water. Do not induce vomiting. Seek medical attention.</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td>Spill Procedure:</td><td colspan="4">Use personal protective equipment. Evacuate personnel to safe areas. Prevent further leakage or spillage if safe to do so. Remove all sources of ignition. Soak up with inert absorbent material. Non-sparking tools should be used. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

<table>
<tr><td><u>Tank Contents</u></td><td colspan="4"><u>Ethylene Glycol- Industrial Grade</u></td></tr>
<tr><td colspan="5">** Refer to Safety Data Sheet for Further Information **</td></tr>
<tr><td>Release Type :</td><td colspan="4">Liquid, Air</td></tr>
<tr><td>DNALP/Air Toxic/Toxic Substance:</td><td colspan="4">Air Toxics</td></tr>
<tr><td>WHMIS Classification :</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Composition Information :</td><td colspan="2"><u>Ingredient</u></td><td><u>CAS#</u></td><td><u>Percent</u></td></tr>
<tr><td colspan="2">Ethylene Glycol</td><td>107-211</td><td>99-100</td></tr>
<tr><td rowspan="2">Physical Properties:</td><td>Appearance & Odour</td><td>Boiling Point</td><td>Melting/Freezing Point</td><td>Vapour Pressure</td></tr>
<tr><td>Clear, odourless liquid.</td><td>197.4C</td><td>-13c</td><td>0.123 hpa</td></tr>
<tr><td>Reactivity Information:</td><td colspan="4">No applicable information available. No corrosive effect on metal, not classified as oxidizing.</td></tr>
<tr><td>First Aid Procedure:</td><td colspan="4">Inhaled: Move to Fresh air and keep the person calm. Assist breathing if necessary. Seek medical attention.
Skin: Wash affected area thoroughly with soap and water.
Eyes: Rinse with plenty of water.
Ingested: Rinse mouth with water and then drink 200-300ml of water. Induce vomiting. Seek medical attention.</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td>Spill Procedure:</td><td colspan="4">Use personal protective equipment. Spills should be contained, solidified, and placed in suitable containers for disposal. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

<table>
<tr><td><u>Tank Contents</u></td><td colspan="4"><u>Furnace Oil</u></td></tr>
<tr><td colspan="5">** Refer to Safety Data Sheet for Further Information **</td></tr>
<tr><td>Release Type :</td><td colspan="4">Liquid, Air</td></tr>
<tr><td>DNALP/Air Toxic/Toxic Substance:</td><td colspan="4">Air Toxics</td></tr>
<tr><td>WHMIS Classification :</td><td colspan="4"></td></tr>
<tr><td rowspan="6">Composition Information :</td><td colspan="2"><u>Ingredient</u></td><td><u>CAS#</u></td><td><u>Percent</u></td></tr>
<tr><td colspan="2">Fuels, Distillate</td><td>683347-30-5</td><td>0-100</td></tr>
<tr><td colspan="2">Distillates (Fischer- Tropsch), C8-26 Branched and Linear</td><td>848301-67-7</td><td>0-50</td></tr>
<tr><td colspan="2">Alkanes, C10-20, branched and linear</td><td>928771-01-1</td><td>0-30</td></tr>
<tr><td colspan="2">Cumene</td><td>98-82-8, 202-704-5</td><td>0-0.5</td></tr>
<tr><td colspan="2">Naphthalene</td><td>91-20-3, 202-049-5</td><td>0-0.5</td></tr>
<tr><td rowspan="2">Physical Properties:</td><td>Appearance & Odour</td><td>Boiling Point</td><td>Melting/Freezing Point</td><td>Vapour Pressure</td></tr>
<tr><td>Liquid, undyed, no odour.</td><td>150-400C</td><td>40-60C</td><td><=0.4 kpa</td></tr>
<tr><td>Reactivity Information:</td><td colspan="4">Stable under normal use conditions. Avoid heat, sparks, open flames, and other ignition sources. Incompatible with strong oxidising agents. Hazardous decomposition products are not expected to form during normal storage.</td></tr>
<tr><td>First Aid Procedure:</td><td colspan="4">Inhaled: Move to fresh air. Seek medical attention if necessary.
Skin: Remove contaminated clothing. Rinse with water for 15 minutes then wash with soap and water. Seek medical attention if necessary.
Eyes: Rinse with plenty of water. Seek medical attention if necessary.
Ingested: Do not induce vomiting. Seek medical attention. If vomiting occurs keep head below hips to avoid aspiration.</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td>Spill Procedure:</td><td colspan="4">Use personal protective equipment. Do not breathe fumes, vapor. Shut of leaks if possible without personal risk. Evacuate personnel. Contain residual materials at affected sites to prevent material from entering drains. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

<table>
<tr><td><u>Tank Contents</u></td><td colspan="4"><u>Gasoline Unleaded</u></td></tr>
<tr><td colspan="5">** Refer to Safety Data Sheet for Further Information **</td></tr>
<tr><td>Release Type :</td><td colspan="4">Liquid</td></tr>
<tr><td>DNALP/Air Toxic/Toxic Substance:</td><td colspan="4">Air Toxic</td></tr>
<tr><td>WHMIS Classification :</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Composition Information :</td><td colspan="2"><u>Ingredient</u></td><td><u>CAS#</u></td><td><u>Percent</u></td></tr>
<tr><td colspan="2">Ethylene Alcohol</td><td>64-17-5</td><td>0-1%</td></tr>
<tr><td colspan="2">Gasoline</td><td>86290-81-5</td><td>98-100%</td></tr>
<tr><td rowspan="2">Physical Properties:</td><td>Appearance & Odour</td><td>Boiling Point</td><td>Melting/Freezing Point</td><td>Vapour Pressure</td></tr>
<tr><td>Clear, liquid, petroleum/solvent odour</td><td>>20C</td><td>n/a</td><td>45kpa</td></tr>
<tr><td>Reactivity Information:</td><td colspan="4">Material is stable under normal conditions. Avoid heat, sparks, open flame, and other ignition sources. Avoid alkalies, halogens, strong acids, and strong oxidisers.</td></tr>
<tr><td>First Aid Procedure:</td><td colspan="4">Inhaled: Remove from further exposure. Get medical assistance. Use adequate respiratory protection. If respiratory irritation, dizziness, nausea, or unconscious occurs, seek medical attention.
Skin: Wash contact areas with soap and water. Remove contaminated clothing. If irritation occurs, get medical attention.
Eyes: Flush thoroughly with water. If irritation occurs, get medical attention.
Ingested: Seek immediate medical attention. Do not induce vomiting. Seek medical attention.</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td>Spill Procedure:</td><td colspan="4">Use personal protective equipment. Avoid contact with spilled material. Warn or evacuate occupants in downwind areas if required. Eliminate all ignition sources. Stop leak if you can do so without risk. All equipment when handling the product must be grounded. Do not touch or walk through spilled material. Prevent entry into waterways, sewer, basements, or confined areas. Prevent entry into waterways. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

<table>
<tr><td><u>Tank Contents</u></td><td colspan="4"><u>Hydrophobe 41 ER 3.12</u></td></tr>
<tr><td colspan="5">** Refer to Safety Data Sheet for Further Information **</td></tr>
<tr><td>Release Type :</td><td colspan="4">Liquid</td></tr>
<tr><td>DNALP/Air Toxic/Toxic Substance:</td><td colspan="4">Toxic Substance</td></tr>
<tr><td>WHMIS Classification :</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Composition Information :</td><td colspan="2"><u>Ingredient</u></td><td><u>CAS#</u></td><td><u>Percent</u></td></tr>
<tr><td colspan="2">Diethylene Glycol</td><td>111-46-6</td><td>5-10%</td></tr>
<tr><td colspan="2">Laurel ether sulfate, sodium salt</td><td>9004-82-4</td><td>1-2%</td></tr>
<tr><td rowspan="2">Physical Properties:</td><td>Appearance & Odour</td><td>Boiling Point</td><td>Melting/Freezing Point</td><td>Vapour Pressure</td></tr>
<tr><td>Liquid, not determined odour.</td><td>Undetermined.</td><td>Undetermined.</td><td>Undetermined.</td></tr>
<tr><td>Reactivity Information:</td><td colspan="4">Stable under normal conditions.</td></tr>
<tr><td>First Aid Procedure:</td><td colspan="4">Inhaled: Move to fresh air. Consult with doctor if symptoms persist.
Skin: Immediately wash contaminated skin with soap or mild detergent and water.
Eyes: Rinse cautiously with water for several minutes.
Ingested: Rinse mouth. Seek medical treatment.</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td>Spill Procedure:</td><td colspan="4">Use personal protective equipment. Contain and/or absorb spill with inert material. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

<table>
<tr><td>**Tank Contents**</td><td colspan="4">**Ice Axe NB**</td></tr>
<tr><td colspan="5">**** Refer to Safety Data Sheet for Further Information ****</td></tr>
<tr><td>**Release Type :**</td><td colspan="4">Liquid</td></tr>
<tr><td>**DNALP/Air Toxic/Toxic Substance:**</td><td colspan="4">Toxic Substance</td></tr>
<tr><td>**WHMIS Classification :**</td><td colspan="4"></td></tr>
<tr><td rowspan="2">**Composition Information :**</td><td colspan="2">**Ingredient**</td><td>**CAS#**</td><td>**Percent**</td></tr>
<tr><td colspan="2">Calcium Chloride</td><td>10043-52-4</td><td>15-20%</td></tr>
<tr><td rowspan="2">**Physical Properties:**</td><td>**Appearance & Odour**</td><td>**Boiling Point**</td><td>**Melting/Freezing Point**</td><td>**Vapour Pressure**</td></tr>
<tr><td>Clear/Slight haze. Blue.</td><td>115C</td><td>-32C</td><td>n/a</td></tr>
<tr><td>**Reactivity Information:**</td><td colspan="4">Stable under normal conditions.</td></tr>
<tr><td>**First Aid Procedure:**</td><td colspan="4">**Inhaled:** Promptly remove to fresh air. Get medical attention if any discomfort from inhalation.
Skin: Remove contaminated clothing. Wash with plenty of soap and running water. Get medical attention if irritation persists.
Eyes: Flush eyes promptly with plenty of running water, continuing for at least 15 minutes. Get medical attention.
Ingested: If conscious, immediately give 2 to 4 glasses of water and induce vomiting under medical supervision. Get medical attention promptly.</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td>**Spill Procedure:**</td><td colspan="4">Use personal protective equipment. Contain and/or absorb spill with inert material. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

<table>
<tr><td><u>Tank Contents</u></td><td colspan="12"><u>MTDA/CBA Grinding Aid</u></td></tr>
<tr><td colspan="13">** Refer to Safety Data Sheet for Further Information **</td></tr>
<tr><td>Release Type :</td><td colspan="12">Liquid, Air</td></tr>
<tr><td>DNALP/Air Toxic/Toxic Substance:</td><td colspan="12">Air Toxics</td></tr>
<tr><td>WHMIS Classification :</td><td colspan="12"></td></tr>
<tr><td rowspan="4">Composition Information :</td><td colspan="6"><u>Ingredient</u></td><td colspan="4"><u>CAS#</u></td><td colspan="2"><u>Percent</u></td></tr>
<tr><td colspan="6">Triisopropanolamine</td><td colspan="4">122-20-3</td><td colspan="2">20-25%</td></tr>
<tr><td colspan="6">Diethylene glycol</td><td colspan="4">111-46-6</td><td colspan="2">2-5%</td></tr>
<tr><td colspan="6">Triisobutyl Phosphate</td><td colspan="4">126-71-6</td><td colspan="2">0.1-1%</td></tr>
<tr><td rowspan="2">Physical Properties:</td><td colspan="3">Appearance & Odour</td><td colspan="3">Boiling Point</td><td colspan="3">Melting/Freezing Point</td><td colspan="3">Vapour Pressure</td></tr>
<tr><td colspan="3">Liquid,
Characteristic odour</td><td colspan="3">100C</td><td colspan="3">Undetermined</td><td colspan="3">Not Determined</td></tr>
<tr><td>Reactivity Information:</td><td colspan="12">Stable under normal conditions. May degrade Polyvinylchloride.</td></tr>
<tr><td>First Aid Procedure:</td><td colspan="12">Inhaled: Supply fresh air. If required provide artificial respiration. Consult doctor if symptoms persist.
Skin: Immediately wash contaminated skin with soap or mild detergent and water.
Eyes: Rinse opened eye for several minutes under running water.
Ingested: Wash out mouth with water. Rinse mouth. Do not induce vomiting. Seek medical attention.</td></tr>
<tr><td></td><td colspan="12"></td></tr>
<tr><td>Spill Procedure:</td><td colspan="12">Use personal protective equipment. Contain residual materials at affected sites to prevent material from entering drains. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

<table>
<tr><td>**Tank Contents**</td><td colspan="6">**RDA 330**</td></tr>
<tr><td colspan="7">**** Refer to Safety Data Sheet for Further Information ****</td></tr>
<tr><td>**Release Type :**</td><td colspan="6">Liquid</td></tr>
<tr><td>**DNALP/Air Toxic/Toxic Substance:**</td><td colspan="6"></td></tr>
<tr><td>**WHMIS Classification :**</td><td colspan="6">Not applicable.</td></tr>
<tr><td rowspan="2">**Composition Information :**</td><td colspan="3">**Ingredient**</td><td colspan="2">**CAS#**</td><td>**Percent**</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="2">**Physical Properties:**</td><td>**Appearance & Odour**</td><td>**Boiling Point**</td><td colspan="2">**Melting/Freezing Point**</td><td colspan="2">**Vapour Pressure**</td></tr>
<tr><td>Liquid, Characteristic Odour</td><td>>100C</td><td colspan="2">Undetermined</td><td colspan="2">Not Determined</td></tr>
<tr><td>**Reactivity Information:**</td><td colspan="6">Stable under normal conditions.</td></tr>
<tr><td>**First Aid Procedure:**</td><td colspan="6">**Inhaled:** Supply fresh air. If required provide artificial respiration. Consult doctor if symptoms persist.
Skin: Immediately wash contaminated skin with soap or mild detergent and water.
Eyes: Rinse cautiously with water for several minutes.
Ingested: Rinse mouth. Do NOT induce vomiting. Seek medical attention.</td></tr>
<tr><td></td><td colspan="6"></td></tr>
<tr><td>**Spill Procedure:**</td><td colspan="6">Use personal protective equipment. Contain residual materials at affected sites to prevent material from entering drains. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

<table>
<tr><td><u>Tank Contents</u></td><td colspan="12"><u>Transformer Oil – Voltesso 35</u></td></tr>
<tr><td colspan="13">** Refer to Safety Data Sheet for Further Information **</td></tr>
<tr><td>Release Type :</td><td colspan="12">Liquid</td></tr>
<tr><td>DNALP/Air Toxic/Toxic Substance:</td><td colspan="12"></td></tr>
<tr><td>WHMIS Classification :</td><td colspan="12"></td></tr>
<tr><td rowspan="4">Composition Information :</td><td colspan="6"><u>Ingredient</u></td><td colspan="3"><u>CAS#</u></td><td colspan="3"><u>Percent</u></td></tr>
<tr><td colspan="6">2,6-Di-Tert-Butyl-P-Cresol</td><td colspan="3">128-37-0</td><td colspan="3">0.89%</td></tr>
<tr><td colspan="6">Hydrotreated Light Naphthenic Distillate (Petroleum)</td><td colspan="3">64742-53-6</td><td colspan="3">79%</td></tr>
<tr><td colspan="6">Lubricating Oils – (Petroleum), Hydrotreated Neutral Oil-Based</td><td colspan="3">72623-86-0</td><td colspan="3">19%</td></tr>
<tr><td rowspan="2">Physical Properties:</td><td colspan="3">Appearance & Odour</td><td colspan="3">Boiling Point</td><td colspan="3">Melting/Freezing Point</td><td colspan="3">Vapour Pressure</td></tr>
<tr><td colspan="3">Liquid, Characteristic Odour</td><td colspan="3">>100C</td><td colspan="3">Undetermined</td><td colspan="3">Not Determined</td></tr>
<tr><td>Reactivity Information:</td><td colspan="12">Stable under normal conditions. Avoid excessive heat, avoid high energy sources of ignition.</td></tr>
<tr><td>First Aid Procedure:</td><td colspan="12">Inhaled: Remove from further exposure. For those providing assistance, avoid exposure to yourself or others. If respiratory irritation, dizziness, nausea, or unconsciousness occurs, seek medical assistance.
Skin: Wash contact areas with soap and water. Remove contaminated clothing.
Eyes: Flush thoroughly with water. If irritation occurs, get medical assistance.
Ingested: Seek immediate medical attention. Do not induce vomiting.</td></tr>
<tr><td></td><td colspan="12"></td></tr>
<tr><td>Spill Procedure:</td><td colspan="12">Use personal protective equipment. Avoid contact. Warn or evacuate occupants in surrounding downwind areas if required. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

Tank Contents	**Varsol Solvent**			
** Refer to Safety Data Sheet for Further Information **				
Release Type :	Liquid			
DNALP/Air Toxic/Toxic Substance:				
WHMIS Classification :				
Composition Information :	**Ingredient**	**CAS#**	**Percent**	
	Stoddard Solvent	8052-41-3	100	
Physical Properties:	**Appearance & Odour**	**Boiling Point**	**Melting/Freezing Point**	**Vapour Pressure**
	Clear Colourless liquid, pungent petroleum odour	159-200C	n/a	4.8kpa
Reactivity Information:	Material is stable under normal conditions. Avoid heat, sparks, open flames, and other ignition sources.			
First Aid Procedure:	**Inhaled:** Remove from further exposure. For those providing assistance, avoid exposure to yourself or others. If respiratory irritation, dizziness, nausea, or unconsciousness occurs, seek medical assistance. **Skin:** Wash contact areas with soap and water. Remove contaminated clothing. **Eyes:** Flush thoroughly with water. If irritation occurs, get medical assistance. **Ingested:** Seek immediate medical attention. Do not induce vomiting.			
Spill Procedure:	Use personal protective equipment. Avoid contact. Warn or evacuate occupants in surrounding downwind areas if required. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)			

<table>
<tr><td><u>Tank Contents</u></td><td colspan="4"><u>WD-80</u></td></tr>
<tr><td colspan="5">** Refer to Safety Data Sheet for Further Information **</td></tr>
<tr><td>Release Type :</td><td colspan="4">Liquid</td></tr>
<tr><td>DNALP/Air Toxic/Toxic Substance:</td><td colspan="4"></td></tr>
<tr><td>WHMIS Classification :</td><td colspan="4">N/A</td></tr>
<tr><td rowspan="2">Composition Information :</td><td colspan="2"><u>Ingredient</u></td><td><u>CAS#</u></td><td><u>Percent</u></td></tr>
<tr><td colspan="2">Stoddard Solvent</td><td>8052-41-3</td><td>100</td></tr>
<tr><td rowspan="2">Physical Properties:</td><td>Appearance & Odour</td><td>Boiling Point</td><td>Melting/Freezing Point</td><td>Vapour Pressure</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Reactivity Information:</td><td colspan="4"></td></tr>
<tr><td>First Aid Procedure:</td><td colspan="4">Inhaled: Promptly remove to fresh air. Get medical attention if any discomfort from inhalation.
Skin: Wash with plenty of soap and running water.
Eyes: Flush eyes promptly with plenty of running water, continuing for at least 15 minutes. If irritation persists, consult a physician.
Ingested: Do NOT induce vomiting. Never give anything by mouth to an unconscious or convulsing person. Get medical attention promptly. If vomiting occurs spontaneously keep head below hips to prevent aspiration of liquid into the lungs.</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td>Spill Procedure:</td><td colspan="4">Use personal protective equipment. Avoid contact. Warn or evacuate occupants in surrounding downwind areas if required. Refer to Site Spill Response Procedure (Appendix D) and dispose of as hazardous waste (Appendix C)</td></tr>
</table>

3.2.2 Handling, Processing, Storage, and Disposal

The primary handling areas for the chemicals, as listed in Section 3.1: Potential Spill Sources, are the same as the storage areas listed above. St. Marys has several procedures in place for the handling of the pollutants at the Facility, such as:

A standard operating procedure (SOP) for the handling and disposal of waste that has resulted from a spill or release is included in Appendix C – PD00877 Waste Handling, Dispersion, and Disposal.

An SOP for Spill Containment exists to minimize/eliminate and safely and properly address spills of fuel and other substances to the environment (ground, drains, natural waterways, etc.), as well as maintain a safe working environment in the affected area during cleanup, and reporting obligations. A copy of the Spill Containment SOP (PO00332- Spills Response Procedure) is included as Appendix D.

A new SOP for the use of 19% aqueous ammonia, the highest risk substance on the property, has been included in Appendix E- PD01337 Aqueous Ammonia Handling Procedure. This material is located at grade on the east side of the north end of the rotary kiln. Aqueous Ammonia is not considered under the E2 regulation for Ammonia System as per the Canadian Environmental Protection Act because it falls below the 20% requirement under Schedule 1 of E2 Regulations.

All **fuel ASTs are inspected annually by the fuel distributor** to observe the integrity of the tanks and prevent any potential spills. A visual inspection of all ASTs is performed monthly to observe the integrity of the tanks and prevent any potential spills. Inspections are completed by qualified Facility personnel and include ensuring that there is no accumulation of surface water or product in the dyke area, inspection of hoses, nozzles, pumps, vacuum gauges, if applicable, and ensuring the paint is in proper condition to prevent corrosion.

Annual training and certification is required for all forklift operators. This would include the proper handling procedures for the attachment and detachment of propane fuel tanks. More information is available from the Health & Safety and Human Resource departments.

All other bulk storage of chemicals are not handled by Employees directly as chemicals are loaded directly at the storage location and discharged directly to the Facility processes.
The processing of the chemicals of concern, as listed in Section 3.1: Potential Spill Sources, are primarily limited to their use as a fuel or heating source (i.e., furnace oil, gasoline, and diesel). The ethylene glycol is used as a non-contact cooling agent for two processes at the Facility. The Grinding Additives in the Finish Mill area are used as cement additives. Aqueous ammonia is used for the reduction of nitrogen oxide (NO_x) emissions from the Facility.

See Appendix I: Site Location and Plant Areas for locations of tanks and their contents as related to the processing areas of the Facility.

There are no active disposal areas at the Facility. Waste storage areas include areas for the storage of waste oils, chemicals, batteries and fluorescent bulbs. Locations of the disposal areas are as follows:

Light Waste oils: are contained in ASTs 12-0-248 beside Z1, and M-28-5 located at the Waste drum storage area.
Waste Grease, Lubricants and Glycol: are stored in drums in the waste storage area;
Batteries: All battery types are collected underneath the stairwell in the back hallway; lead acid batteries from mobile equipment is kept at the Garage and Quarry Garage;
Lighting Lamps: All lightbulb types are collected underneath the stairwell in the back hallway.
Tires: Garage area. Supplier contacted for pickup.
Recycling: appropriate containers throughout plant.
See Appendix C for the Site's Waste Handling, Diversion, and Disposal procedure.

St. Marys Cement retains Provincial Environmental Services to collect and dispose of all light and heavy waste oil, waste ethylene glycol, waste greases, spill cleanup material, spent batteries, and fluorescent bulbs on-site. St. Marys retains Canutec (613-996-6666) for emergency spill clean-up and disposal.

3.2.3 Physical and Geographical Characteristics

Physical and geographical characteristics of concern would include such things as roadways, forklift traffic, proximity to actual work areas, etc. The following table lists any factors that could contribute to the possibility of a spill occurring at any of the locations listed in Section 3.1:

	Location	*Tank / Equipment ID*	*Contents*	*Physical or Geographical Characteristics of Concern*
1	Removed 2019			
2	Beside Butler Building	M-28-1	Diesel	None; tank out of main roadway, not within a work area.
3	Z1 Area – Outside North Wall of Z1 Building	12-0-248	Light Waste Oil	None; tank out of main roadway, not within a work area.
4	Garage	M-28-4	Diesel	None; tank out of main roadway, not within a work area.
5	Waste Oil Storage	M-28-5	Light Waste Oil	None; tank out of main roadway, not within a work area.
6	Beside Oil House	M-28-7	Gasoline, Diesel, Varsol	Tank adjacent to main roadway, but not within a work area.
7	Thomas Street Quarry – between gate and garage	A-2	Diesel	Tank adjacent to main roadway, but not within a work area.
8	Thomas Street Quarry – beside A-2 Diesel Tank	TSQ-Gasoline	Gasoline	Tank adjacent to main roadway, but not within a work area.

9	Thomas Street Quarry	N/A	Ice Axe – L - NB	Tank adjacent to main roadway, but not within a work area.
10	CBM Sanimax – Dryer Plant Fuel	CBM Diesel	Diesel	Tank adjacent to main roadway, but not within a work area.
11	Burner Floor	12-01	Ethylene Glycol	None; tank out of main roadway, not within a work area.
12	Between Glycol fans and backend firing building	W1K94	Ammonia (19% Solution)	None; tank out of main roadway, not within a work area, and is on an elevated concrete pad.
13	Finish Mill Building – Grind Additives	Z1K09	MTDA/CBA Grinding aid	None; tank out of main roadway, not within a work area. Contained in Z1 building.
14		Z1K14	Hydrophobe 3.12 Air Entrainer	None; tank out of main roadway, not within a work area. Contained in Z1 building.
15		Z1K22	RDA 330 Set Time Extender	None; tank out of main roadway, not within a work area. Contained in Z1 building.
16		Z1K25	Ethylene Glycol	None; tank out of main roadway, not within a work area. Contained in Z1 building.
17	Main Plant – Standby Generator	10-0-120	Diesel	None; tank out of main roadway, not within a work area. Contained within Core Building.
18	West of Kiln	N/A	Kiln Condensate	None; tank out of main roadway, not within a work area.
19	Impactor Building	Removed 2019		
20		Removed 2019		
21		N/A	WD-80 De-icer	None; tank out of main roadway, not within a work area.
22	Stores Area	N/A	Water Softener	None; tank out of main roadway, not within a work area.
23	Finish Mill	N/A	MTDA/CBA Grinding aid	None; tank out of main roadway, not within work area.

The geographical locations of these tanks are included in Appendix I: Site Location and Plant Areas - Tank Locations on Site.

3.2.4 Spill History

St. Marys retains a document for spill and complaint history that has indicated that the following reportable spills have occurred at St Marys Cement:

1. CBM Dust Release – August 12, 2019
   - Spills Action Center; Reference # 5538-BEYKJ5
   - CBM is an on site sister company with operations at the northeast corner of the plant. The operations include a dryer building which grinds and dries aggregate to be sold to consumers.
     - An undetermined amount of dust blew out of the back bay door of the dryer building while loader was loading truck with limestone material from bay door. Door open for approximately 8 minutes.
     - The reportable spill was not from SMC however it is included in this report because it occurred within site boundaries.
     -
2. Truck Roll Over – October 10, 2017
   - Spills Action Center; Reference #0822-ARZVL9.
   - Email internally to SMC staff reviewing the incident:
     - SMC had a reportable diesel spill which occurred during the truck roll over on October 10. Upon arrival on the scene of the truck which had tipped over, it was noted that approximately 100L of diesel and 5L of engine oil and antifreeze was leaking from the truck. The local police department called the spill in to the Spills Action Center; Reference #0822-ARZVL9.Our production team did a fantastic job of cleaning up the spill and disposing of absorbent materials as per our Spills Response Procedure. Upon determining the source of the spill and the material involved, 20 bags of absorbent were used along with CKD to stabilize the soil and prevent the spill from spreading.

3. Dust Spill – October 4, 2017
   - Spills Action Center; Reference # 4460-ARUGWH.
   - Email internally to MECP reviewing the incident:
     - Regarding the events of yesterday's dust spill, SAC Reference #4460-ARUGWH. The Main Baghouse had elevated differential pressure due to a plugged compartment. In the process of inspecting the baghouse while maneuvering dampers, a spike in the differential pressure caused the Main ID fan to shut down immediately. As a result of the sudden shutdown the pressure in the system became positive and created a spill of dust from the gaps in the baghouse. To avoid recurrence, communication is being put out to the involved parties to avoid closing dampers under the condition of higher differential pressure. No complaints have been received by SMC in relation to this incident.

4. Lubricant Oil Leak – October 10, 2014

- Spills Action Center; Reference #37779-PQPRH
    - On-site contractor had a hydraulic leak on his truck. He drove through the site leaving a trail of fluid behind him.

3.3 Spill Potential and Extent of Impacts

As per O. Reg 224-07 s. 5 (1) and clause 91.1 (a) of the Environmental Protection Act, Plans required to prevent or reduce the risk of spills of pollutants must contain the following, in writing,

3. For each spill analyzed under paragraph 2, an explanation of how the conclusion relating to the likelihood of the spill was reached.

In the MECP guidance document "Guideline for Implementing Spill Prevention and Contingency Plans Regulatory Requirements (O.Reg. 224/07)", May 2007, it is suggested that the spill probability at each location be determined using a common scale approach, such as the following:

Very Unlikely	Less than 1 event every 200 years
Unlikely	At least 1 event every 200 years
Possible	At least 1 event every 30 years
Very Possible	At least 1 event every 10 years
Certain	1 or more event every year

The Guidance Document also suggests that the following factors may also be considered, to assist in categorizing the likelihood of **causes** of a given real or potential spill event:

- Historical weather date
- Equipment failure rates
- Preventative maintenance data
- Professional judgment
- Human error analysis

In assessing potential adverse **effects** for each potential spill the suggested approach discussed in the Guidance Document was followed. Specifically, the following criteria were considered in estimating potential adverse effects, in order of importance:

- Physical and chemical characteristics of the pollutant
- Which media the pollutant would be released to in the event of a spill (i.e., air, land or water)
- Known human health and environmental threats posed by pollutant

- Professional judgment
- Characteristics of the receptor

Once the estimate of the adverse effect was determined, the scale of the adverse effect was categorized using the following table:

Impact	***Description***
Catastrophic	May cause fatalities
Severe	Impacts to health (non-fatal) or widespread injury or damage to the environment that is difficult to remediate
Moderate	Material discomfort or localized impacts to property or the natural environment that can be remediated
Low	Easily remediated impacts to individual property
None	No impact

The following pages discuss the spill potential and impact extents for each source (in order of tanks as listed in section 3.1), including an analysis of spill probability and potential impact.

3.3.1 Spill Potential of Tanks on Site

1.	Removed 2019

2.	**Tank Contents**	**Diesel**
	ID Number:	M-28-1
	Volume :	25,000 L

Spill Probability: **Unlikely**

ASTs M-28-is a double walled tank. A visual inspection of the integrity of all the tanks at the Facility is performed monthly. Diesel is loaded into the AST by a licensed contractor, and handled only by those St. Marys employees who have the proper training and PPE. M-28-1 is adjacent to a roadway but not within a major work area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that these tanks and their contents present a low or **unlikely spill potential**.

Potential Impact: **Low**

In the event of a small spill due to the overfilling of a container/tank, or due to a leak in a pipe, minimal product would leak to the ground surface. The leaked volume would be cleaned up by a St. Marys employee, and the pump for the diesel distribution, turned off. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. The liquids may flow overland to a storm water drain, ultimately discharging to the on-Site storm water ponds. Immediate danger of impacts would be limited to St. Marys employees and property. Impacted soils would be remediated by St. Marys to prevent ongoing contamination. The product is not volatile and appreciable quantities are not expected to be released to air.

Repeated exposure may cause skin dryness or cracking. If swallowed, may be aspirated and cause lung damage. May be irritating to eyes, nose, throat, and lungs. It is unlikely that human exposure would go beyond risk associated with inhalation or dermal contact (i.e., ingestion of liquid). Exposure to diesel vapours is possible immediately adjacent to the AST in the event of a spill, and proper PPE would be required during cleanup activities. Exposure is unlikely further from the AST and even more unlikely off-Site due to the relatively low volatility of the material.

3.	**Tank Contents**	**Light Waste Oil**
	ID Number:	12-0-248
	Volume :	10,000 L

Spill Probability: **Unlikely**

ASTs 12-0-248 is a double walled tank. A visual inspection of the integrity of all the tanks at the Facility is performed monthly. As necessary, spent/used oil as part of the multiple processes at the Facility, is dumped or pumped into these ASTs. Once filled, the tank is pumped out by a licensed contractor, and the contents disposed of/recycled at an appropriate facility. 12-0-248 is located in a light work and traffic area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that these tanks and their contents present a low or **unlikely spill potential**.

Potential Impact: **Low**

In the event of a small spill due to a leak in a pipe or during loading of product into the tanks, minimal product may leak to the ground surface. The leaked volume would be cleaned up by a St. Marys employee and (if necessary) the leak fixed. An uncontained complete spill of the contents of tank 12-0-248 would likely result in the contents flowing overland to a nearby watercourse, which discharges to the on-Site storm water ponds. A small potential of a localized spill exists with the handling of containers that get pumped into these ASTs with the integrated vacuum pump. This pump cannot discharge material from the tank into the environment.

The product is not volatile and appreciable quantities are not expected to be released to air.

Product may cause eye and skin irritation on contact. Ingesting small amounts of this liquid drawn into the lungs from swallowing or vomiting may cause severe health effects. However, exposure to the spilled material is unlikely given the low volatility of the material and provided proper PPE is worn during cleanup activities.

4.	**Tank Contents**	**Diesel**
	ID Number:	M-28-4
	Volume :	1,000 litres

Spill Probability:	**Unlikely**

ASTs 12-0-328 and M28-4 are double walled tanks. A visual inspection of the integrity of all the tanks at the Facility is performed monthly. M-28-4 tanks was replaced with a new unit in November 2014.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that these tanks and their contents present a low or **unlikely spill potential**.

Potential Impact:	**Low**

In the event of a small spill due to a leak in a pipe, minimal product would leak to the ground surface. The leaked volume would be cleaned up by a St. Marys employee and the leak fixed. In a worst-case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. The liquids may flow overland to a storm water drain, ultimately discharging to the on-Site storm water ponds. It is unlikely that a spill from these ASTs would run off-Site due to its distance from the Facility Property boundary and off-Site water bodies/waterways. The product is not volatile and appreciable quantities are not expected to be released to air.

Product may cause eye and skin irritation on contact. Ingesting small amounts of this liquid drawn into the lungs from swallowing or vomiting may cause severe health effects. However, exposure to the spilled material is unlikely given the low volatility of the material and provided proper PPE is worn during cleanup activities.

5.	**Tank Contents**	**Light Waste Oil**
	ID Number:	M-28-5
	Volume :	7,570 L
Spill Probability:		**Unlikely**

M-28-5 is a double walled tanks. A visual inspection of the integrity of all the tanks at the Facility is performed monthly. As necessary, spent/used oil as part of the multiple processes at the Facility, is dumped or pumped into these ASTs. Once filled, the tank is pumped out by a licensed contractor, and the contents disposed of/recycled at an appropriate facility. The M-28-5 tank is within a covered structure and out of the way of any factors that may contribute to spill probability such as road traffic or vicinity to work areas.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that these tanks and their contents present a low or **unlikely spill potential**.

Potential Impact:	**Low**

In the event of a small spill due to a leak in a pipe or during loading of product into the tanks, minimal product may leak to the ground surface. The leaked volume would be cleaned up by a St. Marys employee and (if necessary) the leak fixed. In a worst case scenario, an uncontained complete spill of tank contents from M-28-5 would likely result in the contents flowing overland to a drainage ditch, then into the creek that discharges into the North Thames River. A small potential of a localized spill exists with the handling of containers that get pumped into these ASTs with the integrated vacuum pump. This pump cannot discharge material from the tank into the environment.

The product is not volatile and appreciable quantities are not expected to be released to air.

Product may cause eye and skin irritation on contact. Ingesting small amounts of this liquid drawn into the lungs from swallowing or vomiting may cause severe health effects. However, exposure to the spilled material is unlikely given the low volatility of the material and provided proper PPE is worn during cleanup activities.

6.	**Tank Contents**	**Gasoline, Diesel, Varsol**
	ID Number:	M-28-7
	Volume :	6,300 L

Spill Probability: **Unlikely**

AST M-28-7 is a double walled tank with three individual compartments (occupied by gasoline, diesel, and varsol). A visual inspection of the integrity of all the tanks at the Facility is performed monthly. Gasoline is loaded into the AST by a licensed contractor, and handled only by those St. Marys employees who have the proper training and PPE (the gasoline is pumped out of the tank using a pump and nozzle, similar to that for the varsol and diesel). The tank itself is adjacent to a roadway but not within a major work area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a low or **unlikely spill potential**.

Potential Impact: **Low**

In the event of a small spill due to the overfilling of a container/tank, or due to a leak in a pipe, minimal product would leak to the ground surface. The leaked volume would be cleaned up by a St. Marys employee, and the pump for the gasoline distribution, turned off. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. The liquids may flow overland to a storm water drain, ultimately discharging to the on-Site storm water ponds. Gasoline also has an explosive potential; in the event of a leak, potential combustion of the volatilizing gasoline is lessened by the fact that the tank is located in a well-ventilated open area, and away from work areas and potential ignition sources. In the event that some gasoline escapes to atmosphere, it is not anticipated that the gasoline would affect any other parties as the gasoline dilutes in the surrounding air. Immediate danger of impacts would be limited to St. Marys employees and property. Impacted soils would be remediated by St. Marys to prevent ongoing contamination.

Vapor resulting from a gasoline spill may irritate eyes, nose, throat and lungs; may cause headaches and dizziness. Eye contact may cause irritation. Frequent or prolonged contact to skin may cause irritation or a rash. Small amounts of liquid in lungs from swallowing or vomiting may cause severe health effects. It is unlikely that human exposure would go beyond risk associated with inhalation or dermal contact (i.e., ingestion of liquid). Exposure to gasoline vapours is possible immediately adjacent to the AST in the event of a spill, and proper PPE would be required during cleanup activities. Exposure is unlikely further from the AST and even more unlikely off-Site due to the relatively low volume of gasoline and the volatility of the material.

7.	**Tank Contents**	**Diesel**
	ID Number:	A-2
	Volume :	45,400 L

Spill Probability: **Unlikely**

ASTs A-2 is a double walled tank. The integrity of all the tanks at the Facility is monitored monthly. Diesel is loaded into the AST by a licensed contractor, and handled only by those St. Marys employees who have the proper training and PPE. AST A-2 is adjacent to a roadway but not within a major work area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a low or **unlikely spill potential**.

Potential Impact: **Severe**

In the event of a small spill due to the overfilling of a container/tank, or due to a leak in a pipe, minimal product would leak to the ground surface. The leaked volume would be cleaned up by a St. Marys employee, and the leak source fixed. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. The liquids may flow overland to a drainage ditch, ultimately discharging to the on-Site storm water ponds. In this case, immediate danger of impacts would be limited to St. Marys employees and property. Impacted soils would be remediated by St. Marys to prevent ongoing contamination. **Based on the larger volume that could potentially be spilled by AST A-2, the overall impact to the St. Marys Facility would be more substantial than from the other on-Site diesel tanks, and would likely involve a more extensive remediation program to prevent ongoing contamination. Based on the elevated location of AST A-2, contents may also flow by gravity towards Thomas Street and the North Thames River. As AST A-2 has the potential not only to cause environmental impacts on-Site that may be remediated, but also off-Site via the North Thames River, which would be very difficult to remediate, the potential impacts for this worst case spill have been classified as severe.** The product is not volatile and appreciable quantities are not expected to be released to air.

Repeated exposure may cause skin dryness or cracking. If swallowed, may be aspirated and cause lung damage. May be irritating to eyes, nose, throat, and lungs. It is unlikely that human exposure would go beyond risk associated with inhalation or dermal contact (i.e., ingestion of liquid). Exposure to diesel vapours is possible immediately adjacent to the AST in the event of a spill, and proper PPE would be required during cleanup activities. Exposure is unlikely further from the AST and even more unlikely off-Site due to the relatively low volatility of the material.

8.	**Tank Contents**	**Gasoline**
	ID Number:	**TSQ-Gasoline**
	Volume :	2,200L

Spill Probability: **Unlikely**

TSQ-Gasoline is a double walled tank. The integrity of all the tanks at the facility is monitored monthly. Gasoline is loaded into the AST by a licensed contractor, and handled only by St Marys Employees who have proper training and PPE. The tank is adjacent to a roadway but not within a major work area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a low or **unlikely spill potential.**

Potential Impact: **Severe**

In the event of a small spill due to the overfilling of a container/tank, or due to a leak in a pipe, minimal product would leak to the ground surface. The leaked volume would be cleaned up by a St. Marys employee, and the leak source fixed. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. The liquids may flow overland to a drainage ditch, ultimately discharging to the on-Site storm water ponds. In this case, immediate danger of impacts would be limited to St. Marys employees and property. Impacted soils would be remediated by St. Marys to prevent ongoing contamination. **Based on the elevated location contents may also flow by gravity towards Thomas Street and the North Thames River. As TSQ-Gasoline as the potential not only to cause environmental impacts on-Site that may be remediated, but also off-Site via the North Thames River, which would be very difficult to remediate, the potential impacts for this worst case spill have been classified as severe.** The product is volatile and appreciable quantities are not expected to be released to air.

9.	**Tank Contents**	**Ice-AXe – L - NB**
	ID Number:	N/A
	Volume :	11356 Litres

Spill Probability: **Possible**

Multiple tanks of ice removing chemical are kept on site to use during winter months on equipment. Containers are located next to roadways on gravel areas. During handling PPE is used by employees.

The tanks have no secondary containment. Visual inspection is not performed on the tanks. The tanks are adjacent to roadway traffic posing a possible spill potential.

Potential Impact: **Low**

In the event of a spill, the contents would discharge directly to the gravel and the surrounding area. This could potentially infiltrate into the overburden or evaporating to atmosphere. In the event of a spill such as this, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area. Even in the event of a worst case scenario spill from the AST, where all of its contents spilled to ground surface, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area.

<table>
<tr><td rowspan="3">10.</td><td><u>Tank Contents</u></td><td><u>CBM - Diesel</u></td></tr>
<tr><td>ID Number:</td><td>CBM Diesel</td></tr>
<tr><td>Volume :</td><td>2,200L</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="2">Spill Probability:</td><td>Unlikely</td></tr>
<tr><td colspan="3">The CBM Diesel tank is a double walled tank. Diesel is loaded into the AST by a licensed contractor, and handled only by those St. Marys employees who have the proper training and PPE. The tank is not within a work area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that these tanks and their contents present a low or <u>unlikely spill potential</u>.</td></tr>
<tr><td colspan="2">Potential Impact:</td><td>Low</td></tr>
<tr><td colspan="3">In the event of a spill, the contents would discharge directly to the gravel and the surrounding area. This could potentially infiltrate into the overburden or evaporating to atmosphere. In the event of a spill such as this, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area. Even in the event of a worst case scenario spill from the AST, where all of its contents spilled to ground surface, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area.</td></tr>
</table>

11.	**Tank Contents**	**Ethylene Glycol**
	ID Number:	12-01
	Volume :	400 L

Spill Probability: **Possible**

This AST has no secondary containment measures in place. As necessary, ethylene glycol, used as part of the closed-circuit process cooling, is added into this AST, and then into the closed circuit cooling loop. A visual inspection of the integrity of all the tanks is performed monthly. The tank is also out of the way of any roadway traffic, although relatively close to a busy work area (burner floor). The tank, however, is elevated, which protects it from mechanical damage.

Based on the lack of secondary containment for the ethylene glycol, it is believed that this tank and its contents present a **possible** spill potential. There was a spill of the entire contents of the tank (> 100L) that occurred in 2014 that remained entirely within the building; i.e. there was no discharge to the environment.

Potential Impact: **Low**

In the event of a spill, the contents would discharge directly to the concrete floor of the Burner Floor building and potentially to levels below, as had occurred during the spill in 2014. The potential exists for some of the tank's contents to escape the building and run onto the ground surface, potentially infiltrating into the overburden or evaporating to atmosphere. In the event of a spill such as this, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area. Even in the event of a worst case scenario spill from the AST, where all of its contents spilled to ground surface, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area as the total volume of ethylene glycol in very small.

Cleanup of this material if it were to enter a body of water would be impractical given that the ethylene glycol is completely soluble in water. However, migration of spilled ethylene glycol to any water body is unlikely given the distance between this AST and the on-Site water ponds to the west and the relatively small volume of the AST. Following the spill of 2014, it was observed that a large quantity did not leave the building; therefore it is unlikely that any ethylene glycol may be collected in the on-Site storm water discharge pipe leading to the SWM ponds.

Ingestion of ethylene glycol may result in nausea, vomiting, abdominal cramps, blindness, liver damage, irritation, reproductive effects, nerve damage, convulsions, edema of the lung, cardiopulmonary effects, pneumonia and kidney failure which could result in death. Ingestion of the product is believed to be highly unlikely. Inhalation of high levels of vapor or mists for prolonged periods of time may also result in toxic effects. Excessive exposure may result in eye, skin, or respiratory irritation. However, inhalation or ingestion of ethylene glycol during a spill event is unlikely given the lower volatility of the ethylene glycol.

12.	**Tank Contents**	**Ammonia – 19% Solution**
	ID Number:	W1K94
	Volume :	38,000 litres

Spill Probability: **Possible**

This AST is within a concrete containment area that is capable of containing greater than 110% of the volume of liquids stored within this area. The integrity of all the tanks at the Facility is monitored monthly. Ammonia is loaded into the AST by a licensed contractor, and is not handled directly by St. Marys employees. The tank is not in or adjacent to a major roadway or in a major work area.

Any leakage from the pump/lines falls into open concrete sump (secondary containment) below. Based on the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a low or **possible spill potential**.

Potential Impact: **Moderate**

In the event of a small spill due to a leak in a pipe, minimal product would leak to the ground surface, within the concrete pool enclosure. The leaked volume would be cleaned up by a St. Marys employee, and the pump for the distribution of the product, turned off. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. Aqueous ammonia is **completely soluble in water** and should not be discharged to any uncontrolled water bodies, as **ammonia is hazardous to aquatic life in very low concentrations**.

AST W1K94 is located below the elevation of the North Thames River. Based on the location for this potential spill, any spilled material would likely be collected in the on-Site storm water discharge pipe leading to the SWM ponds. Within this storm water pipe is a remote operated air bladder that has been installed to isolate any spills entering the south storm water catchment area. As a further preventative measure, if the air bladder were unable to prevent the spill from entering the SWM ponds, the sump pumps may also be turned off, preventing any material in these ponds from discharging to MISA 0100. In addition, it is unlikely that a spill from these ASTs would run off-Site due to its distance from the Facility Property boundary and off-Site water bodies/waterways. Immediate danger of liquid ammonia impacts would be limited to St. Marys employees and property. Impacted soils would be remediated by St. Marys to prevent ongoing contamination.

The volatility of the ammonia and its subsequent health effects on humans, is the primary impact associated with ammonia. The extent of the injury ranges from mild skin irritation or cough, to severe burns or laryngeal edema, and life-threatening pulmonary edema. Direct contact with eyes may range from irritation to severe injury and blindness. Ingestion may cause corrosion to the esophagus and stomach with perforation and peritonitis. Ingestion may be fatal. In the event that the ammonia escapes to atmosphere it is anticipated that the ammonia may affect any other parties in the surrounding area such as the residential zones surrounding the Facility and the nearby roadways; though as the distance increases, and the ammonia is diluted in the surrounding air, the potential health impacts would decrease. The immediate danger due to ammonia vapour therefore, would be to the St. Marys Facility and its employees. It is anticipated that impacts to the environment would be **moderate.**

13.	**Tank Contents**	**MTDA/CBA Grinding Aid**
	ID Number:	Z1K09
	Volume :	30,000 Liters

Spill Probability:	**Unlikely**

This AST is within a concrete containment area that is capable of containing greater than 110% of the volume of liquids stored within this area. A visual inspection of the integrity of all the tanks at the Facility is performed monthly. Material is loaded into the AST by a licensed contractor, and is not handled directly by St. Marys employees. The tank is not in or adjacent to a major roadway or in a major work area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a low or **unlikely spill potential**.

Potential Impact:	**Low**

In the event of a small spill due to a leak in a pipe, minimal product would leak to the ground surface, within the concrete pool enclosure. The leaked volume would be cleaned up by a St. Marys employee, and the pump for the distribution of the product to the process turned off. A sump pump that clears any spilled product from the containment area would be turned on only once it is ensured that the discharge of the sump pump flows into an adequately sized and labeled container of the appropriate type. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. AST Z1K09 is located below the elevation of the North Thames River. Based on the location for this potential spill, any spilled material would likely be collected in the on-Site SWM ponds. The sump pumps in the SWM ponds may be turned off, preventing any material in these ponds from discharging to MISA 0100 and the North Thames River. In addition, it is unlikely that a spill from these ASTs would run off-Site due to its distance from the Facility Property boundary and off-Site water bodies/waterways. Impacted soils would be remediated by St. Marys to prevent ongoing contamination. The product is not volatile and appreciable quantities are not expected to be released to air.

14.	**Tank Contents**	**Hydrophobe 3.12 Air Entrainer**
	ID Number:	Z1K14
	Volume :	30,000 Liters

Spill Probability: **Unlikely**

This AST is within a concrete containment area that is capable of containing greater than 110% of the volume of liquids stored within this area. A visual inspection of the integrity of all the tanks at the Facility is performed monthly. Material is loaded into the AST by a licensed contractor, and is not handled directly by St. Marys employees. The tank is not in or adjacent to a major roadway or in a major work area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a low or **unlikely spill potential**.

Potential Impact: **Low**

In the event of a small spill due to a leak in a pipe, minimal product would leak to the ground surface, within the concrete pool enclosure. The leaked volume would be cleaned up by a St. Marys employee, and the pump for the distribution of the product to the process turned off. A sump pump that clears any spilled product from the containment area would be turned on only once it is ensured that the discharge of the sump pump flows into an adequately sized and labeled container of the appropriate type. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. AST Z1K14 is located below the elevation of the North Thames River. Based on the location for this potential spill, any spilled material would likely be collected in the on-Site SWM ponds. The sump pumps in the SWM ponds may be turned off, preventing any material in these ponds from discharging to MISA 0100 and the North Thames River. In addition, it is unlikely that a spill from these ASTs would run off-Site due to its distance from the Facility Property boundary and off-Site water bodies/waterways. Impacted soils would be remediated by St. Marys to prevent ongoing contamination. The product is not volatile and appreciable quantities are not expected to be released to air.

15.	<u>**Tank Contents**</u>	<u>**RDA 330 Set Time Extender**</u>
	ID Number:	Z1K22
	Volume :	30,000 Liters
Spill Probability:		**Unlikely**

This AST is within a concrete containment area that is capable of containing greater than 110% of the volume of liquids stored within this area. A visual inspection of the integrity of all the tanks at the Facility is performed monthly. Material is loaded into the AST by a licensed contractor, and is not handled directly by St. Marys employees. The tank is not in or adjacent to a major roadway or in a major work area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a low or <u>**unlikely spill potential**</u>.

Potential Impact:	**Low**

In the event of a small spill due to a leak in a pipe, minimal product would leak to the ground surface, within the concrete pool enclosure. The leaked volume would be cleaned up by a St. Marys employee, and the pump for the distribution of the product to the process turned off. A sump pump that clears any spilled product from the containment area would be turned on only once it is ensured that the discharge of the sump pump flows into an adequately sized and labeled container of the appropriate type. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. AST Z1K22 is located below the elevation of the North Thames River. Based on the location for this potential spill, any spilled material would likely be collected in the on-Site SWM ponds. The sump pumps in the SWM ponds may be turned off, preventing any material in these ponds from discharging to MISA 0100 and the North Thames River. In addition, it is unlikely that a spill from these ASTs would run off-Site due to its distance from the Facility Property boundary and off-Site water bodies/waterways. Impacted soils would be remediated by St. Marys to prevent ongoing contamination. The product is not volatile and appreciable quantities are not expected to be released to air.

16.	**Tank Contents**	**Ethylene Glycol**
	ID Number:	Z1K25
	Volume :	151 Liters

Spill Probability: **Unlikely**

This AST is within a concrete containment area that is capable of containing greater than 110% of the volume of liquids stored within this area. A visual inspection of the integrity of all the tanks at the Facility is performed monthly. Ethylene Glycol is loaded into the AST by a licensed contractor, and is not handled directly by St. Marys employees. The tank is not in or adjacent to a major roadway or in a major work area.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a low or **unlikely spill potential**.

Potential Impact: **Low**

In the event of a small spill due to a leak in a pipe, minimal product would leak to the ground surface, within the concrete pool enclosure. In the event a worst case scenario spill from the AST, where all of its contents spilled to ground surface, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area as the total volume of ethylene glycol in very small. The sump pump in the liquid additives room would likely not be required for this low volume, unless washing the floor occurred after clean up.

Cleanup of this material if it were to enter a body of water would be difficult given that the ethylene glycol is completely soluble in water. However, migration of spilled ethylene glycol to any water body is unlikely given the distance between the AST and the on-Site water ponds to the west and the relatively small volume of the AST.

Ingestion of ethylene glycol may result in nausea, vomiting, abdominal cramps, blindness, liver damage, irritation, reproductive effects, nerve damage, convulsions, edema of the lung, cardiopulmonary effects, pneumonia and kidney failure which could result in death. Ingestion of the product is believed to be highly unlikely. Inhalation of high levels of vapor or mists for prolonged periods of time may also result in toxic effects. Excessive exposure may result in eye, skin, or respiratory irritation. However, inhalation or ingestion of ethylene glycol during a spill event is unlikely given the lower volatility of the ethylene glycol.

17.	**Tank Contents**	**Diesel (Emergency Generator)**
	ID Number:	10-0-120
	Volume :	2,000 Liters

Spill Probability: **Possible**

This AST has no secondary containment measures in place, though is located within a building, in its own separate area, with a concrete flooring that may act as a form of containment should a spill occur. A visual inspection of the integrity of all the tanks at the Facility is performed monthly. Diesel is loaded into the AST by a licensed contractor, and handled only by those St. Marys employees who have the proper training and PPE.

Based on secondary containment measures and given the presence of some factors promoting spill potential, it is believed that this tank and its contents present a **possible spill potential**.

Potential Impact: **Low**

In the event of a small spill due to the overfill of the tank, or due to a leak in a pipe, minimal product would leak to the ground surface. The leaked volume would be cleaned up by a St. Marys employee, and the pump for the diesel distribution to the generator turned off. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling into the storm sewer pipe leading to the SWM ponds. If diesel fuel were to enter the SWM ponds, the sump pumps may also be turned off, preventing any material in these ponds from discharging to MISA 0100. Immediate danger of impacts would be limited to St. Marys employees and property. Any potentially impacted soils would be remediated by St. Marys to prevent ongoing contamination.

Repeated exposure may cause skin dryness or cracking. If swallowed, may be aspirated and cause lung damage. May be irritating to eyes, nose, throat, and lungs. It is unlikely that human exposure would go beyond risk associated with inhalation or dermal contact (i.e., ingestion of liquid). Exposure to diesel vapours is possible immediately adjacent to the AST in the event of a spill, and proper PPE would be required during cleanup activities. Exposure is unlikely further from the AST and even more unlikely off-Site due to the relatively low volatility of the material.

18.	**Tank Contents**	**Kiln Condensate**
	ID Number:	-
	Volume :	2,000 Liters
Spill Probability:		**Possible**
This AST has no secondary containment measures in place. Kiln Condensate is loaded into the tank through a condensate pipe. Based on secondary containment measures and given the presence of some factors promoting spill potential, it is believed that this tank and its contents have **possible spill potential.**		
Potential Impact:		**Low**
In the event of a small spill due to the overfill of the tank, or due to a leak in a pipe, minimal product would leak to the ground surface. The leaked volume would be cleaned up by a St. Marys employee. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling into the storm sewer pipe leading to the SWM ponds. The nature of the material does not pose any hazard to the SWM ponds, posing an overall **low** potential impact.		

<table>
<tr><td>19. 20.</td><td colspan="3">Removed 2019</td></tr>
<tr><td colspan="4"></td></tr>
</table>

<table>
<tr><td rowspan="3">21.</td><td>Tank Contents</td><td colspan="2">WD-80</td></tr>
<tr><td>ID Number:</td><td colspan="2">N/a</td></tr>
<tr><td>Volume :</td><td colspan="2">5,500L</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="2">Spill Probability:</td><td colspan="2">Possible</td></tr>
<tr><td colspan="4">Tanks of ice removing chemical are kept on site to use during winter months on equipment. Containers are located next to roadways on gravel areas. During handling PPE is used by employees.
The tanks have no secondary containment. Visual inspection is not performed on the tanks. The tanks are adjacent to roadway traffic posing a possible spill potential.</td></tr>
<tr><td colspan="2">Potential Impact:</td><td colspan="2">Low</td></tr>
<tr><td colspan="4">In the event of a spill, the contents would discharge directly to the gravel and the surrounding area. This could potentially infiltrate into the overburden or evaporating to atmosphere. In the event of a spill such as this, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area. Even in the event of a worst case scenario spill from the AST, where all of its contents spilled to ground surface, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area.</td></tr>
</table>

<table>
<tr><td rowspan="3">22.</td><td><u>Tank Contents</u></td><td><u>Water Softener</u></td></tr>
<tr><td>ID Number:</td><td>N/a</td></tr>
<tr><td>Volume :</td><td>1,000L</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="2">Spill Probability:</td><td>Unlikely</td></tr>
<tr><td colspan="3">The tank of water softener is located within the main building outside of stores. The tank is not in a high worked in area and is an <u>unlikely</u> spill source.</td></tr>
<tr><td colspan="2">Potential Impact:</td><td>Low</td></tr>
<tr><td colspan="3">In the event of a spill, the contents would discharge into the core building. Material would be cleaned up by a St Marys employee and the leak fixed. In a worst-case scenario an uncontained complete spill of tank contents would likely result in the content spilling out of the door. The liquids may overflow to a storm water drain, ultimately discharging to the on-site storm water ponds. It is unlikely that a spill from these stormwater ponds would run offsite due to distance from the facility property boundary and off-Site water bodies/waterways. The product is not volatile and appreciable quantities are not expected to be released to air.</td></tr>
</table>

23.	**Tank Contents**	**MTDA/CBA Grinding Aid**
	ID Number:	n/a
	Volume :	1,300 Litres

Spill Probability:	**Low**

This AST is located outside the Finish Mill and away from the roadway area. Based the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a **low spill potential**.

Potential Impact:	**Low**

In the event of a small spill due to a leak in a pipe, minimal product would leak to the ground surface, within the concrete pool enclosure. The leaked volume would be cleaned up by a St. Marys employee, and the pump for the distribution of the product to the process turned off. A sump pump that clears any spilled product from the containment area would be turned on only once it is ensured that the discharge of the sump pump flows into an adequately sized and labeled container of the appropriate type. In a worst case scenario, an uncontained complete spill of tank contents would likely result in the contents spilling and infiltrating into the ground surface. AST Z1K09 is located below the elevation of the North Thames River. Based on the location for this potential spill, any spilled material would likely be collected in the on-Site SWM ponds. The sump pumps in the SWM ponds may be turned off, preventing any material in these ponds from discharging to MISA 0100 and the North Thames River. In addition, it is unlikely that a spill from these ASTs would run off-Site due to its distance from the Facility Property boundary and off-Site water bodies/waterways. Impacted soils would be remediated by St. Marys to prevent ongoing contamination. The product is not volatile and appreciable quantities are not expected to be released to air.

Tank Contents	**Oils and lubricants**
ID Number:	Oil Storage Area
Volume :	Generally 205L per drum

Spill Probability: **Unlikely**

Multiple containers of oil and lubricants are stored within this area. The vast majority are in household sized containers. These containers are within a concrete containment area with no floor drains that is capable of containing greater than 110% of the volume of liquids stored within this area. During the handling of the materials in this stores area, workers wear PPE, as directed by the chemical MSDS. The Stores area is out of the way of any work areas or any other activities that might contribute to spill potential.

Based on secondary containment measures and the absence of any major factors promoting spill potential, it is believed that this tank and its contents present a low or **unlikely spill potential**.

Potential Impact: **Low**

In the event of a spill, the chemical spill would be restricted to within the stores area. Any spilled materials would be pumped out and disposed of by a licensed contractor. In a worst case scenario where some of the chemicals manage to spill outside of the stores area, absorbent materials would be used to absorb the spilled material and prevent the migration of the material beyond the immediate spill area. Migration of the spilled volume would be limited due to the small volume stored within the stores area. Given the low volume and volatility of the oils and lubricants stored, it is not expected that any appreciable air impacts would result from a spill of any of these materials.

	Tank Contents	**Stockpiles / Fugitive Dust**
	ID Number:	Various
	Volume :	Various
Spill Probability:		**Very Possible**
St. Marys utilizes surface water from the SWM ponds, as well as contracted applications of dust suppressant, for dust control at the Site, as necessary, though the formal fugitive dust management plan (BMPP) for the Site is not yet fully implemented. A formal fugitive dust management plan is a requirement of the facility's C of A (Air). This draft plan was developed to minimize the potential impacts from fugitive dust emissions, such that they do not pose a threat to human health on and outside the Site. Despite the practices currently in place to minimize dust emissions, according to the ranking scale developed at the beginning of Section 8.0, a fugitive dust spill is **very possible**.		
Potential Impact:		**Low**
In the event that the preventative measures noted in the BMPP fail it is expected that the impact could reach the neighbouring areas. It is not anticipated that the fugitive dust emissions from the Facility would be of harm to human health or the environment given the generally inert nature of the material used and produced at the Facility. Some particulate is at least partially cementitious or hygroscopic in nature and will appropriate necessitate remediation.		

	Tank Contents	**Transformer Oil (Voltesso 35)**
	ID Number:	Transformers
	Volume :	Various

Spill Probability: **Unlikely**

The transformers have no secondary measures in place. All transformers are located outside of work areas, with some located away from any roadways. For those transformer located adjacent to roadways, they are located on concrete pads, within a fenced area. No spill history exists to suggest a probability of a spill from any of the transformers at the Site.

Based on the lack of secondary containment measures, but taking into consideration the absence of any major factors promoting spill potential and spill history, it is believed that these transformers and their contents present a low or **unlikely risk**.

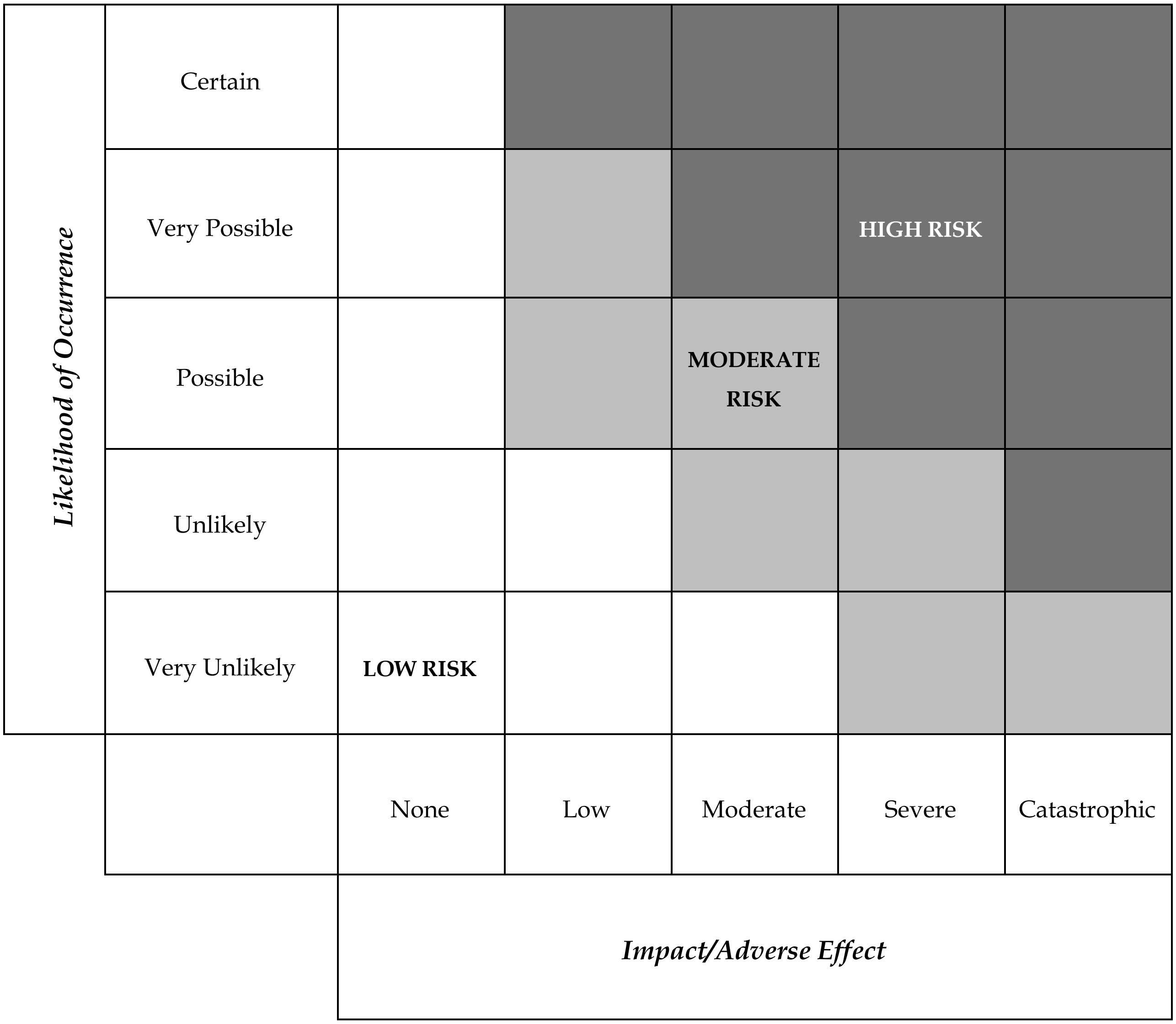
Potential Impact: **Low**

In the event of a spill (a small leak or worst case scenario where all the oil leaks out from the transformers), the product would spill directly to the ground surface. Based on the location of the transformers with respect to surface water drainage courses and the Property boundary and the low volumes of transformer oil in the majority of the transformers at the Site, it is unlikely that the oil would migrate off-Site. Transformers 10-0-112, 10-0-113, OCB, and 10-0-501, are located below the elevation of the North Thames River. Based on the location for these potential spills, any spilled material would likely be collected in the on-Site storm water discharge pipe leading to the SWM ponds. If transformer oil were to enter the SWM ponds, the sump pumps may also be turned off, preventing any material in these ponds from discharging to MISA 0100 and the North Thames River. Any impacted soils would be remediated by St. Marys to prevent ongoing contamination. Immediate danger of impacts would be limited to St. Marys employees and property. Any potentially impacted soils or oil discharging to the on-Site SWM ponds would be remediated by St. Marys to prevent ongoing contamination. The product is not volatile and appreciable quantities are not expected to be released to air.

If swallowed, may be aspirated and cause lung damage. May be irritating to eyes, nose, throat, and lungs. Frequent or prolonged contact may de-fat and dry skin, leading to discomfort and dermatitis.

3.4 Risk Analysis - Priority Ranking

Below is a priority ranking matrix, which aids in the determination of the overall risk of spill occurrences based on the likelihood of occurrence and impact/adverse effect ranking provided in Section 3.3



Likelihood of Occurrence	Certain		▓	▓	▓	▓
	Very Possible		░	▓	▓ **HIGH RISK**	▓
	Possible		░	░ **MODERATE RISK**	▓	▓
	Unlikely			░	░	▓
	Very Unlikely	**LOW RISK**			░	░
		None	Low	Moderate	Severe	Catastrophic
		Impact/Adverse Effect				

A summary of the priority rankings of potential spills at the Facility are summarized in the table below:

	Tank / Equipment ID	*Contents*	*Spill Risk Summary*		
			Low Risk	*Moderate Risk*	*High Risk*
1	Removed 2019				
2	M-28-1	Diesel	X		
3	12-0-248	Light Waste Oil	X		
4	M-28-4	Diesel	X		
5	M-28-5	Light Waste Oil	X		
6	M-28-7	Gasoline, Diesel, Varsol	X		
7	A-2	Diesel			X
8	TSQ-Gasoline	Gasoline			X
9	N/A	Ice Axe – L - NB	X		
10	CBM Diesel	Diesel	X		
11	12-01	Ethylene Glycol	X		
12	W1K94	Ammonia (19% Solution)		X	
13	Z1K09	MTDA/CBA Grinding aid	X		
14	Z1K14	Hydrophobe 3.12 Air Entrainer	X		
15	Z1K22	RDA 330 Set Time Extender	X		
16	Z1K25	Ethylene Glycol	X		
17	10-0-120	Diesel	X		
18	N/A	Kiln Condensate	X		
19	Removed 2019				
20	Removed 2019				
21	N/A	WD-80 Deicer	X		
22	N/A	Water Softener	X		
23	n/a	MTDA/CBA Grinidng Aid	X		
	N/A	Oil and Lubricants	X		
	N/A	Stockpiles / Fugitive Dust	X		
	N/A	Transformer Oil	X		

3.5 Significant Risk Mitigation Procedures

For the sources presenting a moderate spill risk (also referred to as a significant risk) an analysis must be conducted, identifying steps that could be taken to prevent or reduce the risk of the spill occurring (O.Reg. 224/07 Section 5 (1) Subsection 7-9).

	Source		*Prevention/Mitigation Steps*	*Procedures to Ensure Steps are Maintained*
7	A-2	Quarry Diesel	-Placement of additional spill response kits in the vicinity of diesel tank; -Placement of secondary containment measures and/or dyking to ensure spill has no potential to migrate off-Site towards North Thames River.	-Additional training of employees in the use of spill kit contents and on the hazards of diesel; -Regular documented inspection of secondary containment measures to ensure structure is maintained in good repair.
8	TSQ-Gasoline	Gasoline, Quarry	Placement of additional spill response kits in the vicinity of gasoline tank.	-Additional training of employees in the use of spill kit contents and on the hazards of gasoline; -Regular documented inspection of secondary containment measures to ensure structure is maintained in good repair.
11	12-01	Ethylene Glycol	-Installation of secondary containment such as a steel or concrete enclosure, or a new tank.	-Regular documented inspections of secondary containment to ensure structure is maintained in good repair.
12	W1K94	Ammonia	-Placement of additional spill response kits in the vicinity of the ammonia tank; -Prevention of access to stormwater (SWM) pond by containing to small ground surface area.	-Additional training of employees in the use of spill kit contents and on the hazards of ammonia, including use of proper PPE.
17	10-0-120	Diesel	-Replace existing tank and lines with those up to current TSSA requirements; -Modify enclosure around tank to facilitate inspections and maintenance.	-Ensure new tank is integrated into internal routine inspection routes.
9/ 21	Quarry/ Impactor	De-Icer & Ice Axe	-Ensure quality of tanks are maintained.	-Ensure internal and external parties are aware of tank presence.

	Stockpiles / Fugitive Dust	Fugitive Dust	- Best Management Practices Plan for Fugitive Dust (BMPP)	-Communicate output of BMPP to relevant workers; -Ensure internal and external resources are in place to support BMPP.
	Quarry/ Impactor	De-Icer & Ice Axe	-Ensure quality of tanks are maintained.	-Ensure internal and external parties are aware of tank presence.

3.6 Potentially Affected Parties

As per O. Reg 224-07 s. 5 (1) and clause 91.1 (a) of the Environmental Protection Act, Plans required to prevent or reduce the risk of spills of pollutants must contain the following, in writing,

4. A map of the area surrounding the plant identifying all of the following places that are within the area that may be affected by a spill identified in Paragraph 1:
    i. Health care facilities
        - St Marys Memorial Hospital - 267 Queen St W, St. Marys, ON N4X 1C4
    ii. Senior citizen's residences and long-term care facilities.
        - Wildwood Care Centre Inc. - 100 Ann St, St. Marys, ON N4X 1A1
        - Kingsway Lodge - 310 Queen St E, St. Marys, ON N4X 1C8
    iii. Child care facilities.
        - St Marys Early Learning Centre - 161 Peel St N, St. Marys, ON N4X 1B6
    iv. Educational facilities.
        - St Mary Adult Learning Program - 26 Wellington St S, St. Marys, ON N4X 1B4
        - St. Marys District Collegiate and Institute 338 Elizabeth St, St. Marys, ON N4X 1B6
        - Little Falls Public School- 25 Lindsay Atkinson Dr, St. Marys, ON N4X 1B8
    v. Dwellings.
        - Residential dwellings can be found in all directions surrounding the facility, primarily North, East, and West
    vi. Places of Business.
        - Places of Business can be found in all directions surrounding the facility, primarily North, East, and West
    vii. Transportation Corridors.
        - Transportation corridors can be found in all directions surrounding the facility, primarily North, East, and West
    viii. Vulnerable areas as defined in subsection 2 (1) of the Clean Water Act, 2006
        - Directly between the plant and the quarry is the Thames River which flows through St Marys.
    ix. Sensitive groundwater and surface water features identified in an instrument under the Planning Act.
        - Directly between the plant and the quarry is the Thames River which flows through St Marys.
    x. Wells and intakes of drinking water systems.
        - Refer to Appendix I: Site Location and Plant Areas - SMC Site Location and Water Features
    xi. Flood plain areas.
        - Flood plains are located next to the plant to the north and west of the plant along the Thames River.
    xii. Fish and wildlife habitat.

- Onsite the plant has two stormwater retention ponds which have an abundance of wildlife including various flora and fauna. In addition the plant is located on either side of the Thames River which flows through St Marys towards the Upper Thames Watershed.

A map for the area surrounding the Facility has been included in Appendix I: Site Plan and Locations, indicating the footprint of the Site. Refer to Appendix I: Site Plan and Locations: Surrounding Facilities.

3.6.1 Likelihood of impacting Potentially Affected Parties

As per s. 5 (1) 5. and 5 (1) 6., analysis of likelihood that a spill will cause an adverse effect and an explanation on the likelihood is as follows.

Based on lable zoning maps and visual inspection, the immediate area surrounding the Facility is predominantly industrial to the east, agricultural to the south and west, and residential and agricultural to the north. The immediate area to the west of the Cement Plant is an environmental constraint zone. Residential areas are also observed to the south and west. To the northwest of the Site there are development areas and flood plain zones between Water Street South and the North Thames River. A railway also runs along the eastern property line of the Cement Plant.

The primarily affected parties in the event of a spill therefore, include:

- Flood plain areas (north and west)
- Residential zone areas (north, east, south, and west)
- Environmental constraint area (central)
- Railways (east)
- Roadways – Perth Road 123, Water Street South, and Elginfield Road (south)
- Waterways – North Thames River

Based off the nature of the contaminants on site and their locations relative to the facility, the only potential impacts are in the instance of an ammonia spill or a dust spill. The vapours from an ammonia spill have potential to be dispersed towards town, and fugitive dust from stockpiles could also impact neighbouring areas.

Refer to Section 4.3.1: Spills that Could Impact Neighbouring Facilities for plans and procedures to mitigate Spills that could impact neighbouring facilities.

4 PLANS TO RESPONSE TO SPILLS

As per O. Reg 224-07 s. 6 (1) and clause 91.1 (a) of the Environmental Protection Act, Plans required to prevent, eliminate, or ameliorate any adverse effects that result or may result from spills of pollutants must contain the following:

1. For each spill identified (in Section 3 of this SPCP), an identification of the steps that will be taken to prevent, eliminate or ameliorate any adverse effects that result or may result from the spill, where the identification includes a consideration of the appropriateness of taking each of the following steps.
    i. Acquiring spill response equipment
        - Refer to Section 4.1: Spill Response Equipment
    ii. Installing and maintaining an alarm system or other notification system to alert personnel who operate the plant when the spill occurs and to notify members of the public who may be adversely affected by the spill.
        - Refer to Section 4.2: Alarm System and Notifications

4.1 Spill Response Equipment

4.1.1 Spill Kits

All incidents that have been classified as “spills” which cause or are likely to cause an adverse effect or impairment on the natural environment and or the safety of plant personnel are handled as per St. Marys existing Spill Response Procedure.

Spill kits are found at the following locations at the Site:

- Outside of roller mill lube shack door;
- #5 Packhouse; at wall beside shrink wrap machine;
- Thomas Street quarry garage; wall just inside east garage door;
- Thomas Street quarry beside the primary crusher
- Old plant garage inside oil house;
- Finish Mill building, west of the entrance to the liquid additives room;

Spill kit locations are shown in Appendix I - Site Location and Plant Areas - Spill Kit Locations.

Each spill kit contains the following equipment:

- Universal Attack Pac Kit containing 15 pads (16'' x 20''), 3SOCs (3''x 4'), goggles, Nitrile gloves, 1 disposal bag, instruction sheet
- (100) 15" x 19" absorbent pads
- 36" x 36" rubber drain cover

- 3" dia X 4 ft long oil boom
- 8" dia x 10 ft long oil boom

Spill kits are checked quarterly for inventory and restocked as necessary to contain the above quantities of items.

Spill kits have red seals on them which break when spill kits are opened. Seals are not used to control the contents of the kits but are used only as a reminder to employees to restock spill kits once they have been opened. During quarterly inspections, if the seal is intact it is not necessary to check the contents. The seals indicate that the kits have been opened and contents should be checked.

4.1.2 Containment of Spills

St. Marys owns a vacuum truck for the capture and removal of spills. Provincial Environmental Services is contracted to collect and dispose of all light waste oils through vacuum process, heavy waste oils, greases and lubricants, as well as spent batteries, lab wastes, light bulbs of various type, and other on-Site classes of wastes that are registered on HWIN (MECP Hazardous Waste Information Network).

In the Cement Plant storm water discharge pipe to the SWM ponds on-Site, the MISA 0100 Pump can be turned off to prevent material from being discharged to the Thames River.

For the northern areas of the Cement Plant area, storm water draining to the on-Site watercourse can be blocked using soil and readily available earth moving equipment.

4.1.3 Emergency Response to Spills

St. Marys retains Canutec (613-996-6666) for emergency spill clean-up.

4.1.4 Spill Disposal

Refer to Appendix C: PD00877 – Waste Handling, Diversion, and Disposal

4.2 Alarm System and Notifications

Alarms exist at all St. Marys buildings to signal evacuation to a designated safe area. A personnel count follows the evacuation. Evacuation information is communicated to all site visitors during site orientation.

4.3 Monitoring Pollutants that have Potential to Impact Potentially Affected Parties

For spills identified to have potential to cause adverse effects at Health Care Facilities, Senior citizen`s residences and long term care facilities, child care facilities, educational facilities, dwellings, places of businesses, and wells and intakes of drinking water systems; the following steps are taken to monitor the movement of pollutants that are spilled.

4.3.1 Spills that could Impact Neighbouring Facilities

In the instance of an ammonia spill the first responders will identify the direction of the wind to determine whether the neighbouring facilities could be impacted. The quantity of spill would have to be very large to impact neighbours because of the location of the tank at the bottom of the old quarry. SMC Employees responding to the spill would use proper PPE when cleaning the spill and communication post clean up would be communicated to neighbouring areas.

In the instance of a dust spill, SMC would follow PD01446 Responding to Dust Complaints (Appendix J) to follow up with community members who have concerns about dust emissions from the facilities. Refer also to the facility`s BMPP for fugitive dust management.

4.3.2 Spills that could Impact Wells and Drinking Water Systems

4.3.2.1 Test Holes

The Facility has test holes, or groundwater wells, as defined in O.Reg. 903/90 of the Revised Regulations of Ontario (1990) made under the Ontario Water Resources Act (OWRA) for testing surface water and groundwater conditions at the Facility.

Monitoring well locations are shown in Appendix I: Site Location and Plant Area - SMC Site Location and Water Features. Refer also to the Annual Groundwater monitoring report as per Condition 4.7 of SMCs PTTW #5440-8YFHPP.

4.3.2.2 Sumps and Sump Pumps

Sump pumps are found at the following locations at the Facility:

Sump / Sump Pump ID	*Location*	*Description*
09-1-012	Rail Loading	Rail scale pit sump pump
09-1-022	Truck Loading	Truck scale pit sump pump
09-1-032	Loading/Shipping	Scale house sump pump
09-1-073	Masonry Gun	Pump
#1 Packhouse	#1 Packhouse	Small sump pump
#2 Packhouse	#2 Packhouse	2 North B/E pit sump pumps
#3 Packhouse	#3 Packhouse	Small sump pump
Rockpile Tunnel under A-12	Rock Tunnel	Small sump pump
Elevator Sump	Preheater Tower Elevator	Small sump pump
A-6-1	Clay Pit Pump	FlyGT pump
Z1LA1	Z1 Liquid Additives Building - North Wall	Liquid additives sump level monitor; plugged by hand and inspected before being pumped into tote

A-3-11	Storm Water & Process Water Pond	UT Pond pump #1
A-3-13	Storm Water & Process Water Pond	UT Pond pump #2
A-3-10	Quarry – MISA	Quarry sump pump
A1-K01	Quarry – MISA	Quarry sump pump
Garage Sump	Cement Plant Garage	Cement Plant Garage Sump Pump

4.3.2.3 Stormwater Management

The Facility is located entirely within the Thames drainage basin, which is approximately 1,695 hectares (4,187 acres) in area. Surface water in the Cement Plant area drains into drainage ditches at the Site, and the ditches drain into the two stormwater management ponds (SWM) ponds; likewise for the Thomas Street Quarry. The SWM ponds on both the cement plant and quarry properties are pumped through the MISA stations 0100 (Cement Plant) and 0200 (Thomas St. Quarry) and into the North Thames River.

Storm water and cooling water from the cement plant and quarry drain into ditches throughout the Site and enters the SWM ponds located northwest and southeast of the North Thames River. Both sets of SWM ponds (Cement Plant and Thomas Street Quarry) are located at a lower elevation than the North Thames River and their corresponding MISA locations. The automated MISA sampler is programmed to collect a weekly volume of water pumped from the SWM ponds. All water pumped from the SWM ponds passes through the MISA sampling point on its route to the North Thames River.

This area drains both overland and through a number of drainage swales, all of which ultimately discharge through the MISA Stations and into the North Thames River.

There is no treatment of the storm water or non-contact cooling water apart from settling in the SWM ponds prior to discharge through the MISA Stations. In the event that a spill ultimately discharges into these ponds, the contaminated fluid collected will be vacuumed out by a licensed contractor, and the liquids disposed of, as appropriate.

All storm water and non-contact cooling water is discharged to MISA Station 0100 and 0200 and not disposed of. The usual discharge of water, containing some suspended solids, the amount of which is regulated by O.Reg. 561/94, is destined for the North Thames River.

Inspections and monitoring requirements as part of the MISA program (as detailed in O.Reg. 561/94) include (though is not limited to) the following:

1. Collect a MISA Station discharge (process effluent and cooling water effluent) sample once a week, to be analysed for total suspended solids and pH.
2. Quarterly samples for acute lethality testing for rainbow trout and *Daphnia magna* shall be collected and sent to a certified laboratory for analysis and report generation.

3. Semi-Annual samples for chronic toxicity of fathead minnow and *Ceriodaphnia dubia* shall be collected and sent to a certified laboratory for analysis and report generation.

4.4 Reportable and Non-Reportable Spills

As per O. Reg 224-07 s. 6 (1) and clause 91.1 (a) of the Environmental Protection Act, Plans required to prevent, eliminate, or ameliorate any adverse effects that result or may result from spills of pollutants must contain the following:

3. The identification of all spills that are non-reportable under subsection (2) that may occur at the plant or relate to the operations of the plant
4. Procedures to ensure that notification of a non-reportable spill is given in accordance with subsection 10 (3) of Ontario Regulation 675/98 (Classification and Exemption of Spills) made under the Act, if that subsection applies to the spill.

O.Reg. 675/98, Classification and Exemption of Spills, details the classification of spill types at facilities, and states under what conditions that spill may be exempt from reporting, as defined under the Environmental Protection Act, R.S.O. 1990, c. E.19, and Section 92. This section is presented below.

4.4.1 Reportable vs. Non-Reportable Spills

Notice of spills

92. (1) Every person having control of a pollutant that is spilled and every person who spills or causes or permits a spill of a pollutant shall forthwith notify the following persons of the spill, of the circumstances thereof, and of the action that the person has taken or intends to take with respect thereto (as per O.Reg. 675/98, Section 92),

a) the Ministry;
b) any municipality within the boundaries of which the spill occurred or, if the spill occurred within the boundaries of a regional municipality, the regional municipality;
c) where the person is not the owner of the pollutant and knows or is able to ascertain readily the identity of the owner of the pollutant, the owner of the pollutant; and
d) where the person is not the person having control of the pollutant and knows or is able to ascertain readily the identity of the person having control of the pollutant, the person having control of the pollutant.

When duty effective

(2) The duty imposed by subsection (1) comes into force in respect of each of the persons having control of the pollutant and the person who spills or causes or permits the spill of the pollutant immediately when the person knows or ought to know that the pollutant is spilled.

Additional information to Director

(3) The person required by subsection (1) to give notice and the owner of the pollutant shall give to the Director such additional information in respect of the pollutant, the source of the pollutant and the spill of the pollutant as may be required by the Director.

Notice to Ministry by person investigating

(4) A member of a police force or an employee of a municipality or other public authority who is informed of or who investigates the spill of a pollutant shall forthwith notify the Ministry of the spill of the pollutant unless he or she has reasonable grounds for believing that such notice has been given to the Ministry by another person.

Same

(5) The notices required by subsections (1) and (4) shall be given in accordance with any requirements prescribed by the regulations.

Under the OWRA, all spills that are likely to enter water, including groundwater, are reportable.

Under O.Reg. 675/98 the following are the maximum discharge allowances, under which St. Marys may be exempt from reporting in the event of a spill (as defined above).

#	*Tank ID/ Location*	*Contents*	*O.Reg. 675/98 Clause*	*Discharge Allowance (L)*
1	Removed 2019			
2	M-28-1	Diesel	Section 6 or 8	100
3	12-0-248	Light Waste Oil	N/A	100
4	M-28-4	Furnace Oil	Section 8	100
5	M-28-5	Light Waste Oil	N/A	100
6	M-28-7	Gasoline, Diesel, Varsol	Section 6 or 8	100
7	A-2	Diesel	Section 6 or 8	100
8	Quarry	Gasoline	Section 6 or 8	100
	CBM Quarry	Diesel, Gasoline	Section 6 or 8	100
10	CBM SaniMax	Diesel	Section 6 or 8	100
11	12-01	Ethylene Glycol	N/A	*100
12	W1K94	Ammonia	N/A	100
13	Z1K09	HEA2	N/A	N/A
14	Z1K14	HYDROPHOBE 41	N/A	N/A
15	Z1K22	RDA	N/A	N/A
16	Z1K25	Ethylene Glycol	N/A	*100
17	10-0-120	Diesel	Section 6 or 8	100

#	*Tank ID/ Location*	*Contents*	*O.Reg. 675/98 Clause*	*Discharge Allowance (L)*
	10-0-112	Transformer Oil	N/A	N/A
	10-0-113	Transformer Oil	N/A	N/A
	K-11-2	Transformer Oil	N/A	N/A
	K-12-2	Transformer Oil	N/A	N/A
	10-0-501	Transformer Oil	N/A	N/A
	10-0-125	Transformer Oil	N/A	N/A
	OCB	Transformer Oil	N/A	N/A
22	Stores Area	Variable	N/A	N/A
	Oil Storage Area	Oils, Greases, Lubricants	N/A	N/A
	Storage Piles	Variable	N/A	N/A
21	Impactor	WD-80 DeIcer	N/A	100
9	Thomas St Quarry	Ice Axe	N/A	100

Notes: * - no discharge allowance limit available under O.Reg. 675/98. Value shown is an assumed representative discharge allowance; N/A - not applicable

For all spills that fall under O.Reg. 675/98, a record shall be taken and made available for inspection upon the request of a provincial officer. The record shall include:

- The date, time, location and duration of the release of the pollutant
- The identity of the pollutant released
- The quantity of the pollutant released
- The circumstances and cause of the spill
- Details of containment and clean-up efforts
- An assessment of the success of containment and clean-up efforts
- The method used, in accordance with subsection 96 (1) of the Environmental Protection Act, to dispose of or use the pollutant or any matter, thing, plant or animal or any part of the natural environment that is affected by the spill and the location of the disposal site
- Any adverse effects observed as a result of the spill.

All non-reportable spills which do not fall under O. Reg 675/98 are recorded in the Downtime Database. Refer to Appendix H: Sample Incident Report.

4.4.2 Internal Spill Notification

All employees must report a spill, regardless of quantity, immediately to their supervisor and the Shift Production Supervisor who will notify the Environmental Coordinator or Health and Safety Representative.

4.4.3 Reporting Spills to the MECP

The Environmental Coordinator or Health and Safety Coordinator will report spills to the MECP Spills Reporting Center. If the Environmental Coordinator or the Health and Safety Coordinator is not available the Shift Coordinator will report to the MECP Spills Reporting Center.

Contact information mentioned in the Emergency Response and Evacuation Plan is as follows:

St. Marys Shift Supervisor	519-284-1020 ext. 233
St. Marys Environmental Coordinator	519-284-1020 ext. 235
	519-221-1849 (mobile)
St Marys Health & Safety Coordinator	519-284-1020 ext. 316
MECP Spills Reporting Center	416-325-3000
CANUTEC	613-996-6666

4.5 Plans for Spill Response

As per O. Reg 224-07 s. 6 (1) and clause 91.1 (a) of the Environmental Protection Act, Plans required to prevent, eliminate, or ameliorate any adverse effects that result or may result from spills of pollutants must contain the following:

5. Procedures to ensure that before a spill occurs,
    - i. A person who is responsible for implementing plans under this section, and his or her alternate, are identified
        - Refer to Section 2: General Information
    - ii. The anticipated circumstances of the spill and its potential adverse effects are assessed and the appropriate level of response is determined, including whether a team needs to be established to respond to the spill
        - Based off Section 3: Plans Re. Prevention of Spills of this SPCP there is potential for spills to occur on site. All employees are to be trained and ready to respond to spills (See 4.5.1: Training). In addition an Emergency Response Team (ERT) which is trained in handling safety emergencies and first aid response is also capable of handling emergency spills.
    - iii. A spill response team is established, if determined to be necessary under subparagraph ii.
        - Refer to point above.

iv. The roles and responsibilities of personnel in responding to a spill are identified and documented.
  - All employees receive spills response training.
  - Spills are reported to the MECP as per Section 4.4.3: Reporting Spills to the MECP

v. Personnel are trained in their roles and responsibilities under subparagraphs iv and vi and paragraphs 6 and 7 and, as appropriate, in the use of spill response equipment and material, and
  - See Section 4.5.1: Training

vi. Equipment and material referred to in subparagraphs 6 vi and vii that are needed to respond to the spill are regularly inspected and maintained in a state of readiness to respond to a spill.
  - Refer to Section 4.1.1: Spill Kits.

4.5.1 Training

St. Marys personnel involved in spill prevention activities at the Site receive **annual spills training, focusing on prevention, containment and remediation**, as well as regulatory requirements. This training program provides St. Marys personnel with the basic knowledge required as part of spill prevention including the use of appropriate PPE and spill control and countermeasures.

Training documents are maintained by the facility and available for review upon request.

4.6 Spill Procedures

6. Procedures to ensure that if any spill at or related to the operations of the plant occurs,

   i. Sections 92 and 93 of the act are complied with
      - See Section 4.4.1: Reporting vs. Non-Reportable Spills for Section 92 of the EPA
      - See Section 4.6.1: Duty to Mitigate and Restore for Section 93 of the EPA

   ii. Relevant persons at the plant, including the persons identified under subparagraph 5 i, are notified of the spill,
      - Refer to St Marys Cement Spill Response Procedure, Included in Appendix D - PD00332 Spill Response Procedure.

   iii. The appropriate level of response to the spill determined under subparagraph 5 ii is implemented
      - Refer to St Marys Cement Spill Response Procedure, Included in Appendix D - PD00332 Spill Response Procedure.

   iv. members of the public who may be directly affected by the spill, including any persons who may be at a place identified in subparagraphs 4 i to vi of subsection 5 (1) are notified of the spill

    - Refer to Section 4.3.1: Spills that Could Impact Neighbouring Facilities

v. If an alarm system or other notification is in place, it is operated properly
    - Refer to Section 4.2: Alarm Systems and Notifications

vi. Appropriate equipment, material, and personnel are available to monitor the movement of pollutants and the adverse effects of the pollutants for those spills which steps are identified under paragraph 2,
    - Refer to 4.1 : Spill Response Equipment

vii. Appropriate equipment, material, and personnel are available to immediately respond to the spill, and
    - Refer to Section 4: Plans to Response to Spills

viii. Wastes generated as a result of the spill and spill response are disposed of properly
    - Refer to Appendix C - PD00877 Waste Handling, Diversion and Disposal.

4.6.1 Duty to Mitigate and Restore

Section 93 of the EPA states:

(1) The owner of a pollutant and the person having control of a pollutant that is spilled and that causes or is likely to cause an adverse effect shall forthwith do everything practicable to prevent, eliminate, and ameliorate the adverse effect and to restore the natural environment.

(2) The duty imposed by subsection (1) comes into force in respect of each of the owner of the pollutant and the person having control of the pollutant immediately when the owner or person, as the case may be, knows or ought to know that the pollutant is spilled and is causing or is likely to cause an adverse effect.

Refer to St Marys Cement Spill Response Procedure, Included in Appendix D - PD00332 Spill Response Procedure.

4.7 Records of Spills

As per O. Reg 224-07 s. 6.(1) and clause 91.1 (a) of the Environmental Protection Act, Plans required to prevent, eliminate, or ameliorate any adverse effects that result or may result from spills of pollutants must contain the following:

7. Procedures to ensure that all steps taken under Paragraph 6 (Section 4. Plans Re. Response to Spills) to respond to a spill are recorded and that the record is retained for five years.

Records of spills are maintained on the SMC Downtime Database which is used to track plant activities including records of downtime, safety and environmental incidents/concerns, and non-conformances. Refer to Appendix H: Sample Incident Report.

5 SPILL PREVENTION AND CONTINGENCY PLAN MANAGEMENT

5.1 Retention of the Spill Prevention and Contingency Plan

As per O. Reg 224-07 s. 7: Every person to whom this regulation applies shall ensure that copies of the most recent spill prevention and contingency plans are retained at the plant.

A copy of the most recent revision of the SPCP is posted on the environmental board, located in the core building, and is also available in the Central Control Room or electronically.

5.2 Environmental Emergency Plan

As per O. Reg 224-07 s. 8: If a person to whom this Regulation applies has developed plans that wholly or partially address the matters listed in sections 4, 5 and 6 on a voluntary basis or for another government or under another Act of Ontario or Canada or under a by-law, and the plans wholly or partially meet the requirements listed in sections 4, 5 and 6, the person may use the plans for the purposes of meeting those requirements if they amend them, where necessary, to meet all of those requirements.

St Marys Cement does not have any material on site which meets E2 requirements for an emergency response plan. Therefore no plan has been developed for the facility.

5.3 Review of a Plan after a Spill

As per O. Reg 224-07 s. 9 (1): If a spill at or related to the operations of a plant occurs for which notification is required under section 92 of the Act, the person who owns or operates the plant shall,

> (a) review the plans as a whole to determine whether they would be adequate for preventing or responding to the spill if it were to recur; and
>
> (b) if no steps were specified for the spill under subparagraph 8 ii of subsection 5 (1), or if steps that were identified under that subparagraph were not implemented by the time of the review under clause (a), review the risk assessment and identification of steps that were done for the purposes of paragraphs 7 and 8 of subsection 5 (1).
>
> (2) If, after reviewing the plans under subsection (1), the person determines that the plans would be inadequate for preventing or responding to the spill if it were to recur, the person shall revise them and the manner in which they are implemented to ensure that the plant's response to the spill is effective in preventing, eliminating or ameliorating any adverse effects that may result from a spill. O. Reg. 224/07, s. 9 (2).

The facility documents steps taken during actual on-site spills and records them in the Downtime Database as in Appendix H: Sample Incident Report. After reviewing the facility's historic spills in Section 3.2.4, the plant determined that all reasonable steps were taken to prevent reoccurrence of foreseeable spills. The facility will continue to review future spills against current version of the Spill Prevention and Contingency Plan.

5.4 Annual Review of Plan

As per O. Reg 224-07 s. 10 (1); every person to whom this Regulation applies shall do the following, or, if the person is a corporation, an officer or director of the corporation shall do the following:

1. Ensure that the spill prevention and contingency plans are reviewed each year and revised as necessary to ensure compliance with this Regulation.
2. Ensure that the risk assessment and identification of steps required under paragraphs 7 and 8 of subsection 5 (1) are reviewed each year and revised as necessary.
3. Ensure that a portion of the operations of the plant are tested each year to determine whether, if a spill at or related to the operations of the plant occurs, the plant's response to the spill,
    i. would comply with the plans described in section 6, and
    ii. would be effective to prevent, eliminate or ameliorate any adverse effects that may result from the spill.
4. Ensure that each portion of the operations of the plant is tested under paragraph 3 at least once during a five-year period.
5. Ensure that the tests under paragraph 3 include, at least once every two years, a live exercise where every person involved in the planned response to a spill practises their response and every operation involved is physically tested.
6. If the tests in paragraph 3 or 5 identify any inadequacies in the plans or in their implementation, revise the plans and the manner in which they are implemented to ensure that the plant's response to a spill is effective in preventing, eliminating or ameliorating any adverse effects that may result from the spill.
7. For each year after 2008, make a written statement that,
    i. indicates the date on which the steps described in paragraphs 1, 2, 3, 5 and 6 occurred, and
    ii. indicates whether, in the person's opinion, on January 1 of the year,
        A. The information contained in the spill prevention and contingency plans is accurate,
        B. The plans required under section 5 and the implementation of them would be adequate to prevent or reduce the risk of spills that may occur at the plant or relate to the operations of the plant, and
        C. The plans required under section 6 and the implementation of them would be adequate to prevent, eliminate or ameliorate any adverse effects that may result from a spill.

(2) The person who makes the statement mentioned in paragraph 7 of subsection (1) shall ensure that a copy of the statement is retained at the plant for five years.

Annual review is completed by the Environmental Coordinator and the statement is maintained electronically.

6 PLANS AND DRAWINGS OF THE PLANT

Upon request, St. Marys will provide a written summary of the SPCP and of any updates made to the plans to the following:

a) A municipal emergency control group established under Section 12 of Ontario Regulation 380/04 standards made under the *Emergency Management and Civil Protection Act*
b) A Municipal By-Law Inspector
c) The local fire department
d) The local police department
e) The Medical Officer of Health
f) Environment Canada Environmental Emergencies Officer

7 MANAGEMENT APPROVAL

This SPCP will be implemented by management at a level with authority to commit the necessary resources.

Position: Operations Manager

Signature: ______________________________

Printed Name: ______________________________

Date: ______________________________

Position: Environmental Coordinator

Signature: ______________________________

Printed Name: ______________________________

Date: ______________________________

8 CERTIFICATION

I hereby certify that I have examined the facility, and being familiar with O.Reg. 224/07, attest that this SPCP has been prepared in accordance with good engineering practices.

Position: Environmental Coordinator

Signature: ______________________________

Printed Name: ______________________________

Date: ______________________________

APPENDIX I

Curricula Vitae

Education

PhD Osgoode Hall Law School, York University, 2013

LLM Osgoode Hall Law School, York University, 2005

MBA Centre for Innovative Management, Athabasca University, 2001

M.Sc. Earth Sciences, Brock University, 1997

B.Sc. Geological Sciences (Honours), University of Toronto, 1985

Certifications

Professional Geoscientist, P.Geo., Ontario

Certified Professional Accountant, CPA, Ontario

Certified Management Consultant, CMC

Project Management Professional, PMP

Languages

English – Fluent

St. Catharines

Senior Hydrogeologist and Principal

As a Senior Hydrogeologist with Golder, Dr. McFarland has more than 30 years of professional experience and a broad background in conducting, managing and directing aggregate waste management, mining, power, oil and gas, and ground management and protection projects. He served as the project director for work programs for proposed mines, aggregate operations and industrial facilities.

He has a broad background in licensing and permitting of pits and quarries. This includes the licensing for the expansion of the Lafarge Dundas Quarry, the expansion of the Lafarge Woodstock Quarry, the expansion of the Nelson Aggregate Quarry, the RW Tomlinson license application, the St. Mary’s cement Bonis Quarry, the ongoing expansion of the Port Colborne Quarry, and the Lafarge Goodwood Pit and other sites. He is also involved in numerous PPTW applications for pits and quarries. In addition, he has extensive experience in site selection studies and resource evaluations for aggregate sites.

Sean acted as the Project Director and Senior Hydrogeologist for the 2014 and 2015 annual landfill monitoring reports for the Vale Port Colborne site and for 8 landfill monitoring programs in Niagara Region. He was the Project Manager and Senior Hydrogeologist for the extensive Adams Mine landfill project, which involved the successful permitting of a 20 million tonne hydraulic containment engineered landfill facility, within a 200 m deep former open pit mine, following hydrogeological investigations collected over an 8-year period that involved extensive monitoring well installation, electronic instrumentation and testing, pump test analyses and groundwater flow modelling. He has also been an expert witness for hydrogeology at Environmental Assessment (EA) and Ontario Municipal board (OMB) hearings and has been involved in extensive contaminated site investigations including legal disputes.

Additional project experience includes hydrogeological assessments for the low level radioactive (LLRWM) facility concepts of waste management for the Canadian federal government Siting Task Force Secretariat (STFS) in limestone bedrock beneath the Great Lakes, and fractured and faulted Precambrian granitic gneiss at the Chalk River Nuclear Reactor site in northern Ontario, Canada. Further project experience in fractured rock includes the proposed Steetley Landfill, in limestone bedrock of the Niagara escarpment, including an extensive EA level hydrogeological investigation, over a 5-year period, and the existing Brow Landfill including an EPA level investigation, a long-term monitoring program and remediation.

Employment History

Golder Associates Ltd. – Mississauga, Ontario
Senior Geoscientist and Principal (1987 to Present)

Hydrogeologist then Senior Hydrogeologist (1987-present)
Managing Principal, Vice President, Canada (2005-2014)
Associate - 1997 appointment
Principal - 2003 appointment

Geologist and Hydrogeologist (1985 to 1987)
Characterization of proposed and existing metal and industrial mineral facilities and impact assessments for industrial facilities.

Regina Associates Ltd. – Kingston, Ontario
Geoscientist (1983 to 1987)

Characterization of proposed and existing metal and industrial mineral facilities in Ontario, Nova Scotia, Newfoundland, British Columbia and the Northwest Territories; and hydrogeological impact assessments for industrial facilities.

PROJECT EXPERIENCE – AGGREGATE INDUSTRY

Aggregate Resource Evaluation Regional Municipality of Peel, ON	Project Manager and geologist for evaluation of sand and gravel and bedrock resources in the Regional Municipality of Peel, Ontario for the provincial Ministry of Municipal Affairs and Housing (MMAH). The project was carried out as part of the development of the official plan for the Region.
Region of Peel Regional Municipality of Peel, ON	Technical advisor for ARIP (Aggregate Resource Inventory Paper) report for the Regional Municipality of Peel. The project involves and evaluation of shale and gravel, limestone and shale resources in the Region and was submitted to the Ontario Geological Survey for publication as a government document ARIP Paper.
Navan Quarry Navan, ON	Project Manager and geologist for evaluation of sand and gravel and bedrock resources in the Regional Municipality of Peel, Ontario for the provincial Ministry of Municipal Affairs and Housing (MMAH). The project was carried out as part of the development of the official plan for the Region.
Brockville Quarry Brockville, ON	Project Manager and hydrogeologist for hydrogeological evaluation of the Permanent Lafarge Brockville Quarry. The results of the evaluation were used to negotiate the liability of the quarry to alleged water well interference associated with quarry expansion with the Ontario Ministry of the Environment.
Dufferin Aggregates ON	Project Director and senior hydrogeologist for numerous aggregate projects at quarries and sand and gravel pits within Ontario including resource evaluations, hydrogeological investigations and environmental assessments.
Due Diligence Studies Southern Ontario	Project Manager and senior hydrogeologist for due diligence studies as part of the potential purchase of aggregate companies and operating pits and quarries in Ontario.
Site Selection Studies Southern Ontario	Project Director for site selection studies for development of quarries and sand and gravel operations in Ontario.
Lafarge - North Quarry Flamborough, ON	Project Director for hydrogeological program at the Lafarge (formerly Redland) Quarry Operations in Flamborough, Ontario, to meet the regulatory requirements of the Ontario Ministry of the Environment.

Proposed Halminen Quarry Buckhorn, ON	Project Manager for a private application for a license for a proposed limestone quarry near Buckhorn, Ontario. The project involved management of multi-disciplinary project team public meetings, and application for a Class A licence under the Aggregate Resources Act.
Votorantim Cimentos Bowmanville, ON	Project Director for the development of a limestone/dolostone mine under Lake Ontario. The work programs involve drilling and testing of a 275m deep borehole under the lake, development of an underground mine plan, preparation of an EA document for regulatory approvals and public participation programs.
Milton Limestone Quarry Peer Review Milton, ON	Project Director for the peer review of the hydrogeological and adaptive management plan report for the proposed Dufferin Aggregates Milton Quarry expansion. The work program involved meetings with the hydrogeological consultant and legal counsel and attendance at Ontario Municipal Board hearings.
SAROS Study Greater Golder Horseshoe, ON	Evaluation of supply and demand of aggregate resources in the Greater Golden Horseshoe for the MMNR (Ministry of Natural Resources and Forestry). The project includes resource estimates for 25 quarries and 120 pits and unlicensed sand and gravel resources in the study area.
Nelson Quarry Expansion Burlington, ON	Project Director for the proposed Nelson Quarry extension including extensive borehole drilling and monitoring well installations, water quality sampling, a surface water program, groundwater flow modeling, impact assessments, preparation of an Adaptive Management Plan (AMP), reporting and acting as an expert witness at an Ontario Municipal Board hearing.
Lafarge South Quarry Expansion Dundas, ON	Project Director for a hydrogeological and hydrological work programs in support of a license application for the expansion of the Lafarge South Quarry near Dundas, Ontario (ongoing). The work program involves borehole drilling and monitoring well installations, geophysical borehole logging, water quality sampling and analyses, hydrological analyses of streams and wetlands, a karst assessment, a water well survey, geological and hydrogeological interpretation, groundwater flow modeling, agency interaction and attendance at public meetings.
Lafarge Fonthill Pit PTTW Renewal Fonthill, ON	Project Director for a hydrogeological work program in support of a Permit to Take Water (PTTW) application for the Lafarge, The work program included interpretation of pumping wells records, evaluation of drawdown in water wells related to pumping, water quality analyses and preparation and submission of a report in support of the permit application.
Lafarge North Quarry Expansion Dundas, ON	Project Director for a hydrogeological work program conducted in support of a license application for the expansion of the Lafarge North Quarry. The work program involved borehole drilling and monitoring well installations, pumping tests, groundwater flow modelling, a water well survey, an impact assessment of potential effects on water wells and an adjacent provincially significant wetland, agency interaction and preparation of a report submitted in support of the license application. The application was approved with an Ontario Municipal Board hearing.

Lafarge PTTW Monitoring Programs ON	Project Director for hydrogeological monitoring programs for a portfolio of more than 50 pits and quarries in Ontario. The programs involved water level and water quality monitoring, evaluation of pumping records, effects assessments and preparation and submission of monitoring reports for compliance with the permits.
RW Tomlinson Quarry License Application Brechin, ON	Project Co-director for the hydrogeological work program for a hydrogeological work program performed in support of a license application for a dolostone quarry in the Carden Plain. The work program involved borehole drilling and monitoring well installation, geophysical borehole logging, packer testing, well response testing, pump testing, water quality sampling, groundwater flow monitoring, an impact assessment including potential effects on surrounding water wells and an adjacent wetland, development of a monitoring program preparation of a report in support of the application and agency interaction.
Proposed Lafarge Glen Morris Pit ON	Project Director and senior hydrogeologist for the hydrogeological work program in support of a license application for the proposed Glen Morris Pit. The work program included borehole drilling, monitoring well installations, groundwater level monitoring and the provision of data and preparation of a hydrogeological report.
Lafarge Wellington Quarry PTTW and ECA Renewal ON	Project Director and senior hydrogeologist for the Lafarge Wellington Quarry Renewal. The field program involved borehole drilling, packer testing, monitoring well installations, groundwater level monitoring, a field pumping test, development of a water budget and groundwater quality sampling. A hydrogeological impact assessment was developed to assess the potential impacts of quarry groundwater level drawdown related to quarry dewatering activities on surrounding private water wells and municipal wells. The work program included the modification of the regional source water protection to incorporate site data to assess the potential affects on the Guelph municipal wells.
Lafarge Regan Resource Drilling ON	Project Manager and senior geoscientist for resource drilling at the Lafarge Regan site using some drilling techniques. The results of the work program were provided to Lafarge for their resource assessment.
Lafarge Hagersville Quarry Hagersville, ON	Senior Hydrogeologist for the assessment of quarry dewatering and pumping for the Lafarge Hagersville Quarry as part of the PTTW monitoring program.
Arbour Farms License Application ON	Senior Hydrogeologist for the Arbour Farms license application for a pit below water. The work program included borehole drilling, installation of monitoring wells, groundwater level monitoring and assessment of potential affects on an adjacent water course. Three-dimensional groundwater flow and heat transport modeling was completed to assess the potential thermal impacts on the surrounding surface water courses.

Rankin Construction Port Colborne Quarry Extension
Port Colborne, ON

Project Director for a multi-disciplinary work program for a license application for an extension of the Port Colborne Quarry. The work program involved hydrogeological, hydrological, blasting, noise, air, natural environment, planning, agricultural and archaeological studies and a resource estimate. Senior Hydrogeologist for the hydrogeological work program that involved borehole drilling, monitoring well installations, groundwater quality sampling and analysis, an impact assessment and a monitoring and response program for potential impacts on surrounding water wells.

Lafarge Goodwood Pit Extension
Goodwood, ON

Project Director and senior hydrogeologist for a license application for the Lafarge Goodwood Pit extension, for a Category 1 Class EA pit below water. The objective of the work program was to characterize the existing hydrogeological and hydrological conditions in the vicinity of the site, including the depth and elevation of the water table and assess potential affects of the operational and rehabilitation scenarios. The work program involved borehole drilling, monitoring well installations, groundwater level monitoring, development of a water budget and a hydrogeological impact assessment.

Lafarge Woodstock Quarry Expansion
Woodstock, ON

Project Director and senior hydrogeologist for the hydrogeological investigation of the Woodstock quarry for support of a license amendment. The field program involved borehole drilling, packer testing, monitoring well installations, groundwater quality sampling and analysis, a field water well survey and development of a water budget. An impact assessment was conducted to assess the potential affect of quarry related groundwater level drawdown on surrounding water wells and surface water courses.

CRH Resource Evaluation and Due Diligence
ON

Project Manager and senior geoscientist for a resource evaluation of a property near Orangeville, Ontario for potential acquisition for quarry development. The work program included borehole drilling, geological logging of the rock core, monitoring well installations to determine the depth of the water table, aggregate quality testing and reporting.

Limestone and Sandstone Resource Evaluation and Due Diligence
Regional Municipality of Peel, ON

Project Director and senior hydrogeologist for a resource evaluation for a property developer for potential acquisition of an existing quarry near Mississauga. The work program involved borehole drilling, core logging, aggregate quality testing and reporting.

Stouffville Resource Drilling
Stouffville, ON

Project Manager and senior hydrogeologist for the resource drilling at Lafarge Stouffville Quarry. The drilling was conducted using a sonic drill rig with continuous core sampling. The results were provided to the Lafarge geologist for the resource assessment.

Lakeridge Resource Drilling
ON

Project Manager and senior geoscientist for the resource drilling at the Lafarge Lakeridge site. The drilling was conducted using sonic coring and the results provided to the Lafarge geologist for development of a resource assessment.

Votorantim Thomas Quarry License Application ON	Senior hydrogeologist for the hydrogeological component of the Votorantim Thomas Quarry Extension license application. The work program involved borehole drilling, packer testing, geophysical borehole logging monitoring well installations and groundwater quality sampling and analysis. Three-dimensional groundwater flow monitoring was conducted to assessment the potential hydrogeological impacts of the quarry.
Lafarge Pinkney Pit #3 ON	Senior Hydrogeologist for the hydrogeological work program for the Lafarge Pinkney Pit #3 license application. The work program involved borehole drilling, monitoring well installations and a hydrogeological impact assessment.
Lafarge Mosport Resource Drilling ON	Project Manager and senior geoscientist for the sonic borehole drilling at the Lafarge Mosport Pit. The results of the resource drilling were provided to the Lafarge geologist as part of the site resource assessment.
Lafarge Goodwood Resource Drilling ON	Project Manager and senior geoscientist for sonic borehole drilling of the resource near the Lafarge Goodwood Pit. The results of the drilling were provided to the Lafarge geologist for a resource assessment.
APAO (Aggregate Producers Association of Ontario) Water Consumption Study ON	Project Director for a study for the APAO to determine the consumption of water associated with pits and quarries.
Lafarge Sunningdale Pit Monitoring Program ON	Senior Hydrogeologist for the Lafarge Sunningdale Pit Monitoring Program. The work program includes hydrogeological monitoring, an assessment of potential impacts and preparation of an annual monitoring report.
Votorantim Resource Assessment ON	Project Manager and senior geoscientist for a resource assessment at a Votorantim Quarry in central Ontario. The work program involved borehole drilling and borehole geophysics were used to identify and correlate the geological formations and members at the site.
Cox Construction Monitoring Well Network Wellington County, ON	Project Manager and senior hydrogeologist for borehole drilling and monitoring well installations at a property in Wellington County to provide baseline date for potential future licensing as a quarry. The wells were installed in the thick sequence of Amabel Formation at this locates. Groundwater level monitoring was performed to determine the depth to water table.
Cox Construction Resource Evaluation and Due Diligence ON	Project Director for a drilling program to evaluate to the limestone resource for potential acquisition of a property for development. The work program involved borehole drilling, geological logging of the rock core, monitoring well installations, aggregate quality testing and reporting.

PROJECT EXPERIENCE – WASTE MANAGEMENT

Adams Mine Kirkland Lake, ON	Project Hydrogeologist and Project Manager for the hydrogeological assessment of the Adams Mine near Kirkland Lake, Ontario over a five-year period as part of the proposed development of 20 million tonne engineered landfill facility for solid non-hazardous waste. The facility will receive waste from the Greater Toronto Area (GTA) via a rail line system. The landfill facility incorporates a hydraulic containment design, which prevents outward migration of contaminants from the landfill, which reduces environmental impacts and long-term operating costs. Provided expert witness testimony in an environmental assessment (EA) hearing.
Brow Landfill Dundas, ON	Project Hydrogeologist then Project Manager for hydrogeological assessment for landfill expansion of the existing Redland Quarries Inc. (formerly Steetley Quarry Products Ltd.) solid industrial waste Brow Landfill in Flamborough, Ontario. Subsequent work included ongoing groundwater and surface water quality monitoring and preparation monitoring reports submitted to the MOE, followed by development of a closure plan and an ongoing compliance monitoring program.
South Quarry Landfill Flamborough, ON	Project Hydrogeologist for hydrogeological assessment of the proposed Redland Quarries Inc. (formerly Steetley Quarry Products Ltd.) South Quarry in Flamborough, Ontario for the proposed development of an engineered landfill facility. Participated in environmental assessment (EA) hearings and assisted with the preparation of final arguments with legal counsel.
Siting Task Force Secretariat Chalk River, ON	Project Hydrogeologist, then Project Manager for geological and hydrogeological characterizations of the Chalk River Nuclear laboratories property, near Chalk River, Ontario for siting of a proposed facility for the disposal of low-level nuclear waste for the federal Siting Task Force Secretariat (STFS).
Siting Task Force Secretariat Port Hope, ON	Project Hydrogeologist then Project Manager for geological and hydrogeological characterization of the Lakeshore site in Port Hope, Ontario, for the federal Siting Task Force Secretariat (STFS). The work was carried out as part of the feasibility level I study for dispose of low-level waste in engineered caverns beneath Lake Ontario and the Cameco Uranium fuel processing facility in Port Hope.
Interim Waste Authority Regional Municipality of Peel, ON	Project Hydrogeologist for geological and hydrogeological characterization comparative evaluation of five short-listed sites for siting of an engineered landfill facility as part of the provincial Interim Waste Authority (IWA) landfill site selection process for the Region of Peel.
Guelph-Wellington County WMMP Wellington County, ON	Project Hydrogeologist for geological and hydrogeological characterization of five candidate sites and identification of a preferred site in Wellington County for siting of an engineered municipal landfill facility, as part of the joint City of Guelph - County of Wellington Waste Management Master Plan (WMMP).
Model City Landfill Lewiston, NY	Project Hydrogeologist for hydrogeological investigation of the Model City hazardous waste landfill, near Lewiston, New York, carried out as part of landfill expansion.

Welland-Wainfleet WWMP Townships of Welland and Wainfleet, ON	Project Hydrogeologist for the identification of preferred sites for development of a municipal landfill facility, as part of the Welland-Wainfleet Waste Management Master Plan (WMMP).
Brock South Landfill Pickering, ON	Project Hydrogeologist for assessment of the proposed Brock South Landfill near Pickering, Ontario, to assess the suitability of the site for development of an engineered municipal landfill facility for Metropolitan Toronto.
Redland Queenston Quarry Queenston, ON	Project Hydrogeologist for hydrogeological assessment of the Redland Quarries Inc., Queenston Quarry to determine the suitability of the site for disposal of waste rock saline shale, from the construction of the proposed diversion tunnels of the Sir Adam Beck III hydroelectric generating facility in Niagara Falls, Ontario.
Fly Ash Disposal Facility ON	Project Hydrogeologist for hydrogeological investigations at four quarries located near Hagersville, Cayuga, Smithville and Milton to determine their suitability for development an engineered landfill for disposal of fly ash from the Ontario Hydro Lakeview Power Generating Station.
Mohawk Street Landfill Brantford, ON	Project Hydrogeologist for assessment of groundwater and surface water quality impacts at the municipal Mohawk Street Landfill in Brantford, Ontario.
Vale Industrial Landfill Port Colborne, ON	Project director for the preparation of an annual report for the groundwater monitoring program for an industrial waste landfill at a former nickel refinery. The work program included interpretation of groundwater flow directions and water quality trends, evaluation of the extent of the leachate plume, and an impact assessment.
Vale Industrial Refinery Landfill Monitoring Port Colborne, ON	Project Director and senior hydrogeologist for an evaluation of the effectiveness of the purge well system at a former nickel refinery and the development of mitigation and rehabilitation measures for well clogging. The work program involved step drawdown pumping tests, longer term pumping tests, hydraulic analysis of pumping test data, assessment of the decline of well efficiency due to scaling and bio fouling and the development of a work program for well rehabilitation and maintenance including acidification.
Municipal Landfill Annual Monitoring Programs Niagara Region, ON	Project Director for the annual monitoring program for 8 landfills in bedrock and escarpment settings in Niagara Region. The work program involves field water quality sampling, groundwater level monitoring, and provision of progress and annual reports.
Proposed Walker Ingersoll Landfill ON	Senior Hydrogeologist for the hydrogeological investigation for the proposed Walker Landfill near Ingersoll, Ontario. The field program involved borehole drilling, monitoring well installations, packer testing, geophysical borehole logging, downhole flow profiling, groundwater quality sampling and analysis, a karst study and a water well survey. Three-dimensional groundwater flow modeling was conducted to assess the potential impacts of the landfill.

PROJECT EXPERIENCE – SHALE INDUSTRY

Canada Brick Mississauga, ON	Specialist for assessment of geological controls upon shale quality at the Canada Brick Britannia Road quarry site. The work was carried out in conjunction with quality control estimate of shale reservoir on the property.
Canada Brick Halton Region, ON	Project Manager for a hydrogeological work program in support on an application for a license for the Hanson Brick Tremaine Quarry in Halton Region, Ontario.
Brampton Brick Limited Halton and Peel Region, ON	Project Director for a hydrogeological and surface water program in support of a license application for a proposed shale quarry for a brick manufacturer. The work programs involved borehole drilling and monitoring well installations, surface water flow monitoring, water quality sampling, groundwater flow modelling and preparation of an Adaptive Management Plan (AMP).
Hanson Brick Limited Halton Region, ON	Project Director for the assessment of the potential gas migration from a landfill to an adjacent brick manufacturing facility containing a brick kiln. The program identified potential risks and a monitoring and response program.

PROJECT EXPERIENCE – MINING

Stanleigh Mine Elliot Lake, ON	Project Hydrogeologist for assessment of the Rio Algom Stanleigh Mine near Elliot Lake, Ontario. The project included development of a three-dimensional flow model of a low-level radioactive waste tailings facility in Precambrian bedrock of the Canadian Shield. The model was used to develop estimates of seepage rates from the facility and was submitted to the Atomic Energy Control Board (AECB) as part of the regulatory approvals process.
Voisey’s Bay Mine Labrador	Technical specialist for hydrogeological modelling at the Voisey’s Bay Mine site involving development of three-dimensional groundwater flow models of a proposed tailings basin, mine waste rock disposal facility, and an open pit mine at the Voisey’s Bay Mine Site in Labrador. The modelling was carried out for the Voisey’s Bay Nickel Company (VBNC) as part of the hydrogeological assessment of the mine. The work was subject to regulatory review and presented as evidence at an environmental assessment hearing.
Baley Gold Mine Baley, Russia	Project Hydrogeologist for an Environmental Impact Assessment (EIA) as part of a feasibility study for mine expansion. The hydrogeological component included evaluation of potential for water quality impacts for an open pit mine and tailings basin, reduction of flow in stream and interference with the municipal water well supply.
Asacha Gold Mine Kamchatka, Russia	Project Hydrogeologist of the proposed Asacha Gold Mine in northeastern Russia. The assessment focused upon chemical water quality and streamflow impacts associated dewatering of an underground mine and construction of a tailings basin. The results of the assessment formed part of the mine feasibility study.

Timmins Mine Water Study Timmins, ON	Project Hydrogeologist for assessment of flooding of an extensive array of underground mine working beneath the City of Timmins. The assessment included evaluation of the potential impacts arising from the discharge of water from the flooded mine workings at surface within the city.
Cigar Lake Mine Saskatchewan	Project Hydrogeologist for assessment of potential groundwater inflows into proposed shaft in northern Saskatchewan for the Cigar Lake Mining Corporation (CLMC). The results of the assessment were used as the basis for the engineering design at the shaft.
Denison Mines Elliot Lake, ON	Project Hydrogeologist for an assessment of low-level nuclear waste tailings basin at the Denison Mines near Elliot Lake, Ontario. The hydrogeology study included assessment of seepage of uranium-impacted groundwater from the basin.
MaCassa Mines Kirkland Lake, ON	Project Hydrogeologist for hydrogeological assessment at the Lac Minerals MaCassa Mine tailing basins in Precambrian bedrock near Kirkland Lake, Ontario. The work was carried out to evaluate the potential impacts during operation and following decommissioning of the facility.

PROJECT EXPERIENCE – CONTAMINATED INDUSTRIAL SITES

ICI Nobel, ON	Hydrogeological assessment of groundwater and surface water quality at the former ICI explosives and war productions plant near Parry Sound, Ontario for ICI Canada. The program included assessment of groundwater and surface water quality impacts and removal of buried underground fuel storage tanks. The results of the investigations were submitted to the Ontario Ministry of the Environment as part of the site decommissioning.
Ford Motor Company North York, ON	Dewatering of a groundwater collection gallery and discharge of the contaminated (chlorinated solvent) wastewater to the municipal sewer system (under special conditions), at the Ford Motor Company Plant in North York, Ontario.
Shell Oil North York, ON	Dewatering of a groundwater collection gallery and discharge of the contaminated (chlorinated solvent) wastewater to the municipal sewer system (under special conditions), at the Ford Motor Company Plant in North York, Ontario.
Beaver Lumber Cole Harbour, NS	Excavation of underground storage tank (fuel oil) at the Beaver Lumber store at Cole Harbour, Nova Scotia. The results of the investigation favoured Beaver Lumber, by indicating that damage to the store was due to lack of delivery of the fuel supplier rather than leakage from the site fuel storage tank.
ICI Surfactants Oakville, ON	Hydrogeological impact assessment of cadmium concentrations in groundwater at the ICI Surfactants (formerly Atkemix) site in Oakville, Ontario. The results of the monitoring were submitted to the Ministry of Environment and Energy for regulatory purposes.

Bata Footwear Batawa, ON	Participation in the hydrogeological investigation of chlorinated solvent contamination of a bedrock limestone aquifer at the Bata Footwear plant site in Batawa, Ontario. The results of the hydrogeological impact assessment were submitted to the Ministry of Environment and Energy and used during subsequent legal proceedings to determine financial liability of Bata Footwear for the groundwater contamination.
Niagara Recycling Centre Niagara Falls, ON	Project Director and senior hydrogeologist for the annual operational and monitoring programs for a hydrogeological work program involving groundwater contaminated with chlorinated solvents at the Niagara Recycling Centre related to prior industrial land use. The work program involved operation of the groundwater injection remediation system, assessment of subsurface contamination and preparation of annual monitoring reports.
Rankin Construction Fill Management Plan Port Colborne, ON	Project Director and senior geoscientist for the development of a fill management plan for Pit 1 at the Rankin Construction Port Colborne Quarry. The program included a plan to take excess fill from the area to fill Pit 1. This included a sampling and reporting program to meet MECP requirements.

PROJECT EXPERIENCE – OIL & GAS

Assessment of Natural Gas Storage Potential Lake Erie, ON	Project Manager for an assessment of the potential for natural gas storage on Crown Lands beneath Lake Erie. The study involved the assessment of natural gas reservoirs to evaluate their suitability for use as gas storage facilities. Estimated available storage volumes were provided for each of the reservoirs.
Assessment of Natural Gas Storage Potential Southwestern Ontario	Project Manager for an evaluation of the hydrocarbon resources in Southwestern Ontario for the Petroleum Resources Centre of the Ministry of Natural Resources. The study included the interpretation and mapping of pool boundaries for major pools, calculations of in place and recoverable reserves, tabulation of reservoir characteristics, and estimation of potential hydrocarbon resources in the Ordovician strata of southern Ontario.

PROJECT EXPERIENCE – MUNICIPAL GROUNDWATER STUDIES

Groundwater Study for the County of Victoria ON	Project Director and senior hydrogeologist for a large-scale groundwater study for the County of Victoria with funding from the Provincial Water Protection Plan (PWPP). The work program involved a groundwater resource assessment, evaluation of existing groundwater usage, contamination assessment, development of management options and protection strategies, and an economic evaluation.
Groundwater Study for the City of Stratford ON	Project Director and senior hydrogeologist for a Groundwater Study for the City of Stratford involving an assessment of groundwater resources, source of contamination, pump testing of deep wells in limestone bedrock, and development of groundwater management options and protection strategies.

Simcoe and South Simcoe Groundwater Studies
ON

Provided specialist hydrogeological services for both the North Simcoe Groundwater Study and South Simcoe Groundwater Study. The work program involved a characterization of the hydrogeology of the study areas and numerical groundwater modelling of Well Head Protection Areas for municipal wells (WHPAs).

PROJECT EXPERIENCE – KARST

Nelson Quarry Extension
ON

Project Director and Senior Hydrogeologist for karst assessment of the proposed Nelson Quarry extension that involved mapping of the Amabel Formation along the exposed cliff faces of the Mount Nemo outlier, identification of karstic springs in the Medad Valley and associated water courses, mapping of karst features along more than 1 km of exposed quarry faces. Examination of surface karst features including sinkholes and internal drainage were mapped in the area of the quarry. An ERI (Electrical Resistivity Imaging) survey was conducted over a linear distance to identify potential anomalies that could represent karstic features. Boreholes were drilled into the karstic features to evaluate karstic conditions. The boreholes were video logged along the length of the hole to evaluate karstic features such as solution enlarged fractures and voids. The flow in the boreholes were pumped and logged during an impeller flow meter to assess inflow into boreholes from potential karstic features. An array of 8 wells and a pumping well were drilled to conduct a tracer test using fluorescein dye. The dye was injected into the wells and the travel time and dye concentrations were recorded to evaluate karstic flow paths and velocities. The results were incorporated in a report submitted as part of the regulatory approvals process and presented and defended at an Ontario Municipal Board hearing.

Proposed Redland Quarries Landfill
ON

Project Hydrogeologist for a karst study as part of a geological and hydrogeological evaluations of a proposed hydraulic containment engineered landfill facility in a quarry near Dundas, Ontario. The karst study involved examination and evaluation of karstic features in the vicinity of the quarry including solution-enhanced weathering and extensive network of surficial dolostone plain, and examination of epi-karst on more than 1 km of quarry faces including solution enlarged and materialized vertical joints. The results of groundwater level monitoring results were evaluated for patterns indicative of presence of karst including rapid rises in groundwater levels (‘spiking’). Pump tests were analysed to evaluate the drawdown and recovery responses characteristic of karst.

Proposed Dundas Quarry Extension
ON

Project Director and Senior Hydrogeologist for a karst assessment as part of a hydrogeological work program for the approval of an application for a large dolostone quarry near Dundas, Ontario. The work program involved an ERI surface geophysical survey along more than 500 m of line to test for potential karstic anomalies. Boreholes were drilled in the areas of identified anomalies to evaluate the potential presence of karst. The faces of the quarries were also examined for layers of karstic groundwater inflow. The results of the karst study have been peer reviewed and are currently being used in support of the license application for quarry expansion.

Karst Remediation Hamilton, ON	Senior Hydrogeologist for a karst assessment of a remediated industry site in the area of the Eramosa Karst Conservation Area in Hamilton, Ontario. The work program involved a review of literature on karst in the area. An inspection of the karstic features includes sinkholes, internal drainage and inferred subsurface karstic flow pathways was undertaken in areas around the site. A report in support of a property transaction was provided to regulatory authorities and agencies.
Brow Landfill Monitoring Program ON	Project Hydrogeologist for an assessment of leachate seepage from an industrial solid waste landfill along karstic flow pathways including epi-karst, solution weathered vertical joints and horizontal fracture networks. The assessment involved monitoring of the flow rates from leachate springs and water quality of springs.
Hydrocarbon Reserve Evaluation Southwestern Ontario	Project Director and Senior Geologist/Hydrogeologist for the estimation of hydrocarbon reserves in Southern Ontario for the Petroleum Resource Centre of Ontario Ministry of Natural Resources. The work program involved extensive analysis of karstic reservoirs formed and dolomitization from solution weathering and collapse along vertical joints and horizontal sub horizontal fracture networks. Prepared a report summarizing the study and provided to the MNR as a commercial publication.

PROJECT EXPERIENCE – LAND DEVELOPMENT AND INFRASTRUCTURE

Peer Review, Town of Caledon Caledon, ON	Peer review of the hydrogeological work program for a proposed residential development in Palgrave for the Town of Caledon planning department. The work program involved review of hydrogeological reports, discussions with the Town and preparation of a peer review reports with recommendations.
Peer Review, Town of Caledon Caledon, ON	Peer review of the hydrogeological and geotechnical work program for a proposed residential development in Beaverhall for the Town of Caledon planning department. The work program involved review of hydrogeological reports, discussions with the Town and preparation of a peer review reports with recommendations.
Niacon Construction Niagara-on-the-Lake, ON	Hydrogeological assessment of the potential impacts associated with the development of an infrastructure for a zipline facility along the Niagara river at Thompsons Point. The work program involved an evaluation of the potential for reduction of groundwater seepage along the Niagara Gorge and related environmental effects. A report was prepared that was submitted to agencies as part of the regulatory approvals process.
Time Developments Niagara Falls, ON	Senior hydrogeologist for the hydrogeological assessment of the existing conditions and potential impacts associated with the development of a condominium adjacent to the Niagara River in Niagara Falls. The work program involved borehole drilling, monitoring wells installation, groundwater level monitoring and assessment of groundwater levels and flow directions. The results of the work program were incorporated into a geotechnical and hydrogeological report.

Time Developments Niagara Falls, ON	Phase 1 and Phase 2 Environmental Site Assessments (ESA) for regulatory approval for condominium development on River Road in Niagara Falls, Ontario. The work program involved test pitting and surface sampling as well as collection and analysis of soil and water samples and evaluation of potential soil and water contamination.
AECOM Oakville, ON	Hydrogeological assessment of the excavation and construction of a water pumping station in till and bedrock adjacent to a surface water course. The work program involved borehole drilling, monitoring well installations, hydraulic conductivity testing and a hydrogeological assessment of impacts on surrounding private wells associated with construction dewatering.
Geranium Homes Woodview Development ON	Hydrogeological assessment in support of approval for a proposed residential development involving borehole drilling, monitoring well installations, hydraulic conductivity testing, groundwater level monitoring, determination of groundwater levels and flow directions and a hydrogeological impact assessment involving a water balance to evaluate reduction in infiltration and potential interference with surrounding water wells and effects on an adjacent provincially significant wetland. Participated in meetings with the TRCA as part of the approvals process. A report was prepared in support of the approvals process.
Geranium Homes Altona Development ON	Hydrogeological assessment in support of approval for a proposed residential development. The work program involved borehole drilling, monitoring well installations, groundwater level monitoring, development of a water balance and a hydrogeological impact assessment. A report was prepared in support of the application.

Golder Associates Ltd. – Barrie

Devin Hannan, Associate, P.Eng.

Devin Hannan is an environmental engineer and Associate with over 18 years of experience specializing in water resources project management, hydrogeologic site characterization, groundwater modelling and environmental database development. Mr. Hannan has applied his skills to provide conceptualization, design, optimization and permitting solutions to clients in a wide range of settings, including: open pit and underground mining; tailings facilities; oil sands operations; natural gas extraction; sand and gravel pits; rock quarries; municipal water supply; land development; landfills and contaminated sites. Mr. Hannan utilizes a wide variety of tools in his work including database applications such as MS Access and SiteFX, conceptual model development with software such as Leapfrog, Viewlog, Surfer and Manifold, and numerical modelling using Visual MODFLOW, Groundwater Vistas, GMS, MT3D, PEST, SEEP/W and FEFLOW.

Education

B.A.Sc. Environmental Engineering – Civil Specialization – Co-op, University of Waterloo, 2002

Certifications

Professional Engineers Ontario, P.Eng. Licence

OSHA 40-Hour HAZWOPER Certified

U.S. Department of Labor Part 48 MSHA Training (Surface Miner)

CPR and First Aid Trained

Languages

English – Fluent

Employment History

Golder Associates Ltd. – Barrie, Ontario

Associate, Environmental Engineer (May 2002 to Present)

Responsible for: water resources project management; hydrogeological site characterization; regulatory permitting; numerical and analytical groundwater modelling; health, safety and environment oversight; technical reporting; and junior staff mentorship. Client development and liaison in mining; pits and quarries; land development; energy; and municipal infrastructure sectors. Experienced in use of GMS, GWV, Visual MODFLOW, MT3DMS, FEFLOW, Leapfrog, Viewlog, AQTESOLV, SiteFX, Manifold GIS, Surfer, Access and Excel. Supervisor or assistant in field activities including: groundwater monitoring; groundwater and soil sampling; pumping tests, slug tests, overburden and bedrock drilling and land surveying.

University of Waterloo – Waterloo, Ontario

Research Assistant (March 2002 to May 2002)

Assisted in laboratory experiments exploring the use of potassium permanganate as an in-situ remediation technique for removal of hydrocarbon solvents in groundwater.

Jacques Whitford Environment Ltd. – Markham, Ontario

Field Technician (May 2001 to Sept. 2001)

Conducted numerous Phase II environmental activities such as groundwater monitoring and groundwater, soil and air sampling. Also participated in test pitting, drilling and excavations of contaminated sites. Assisted in designing and constructing a GAC groundwater treatment system.

Enbridge Consumers Gas – Richmond Hill, Ontario
Project Manager (Sept. 2000 - Dec. 2000 & Jan 2000 to April 2000)

Planned, priced and implemented small-scale pipeline replacement projects.

Toronto Transit Commission – Toronto, Ontario
Construction Inspector (May 1999 to Aug. 1999)

Supervised concrete, masonry, electrical and HVAC projects.

Master Builders Technologies – Toronto, Ontario
Laboratory Technician (Sept. 1998 - Dec. 1998 & Jan. 1998 to April 1998)

Developed and tested concrete and grout mixes for ready-mix and pre-cast applications.

PROJECT EXPERIENCE – LAND DEVELOPMENT

Orillia Residential Subdivision Ontario, Canada	Managed a joint geotechnical and water resources field program and subsequent technical study / report in support of a proposed large residential subdivision design and permitting process.
Southern Ontario Residential Subdivision Ontario, Canada	Developed a 2D numerical flow model to assess the potential for site flooding as a result of post-development re-grading.
Midhurst Secondary Plan Development Ontario, Canada	Refined a 3D FEFLOW groundwater model to assess hydrogeological impact and sustainability of a proposed residential subdivision water supply. The model was calibrated to both steady-state (long-term) water levels and transient (monthly) stream baseflow. Well capture zones, potential drawdown, well interference, and baseflow changes were assessed.

PROJECT EXPERIENCE – WATER RESOURCES

Stayner Schedule B Municipal Class EA Ontario, Canada	Developed a groundwater model in support of a proposed new water supply for the community of Stayner. The model was used to assess sustainable pumping rates, drawdown and future wellhead protection areas.
Lake Simcoe Region Conservation Authority Ontario, Canada	Developed loosely-coupled groundwater (FEFLOW) / surface water (MIKE-SHE) models in support of the Midland-Penetanguishene Tier Three Water Budget and Local Area Risk Assessment.
Region of Waterloo IUS Project Waterloo, Ontario, Canada	Data manager for a large water supply project. Duties include creating Viewlog sections, pumping test analysis on AQTESOLV, and analyzing water well, permit to take water, chemistry, and well interference databases.
Mount Albert Water Supply Project Mount Albert, Ontario, Canada	Supervised air-rotary drilling and well installation operations for deep overburden test wells.
Wellington County Groundwater Study Wellington County, Ontario, Canada	Assisted with county-wide groundwater study including evaluation of bedrock and quaternary geology maps, creating bedrock surface, aquifer thickness and potentiometric surface maps on Surfer, delineating potential aquifers and recharge areas, manipulating the MOE water well database, creating a database of county-wide groundwater chemistry results, modelling well capture zones using the 3D numerical flow model MODFLOW and companion code MODPATH, and extensively researching and reporting on water use within the county.
North Simcoe Groundwater Study Simcoe County, Ontario, Canada	Completed over 39 analytical and numerical MODFLOW groundwater models to delineate wellhead protection areas. Wrote modelling sections of final report.

PROJECT EXPERIENCE – MINING

New Gold Rainy River Ontario, Canada	Developed a groundwater model in support of an existing open pit gold mine. The model was calibrated to existing monitoring data and mine conditions and thereafter used as part of the water management strategy to assess future mine inflow rates and drawdown over time.
Cliffs Chromite Project Ontario, Canada	Constructed and calibrated a regional scale 3D MODFLOW model of a proposed chromite mine in support of an Environmental Assessment. Drawdown, stream baseflow changes and waste rock seepages were evaluated. In addition, the model served as a supplemental tool in refining waste rock seepage collection system design.
Pershimco Resources Inc. Los Santos, Panama	Developed and managed a baseline hydrogeology study of the Cerro Quema Project proposed mine site in support of a Feasibility Study and Environmental Assessment. The work program included drilling and monitoring well installation, hydraulic response testing, sampling, data analysis and reporting.
Osisko Hammond Reef Ontario, Canada	Constructed a 3D MODFLOW model to assess proposed open pit inflows and assist in slope stability calculations. A code was developed to transfer complex 3D shear and splay structures interpreted in Datamine into the MODFLOW framework.
NICO Fortune Minerals Northwest Territories, Canada	Developed a 3D numerical FEFLOW model to assess the potential impact of a proposed underground and open pit mine on the hydrogeologic system and surface water receptors. The model examined pit progression "seamlessly" over time using unique time-variable boundary nodes to represent the open pit. In conjunction with the 3D model, a 2D transport model was developed to assess saline upwelling into the mine workings.
South Heart Power Project North Dakota, USA	Developed geologic surfaces Surfer and constructed a 3D numerical MODFLOW model in Groundwater Vistas to assist in forecasting hydrogeologic impacts of a proposed coal mine.
Iron Ore Company of Canada Newfoundland and Labrador, Canada	Constructed an “Order of Magnitude” 3D MODFLOW model to assess proposed mine inflows and potential drawdown.

PROJECT EXPERIENCE – TAILINGS

IAMGOLD Cote Gold Project Ontario, Canada	Developed a 3D MODFLOW model in support of a feasiblity study for a proposed tailings management facility in northern Ontario. The model was used to assess potential TMF seepage pathways and rates and was a critical tool in optimizing the conceptual design of the facility.

Agnico Eagle Pinos Altos, Mexico	Built and calibrated a 3D MODFLOW model in support of the Oberon De Weber Crown Pillar and Tailings In-Pit Project. The model was utilized to: 1) estimate inflow rates and water levels at underground mining operations; 2) predict pumping rates required to maintain acceptable water levels in the backfilled pit; 3) simulate groundwater recovery post-mining; and 4) estimate flow rates and pathways of backfill contact water for use in geochemical loading assessments.
Osisko Hammond Reef Ontario, Canada	Constructed 3D MODFLOW model of proposed Tailings Management Facility to simulate groundwater flow within and around the TMF and to evaluate the applicability of the design concept for seepage collection.
Barrick Gold Ontario, Canada	Amalgamated over 30 years of data and reports to develop an updated hydrogeological site characterization of a tailings management facility and regional surrounds. Developed a series of 2D SEEP/W and CTRAN models to assess seepage from a proposed tailings management facility expansion. This work was later advanced upon through the development of a regional 3D FEFLOW model to better understand seepage pathways.
Cameco Key Lake Saskatchewan, Canada	Constructed a MODFLOW model to support a hydrogeological assessment of the long-term performance of a tailings management facility. This modelling work included both regional geologic strata and local, highly-detailed engineered structures

PROJECT EXPERIENCE – AGGREGATE INDUSTRY

CBM Osprey Quarry Ontario, Canada	Developed and reported on a sophisticated groundwater-surface water model (HydroGeoSphere) in support of an active quarry's Adaptive Management Plan submission to the Ontario Ministry of Natural Resources and Forestry. The modelling effort included a successful transient calibration to pre- and post-quarry water levels and stream flows.
Lafarge Stouffville Ontario, Canada	Managed a hydrogeological field program, technical analysis and reporting for a Permit To Take Water at a large aggregate operation. The Permit was eventually granted by the Ontario Ministry of Environment, Conservation and Parks.
Construction Materials Client Ontario, Canada	Managed a hydrogeological field program and subsequent technical analysis and reporting in support of a below water table licence application in an area with sensitive environmental receptors. The project was subject to extensive third party review with stakeholders including municipal government, the conservation authority, and members of the public. The project was eventually approved by the Ontario Ministry of Natural Resources and Forestry.
Brampton Brick Ltd. Ontario, Canada	Developed a 3D numerical FEFLOW model to assess proposed shale quarry inflows and potential impacts to receptors through various stages of quarry development. Provided technical responses to peer reviews from government agencies and other consultants.

Lafarge West Paris Ontario, Canada	Constructed a 3D numerical MODFLOW model to assess the potential impact of a sand and gravel operation expansion on surrounding domestic wells and surface water receptors. A 2D FEFLOW heat transport model was developed to assess the potential thermal impact of the operation on a nearby wetland.
Buckhorn Quarry Ontario, Canada	Carried out bedrock drilling and monitoring well installation program, conducted pumping tests, analyzed data using Excel and AQTESOLV and wrote letter report in support of quarry permit application.
Guelph Limestone Quarry Ontario, Canada	Updated and utilized the Guelph-Puslinch Groundwater Flow Model (FEFLOW) to estimate impacts on the flow system and surrounding municipal pumping wells due to proposed change in quarry water levels.
St. Marys CBM Olszowka Project Ontario, Canada	Constructed a 3D numerical MODFLOW model to assess the potential impact of a proposed gravel extraction operation on surrounding surface water receptors. The model examined effects of seasonal climate change by modelling varying recharge inputs on a monthly basis. In conjunction with the 3D model, a 2D FEFLOW heat transport model was developed to assess the potential thermal impact of the operation on surrounding streams.

PROJECT EXPERIENCE – OIL & GAS

Anglo Coal Gas Project Limpopo, South Africa	Developed a regional transient 3D numerical FEFLOW model to assess the estimated yield and potential impact of pumping wells proposed for use in a deep coal bed methane extraction field.
Long Lake Oil Sands Project Alberta, Canada	Developed a large scale FEFLOW groundwater model of a proposed oil sands development site. The purpose of the model was to serve as a supplemental to an environmental impact assessment, as well as providing a tool for analyzing various water-taking scenarios related to the steam-assisted gravity drainage operations.

PROJECT EXPERIENCE – LANDFILL

Barrie Landfill Ontario, Canada	Developed a set of 2D MODFLOW models to assess the effects of proposed landfill SWM ponds on water table elevation and the expected additional yield required at purge wells to maintain current operating water levels and capture zones.
Walker Environmental Southwest Landfill Ontario, Canada	Developed and reported on a 3D MODFLOW model in support of the hydrogeological component of an Environmental Assessment of a proposed landfill. The model assessed potential landfill seepage rates and pathways and interaction with the surrounding groundwater system.

Key River Landfill Ontario, Canada	Constructed and calibrated a 3D MODFLOW and MODPATH model of the Key River Landfill site and surrounds to: 1) estimate the effect that potential future groundwater mounding at the landfill may have on a proposed rail realignment nearby; and 2) examine the possibility of leachate discharging along the proposed realignment.
Blue Mountains Landfill Ontario, Canada	Constructed and calibrated two 2D numerical flow and transport MODFLOW / MT3DMS models to assess the potential impact of various landfill expansion scenarios on the surrounding hydrogeologic system and surface water receptors.
Edgewood Landfill Ontario, Canada	Conducted drilling, soil sampling, groundwater sampling, monitoring well installation and level surveying at a closed landfill. Constructed a 3D numerical MODFLOW and MT3D flow and contaminant transport model to aid in predicting extent and character of leachate plume.

PROJECT EXPERIENCE – CONTAMINATED LAND REMEDIATION

Industrial Site Ontario, Canada	Developed and managed a field program including monitoring well installation, groundwater sampling and pumping tests at an industrial site with impacted groundwater along the shore of Lake Ontario. Subsequent to this work a pre-existing 3D MODFLOW model was updated to better reflect current site conditions and utilized to better define contaminant plume migration.
Commercial Site Ontario, Canada	Constructed and calibrated a 2D MODFLOW groundwater model to assess the efficacy of a collector trench interceptor system in support of a Risk Assessment at a property in southwestern Ontario.
DWPV Remediation Ontario, Canada	Assisted in drilling, soil sampling, slug testing and groundwater sampling program at a DNAPL contaminated site. Developed MS Access database to store and manipulate soil and chemistry data. Aided in writing hydrogeologic reports.

TRAINING

PEST: Model Independent Parameter Estimation and Uncertainty Analysis Training Course

Introduction to GoldSim

FEFLOW 101

FracMan7 Workshop

Critical Thinking in Aquifer Test Interpretation

Beyond Data: Conceptual Site Models in ESAs

Confined Space Entry and Awareness Course

Golder PM24 (Project Management) Course

Golder Environmental Site Assessment Field Camp

Golder Health and Safety Modules 1 and 2

Golder Technical Writing Course

Golder Communications Course

Golder 101

Geostatistics Short Course

MS Access Database Design

PROFESSIONAL AFFILIATIONS

Registered Professional Engineer, Ontario

PUBLICATIONS

Conference Proceedings

Bishop, Nick, Devin Hannan and Blythe Reiha. 2012. *The Implications Of Mesh Quality Metrics On A 2D Fully-Saturated Problem*. 3rd International FEFLOW User Conference, September. Berlin, Germany.

Education

BSc Engineering (Co-op),
University of Guelph,
Guelph, Ontario, 2007

Languages

English – Fluent

Golder Associates Ltd. – Mississauga

Employment History

Golder Associates Ltd. – Mississauga, Ontario
Water Resources Specialist (2007 to Present)

Responsible for conducting water quantity and water quality investigation programs that include hydraulic and hydrologic modelling, analysis of riverine and lacustrine environments, the design, execution and management of meteorological, hydrological and water quality field programs and development of water balance and water quality modelling analyses. Currently working on various surface mine and mine rehabilitation investigations of hydrology and water quality. Completes water resources projects from desktop reviews to design, construction monitoring and erosion and sediment control inspection.

Golder Associates Ltd. – Mississauga, Ontario
Water Resources (Co-Op) (May 2006 to December 2006)

University of Guelph, Environmental Biology – Guelph, Ontario
Co-Op Student (May 2005 to August 2005)

Ontario Clean Water Agency – Toronto, Ontario
Water Resources (Co-Op) (January 2005 to April 2005)

Hydromantis Inc., Consulting Engineers – Toronto, Ontario
Co-Op Student (June 2004 to September 2004)

PROJECT EXPERIENCE – WATER SUPPLY FORECASTING

City of Iqaluit, Nunavut, Canada	Developed a water balance model (using GoldSim) to quantify water deficit risks under future population growth and climate change scenarios. Analytical output and recommendations were subsequently provided in order to assist the City in water license application process for a supplementary source and provide a risk matrix of long-term probabilistic water supply deficits. (2012 to 2013)
City of Rankin Inlet Rankin Inlet, Nunavut, Canada	Water supply deficits were evaluated using a water balance model (using GoldSim) under future growth and climate change scenarios. The model evaluated water taking from the supply reservoir and an adjacent river while maintain use for aquatic live and social activities. (2015)

PROJECT EXPERIENCE – CHANNEL / CROSSING DESIGN

County of Northhumberland Cobourg, Canada	Ongoing support regarding a channel remediation design/assessment for the County of Northhumberland on a reach of Brookside Creek located downstream of the closed Eagleson Landfill to reroute unaffected surface water flows away from a zone of leachate influenced groundwater – conducted field studies, fluvial geomorphic and hydraulic analyses, preparation of conceptual/detailed design plans, liaison with contractor and reporting. (2009 to 2015)

Region of Durham Whitby, Canada	Completed a hydraulic analysis and fluvial geomorphic assessment at East Corbett Creek and tributary of East Corbett Creek. The analyses were conducted in support of a proposed extension of Consumers Drive that includes culvert crossings at the two watercourses – conducted field investigations, fluvial geomorphic analyses, hydraulic modelling, environmental permitting and reporting. (2014 to 2016)
Confidential Client Timmins, Canada	Ongoing support of a natural channel diversion design/assessment for a proposed pit mine. The channel design incorporates fluvial geomorphic processes to accommodate fish passage and habitat. Hydraulic modelling was conducted to limit erosion and maintain stability of the channel banks and crossings. (2015)
Canadian National Railway Southern Ontario, Canada	Many rail crossings were evaluated at locations of aging bridges, collapsed culverts and areas of flooding. Sites were visited and surveyed to confirm conditions and provide detailed data for desktop analysis. Hydraulic analyses were completed for each site to evaluate existing infrastructure. New crossing designs were evaluated based on MTO and CN guidelines and developed to conceptual and final designs. (2016 to 2020)

PROJECT EXPERIENCE – ENVIRONMENTAL COMPLIANCE APPROVALS, WATER DISCHARGES

Canadian National Railway Algonquin Park, Ontario, Canada	Completed an Environmental Compliance Approval for Industrial Sewage Works for a temporary water treatment facility which was designed to treat contaminated water and sediments from a historic train derailment. The facility discharged to a nearby lake within the Park. (2015 to 2017)
Essroc Aggregates Cambridge, Ontario, Canada	Managed and completed an Environmental Compliance Approval for Industrial Sewage Works for an aggregate pit and wash plant in Cambridge, Ontario. The application included supporting documentation of the wash ponds which only discharged to the environment through the groundwater. (2016 to 2017)
Fish and Bird Emporium Innisfil, Ontario, Canada	Lead a team that completed an Environmental Compliance Approval for Industrial Sewage Works for a tropic fish warehouse and distribution centre. The application included multiple water filtration facilities designed to reduce the effluent contaminant concentrations without impacting the health of the fish at the site. (2016)
Lafarge Canada Inc. – Soares Dundas, Ontario, Canada	Carried out field investigations, water budget analysis and coordinated various project tasks related to the proposed Lafarge Soares License Application. (2007 to 2009)
Amherst Quarries Ltd. Windsor, Ontario, Canada	Performed reconnaissance of the local watersheds and hydrologic features of the quarry sumps. Carrying out quarterly volumetric flow monitoring and water quality sampling. Local drainage channels were evaluated using computer models including HEC-RAS. Developed a water balance to model drainage from the site and the adjacent Canard River. (2008)

O'Shanter Development Company – Arbour Farms Dufferin, Ontario, Canada	Conducting annual dry weather volumetric flow monitoring and groundwater well monitoring related to the Arbour Farms assessment of the proposed quarry. (2007 to 2012)
Brampton Brick – Norval Norval, Ontario, Canada	Performed field investigations and coordinated various project tasks related to the proposed Brampton Brick Norval quarry development. (2007 to 2008)
Lafarge Canada Inc. West Paris, Ontario, Canada	Completed baseline monitoring, including flow and water level monitoring, water quality monitoring. Supported license applications for extension properties and Permit to Take Water applications and continued site plan monitoring. (2016 to 2020)
Lafarge Canada Inc. Wellington, Ontario, Canada	Conducted baseline investigations of site drainage, local watercourses, including the Speed River. Potential impact on the water resources as a result of below water extraction was evaluated to support Permit to Take Water Applications and Environmental Compliance Approvals. (2015-2020)
Lafarge Canada Inc. Woodstock, Ontario, Canada	Completed water quality, water level and flow monitoring at local water features. Developed potential effects assessment of quarry extraction and drain realignments in support of a Major Site Plan Amendment. (2015-2020)
Nelson Aggregate Company Burlington, Ontario, Canada	Carried out volumetric flow monitoring throughout neighbouring watersheds for the proposed Lafarge Nelson License Application. Performed wetland mapping on the proposed quarry site. (2006 to 2007)
CBM Aggregates Various Sites in Southern Ontario	Various aggregate properties have been monitored and evaluated for aggregate license applications. this monitoring included water level monitoring, stream flow monitoring, groundwater piezometer monitoring and meteorological monitoring. Detailed site water balances as well as site and water course characterization have been evaluate and reported as part of the multidisciplinary applications. (2007 to 2020)

PROJECT EXPERIENCE – SITE REHABILITATION

Client Confidential Bancroft, Ontario, Canada	Completed surface water investigations at a decommissioned mine site (uranium) near Bancroft, Ontario, including meteorology, flow and water quality monitoring. Developed a detailed water balance to evaluate the site drainage and adjacent stream networks. Characterized and reported the surface water networks and their impacts. (2010 to 2020)
Client Confidential Near Kenora, Ontario, Canada	Completed surface water investigations at a former mine (nickel) near Kenora, Ontario, including meteorology, flow monitoring, water column profiling and water quality sampling. Flow regimes were characterized and modelled to evaluate impacts of adverse water quality on downstream environments. (2009 to 2018)

Niagara Peninsula Conservation Authority Welland, Ontario, Canada	Completed stream sediment investigations on Lyon’s Creek, downstream of the Welland Canal, including a stream survey, sediment sampling, loading, scour and re-suspension analysis. Reported investigation results as part of the Niagara River remedial options. (2009 to 2010)
Lafarge Canada Inc. Bath, Ontario, Canada	Reporting annually on volumetric flow monitoring and water quality data collected monthly on and adjacent to the Lafarge Bath cement kiln dust landfill and rehabilitation. Engineering drainage features on site was also completed. (2006 to 2008)
Canadian Gypsum Company Ltd. Haggersville, Ontario, Canada	Performing volumetric flow monitoring, water quality and continuous water level monitoring on Boston Creek adjacent to the mine site. Annual reporting was also conducted until rehabilitation completion. (2006 to 2013)

PROJECT EXPERIENCE – THREATS ASSESSMENT

Hanson Brick Ltd. – Tremaine Bronte Creek Burlington, Ontario, Canada	Evaluated the risks of a potential drinking water intake on Bronte Creek. Risks in the watershed were evaluated and analysed using plume dispersion algorithms to estimate contaminate impacts on the potential intake. Evaluation was completed using computer models including HEC-RAS. (2008)
Teck Resources Elk Valley, British Columbia, Canada	Conducted water quality modelling to support mine site investigations for a mining project in British Columbia. Water quality parameters were modelled throughout the watersheds from natural sources, mining and metal processing activities as well as their reactions within the watershed. Modelling efforts were used to evaluate treatment options and water handling / management. (2013 to 2015)

PROJECT EXPERIENCE – URBAN WATER MANAGEMENT

Metrolinx Toronto, Ontario, Canada	Project manager for the program which included stormwater sampling of a Metrolinx rail yard. The sample results were compared to the municipal stormwater sewer quality limits and reported at the season. (2017 to 2018)
Toronto Transit Commission Vaughan, Ontario, Canada	Task Manager of the stormwater monitoring and reporting as part of the ECA requirements at the 407 subways station. The monitoring involved storm event water quality monitoring to evaluate Stormwater Management Pond performance, erosion and sediment control inspections, annual reporting and recommendations for performance improvements. (2018 to 2019)
Town of Oakville Oakville, Ontario, Canada	Project manager for the program which included dry weather outfall sampling and wet weather storm sewer sampling. Results were analysed to develop water quality trends in order to estimate contaminate sources and evaluate the effectiveness of Best Management Practices and Stormwater Management Plans (Town of Oakville). (2008 to 2012)
City of Barrie Barrie, Ontario, Canada	Performing volumetric flow monitoring under flash flooding or melting conditions in areas of low permeability in the City of Barrie. (2008)

Black and McDonald Ltd. – Castrol Toronto, Ontario, Canada	Conducted reconnaissance and water quality sampling regarding the Castrol Oil storm water discharge to the city storm sewer. Testing performance of the on-site water treatment equipment and evaluating replacements. (2007)

PROJECT EXPERIENCE – MINING OPERATIONS AND EXPLORATION

Adrianna Resources Lac Otelnuk, Quebec, Canada	Conducted transducer installations and collected cross sectional geometry information at surface water points of interest influencing site drainage and watersheds adjacent to Lac Otelnuk. (2010)
Xstrata, Copper Las Bambas, Peru	Conducted transducer installations at surface water points of interests influencing the site drainage and watersheds located on and adjacent to site Las Bambas. (2008)
Xstrata, Copper Antapaccay, Peru	Conducted transducer installations at surface water points of interests influencing the site drainage and watersheds located on and adjacent to site Antapaccay. (2008)
Xstrata, Nickel Loma Miranda, Dominican Republic	Managed and carried out quarterly field campaigns for Loma Miranda and Energy Conversion Project, which involved installation and monitoring of river hydrology, water quality sampling and rain data collection. Quarterly reporting was conducted, summarizing campaigns. (2007 to 2010)

PROJECT EXPERIENCE – PIPELINE WORK

Trans Canada Pipelines Channel Rehabilitation Ontario, Canada	Designed a stream channel rehabilitation to remediate TransCanada Line 100-1 exposure caused by erosion and beaver activity near Dryden, Ontario. The project progressed from conceptual design through to construction monitoring. The final design was focused on improving channel stability over the pipelines to reduce meander and erosion. (2017)
Trans Canada Pipelines New Gas Line Ontario, Canada	Managed and supported continuous instream turbidity monitoring of many watercourse crossings as part of the Vaughan Mainline pipeline construction and Gravenhurst pipe replacement. This program included site reconnaissance, equipment installation, intensive 24-hour monitoring and troubleshooting, daily and final reporting. (2017 to 2018)
Trans Canada Pipelines Channel Rehabilitation Ontario, Canada	Developed the design and supported construction of channel rehabilitation works at a tributary of Bear Creek that is crossed by TransCanada pipelines Line 100-1 and Line 100-2 near Barrie, Ontario. The goal of the rehabilitation is to improve long term channel stability at the watercourse crossing. The work includes the completion of field studies and hydraulic modelling, development of conceptual designs, and the preparation of environmental permitting. (2016 to 2017)
Trans Canada Pipelines New Gas Line Ontario, Canada	Completed watercourse baseline investigations for Eastern Mainline Expansion in Ontario (260 km long new gas pipeline spanning central and eastern Ontario). Responsible for field data collection of baseline conditions at major watercourse crossings and evaluating the hydrotechnical characteristics of each potential crossing. (2015 to 2016)

Trans Canada Pipelines Gas Line Construction Ontario, Canada	Designed drainage improvements at a gas pipeline valve station to control flooding in the area to allow maintenance staff to work safely. The work involved conservation authority permitting and negotiation with landowners and other stakeholders. (2018-2020)

PROJECT EXPERIENCE – ENVIRONMENTAL ASSESSTMENT AND PERMITTING

Walker Environmental Group Inc. Ingersol, Ontario, Canada	Completed baseline evaluation and impact assessment for the proposed landfill in the Town of Ingersol. This included the flow and water quality monitoring of the Thames River and local tributaries. Desktop analysis of the potential impacts utilized hydrologic models, climate change predictions, water quality models and stormwater design. (2018-2019)
Marten Falls First Nation Marten Falls, Ontario, Canada	Drafted existing surface water conditions report and impact assessment to support the proposed all season road from Marten Falls to Nakina Ontario. This work involved watercourse crossing surveys utilizing helicopter transportation. The field studies visited a subset of the crossings to evaluate the impacts of the road alignment. (2019-2020)
NextBridge Northern Ontario, Canada	Completed water quality and hydrotechnical analysis to support the NextBridge Infrastructure East-West Tie Transmission Line Project in Northern Ontario (430 km long new transmission line). Conducted baseline studies, effects evaluations, permitting support through hydrotechnical analysis and preliminary design criteria. (2018)

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